MINISTRY OF INVESTMENT AND DOWNSTREAM INDUSTRY/BKPM

ENERGY TRANSITION PARTNERSHIP

UNOPS


REPORT

# Supply Chain Integration of Battery Value Chain for Energy Transition in Indonesia

RFP/2023/49848

2025

**Deliverable 4:** Social and environmental impact assessment related to the supply chain of batteries

**Prepared by:**

- **Hartree Consultores**
- **Kolibri Orbis**

Hartree®

Kolibri Orbis

AFD Agence Française de Développement

Federal Ministry for Economic Affairs and Climate Action

Department for Energy Security & Net Zero

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Australian Government
Department of Climate Change, Energy, the Environment and Water

CIFF CHILDREN'S INVESTMENT FUND FOUNDATION

SEQUOIA CLIMATE FOUNDATION

# UNOPS - Energy Transition Partnership

Social and environmental impact assessment related to the supply chain of batteries – Deliverable 4

"Supply Chain Integration of Battery Value Chain for Energy Transition in Indonesia" - Project

RFP/2023/49848
October 2025

This report has been issued and amended as follows:

| Issue | Revision | Description | Date | Signed |
|---|---|---|---|---|
| | | | | |

Project executed by:
Hartree Consultores and Kolibri

# Disclaimer

# About the Southeast Asian Energy Transition Partnership (ETP) and this project

The Southeast Asia Energy Transition Partnership (ETP) is a program of the United Nations Office for Project Services (UNOPS) and is a dynamic partnership of government and philanthropic partners, working to facilitate sustainable energy transition in Southeast Asia. ETP is strengthened by its knowledge of the region, unwavering commitment to inclusive growth and ability to mobilize support services that cater to unique project requirements.

ETP's teams synergize the strengths of the public and private sectors and implementing partners, with the project management expertise of UNOPS to coordinate technical and financial resources needed to make a difference.

Through the design and delivery of targeted technical assistance programs, aligned with ongoing initiatives in the region, ETP provides the expertise, coordination, dialogue and knowledge expansion needed to expedite energy transition.

ETP's work is structured around four strategic outcome (SO) areas:

I. Policy alignment with climate commitments,
II. De-risking investments on renewable energy, energy efficiency and fossil fuel phasedown,
III. Sustainable and resilient infrastructure, and
IV. Just transition

## Supply Chain Integration of Battery Value Chain for Energy Transition in Indonesia

The overall objective of the "Supply Chain Integration of Battery Value Chain for Energy Transition in Indonesia" project financed by ETP is to help Indonesia expedite its energy transition efforts by integrating the local supply chain for batteries with electric vehicles (EV), Solar Photovoltaic (PV) businesses, and other RE power plants through the development of a supply chain roadmap, policy development, and identification of investment opportunities, along with corresponding investment guidelines.

The methodology and approach provided by the implementing partners in the Inception Report will assist:

1. To catalyse the development of a *sustainable battery supply chain*[1],
2. To develop an integrated electric vehicle (EV) supply chain and
3. To leverage the abundance of natural resources in the country, particularly nickel.

[1] A **sustainable battery supply chain** integrates environmental, social-economic, and financial considerations throughout all stages, from production to end of life. It recognizes potential negative impacts and implements measures to mitigate them, ensuring gender equality, social inclusion, ethical practices, community well-being, and environmental protection from raw material extraction to recycling.

Developed through four workstreams, this report from **Workstream D** evaluates the environmental and social factors that are crucial for the sustainable implementation of activities within the battery supply chain. This report presents an analysis of social and environmental impacts related to the supply chain of batteries, and proposed solutions for social and environmental challenges encountered along the supply chain.

The project will be composed of one additional report that will complement this one. It will serve as a comprehensive summary of the entire project. And will provide stakeholders with a detailed account of the project's objectives, processes, outcomes, and recommendations.

# Contents

# Acknowledgement

This publication has been prepared as part of Deliverable 4: Environmental and Social Impact Assessment for the project Supply Chain Integration of the Battery Value Chain for Energy Transition in Indonesia. It focuses on measuring the potential social and environmental impacts of supply chain development in Indonesia and how these impacts should be mitigated and targets local communities. The research team conducted a literature review, stakeholder consultations, and field observations. We also carried out 18 stakeholder engagement activities to gather insights and perspectives from all relevant actors and affected groups. Most importantly, the study sought to understand how the battery supply chain ecosystem may impact both the environment and society, and how such impacts can be mitigated.

The authors would like to extend their deepest gratitude and appreciation to all stakeholders who shared their knowledge and perspectives, including policymakers, local governments, financial institutions, private companies, local communities, and especially marginalized groups.

We would like to thank Ministry of Energy and Mineral Resources, the Coordinating Ministry for Economic Affairs, the Ministry of Industry, the Ministry of Environment, the Ministry of Transportation, and BAPPENAS (National Development Planning Agency) for contributing valuable input and perspectives on regulatory frameworks through workshops and consultations.

We would like to thank local governments of Karawang and Morowali, including the Regional Development Planning Agency of Karawang, the Environmental Agency of Karawang, the Investment and Integrated One-Stop Service Agency of Karawang, the Energy and Mineral Resources Agency of Central Sulawesi, the Environmental Agency of Morowali, the Transportation Agency of Morowali, the Health Agency of Morowali, and the Regional Development Planning Agency of Morowali. for their insights on emerging issues, regional governance, and data provision were essential in developing the regional snapshots featured in this report.

We would like to thank PT Sulawesi Cahaya Mineral, PT ESG New Energy Material, PT Hyundai Energy Indonesia, and PT Gotion Green Energy Solutions, for sharing valuable insights on operational practices and environmental and social management methods implemented by their companies.

We would like to thank PT Sarana Multi Infrastruktur and PT Bank Mandiri for their perspectives on the role of the financial sector in supporting the development of Indonesia's battery industry.

We would like to thank Department of Women's Empowerment and Child Protection of Karawang Regency (DP3A), the Regional Commission for Child Protection of Karawang (KPAI), and the Village Community, Women's Empowerment and Child Protection Agency of Morowali Regency (DPMDP3A). Their contributions shed light on the challenges faced by women and children in industrial zones, particularly regarding the social implications of battery supply chain development.

We would like to acknowledge the Workers' Community, including the Mining and Energy Workers' Union and the Confederation of Indonesian Labor Unions, for sharing their

perspectives on labor rights, welfare, and the impacts of industrial development on workers.

We would like to thank the Indonesian Association of Persons with Disabilities for sharing their insights and aspirations of disability groups, and for highlighting the importance of ensuring that persons with disabilities are actively included in fostering a more inclusive industry.

We also like to thank To Bungku Indigenous Community for sharing their perspectives on the impacts felt at the intersection of industrial development and local livelihoods.

# Acronyms

| | |
|---|---|
| AEML | Electric Mobility Ecosystem Association |
| AEER | *Aksi Ekologi dan Emansipasi Rakyat* |
| ARED | Accelerated Renewable Energy Development |
| APNI | Nickel Miners' Association (*Asosiasi Penambang Nikel Indonesia*) |
| ASEAN | Association of Southeast Asian Nations |
| ADB | Asian Development Bank |
| ATRBPN | Ministry of Agrarian Affairs and Spatial Planning/National Land Agency |
| BAPPENAS | Ministry of National Development Planning |
| BKPM | Kementerian Investasi dan Hilirisasi (*Badan Koordinasi Penanaman Modal*) |
| BMKG | *Badan Meteorologi, Klimatologi, dan Geofisika* |
| BMS | Battery Management System |
| BOD | Biological Oxygen Demand |
| BPS | Central Bureau of Statistic (*Badan Pusat Statistik*) |
| BWRA | *Badan Registrasi Wilayah Adat* |
| BESS | Battery Energy Storage Systems |
| CAM | Cathode Active Materials |
| CATL | Contemporary Amperex Technology Co., Limited |
| CFPP | Coal-Fired Power Plants |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| $CO_2e$ | Carbon Dioxide Equivalent |
| COD | Chemical Oxygen Demand |
| CMEA | Coordinating Ministry of Economic Affair |
| $Cr^{6+}$ | Chromium ion |
| CPP | Captive Power Plants |
| EIA | Environmental Impact Assessment |
| EOL | End-of-life |
| EPR | Extended Producer Responsibility |
| ESIA | Environmental and Social Impact Assessment |
| EV | Electric Vehicle |
| FDI | Foreign Direct Investment |
| FGD | Focus Group Discussion |
| FPIC | Free, Prior, and Informed Consent |
| Fe | Ferrum |
| GHG | Greenhouse Gases |
| GDP | Gross Domestic Product |
| GRDP | Gross Regional Domestic Product |
| Gaikindo | Association of Indonesian Automotive Industries (*Gabungan Industri Kendaraan Bermotor Indonesia*) |
| GEDSI | Gender Equality, Disability, and Social Inclusion |
| HPAL | High-Pressure Acid Leach |
| HSBC | The Hongkong and Shanghai Banking Corporation |

| | |
|---|---|
| IBC | Indonesia Battery Corporation |
| IADC/CEDA | International Association of Drilling Companies/Central Dredging Association |
| IFC | International Finance Corporation |
| IEEPA | International Emergency Economic Powers Act |
| ICEV | Internal Combustion Engine Vehicle |
| IP | Indigenous People |
| IUCN | International Union for Conservation of Nature |
| IWIP | Indonesia Weda Bay Industrial Park |
| IMIP | Indonesia Morowali Industrial Park |
| KIIC | Karawang International Industrial City |
| KIMK | Kawasan Industri Mitra Karawang |
| KBA | Key Biodiversity Area |
| KNIC | Karawang New Industrial City |
| km | kilometer |
| LCA | Life-cycle assessment |
| LFPR | Labor Force Participation Rate |
| MEMR | Ministry of Energy and Mineral Resources |
| MIND ID | Mining Industry Indonesia |
| MHP | Mixe Hydroxyprecipitate |
| mm | milimeter |
| MMAF | Ministry of Marine Affairs and Fisheries |
| MoE | Ministry of Economy |
| MoF | Ministry of Forestry |
| MoI | Ministry of Industry |
| MoLHR | Ministry of Law and Human Rights |
| MoM | Ministry of Mandpower |
| MoT | Ministry of Transportation |
| MoU | Memorandum of Understanding |
| MoWECP | Ministry of Women's Empowerment and Child Protection |
| MW | Mega Watt |
| NASA | National Aeronautics and Space Administration |
| NDC | Nationally Determined Contributions |
| NGO | Non-Governmental Organization |
| Ni | Nickel |
| NMC | Nickel Manganese Cobalt |
| $NO_3^-$ | Nitrate ion |
| OHS | Occupational Health and Safety |
| OECD | Organisation for Economic Co-operation and Development |
| OMP | One Map Policy |
| pH | Power Hydrogen |
| PM | Particulate Matter |
| PPE | Personal Protective Equipment |
| PPPA | *Pemberdayaan Perempuan dan Perlindungan Anak* |
| PLN | *Perusahaan Listrik Negara* |

| | |
|---|---|
| QA | Quality Assurance |
| RUPTL | *Rencana Usaha Penyediaan Tenaga Listrik* |
| RE | Renewable Energy |
| SMI | PT Sulawesi Mining Investment |
| SPPL | *Surat Pernyataan Kesanggupan Pengelolaan dan Pemantauan Lingkungan Hidup* |
| TDS | Total Dissolved Solid |
| TSS | Total Suspended Solid |
| UKL-UPL | *Upaya Pengelolaan Lingkungan dan Upaya Pemantauan Lingkungan* |
| UN | United Nations |
| UNDRIP | UN Declaration on the Rights of Indigenous Peoples |
| UNOPS | United Nations Office for Project Services |
| UU | Law (*Undang-undang*) |
| WTP | Wastewater Treatment Plant |
| WB ESF | World Bank Environmental and Social Framework |

# List of Tables

# List of Figures

# Executive Summary

**The development of Indonesia's battery supply chain, alongside its broader energy transition agenda, presents both significant opportunities and pressing challenges for communities and the environment.** Leveraging its substantial nickel reserves, Indonesia is positioning itself as a global leader in battery production, with benefits for industrial growth and the transition to cleaner energy. This report provides an integrated analysis of the environmental and social impacts across the battery supply chain and offers solutions to address the challenges identified. The assessment draws on a high-level review of impacts at a national scale in Indonesia, field observations in Morowali (Central Sulawesi), Central Halmahera (North Maluku), and Karawang (West Java), extensive stakeholder engagement activities, and international benchmarking. The findings have been translated into mitigation strategies, policy recommendations, and sustainability metrics to guide the inclusive and sustainable development of Indonesia's battery industry.

**The analysis examines environmental and social impacts across the three core stages of the battery supply chain: production, usage and end-of-life, as well as associated facilities.** Two complementary approaches were applied: a conventional Environmental and Social Impact Assessment (ESIA) to evaluate local-level effects, and an integrated ESIA approach to assess the broader contributions of the industry to Indonesia's Nationally Determined Contributions (NDCs). Impacts across activities were measured against environmental receptors (landscape, air, soil, water, biodiversity, waste generation, and carbon emissions) and social receptors (communities, livelihoods, workers, and vulnerable groups). This dual lens made it possible to capture both site-specific and national-level implications.

**Three regions (Morowali, Central Halmahera, and Karawang) were selected as case studies to illustrate local environmental and social impacts of the battery supply chain.** The regions were selected for their strategic roles across the battery supply chain, with Morowali and Central Halmahera representing the upstream stage with abundant nickel reserves and active mining and refining operations, and Karawang representing the downstream stage with industrial estates and transport infrastructure. Morowali was also selected due to the existence of a battery recycling plant in the region, thus representing the end-of-life stage of the battery supply chain.

**Each of the battery supply chain stages and its activities have environmental and social impacts on different sensitive receptors, with mining having the most negative impacts of all the supply chain activities. Battery Production (Mining, Refining, Manufacturing)** covers raw material extraction, processing, component manufacturing, and assembly. Deforestation and biodiversity loss from land clearing, water contamination due to suspended solids and heavy metals, and carbon emissions from captive coal plants are impacts linked to both mining and refining activities. Socially, impacts are associated with land conversion and displacement, since agricultural livelihoods decline. Community livelihoods are also impacted due to the presence of police or military forces in mining areas. For the material refining stage, impacts are related to community occupational safety of workers. Manufacturing adds emerging

challenges such as dust pollution from heavy metals, generation of hazardous waste, chemical exposure, and gender inequities in industrial zones.

**The main role of Battery Usage (EVs and BESS) is to achieve decarbonization, yet as it is still in its early stage, the identified risks and opportunities are based on early projection with the available information.** This phase focuses on the operational lifespan of batteries in their usage. While usage contributes to decarbonization, the current EV adoption rates may only reduce transport emissions by 5–6% in 2030 and 10-13% in 2034. For BESS; the RUPTL 2025-2034 projects a potential reduction of 30% reduction in carbon emission from incorporating this technology into the Indonesian grid. Deliverable 3[2] of this project identified a gap in EV production 30,069 in 2025 to reach the 98,764 EV target of the same year. Based on the RUPTL, BESS systems are either developed as new electricity systems or integrated to existing power as a means to reduce fossil fuel reliance and promote higher renewable energy inclusion. That said, the legal framework and roadmap on BESS usage still lacks has not reached the same maturity as battery usage in EVs. There is an opportunity to accelerate the development of BESS frameworks to scale up its usage and inclusion in the main grid.

**End-of-Life Management and Recycling remain the weakest link in the chain due to limited policy guidance and data to support system development, and the fact that this stage is still in its early phase.** This link involves collection, repurpose, and recycling to recover materials and reduce environmental impact. However, impacts are related to battery waste collection. Without proper collection systems and recycling processes in place, unmanaged waste, illegal removals of batteries from EVs, and unsafe informal practices pose risks to worker safety and community health. This is due to the inadequate handling of toxic components. For environmental impacts, battery material recycling processes mirror many of the battery manufacturing impacts. Dismantling process may also contribute to increased solid waste from battery packaging.

**Associated Facilities** supporting the supply chain include industrial estates, special terminals, and captive power plants (CPP), which provide essential infrastructure and energy inputs. Industrial estates, shipping ports, and logistics hubs allow clustering, effectively containing impacts within their surrounding environment. However, this also created localized pressures such as air and water pollution, waste mismanagement, displacement, and traffic-related accidents. During the operation phase, impacts from the industrial estates are ruled mainly by their tenants, although the industrial estate holds full accountability to the management of processing waste. Labor rights issues are common, particularly affecting vulnerable groups and migrant workers. For example, immigration pressures can generate tensions with residents, wages are low or there are disparities between groups, retaliation against union activities, and the absence of gender-sensitive measures.

[2] Supply Chain Integration of Battery Value Chains for Energy Transition – Southeast Asia Energy Transition Partnership

**Sustainability metrics were defined to represent the overall health of the battery supply chain in Indonesia.** The metrics use sensitive receptors as the primary measures, and the indicators used as parameters that are considered major representations for each receptor. Air quality from refiling and transport activities, water quality degradation from mining wastewater discharges and marine transport, deforestation from massive land conversion and high life cycle GHG emissions per kWh for batteries due to material extraction activities are the sustainability metrics that have been defined to have the highest risk.

**Based on the impact assessment results, mitigation strategies were determined based on residual impacts.** For environmental impacts, mitigation strategies employ the mitigation hierarchy approach: avoidance, minimization, restoration, offset and enhancement. Mitigation strategies related to social effects consider the involvement of vulnerable groups in the five domains of GEDSI, including access, decision-making, participation, systems, and well-being.

**The study identifies a set of safeguards and solutions organized around five thematic priorities that cut across the battery supply chain:**

1. **Governance and Compliance:** There are recurrent gaps related to governance, particularly in regional development and industrialization, land use and permitting, law enforcement, and consistent practice of Free, Prior, and Informed Consent (FPIC) are essential to avoid conflicts with communities and Indigenous Peoples. Enhanced coordination among government institutions, improved multi-stakeholder involvement, transparent land acquisition, robust grievance mechanisms, and independent audits will strengthen accountability and build trust across the sector.
2. **Social Safeguards:** Given the importance of workers and communities in sustaining the supply chain, social safeguards must focus on stronger occupational health and safety (OHS) standards, enforcement of labor rights, and inclusion of vulnerable groups. Gender-responsive workplace policies—including childcare support, protections against gender-based violence, and expanded training opportunities—will enable broader participation of women and vulnerable groups, while community investments in healthcare and education can help offset social disruption in host regions.
3. **Environmental Management:** To address the sector's environmental footprint, environmental safeguards should prioritize biodiversity protection; stricter monitoring of air, water, and soil quality; and stronger waste management systems. At the refining stage, reducing reliance on captive coal power plants and incentivizing renewable energy use will lower the sector's carbon intensity, while aligning expansion with Indonesia's NDC commitments.
4. **Associated Infrastructure:** The facilities that enable the supply chain must also be managed responsibly. Industrial estates, ports, and logistics hubs should adopt higher environmental standards, including wastewater treatment, waste management, and green port initiatives. Logistics planning can reduce traffic and accident risks in surrounding communities, while stronger worker protections and accessible grievance systems—particularly for women and migrant workers—will address persistent labor challenges in these facilities.

5. **Circular Economy and Innovation:** As of this study, battery end-of-life is underdeveloped, requiring innovation and circular solutions. Building formal systems for collection, safe dismantling, and environmentally sound recycling will be critical, alongside expanding domestic recycling capacity. Extended Producer Responsibility (EPR) schemes and incentives for formal-sector recovery can reduce reliance on unsafe informal practices while encouraging eco-design and material efficiency.

**ESG standards are emerging as a critical factor in shaping the sustainability and competitiveness of Indonesia's battery supply chain.** As global regulations tighten, companies involved in mining, refining, cell manufacturing, EVs, BESS, and recycling will face growing expectations around carbon intensity, human rights, transparency, and waste management. A range of international frameworks like GRI, CDP, SBTi, OECD Due Diligence Guidance, and the upcoming Global Battery Alliance's Battery Passport, offer tools to guide reporting, ensure traceability, and align with investor demands. Best practices from global actors show that integrating ESG principles into project design and disclosure can unlock competitive advantages while reducing risks. For Indonesia, aligning with these frameworks is not only essential for compliance but also for positioning its battery sector as a responsible and future-proof player in the energy transition

**Battery recycling is becoming a decisive factor for Indonesia's ambitions to position itself as a global battery exporter.** With the EU, US, and China tightening regulations on recovery rates, recycled content, and carbon footprint disclosure, compliance with international standards will be essential. Recycling not only reduces dependence on raw material extraction but also mitigates risks of supply disruptions and aligns with circular economy strategies. Technologies such as hydrometallurgy and emerging direct recycling methods offer opportunities to recover critical minerals more efficiently, though challenges remain in cost, waste management, and scaling innovation. Global capacity is currently concentrated in China, with the US leveraging subsidies and the EU focusing on strict regulatory targets, highlighting different pathways to sector growth. For Indonesia, advancing domestic recycling capabilities and regulatory frameworks will be critical to strengthen its competitiveness, secure supply chains, and capture value in the fast-growing global recycling market.

**Integrating sustainability into Indonesia's battery supply chain represents a strategic opportunity to accelerate national economic growth and support the global energy transition**. With its strong resource base, expanding industrial capacity, and active policy agenda, the country is well placed to become a leading player in this sector. Realizing this potential, however, requires careful management of environmental pressures, social risks, and gaps in current practices, particularly in refining, workforce inclusion, and end-of-life management. By embedding stronger governance, advancing environmental safeguards, reinforcing social protections, and investing in circular economy solutions, Indonesia can ensure that the growth of its battery industry is both competitive and sustainable. Continued stakeholder engagement, clear accountability, and the use of measurable sustainability metrics will be critical for delivering long-term benefits for the economy, communities, and the environment.

# 1 Introduction

This chapter describes the study background and provides an overview of the objectives and measurable goals.

## 1.1 Context

The objective of the Environmental and Social Impact Assessment (ESIA) presented in this document is to evaluate environmental and social risks, impacts, and opportunities across the battery supply chain, with a focus on ensuring alignment with sustainable and responsible practices. The assessment identifies current practices, gaps, challenges, and opportunities for improvement at each stage of the battery supply chain, providing practical policy and investment recommendations to enhance environmental performance, strengthen social safeguards, and promote inclusive and sustainable growth within the batteries ecosystem.

This report intends to provide essential information to investors and policymakers about the inherent social and environmental impacts associated with the supply chain. It identifies, evaluates, and provides recommendations to mitigate these impacts, focusing both on potential negative and positive outcomes. Furthermore, field activities were conducted to ensure participatory development of the analysis and to gather information from local communities currently related to the battery supply chain or those who could potentially be affected by its activities, thereby obtaining firsthand information. Special consideration was given to gender, equity, and social inclusion concerns, ensuring that the benefits of the supply chain development promote inclusive growth. Concerns on biodiversity conservation within the region of mineral-rich battery supply chain focus regions are also addressed.

Recent developments underscore the urgency of this assessment. For instance, LG's withdrawal from the Titan battery project in Indonesia, alongside previous cases of investors exit such as Eramet and BASF, highlights how environmental and social risks, coupled with regulatory and resource-related uncertainties, can lead to project cancellations[3]. BASF's proposed Sonic Bay project, located on the island of Halmahera in Indonesia, had planned to build a refinery producing 67,000 metric tons of nickel and 7,500 metric tons of cobalt annually. Both minerals were going to be sourced from the nearby Weda Bay Nickel mine.

Activists such as Survival International protested the refinery. The project extension of the Weda Bay Nickel operations threatened the ancestral lands of the Forest Tobelo, and the indigenous group *Hongona Manyawa*, numbering between 300-500 people, since the Forest Tobelo people could not feasibly be consulted on projects affecting their lands nor could they provide free, prior and informed consent as stipulated by international standards. There were reports of tribe members emerging from isolation to find their

[3] Hasiana, D. (2025, April 26). *5 companies cancel EV battery investments in Indonesia*. Bloomberg Technoz. Link

forests lost to mining activities, demonstrating the impact the project could have on their way of life[4].

BASF has not commented directly if this was the main reason for their decision. However, the president of BASF's Catalyst division stated that "*A secure, responsible and sustainable supply of critical raw materials for the production of precursor cathode active materials, which may also originate from Indonesia, remains crucial for the future development of our battery materials business*"[5]. Other global companies have withdrawn from projects in Indonesia citing the country's undeveloped green industrial ecosystem. This decision is also attributed to the decreased demand resulting from the 'sluggish' growth of EV sales. The availability of battery-grade nickel has surged globally leading to a decline in nickel and cobalt prices. In response to these market changes, BASF has invested in a new battery recycling plant in Germany to bolster raw material supply for EU operations[6].

Both these issues represent reasons as to why BASF withdrew from the project and showcase why Indonesia's should also focus on ESG regulations.

Situations like these also illustrate the importance of identifying potential impacts early and implementing robust mitigation strategies to maintain investor confidence and ensure the sustainable development of Indonesia's battery supply chain[7].

## 1.2 Aim and Objectives

The study's aims and objectives, along with corresponding activities and measurable goals are outlined in the Table 1.1.

**Table 1.1 Objectives, activities, and goals**

| Objective | Activity | Measurable Goal |
|---|---|---|
| **Assess the environmental and social impacts of the battery supply chain** | Conduct an environmental and social impact assessment using relevant sustainability standards, e.g., IFC Performance Standards, OECD Due Diligence Guidance, and relevant UN frameworks | ▪ Environmental Impact Assessment<br>▪ Social Impact Assessment |
| **Include engagement of relevant stakeholders to gather concerns and insights on the battery supply chain** | Engage with stakeholders, including local communities, NGOs, government institutions, and businesses, as part of the impact assessment and mitigation development process | Stakeholder consultations, e.g., FGDs, interviews |
| **Conduct site visits at two locations relevant to the battery supply chain** | Conduct field verification as part of the data collection process at two locations that are representative of the upstream and downstream battery supply chain, Karawang and Morowali | Field verification |
| **Develop sustainability metrics to capture the implications of** | Develop sustainability metrics that visually represent the environmental and social impact | Sustainability metrics |

[4] Environmental and indigenous rights concerns Lead BASF and Eramet to withdraw from Indonesian nickel project | Mining South East Europe
[5] BASF decides against investment in nickel-cobalt refining complex in Indonesia
[6] BASF and Eramet Cancel $2.6B Refinery Plan in Indonesia - CTOL Digital Solutions
[7] Modern Diplomacy. (2023, May 27). *Behind the cancellation of Tesla's investment in Indonesia*. Link

| Objective | Activity | Measurable Goal |
|---|---|---|
| **environmental and social parameters of the supply chain** | assessment results, covering all sensitive receptors and relevant supply chain phases | |
| **Develop targeted mitigation strategies and policy recommendations** | Develop measurable and actionable mitigation strategies based on the impact assessment, as well as policy recommendations relevant to the beneficiary's position as a key policymaker | Mitigation strategies |

# 2 Study Methodology

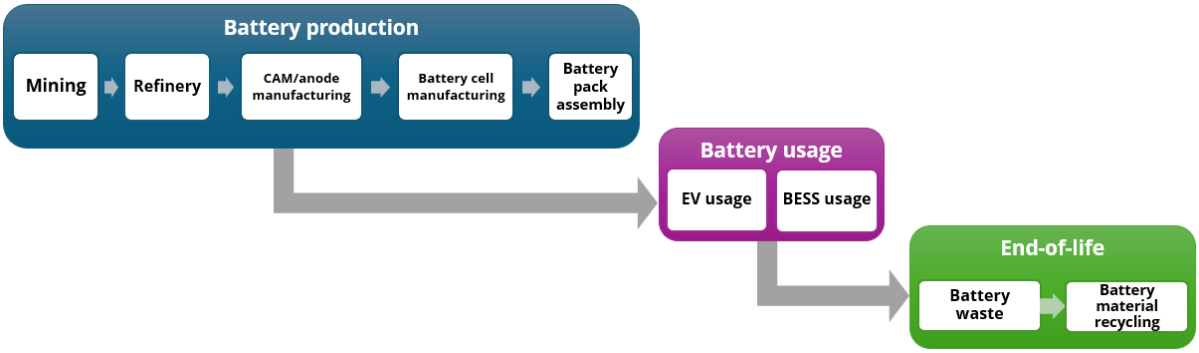
This chapter describes the study approach, scope, and limitations of the environmental and social impact assessment.

## 2.1 Study Scope and Approach

For the purpose of this study, the supply chain phases shall be categorized into four (4) large groups (Figure 2.1):

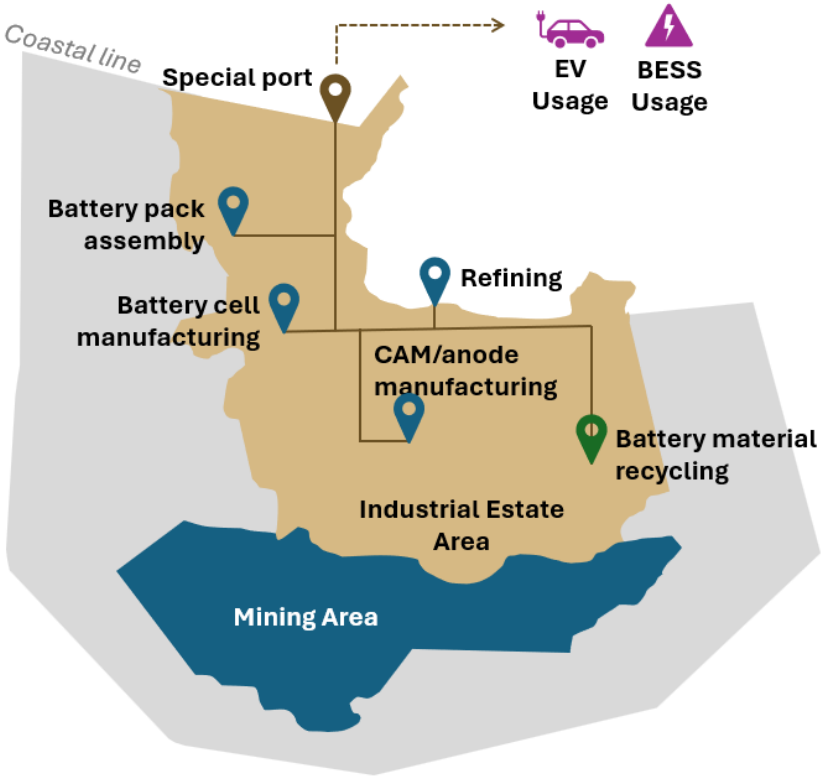
1. **Battery Production:** This phase covers the extraction and processing of raw materials, component manufacturing, and the assembly of battery packs ready for consumer use.
2. **Battery Usage:** This phase focuses on the operational lifespan of batteries during their use by end consumers, which includes applications in electric vehicles (EVs) and battery energy storage systems (BESS).
3. **End-of-Life (EOL):** This phase encompasses the collection, repurposing, and recycling processes aimed at recovering materials and minimizing environmental impacts at the end of the battery's useful life.
4. **Associated Facilities:** In addition to these core phases, the study also considers associated facilities that directly or indirectly support the supply chain, including industrial estates, special ports, and transport and logistics, which provide critical infrastructure and energy inputs to the supply chain.

**Figure 2.1 Battery supply chain activities**




A typical interaction between different supply chain phases is illustrated in Figure 2.2. Associated facilities are spatially interconnected with the core activities, forming an integrated system that supports the overall production flow. Mining concessions—typically located outside industrial estates—supply raw ore to refinery plants located in the industrial estate. The industrial estate also hosts the subsequent stages of battery production, such as battery component and cell manufacturing as well as pack assembly. Goods are shipped through land via roads within or outside the industrial estate, or sea transport via special terminals. From these transportation hubs, goods are shipped for battery usage. Apart from that, battery recycling plants are also planned for development within industrial estates.

**Figure 2.2 Typical interaction between core activities and associated facilities**




For each activity, impacts are assessed against environmental and socially sensitive receptors. Sensitive receptors are parameters used as benchmarks for assessing impacts and are categorized into environmental receptors and social receptors. The sensitive receptors and impacts evaluated in this study are listed in Table 2.1.

**Table 2.1 List of sensitive receptors and corresponding impacts**

| Category | Sensitive Receptors | Impact |
|---|---|---|
| Environmental | **Landscape** | – Land cover<br>– Landscape and morphology |
| | **Air** | – Air quality<br>– Noise |
| | **Soil** | – Soil quality<br>– Soil erosion and landslide |
| | **Water quality** | – Surface water<br>– Groundwater<br>– Marine water |
| | **Biodiversity** | – Terrestrial biodiversity<br>– Aquatic biodiversity<br>– Marine biodiversity<br>– Ecosystem services |
| | **Waste generation** | – Solid waste<br>– Wastewater<br>– Hazardous waste |
| | **Energy** | – Power/electricity consumption |
| | **Carbon emissions** | – $CO_2$ metric tonnes |

| Category | Sensitive Receptors | Impact |
|---|---|---|
| **Social** | **People** | – Community health<br>– Community safety<br>– Human rights |
| | **Livelihood** | – Job and business opportunities<br>– Regional income |
| | **Workers** | – Labor rights<br>– Occupational health and safety (OHS) |
| | **Vulnerable groups** | – GEDSI<br>– Indigenous people |

To optimize the assessment of the sensitive receptors mentioned above, two assessment approaches are employed in this study. A conventional ESIA approach is used to assess the impacts of the supply chain activities at the local level (see Table 2.2). However, impacts beyond the project locality are also conducted to capture the overall impact of the battery industry on Indonesia's Nationally Determined Contributions (NDC) targets. Specific material topics, dubbed "off-site" impacts, that are not typically covered in an ESIA study will be assessed using an integrated ESIA approach, which employs life-cycle assessment (LCA) approaches[8,9].

**Table 2.2 Impacts assessed in conventional and integrated ESIA approaches**

| Approach | Conventional ESIA | Integrated ESIA |
|---|---|---|
| **Description** | Assessment of on-site and local impacts using IFC Performance Standards (IFC PS)[10] and World Bank Environmental and Social Framework (WB ESF)[11]. Material topics to be covered, among others, are air and water pollution, biodiversity, socioeconomic, and GEDSI. | An integrated ESIA approach is necessary to assess off-site impacts and provide a more comprehensive overview of the supply chain's impact at the national level. |
| **Sensitive receptors** | ▪ Landscape<br>▪ Air<br>▪ Soil<br>▪ Water<br>▪ Biodiversity<br>▪ Waste generation<br>▪ Energy<br>▪ People<br>▪ Livelihood<br>▪ Workers<br>▪ Vulnerable Group | ▪ Carbon emissions |

As mentioned above, the impact assessment will be done through snapshots of each supply chain phase and its impacts within its locality (see Table 2.3). The regions were selected for their strategic roles across the battery supply chain—representing the upstream stage with abundant nickel reserves and active mining and refining operations, and the other representing the downstream stage with industrial estates and transport infrastructure. Below is an elaboration of the chosen regions and the relevant supply chain phases. In addition, Figure 2.3 and Table 2.3 show an overview of each snapshot region in maps.

[8] Larrey-Lassalle, Pyrène. *et al*. (2017). An innovative implementation of LCA within the EIA procedure: Lessons learned from two Wastewater Treatment Plant case studies. *Environmental Impact Assessment Review*. Link
[9] Zhang, H., Xue, B., Li, S. *et al.* (2023). Life cycle environmental impact assessment for battery-powered electric vehicles at the global and regional levels. *Sci Rep* 13, 7952. Link
[10] International Finance Corporation. *2012 Performance Standards*. Link
[11] World Bank. *Environmental and Social Framework*. Link

**Figure 2.3 Scope of snapshot regions**


**Table 2.3 Regions as snapshots of different battery supply chain phases**

Battery production  Battery usage  EOL management  Associated facilities

| Battery supply chain phase | | Region | | |
|---|---|---|---|---|
| | | Karawang* | Morowali* | Central Halmahera |
| **Battery production** | Mining | | ■ | ■ |
| | Refinery | | ■ | ■ |
| | Battery component manufacturing | ■ | ■ | |
| | Battery cell manufacturing and assembly | ■ | | |
| **Battery usage** | Battery usage in EVs | Assessed off-site by inherent impact per EV unit | | |
| | Battery usage in BESS | Assessed off-site by inherent impact per BESS unit | | |
| **EOL** | Battery recycling | | ■ | |
| **Associated facilities** | Industrial estate | ■ | ■ | ■ |
| | Special port | | ■ | ■ |
| | Transport & logistics | | ■ | ■ |

**field visit destinations*

## Morowali, Central Sulawesi

Morowali is home to various nickel mining concessions. Although Sulawesi generally has many mining concessions, Morowali takes precedence as it is also home to two operational HPALs (PT QMB Energy Materials and PT Huayue Nickel Cobalt), anode manufacturer PT BTR New Energy Materials, and the only battery recycling plant in Indonesia (PT Indonesia Puqing Recycling Technology). All companies are situated at the Indonesia Morowali Industrial Park (IMIP), a prominent industrial estate in the region.

As a region, it is experiencing rapid growth in the battery industry. Lithium processing facilities are reportedly under development in Morowali as well[12]. Opportunities and lessons learned at the regional level can give an overview of the upstream battery supply chain.

[12] RI Lagi Bangun Pabrik Lithium, Ini Dia Pemiliknya (CNBC Indonesia 2023)

**Central Halmahera, North Maluku**

The islands of North Maluku have recently become a hotspot for nickel mining and refinery. Out of the many regencies, Central Halmahera is chosen as it is located in the Indonesia Weda Bay Industrial Park (IWIP).

The presence of IWIP signifies potential future developments. Tenants in IWIP include nickel mining company PT Weda Bay Nickel and nickel refining companies PT Yashi Indonesia Investment, and PT Youshan Nickel Indonesia[13], although nickel refining is reportedly not yet operational. Battery manufacturing facilities have also begun development on the estate although not yet in an operational state[14].

**Karawang, West Java**

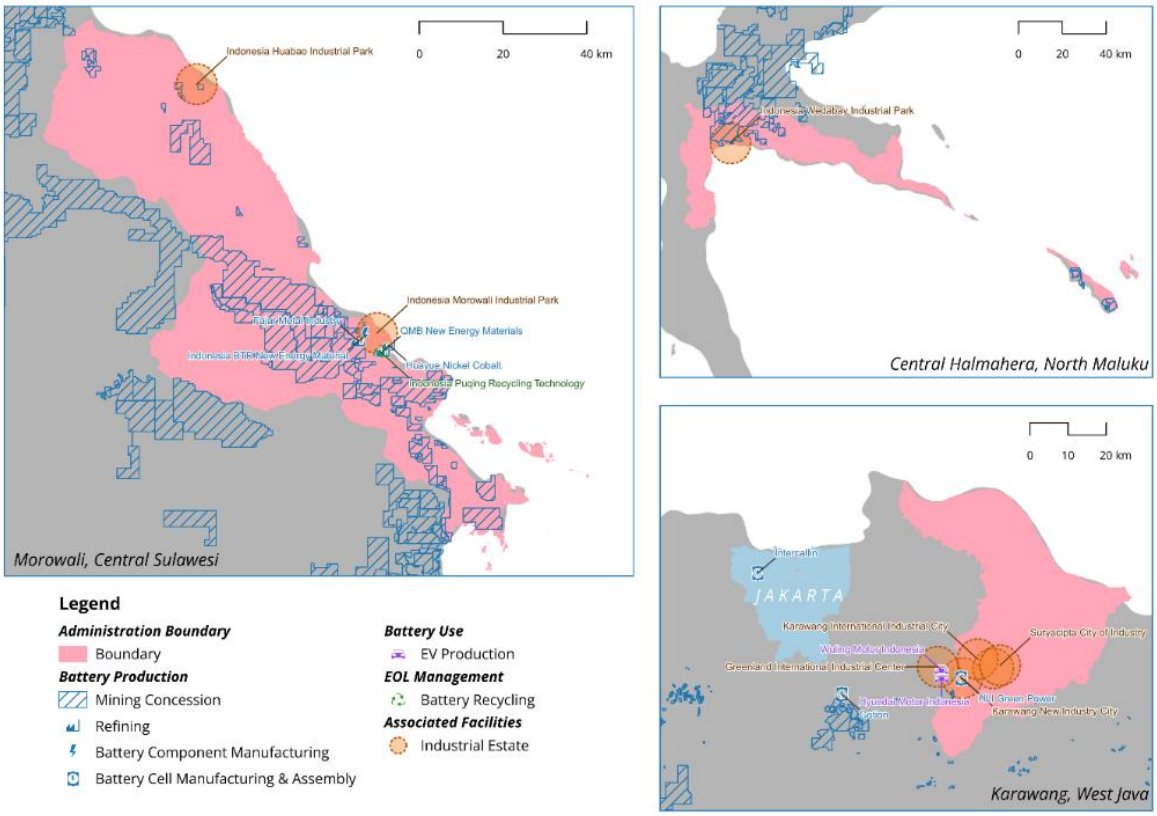
Located near Greater Jakarta, Karawang and its surrounding areas have long established themselves as a robust industrial hub. Industrial complexes in this area are relatively rampant compared to the other two regions. Karawang International Industrial City (KIIC), Kawasan Industri Mitra Karawang (KIMK), and Karawang New Industrial City (KNIC) are among the few industrial complexes located in the area. NMC battery producer PT HLI Green Power is a tenant in KNIC.

Being close to the industrial hub in Greater Jakarta, other supply chain industries are also located near Karawang. In Cikarang, automotive companies such as Hyundai Motors Indonesia and Wuling Motors Indonesia (PT SGMW Indonesia) are known to manufacture 4W EV units. Battery cell manufacturing facilities operated by PT International Chemical Industry (Intercallin) and PT Gotion Green Energy Solutions (Gotion) are also located in Jakarta and Bogor, respectively.

[13] Indonesia Weda Bay Industrial Park. (2025). Official website. Link

[14] Menperin apresiasi IWIP bakal ekspor prekursor nikel untuk baterai EV (Antara 2024)

**Figure 2.4 Maps of snapshot regions: Morowali, Central Halmahera, and Karawang**




*Source: Own elaboration, with map sources from ESDM One Map[15] and Google Earth (2025)*

## 2.2 Data Collection

Data collection was conducted through desktop research, beneficiary engagement, stakeholder focus group discussions (FGD), and field verification. See Table 2.4 for a detailed overview for each data collection approach.

**Table 2.4 Data collection methods**

| Approach | Description | Timeline |
|---|---|---|
| **Desktop research** | Comprehensive desktop research was conducted to determine current industry practices, identify supply chain issues, perform impact analysis, and develop mitigation strategies. Desktop research encompasses a review of existing literature and publications, publicly available databases, government reports, and conference proceedings. | Continuous |
| **Stakeholder FGD** | FGD sessions were conducted good business practices, lessons learned, and grievances. Depending on the stakeholders' availability, FGD can be conducted either before (online or in-person in Jakarta) or during field visits. See Annex A for a detailed overview of these activities. | Jul 10 – Aug 28 |
| **Field verification** | On-site field verifications by the consultant team were conducted to confirm data collection findings. The proposed destinations are Karawang and Morowali, as both regions can capture the upstream, midstream, and downstream of the battery supply chain. See Annex A for a detailed overview of these activities. | Jul 28 – Sep 3 |

[15] MEMR. (2025). *ESDM One Map*. Link

## 2.3 Study Limitations

The following section outlines the key limitations identified in the study's methodology. These constraints highlight factors that may influence the generalizability of findings. Understanding these boundaries is essential for placing the outcomes in the proper context. These limitations are:

- This study applies the Conventional Environmental and Social Impact Assessment (ESIA) approach, which traditionally focuses on on-site and localized impacts. To align with the broader study objectives, the approach has been expanded to incorporate aspects of resource efficiency, including $CO_2$ emissions and waste generation, across the supply chain. However, this expanded scope introduces inherent limitations related to data availability, modelling assumptions, and the broader spatial scale of upstream and downstream impacts.
- The assessment specifically focuses on Indonesia's national battery supply chain, with particular emphasis on batteries intended for electric vehicle (EV) applications. This obeys the Government of Indonesia's priorities, since the country is ramping up production of 4W EVs**,** establishing incentives for investments in downstream businesses and demand incentives have been implemented to encourage sector growth**.** Among others, these incentives include corporate income tax holidays for EV industry investments, tax import exemption for fully assembled EVs, and loans for EV purchases. This is in line with global trends, since transportation represents more than half of the total end-use sectors for batteries[16]. Consequently, the battery usage phase is limited to EV-related usage and applications and does not cover other batteries or derived enablers, such as stationary storage systems.
- While the study addresses the battery's role within the EV and BESS production and usage phases, it is important to note that this is not a full assessment of the EV nor BESS supply chain. Non-battery EV and BESS components, such as vehicle bodies, containers, motors, and other electronic and nonelectronic components, are excluded from the scope.
- The geographic and specified timeline scope of the study covers specified locations and may require limitations in stakeholder participation, which, while selected to represent key points along the supply chain, may not capture the full diversity and operational variations across Indonesia's national battery supply chain. Therefore, findings from these locations and representations are indicative rather than fully representative.
- Given the short study period, the assessment does not capture seasonal variations in environmental impacts (e.g., air quality fluctuations and water availability).
- The rapidly evolving policy landscape for battery supply chains and EVs in Indonesia means that some policy and regulatory assumptions may become outdated soon after the study's completion.

[16] See Deliverables 2 and 3 from this project to know more about incentives and end-uses for batteries

# 3 Supply Chain Activities

This chapter describes the core supply chain activities and relevant associated activities that are crucial for assessing environmental and social impacts.

Although this study addresses the upstream and downstream of the battery supply chain, it is worth noting that the industrial maturity, scalability, and regulatory framework across the supply chain leaves room for improvement. Consequently, the data available for analysis is uneven across phases of the supply chain.

## 3.1 Core Activities

The core activities in the battery supply chain encompass the entire life cycle of the battery, from the collection of its raw materials to its use and eventual end-of-life. The study identifies these phases as follows: battery production, battery usage and applications, and end-of-life (EOL). Since the main uses of batteries are EVs and BESS, only these two applications are considered, excluding other uses such as industrial or portable electronics. Each supply chain phase is broken down into several stages, as shown in Table 3.1.

**Table 3.1 Overview of core activities in the battery supply chain**

| | |
|---|---|
| **Battery Production** | |
| **Mining** | Extraction of raw materials essential for battery production, such as nickel, manganese, and graphite. |
| **Refining** | Raw ore extracted in the mining stage is refined into battery precursors, typically through metallurgical processing. |
| **Cathode Active Materials (CAM) and anode manufacturing** | Battery components, such as cathode active materials (CAM) and anodes, are manufactured using battery precursors produced in the refining stage. |
| **Battery cell manufacturing** | Battery cells are manufactured from battery components collected from the previous stage. |
| **Battery pack assembly** | Battery cells are assembled and packed for consumer use. |
| **Battery Usage** | |
| **EV usage** | Represents the period where batteries are used as a power source for electric vehicles (EVs). |
| **BESS usage** | Represents the period where batteries are used for battery energy storage systems (BESS) applications in a variety of applications, e.g., renewable energy (RE) technologies, grid systems. |
| **End-of-Life** | |
| Battery waste | The phase where the battery is no longer usable and is subject to waste collection. |
| Battery material recycling | Battery recycling enables the reuse of batteries by recovering their materials and reprocessing them. |

### 3.1.1 Battery Production

The battery production phase consists of the following activities: mining, refining, CAM and anode manufacturing, battery cell manufacturing, and battery pack assembly. To date, the battery production stage in Indonesia has demonstrated scalability through emerging industries, supporting policies and framework, and the government's political willingness. However, a robust regulatory framework and industrial readiness are shown mainly in the mining and refinery phases. The phases afterwards—battery component and cell manufacturing, as well as pack assembly—are still relatively new.

#### Mining

The mining activities cover the ore extraction process. It consists of four (4) phases, which are pre-construction, construction, operation, and post-operation (see Table 3.2). In the pre-construction phase, the land acquisition and exploration activities are mapped as significant in terms of impact and important to project implementation. The construction phase encompasses the construction of the overall mining facilities, including offices and buildings, the hauling road, and other supporting facilities. The operation phase covers the overall mining operation, which in Indonesia is typically that of a surface mine operation. This phase consists of soil removal, ore extraction and stockpiling, and backfilling. The post-operation phase covers the closure of the mining site.

As a resource-rich country, mining is one of the longest-running industries in Indonesia. Thus, Indonesia's mining industry is well equipped with strong institutional infrastructure and experience, as well as evolving sustainability practices[17]. Thus, companies have more than likely demonstrated good practices that are aligned with global standards[18].

**Table 3.2 Detailed overview of mining activities**

| | | |
|---|---|---|
| **Pre-construction** | **Land acquisition** | The process of acquiring community-owned land for mining concessions. The process typically involves providing compensation to landowners in exchange for the displacement of their homes and the disruption of their livelihoods. |
| | **Exploration** | This activity encompasses the field research conducted to determine ore resources and reserves within a concession. |
| **Construction** | **Construction of mining facilities** | Construction of facilities, such as offices, accommodation, workshops, hauling roads, and other supporting facilities. |
| **Operation** | **Topsoil and overburden removal** | The process of removing the topsoil, soil, and rocks to access the ore veins that are essential for extraction. |
| | **Ore extraction** | General ore extraction process. This can be conducted via surface or underground mining. |
| | **Ore stockpiling** | Extracted ore is stockpiled in a designated area in the mining area before it is shipped to refining facilities. |
| | **Backfilling** | After extraction is completed, the pits are backfilled with topsoil and overburden following the mine plan. |

[17] See Annex A: Stakeholder Consultation and Field Verification Reports – *FGD with Policymakers*
[18] See Annex A: Stakeholder Consultation and Field Verification Reports – *Morowali Stakeholder Consultation and Field Verification*

| | | |
|---|---|---|
| **Post-operation** | **Mine closure** | After operational mining activities are concluded, the exploited land is subjected to rehabilitation and revegetation to restore it to its baseline conditions. |

### Refining

Refining is the processing of raw ore into battery precursor materials, such as mixed hydroprecipitate (MHP), nickel sulfate, and cobalt sulfate. As it is typically located within an industrial estate, the process consists of two (2) phases: construction and operation (see Table 3.3). The construction phase is where the refining plant, captive power plant, and other supporting facilities are constructed. The operation phase covers the whole refining process, which includes ore crushing and milling, separation, purification, and refinement.

The refining industry in Indonesia has experienced rapid growth in the last decade. The current practice in Indonesia still normalizes the use of coal as the power source[18]. Policymakers are currently seeking opportunities to decarbonize this phase through cleaner energy sources, such as LNG, biomass, and renewables, to make the industry more environmentally resilient[17].

**Table 3.3 Detailed overview of refining activities**

| | | |
|---|---|---|
| **Construction** | **Construction of refining facilities** | Construction of the refining plant, captive power plant, and its supporting facilities. |
| **Operation** | **Crushing** | Raw ore that is shipped to the facility is crushed into smaller sizes to smooth the refining[19]. |
| | **Milling/grinding** | The crushed ore is further ground into fine particles using mills, e.g., ball mills, rod mills[19]. |
| | **Separation** | The ground ore is separated from the gangue or waste minerals and divided into different size fractions. This is achieved through methods such as flotation, gravity separation, and magnetic separation[19]. |
| | **Purification** | The separated ore goes through further purification to remove the remaining impurities. This is where hydrometallurgy and pyrometallurgy separate—hydrometallurgical processes involve the use of chemical processes (e.g., leaching), whereas pyrometallurgical processes involve heating the ore to high temperatures to separate the metal from other elements (e.g., smelting in furnaces)[19]. |
| | **Refinement** | A final step is required to ensure the extracted mineral is refined to the desired concentration[19]. |

### CAM and Anode Manufacturing

The manufacturing of CAM and anodes is crucial for providing components vital to battery cell production. As it is typically located within an industrial estate, the process consists of two (2) phases: construction and operation (see Table 3.4). The construction phase is where the manufacturing plant and other supporting facilities are constructed.

[19] Smith, Y. R., Kumar, P., & McLennan, J. D. (2017). On the Extraction of Rare Earth Elements from Geothermal Brines. Resources, 6(3), 39. https://doi.org/10.3390/resources6030039

The operation phase encompasses the entire manufacturing process from precursors to CAMs or anodes ready for battery cell manufacturing.

Battery component manufacturing is still relatively new in Indonesia. There are not many players in the country, and this may be attributed to limited technology and policy readiness[17]. This limitation is extended to battery cell manufacturing as well.

**Table 3.4 Detailed overview of CAM and anode manufacturing activities**

| | | |
|---|---|---|
| **Construction** | **Construction of facility** | Construction of the manufacturing plant and its supporting facilities. |
| **Operation** | **Mixing** | The precursor materials are mixed before being processed in the coating machine[20]. |
| | **Coating** | The electrodes (i.e., CAMs and anodes) are coated separately. The CAM's coatings are attached to an aluminum electrode, whereas anode coatings are adhered to copper[20]. |
| | **Drying** | The electrodes are dried after coating with convective air dryers in a continuous process[20] |
| | **Calendaring** | Electrodes are rolled to a controlled thickness and porosity[20]. |
| | **Slitting and notching** | Electrodes are cut down to the desired size that matches the dimensions required for cell manufacturing[20]. As most battery facilities in Indonesia combine component and cell manufacturing, the slitted electrodes are typically directly manufactured into battery cells. |

## Battery Cell Manufacturing

Battery cell manufacturing is the process by which battery cells are produced. As it is typically located within an industrial estate, the process consists of two (2) phases: construction and operation (see Table 3.5). The construction phase is where the manufacturing plant and other supporting facilities are constructed. The operation phase encompasses the entire battery cell manufacturing process before cells are shipped for pack assembly.

**Table 3.5 Detailed overview of battery cell manufacturing activities**

| | | |
|---|---|---|
| **Construction** | **Construction of facility** | Construction of the manufacturing plant and its supporting facilities. |
| **Operation** | **CAM and anode lamination** | Electrodes, i.e., CAMs and anodes, are laminated before combined through stacking. |
| | **Winding or stacking** | Depending on the type of battery cell, the electrodes are combined in different ways. In a cylindrical cell, the electrodes and separator are either wound into a spiral. In a pouch cell, electrodes are stacked[20]. |
| | **Terminal welding** | The cells undergo terminal welding, where the anodes are connected to the negative terminal whereas the CAMs are connected to the positive terminal[20]. |
| | **Filling, degassing, and sealing** | The dry cell is filled with electrolytes and partially vacuumed to ensure an even distribution of electrolytes within the cell. The cell is charged, where gases typically form within the cell, prompting degassing before the cell is eventually sealed[20]. |

[20] Battery Design. (2024). "Battery Cell Manufacturing Process". Link

| | | |
|---|---|---|
| | **Formation and aging** | The cells are stored at a controlled temperature (dry room) for a specified period[20]. |
| | **Testing and QA** | Quality assurance through a cycle of charges and discharges, as well as other tests, before the product is shipped[20]. |

**Battery Pack Assembly**

The battery pack assembly is the process by which battery cells are packed into battery packs that are ready for consumer usage. As it is typically located within an industrial estate, the process consists of two (2) phases: construction and operation (see Table 3.6). The construction phase is where the manufacturing plant and other supporting facilities are constructed. The operation phase covers the entire battery packing and assembly process.

Before battery component and cell manufacturing emerged, Indonesia already had several battery pack assembly plants where battery parts were imported from overseas[21]. At the time of the study, battery manufacturing was facing significant changes in the policy framework and investment climate. Good practices, proper waste handling, and standards are still in their development stage at this point.

**Table 3.6 Detailed overview of battery pack assembly activities**

| | | |
|---|---|---|
| **Construction** | **Construction of facility** | Construction of the manufacturing plant and its supporting facilities. |
| **Operation** | **Cell matching and preparation** | Battery cells, especially those shipped from outside the facility, are matched and prepared before assembly[22]. |
| | **Cell connection** | All parts and assemblies are batch-tested[22]. |
| | **Module assembly and integration** | Battery cells are assembled into groups or modules and integrated into a Battery Management System (BMS)[22]. |
| | **Testing and QA** | Quality assurance through electrical testing at power terminals before the product is packed[22]. |
| | **Final packaging** | Final packaging prior to shipping, including clear labels and serial numbers for database requirements[22]. |

### 3.1.2 Battery Usage

The battery usage phase covers the intended uses of batteries in Indonesia. To date, issued policies and regulations show that Indonesia's battery supply chain is headed towards electric vehicles (EVs) and battery energy storage systems (BESS).

The following overview outlines current national production and development targets, which will serve as the basis for the impact assessment.

[21] See Annex A: Stakeholder Consultation and Field Verification Reports – *Karawang Stakeholder Consultation and Field Verification*

[22] Battery Design. (2024). "Battery Pack Assembly Bill of Process". Link

### EV Usage

Based on the existing roadmap and regulatory framework, Indonesia's battery supply chain demonstrates an inclination towards supplying the EV production. The most recent EV production targets by 2030 are said to be 2,000,000 units of 4W EVs and 13,000,000 units of 2W EVs[25]. That said, MEMR projected that EV adoption will peak at 943,764 units by 2030 and 2,883,764 units by 2034[25] while the amendment to the Ministry of Industry's decree of 2022 establishes an EV production target of 600,000 by 2030[23]. This is summarized in Table 3.7.

**Table 3.7 National EV production target and projection (units)**

| Type | Target | Projection | |
|---|---|---|---|
| | **2030[24]** | **2030[25],** | **2034[26]** |
| **4W EV** | 2,000,000 | 943,764 | 2,883,764 |
| **2W EV** | 13,000,000 | | |

### BESS Usage

Compared to EV, the national roadmap and regulatory framework on BESS are still very limited. That said, the RUPTL 2025-2034[26] has addressed the targeted applications of BESS in standalone assemblies and hybrid systems with renewable energy (RE) technologies (see Table 3.8).

RUPTL 2025 also addressed these targets in two scenarios: the RE Base Scenario and the ARED Scenario. The RE Base Scenario pursues cost optimization and supply reliability, whereas the ARED Scenario pursues carbon emission reduction (see Table 3.9).

**Table 3.8 National BESS production targets (MW)**

| Type | Target by 2035[26] | |
|---|---|---|
| | **RE Base Scenario*** | **ARED Scenario**** |
| **BESS** | 2,464 | 6,014 |
| **Solar-BESS hybrid** | 2,506 | 3,630 |
| **Wind-BESS hybrid** | 130 | 930 |

**Table 3.9 Definition of energy scenarios in the RUPTL 2025-2034**

| | |
|---|---|
| **RE Base (Renewable Energy Base)** | This scenario does not pursue emission reduction or energy mix targets, but instead optimizes cost and supply reliability while still prioritizing the development of new renewable energy power plants. |
| **ARED (Accelerated Renewable Energy Development)** | This scenario focuses on power system infrastructure development that contributes to achieving a 151 million ton $CO_2$ emission reduction by 2030 compared to the BAU scenario. |

[23] Peraturan Menteri Perindustrian Nomor 28 Tahun 2023 (Permenperin No 28 Tahun 2023) | catatanhukum.id
[24] Based on Presentation Event 3 (PE3) on February 26th, 2025
[25] As stated in the Minister of Energy and Mineral Resources (MEMR) Decree 24/2025
[26] Based on MEMR Decree 188.K/TL.03/MEM.L/2025 on the Legalization of PLN's 2025-2034 Electricity Business Plan (RUPTL 2025-2034) issued on May 26th 2025. Link

### 3.1.3 End-of-life

The battery EOL phase covers the potential pathways a battery may encounter at the end of its usage. The study identifies the following stages: battery waste, which is the stage after the battery has exhausted its resources at the consumer end and is ready for collection; and battery material recycling, which is the phase where batteries are recycled in recycling plants.

It is worth noting that Indonesia is still exploring strategic options for EOL management and material recovery. Although the current recycling capacity is limited, there is marked interest from stakeholders to scale up capacity and infrastructure in this aspect[1724]

**Battery Material Recycling**

The battery recycling stage represents the factory process where a used battery is dismantled, and its materials are recovered for second-life battery production. As it is typically located within an industrial estate, the process consists of two (2) phases: construction and operation (see Table 3.10). The construction phase is where the recycling plant and other supporting facilities are constructed. The operation phase covers the sorting and dismantling of battery waste materials and further material recovery. Due to the low adoption of battery usage in Indonesia, there is a limited amount of feedstock domestically. Thus, recycling plant operators, currently represented by a single operational facility, opted to import used batteries to support the facility's operation[17]. Key issues remain, such as the potential for these imported products to be classified as hazardous and the domestic restrictions on these recovered materials for downstream use.

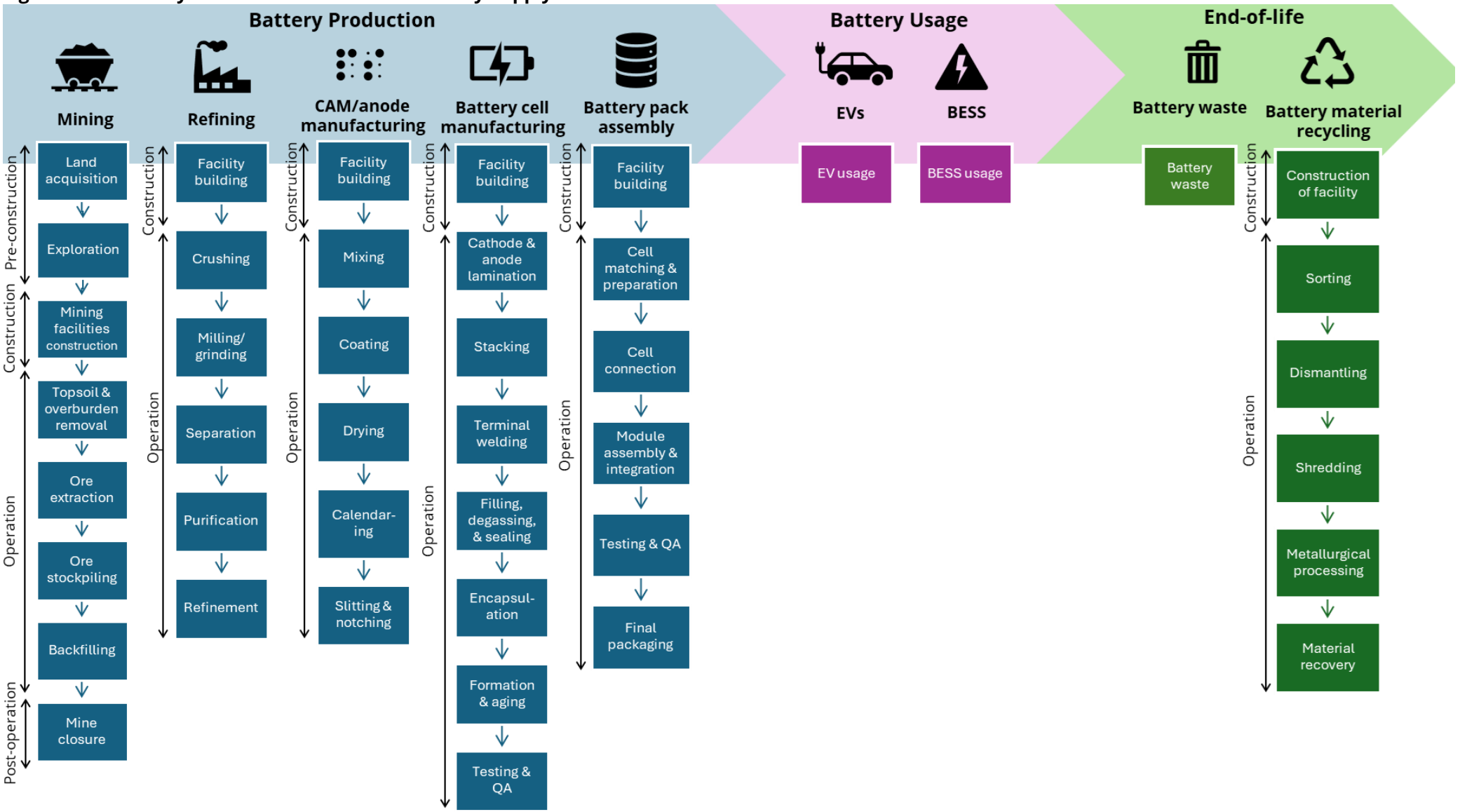
**Table 3.10 Detailed overview of battery recycling activities**

| | | |
|---|---|---|
| **Construction** | **Construction of facility** | Construction of the recycling facility after pre-feasibility studies. No land acquisition is required, as recycling facilities are typically located within industrial estates. |
| **Operation** | **Sorting** | Used batteries are sorted by type[27]. |
| | **Dismantling** | Batteries are disassembled and dismantled before further processing[27]. |
| | **Shredding** | Sorted used batteries are shredded into smaller pieces to smooth the component separating process[27]. |
| | **Metallurgical processing** | Used batteries are further broken down and separated into their constituent materials, including cobalt, nickel, manganese, and lithium. This is typically done through pyrometallurgy or hydrometallurgy[27]. |
| | **Material recovery** | The smaller battery components are melted in a smelting furnace to separate valuable metals from plastic and other materials. Components also undergo purification, resulting in high-quality metals for use in new batteries and other products[27]. |

Figure 3.1 provides a high-level summary of each supply chain phase and activity in consecutive order.

[27] Wagner-Wenz, R., van Zuilichem, AJ., Göllner-Völker, L. et al. (2023). Recycling routes of lithium-ion batteries: A critical review of the development status, the process performance, and life-cycle environmental impacts. MRS Energy & Sustainability 10, 1–34 (2023). Link

**Figure 3.1 Summary of Core Activities in the Battery Supply Chain**



## 3.2 Associated Facilities

Associated facilities are activities that, while they are not core to the battery industry, indirectly contribute to strengthening the supply chain. The associated facilities that are present in Indonesia include: industrial estates, special ports, and transport and logistics. Industrial estates are essential to creating an integrated battery production ecosystem, which has been proven in Sulawesi and Maluku (see Environmental and Social Baseline). The development of special ports is essential to the shipping of raw materials and goods, which further strengthens the transport and logistics aspect that is key to connecting the supply chain.

### Industrial Estate

The industrial estate is considered an associated facility because it does not produce impacts on its own; it provides the opportunity for core activities to be situated in a particular area and create impacts on its surroundings. See Table 3.11 for a summary of industrial estate activities.

According to the national legal framework, all tenant activities within the industrial estate are subject to the full accountability of the industrial estate. The industrial estate approves of tenant activities, whereas the government approves of the activities of the industrial estate[18,21]. This dynamic is vital to how industrial estates can be held accountable in the event of an environmental disaster or major social conflict.

**Table 3.11 Detailed overview of industrial estate activities**

| | | |
|---|---|---|
| **Pre-construction** | **Land acquisition** | The process of acquiring community-owned land for industrial areas. The process typically involves providing compensation to landowners in exchange for the displacement of their homes and the disruption of their livelihoods. |
| **Construction** | **Construction of the industrial estate** | Construction of the industrial estate lots, roads, offices, buildings, and other supporting facilities. |
| **Operation** | **Operational tenant activities** | Based on national regulations, tenants' operational activities are considered part of the industrial estate's scope. This includes the tenants' construction and operation, waste generation, and relevant impacts. |
| | **Operation of industrial estate facilities** | An industrial estate typically provides services such as water treatment plants (providing clean water to tenants), sewage treatment plants (centralized processing of tenants' wastewater), temporary hazardous waste storage, and solid waste management, among other services. |

### Special Port

The special port is considered an associated facility because although it is not core to the supply chain, its presence is essential to the supply chain. This activity covers the scope of the special port's construction and operation, which is separate from transport and logistics (see Table 3.12).

Although special ports also occur outside of industrial estates, newer ports are shown to be built within industrial estates to promote integration and logistics efficiency[28]. For that matter, this study does not identify land acquisition as part of the special port development, assuming that the development of new ports would be conducted within industrial estates.

**Table 3.12 Detailed overview of special port activities**

| | | |
|---|---|---|
| **Construction** | **Construction of the special port** | Construction of the special port and its supporting facilities. |
| | **Dredging** | Dredging is a common process in port development. It is the process of removing sediment and other materials from the ocean floor to create more space for port construction[29]. |
| **Operation** | **Operational special port activities** | The overall operation phase of the special port includes vessel traffic management, cargo handling, and infrastructure maintenance. |

## Transport and Logistics

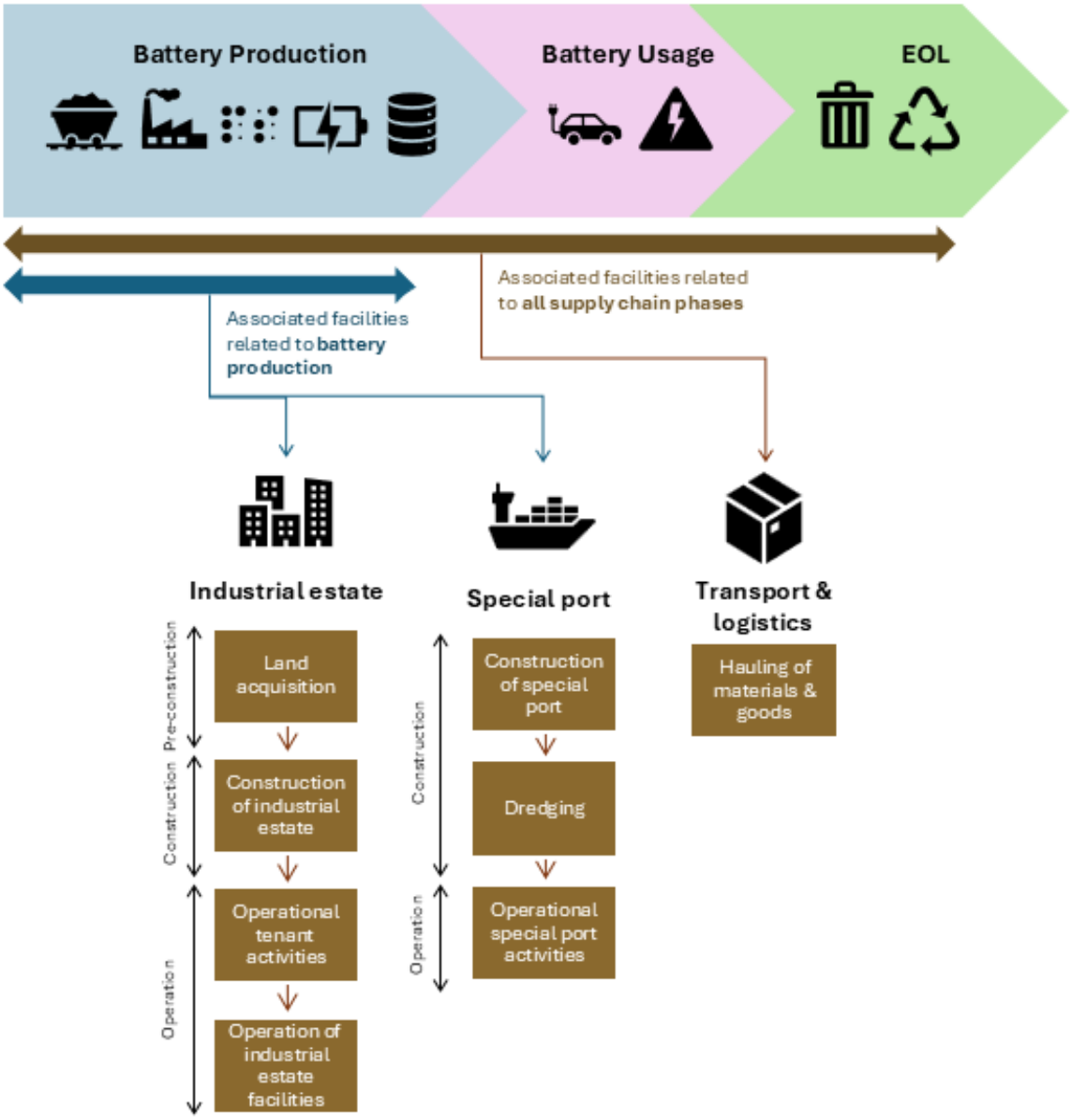
In a nationwide supply chain, transport and logistics are essential for supply chain integration. These processes are expected to occur throughout the entire supply chain. This is crucial for the construction of facilities, including the mobilization of equipment and materials, as well as the operational process, where raw materials and goods are transported across the various supply chain phases (see Table 3.13). Transportation of materials and goods is expected to occur through land and sea.

**Table 3.13 Overview of transportation modes relevant to the battery supply chain**

| Mode | Where relevant | Potential destination | Relevant infrastructure |
|---|---|---|---|
| **Land** | Transporting goods within the industrial estate tenants, i.e., from mining to refining in IMIP. | Domestic | - National road (highway and non-highway)<br>- Provincial road (highway and non-highway) |
| **Sea** | - Transporting goods from one province to another province, i.e., refining products shipped from Morowali to Karawang<br>- Transporting goods from one island to another island, i.e., logistics shipping in Central Halmahera. | Domestic and overseas | - Special ports<br>- Public ports |

[28] ASEAN Briefing. (2023). "An Introduction to Special Economic Zones in Indonesia". Link
[29] NOAA. (2024). "What is dredging?". Link

**Figure 3.2 Summary of Associated Facilities in the Battery Supply Chain**



# 4 Environmental and Social Baseline

This chapter provides a summary of the social and environmental baseline for Indonesia against which each region will be compared, and a summary of each snapshot region. The baseline information serves as a reference point for assessing potential environmental and social impacts and for developing appropriate mitigation measures. A comprehensive overview of environmental and baseline data is shown in the Annex B: Environmental and Social Baseline Data.

The information is presented at a national and regional level to better capture social dynamics, with input from the Focus Discussion Groups (FDG).

For this research, the social impact analysis begins with establishing a social baseline, capturing key aspects of the country and the supply chain at different stages, including demography, education, employment, community health, local organizations, and cultural dynamics. This baseline has been developed from national and regional statistical data and compared with information from the FGD activities.

## 4.1 National baseline for Indonesia

Indonesia is a large, youthful and rapidly urbanizing nation, with an estimated population of 283.5 million in 2025[30]. As a maritime and archipelagic nation, it has an extensive coastline of over 99,123 km, the second-longest coastline in the world. The country's demographic profile is heavily weighted toward younger age groups with the majority of the population aged 0 – 35, providing a substantial potential workforce in the coming years.

By 2025, Indonesia's labour force is projected to reach 153 million, with unemployment estimated at around 3% (2024). Employment is concentrated in Agriculture, Forestry, and Fishing (28%), followed by Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles (17%), and Manufacturing (12%). In all three sectors, workers with primary school form the largest share, exceeding those with senior high school, diploma, or university qualifications. This skill imbalance contributes to uneven income distribution and regional disparities. Poverty rates vary considerably - from around 3.8% in Bali to 30% in the Papua Mountains – reflecting significant differences in economic opportunity and access to services.

Indonesia's urban population continues to grow most rapidly in Java and Sumatra, while approximately 43% of citizens still reside in rural areas dependent on agriculture and resourced-based livelihoods. The country's mining sector, particularly in coal, copper and nickel, has expanded significantly. However, economic growth in mineral-rich provinces has not consistently translated into poverty reduction or decent wages for local communities. Access to health services and the availability of occupational health

[30] World Bank Group. Data & Profile for Indonesia. Available at: https://data.worldbank.org/country/ID

infrastructure also remain highly uneven across provinces[31], underscoring persistent inequalities in the distribution of social and economic benefits.

### 4.1.1 Indigenous communities

Indonesia is home to one of the world's largest Indigenous populations, yet the recognition of Indigenous Peoples (IPs) remains highly contested. Estimates vary widely depending on the source, reflecting persistent policy and legal gaps. Civil society organizations argue that millions of Indigenous Peoples remain unrecognized under national law, leaving them without adequate protections.

However, the International Work Group for Indigenous Affairs (IWGIA) mention that between 50-70 million people in Indonesia identify as Indigenous, out of 283.5 million. By contrast, the Aliansi Masyarakat Adat Nusantara (AMAN), the largest national Indigenous organization, currently represents about 15 million people organized into 2,272 communities. These figures alongside Table 4.1 illustrate the lack of a common baseline definition, which is considered a key obstacle to the recognition and enforcement of Indigenous rights.

**Table 4.1 Indonesian regulations concerning Indigenous Peoples**

| Regulation | Scope / Definition |
|---|---|
| **Indonesian Constitution** | Article 18b-2 recognizes the rights of Masyarakat adat or Masyarakat hukum adat, |
| **Indigenous Peoples Bill (RUU Masyarakat Adat) – Drafted since 2009 yet it has not been issued.** | Defines Indigenous Peoples as groups of people who have lived for generations in a specific geographical area, have ancestral origins and/or shared residence, cultural identity, customary law, a strong relationship with land and the environment, and a value system that guide their economic, political, social, cultural, and legal institutions. |
| **Ministerial Regulation of Agrarian Affairs and Spatial Planning/ Head of the National Land Agency of the Republic of Indonesia No. 14 of 2024[32]** | Indigenous Peoples are groups of people bound by their customary legal order as collective citizens of a legal alliance, based on common residence or lineage. |
| **Law No. 17 of 2019 on Water Resources** | Indigenous Peoples are customary law communities and/or traditional communities who have lived for generations in a particular geographical area and are bound by cultural identity, a strong relationship with land, territory, and natural resources in their customary areas. |
| **Law No. 2 of 2021** | Indigenous Peoples are indigenous Papuan people who, since birth, have lived in a particular area and are bound to and subject to specific customary laws, with a strong sense of solidarity among their members. |
| **Decree of MPR No X/2001** | Provides the legal basis for Agrarian Reform |

[31] World Bank Group. Data for Indonesia. Available at: https://data.worldbank.org/country/indonesia
[32] Ministerial Regulation No. 14 of 2024. Available at: https://berkas.dpr.go.id/akd/dokumen/RJ2-20171106-094054-7086.pdf

| Regulation | Scope / Definition |
|---|---|
| **Law No. 27/2007** | Governance of coastal and small islands, with reference to customary rights. Defines "Indigenous Peoples are coastal communities who have for generations inhabited a specific geographical area due to ancestral ties, have a strong relationship with coastal and small island resources, and possess a value system that determines their economic, political, social, and legal institutions." |
| **Law No. 32/2010** | Refers explicitly to Masyarakat Adat and incorporates AMAN's practical definition |

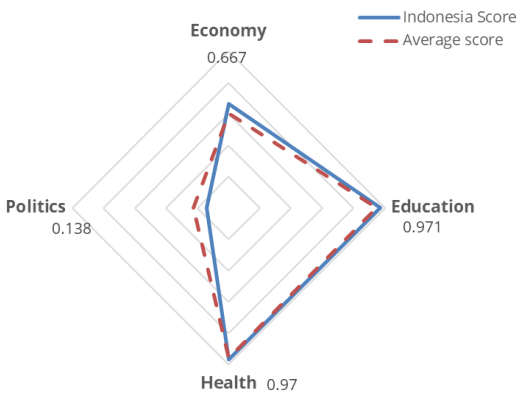
Despite being a signatory to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), it has been discussed the applicability of the Indigenous Peoples concept's applicability to the Indonesian context. It is argued that, except for people of Chinese descent, all Indonesian are Indigenous and thus equally entitled to rights. This position has limited progress on policies addressing the specific socio-economic vulnerabilities of communities that self-identify as Indigenous Peoples, including land tenure, livelihoods, and access to basic services.

At the same time, Indonesia's legal framework does contain important entry points. Constitutional provisions and sectoral laws explicitly acknowledge the rights of Masyarakat Adat (customary law communities). These include recognition of communal land rights, human rights protections, and regulation for natural resource governance. However, the implementation of these provisions remains fragmented, and formal recognition of Indigenous territories is slow. While Indonesia has taken steps to embed Indigenous rights into its legal framework, the lack of consistent recognition and implementation limits their effectiveness. Addressing this gap—particularly by harmonizing government definitions with community self-identification—will be essential to improving living standards, ensuring equitable participation in resource governance, and reducing social conflict in regions hosting large-scale industrial projects.

### 4.1.2 Gender equality in the country

Regarding international benchmark, the Global Gender Gap (GGG) Index, developed by the World Economic Forum, reported that Indonesia's gender parity score in 2024 was 0.686 out of 1.0, ranking the country 11$^{th}$ within the East Asia and Pacific region. The GGG Index measures gender gaps in outcomes across four domains: economic participation, education, health and survival, and political empowerment (See Figure 4.1).

**Figure 4.1 Indonesia's latest results in the Gender Gap Index and its subindices[36]**




| Subindex | Score | Global rank |
|---|---|---|
| **Economic participation and opportunity** | **0.667** | **89** |
| Labour-force participation rate [%] | 0.645 | 112 |
| Wage equality for similar work | 0.755 | 15 |
| Estimated earned income | 0.517 | 113 |
| **Educational attainment** | **0.971** | **105** |
| **Health and survival** | **0.970** | **72** |
| **Political empowerment** | **0.138** | **107** |

By contrast, the Gender Inequality Index (GII), produced by UNDP and applied nationally by BPS – Statistics Indonesia, assesses inequality between women and men across three dimensions: reproductive health, empowerment (education and representation), and labor force participation. Unlike the GGG Index, the GII reflects the loss of human development potential due to gender disparities, with scores ranging from 0 (full equality) to 1 (maximum inequality). Indonesia's GII has consistently declined to 0.421 in 2024, with the most notable progress in the labor market dimension. In line with the GII framework, the following sections describe the situation of women in each dimension:

**Reproductive health:** Women health outcomes in Indonesia have improved significantly in recent years, particularly through increased access to health facilities for childbirth. This progress is partly attributed to the national health insurance program, which aims to provide universal prenatal health coverage across the country. Nevertheless, healthcare facilities and providers are unevenly distributed, with a high concentration in urban areas and limited availability in remote regions.

Indonesia has set an ambitious national target to reduce maternity mortality to 70 deaths per 100,000 live births by 2030 under the Sustainable Development Goals. The country has also strengthened its legal and institutional framework for maternal and child health, supported by technical assistance from the International Labor Organization in the adoption of the Maternal and Child Welfare Law.

Despite this progress, several challenges persist. The teenage pregnancy rate remains high, at 26.6 per 1,000 girls aged 15-19, highlighting the need for enhanced youth friendly reproductive education and access to health services. While the legal minimum marriage age for girls has been raised to 19, achieving parity to boys, socio-cultural norms continue to influence early marriage practices in some regions[33]. To address gender-based violence, Indonesia has enacted both Domestic Violence Law and a Sexual Violence Crime Law, which broaden the definitions of sexual offenses and strengthen penalties for sexual

[33] Gender Equity Unit (2023). Indonesia, a gender equity report. https://genderhealthdata.org/wp-content/uploads/2024/03/Indonesia-Gender-Report-website.pdf

abuse. Together, these efforts mark significant progress toward improving women´s reproductive health, autonomy and protection under the law.

**Empowerment:** The education sector reflects a relatively balanced gender distribution, with male and female students representing 48% and 52% respectively. Female representation is even higher in secondary and tertiary enrolment, where gender parity has been fully achieved. However, a critical area where women continue to lag is land ownership, which directly influences their economic security, social status, and decision-making power. In 2023[34], only 23.9% of women in Indonesia owned agricultural land. Regional disparities are pronounced: West Sumatra reported the highest share of women's land rights (53.9%), while Bali recorded the lowest (8.9%). These differences are closely tied to local cultural norms and inheritance systems. For instance, West Sumatra's matrilineal system grants women right to land through maternal lineage, whereas Bali's patriarchal system restricts women's access to land ownership, reinforcing structural gender gaps in agrarian assets.

**Labour force participation:** Women represent almost 40% of the labor force. However, also represent a significant majority (62%) of individuals outside the labor market, mostly involved in unpaid housekeeping activities.

**Table 4.2 Labor force divided by sex in the country, 2023**

| Type of activity | Male (%) | Female (%) |
|---|---|---|
| **Working** | 61% | 39% |
| **Unemployment** | 62% | 38% |

Source: Badan Pusat Statistik, Survei Angkatan Kerja Nasional (Sakernas) Agustus/BPS-Statistics Indonesia, August National Labor Force Survey

In Indonesia, the fisheries sector provides livelihood for an estimated 56 million people, encompassing activities such as catching, processing, transporting and marketing. Women play a crucial role in this sector, representing around 70% (about 39 million people) of those engaged in fishing related work. Despite their vital contribution, most fisherwomen work over 17 hours per day[35], often in informal and unpaid roles, with limited access to social protection or economic recognition.

In contrast, the representation of women in professional and technical occupations has grown. However, gender parity remains limited in senior, official, and managerial positions. On average, women's estimated income earned is just half that of men's, reflecting persistent wage gaps and occupational segregation.

While small and medium-sized enterprises (SMes) generally employ fewer women compared to larger firms, a higher proportion of small businesses are either fully or partially owned and managed by women. Women hold 12.3% of board positions, and

[34] According to the Integrated Agricultural Pilot Survey (SITASI)
[35] KIARA. The Fate of Fisherwomen. Available at: https://www.kiara.or.id/2014/05/28/nasib-perempuan-nelayan/

52.9% of firms have female majority ownership. Despite these advances, women still make up only 22% of top managerial roles[36].

Beyond the dimensions considered in the GII, progress toward gender equality in the country is reflected in how gender considerations are integrated across government-led strategies, public-private collaboration, and international initiatives. Key findings are summarized below.

**Government led strategies:** Gender equality and women´s empowerment is central to Indonesia´s Mid-Term National Development Plan RPJMN 2025-2029, which emphasizes women's recognition, empowerment and participation in national development. The Ministry of Women Empowerment and Child Protection is driving efforts to integrate gender concerns across all sectors of national development[37]. A key instrument in this process is the institutionalization of Gender-Responsive Budgeting (GRB) – a mechanism ensuring that public resources address gender gaps effectively.

In line with SDG Goal 5 on Gender Equality, the Government monitors progress through two national indicators: The Gender Inequality Index and the Family Quality Index, both designed to track gender equality throughout the life course. Additionally, in 2024, Indonesia launched the Gender and Climate Change National Action Plan, to create climate change planning and budgeting that are gender-responsive and inclusive.

That same year, the National Development Planning Agency (Bappenas) in collaboration with the Ministry of Finance and Impact Investment Exchange launched Orange Bonds – a financial instrument designed to promote social and economic inclusion by providing greater financial access to women and marginalized groups[38].

**Public-private sector collaboration:** The Government is fostering collaboration with the private sector to advance gender equality in the workplace. A Memorandum of Understanding (MoU) between the Ministry of Manpower and multinational companies serves as a framework to promote gender responsive employment practices. In parallel, Indonesia has advanced the Women's Empowerment Principles initiative, which 219 companies to date committing to integrate gender-responsive policies and practices across their value chains[39].

[36] WEF (2024). Global Gender Gap 2024. Insight report. Available at: https://www3.weforum.org/docs/WEF_GGGR_2024.pdf
[37] Indonesia Voluntary National Review 2025. Fostering Inclusive Growth: Advancing Sustainable and Resilient Indonesia. Available at: https://sdgs.bappenas.go.id/website/wp-content/uploads/2025/08/VNR-2025-Main-book.pdf?
[38] Chambers and Partners. ESG 2024 Trend and developments. Available at: https://practiceguides.chambers.com/practice-guides/esg-2024/indonesia/trends-and-developments#:~:text=The%20standard%20can%20either%20be,for%20small%20and%20medium%20industries.
[39] UN WOMEN. Asia and the Pacific. UN Women, Government and State-Owned Enterprises Unite to Transform the future of Work for Gender Equality in Indonesia. Available at: https://asiapacific.unwomen.org/en/stories/press-release/2025/07/un-women-gov-soe-unite-to-transform-the-future-of-work-for-gender-equality-in-indonesia

**Industry-level gender mainstreaming:** In traditionally male-dominated industries – particularly energy and mining companies- have started to integrate gender considerations into recruitment, promotion, and training processes, while also adopting gender-sensitive workplace policies. However, information regarding the provision of gender responsive facilities, such as separate amenities for men and women in the workplace remains limited.

Notably, some firms have extended paternity leave provisions to encourage more equitable caregiving roles. Despite these positive developments, access to affordable and high-quality childcare remains a significant challenge. According to an IFC report[40], Indonesia has fewer than seven facilities per 1,000 children aged 0 to 6, representing significant barriers to working parents to balance family and professional responsibilities. This shortage reflects one of the country's most pressing gender challenges – the unequal distribution of household and caregiving responsibilities between spouses[40] and highlights the continued need for family friendly workplace policies.

Major energy companies such as PT Pertamina Persero and PT Medco Energi Internasional have implemented comprehensive policies to prevent sexual harassment in accordance with the Decree of the Minister or Manpower No. 88/2023[41]. A positive recruitment example can be found in the Indonesia Morowali Industrial Park (IMIP), which has formally adopted anti-discrimination principles for its workforce[42]. Within IMIP's hoist crane operations, 10 out of 23 operators are women, demonstrating progress in breaking gender stereotypes in traditionally male-dominated roles. IMIP has also introduced gender-responsive policies, including paid sick leave for menstruation, maternity leave, and bereavement leave in the event of miscarriage, demonstrating institutional commitment to women's well-being at work.

Strengthening gender mainstreaming in Indonesia's industrial sector requires **systematic data collection** on gender-disaggregated employment and workplace facilities, alongside **monitoring of policy implementation**. Recommendations on this matter are in Section 6.2 Mainstreaming Social and Gender Considerations into the Development of the Supply Chain including international experiences using standards that integrate gender equality, inclusion and workplace safety. Further analysis of maternal and child welfare considerations for working mothers is provided in Annex E: Maternal and Child Welfare for Working Mothers.

[40] IFC (2025). From barriers to breakthroughs: Family-friendly workplaces for Indonesia´s future. Available at: https://www.ifc.org/en/insights-reports/2025/from-barriers-to-breakthroughs-family-friendly-workplaces-for-indonesia-s-future

[41] The Purnomo Yusgiantoro Center (2024). Brief Report Vol. (III): GESI Mainstreaming Strategy for a Just Energy Transition in Indonesia. Available at: https://purnomoyusgiantorocenter.org/wp-content/uploads/2025/07/Eng_Brief-Report-Vol.-III.pdf

[42] Siaran Pers – IMIP Terapkan Prinsip Anti-Diskriminasi Karyawan. Available at: https://imip.co.id/siaran-pers-imip-terapkan-prinsip-anti-diskriminasi-karyawan/

**International platforms:** Indonesia joined the Just Energy Transition Partnership (JETP[43]) platform during the G20 Summit in Bali (2022). The partnership's first milestone was the preparation of a Comprehensive Investment and Policy Plan (CIPP), which explicitly integrates the principles of Gender Equality and Social Inclusion (GESI). Under JETP, financing is restricted to:

- The development and strengthening of electricity transmission,
- The early retirement or managed phase down of coal fired power plants, and
- The expansion of both dispatchable and variable renewable energy sources.

Additionally, commercial financing mobilized under JETP may be directed toward building a domestic renewable energy value chain. Despite these commitments, significant GESI-related challenges remain in the energy sector. These include unequal opportunities for employment and entrepreneurship, limited participation of women and marginalized groups in decision-making processes, and restricted access to affordable and reliable energy services.

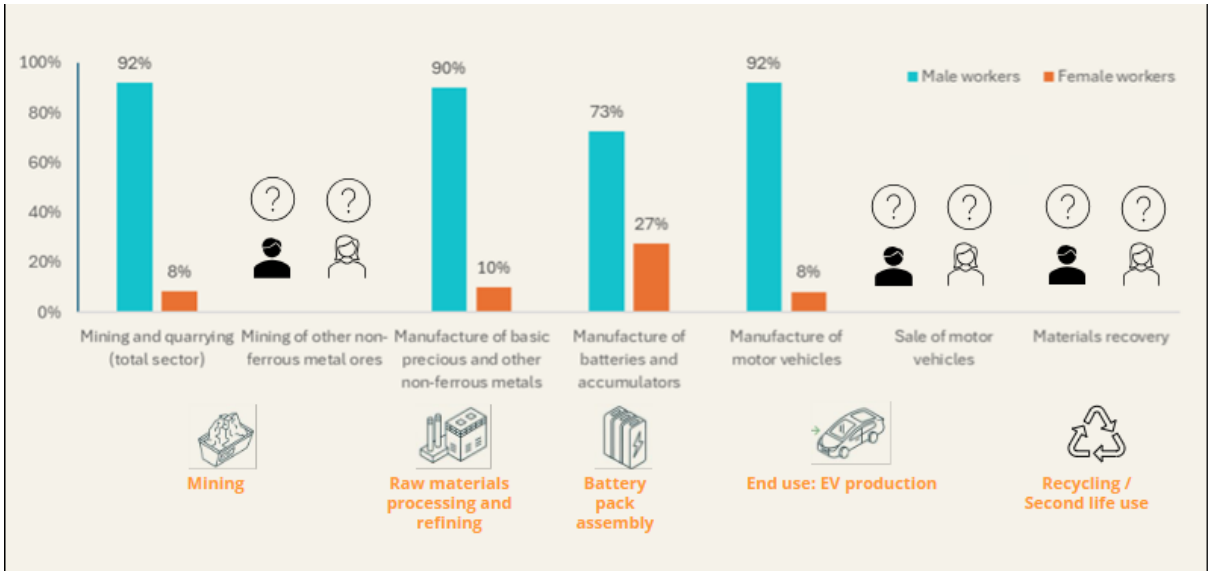
**Gender disaggregated data in the battery supply chain.** There is currently limited gender disaggregated data available across different stages of Indonesia's battery supply chain. For the mining and quarrying sector, data from the *annual survey of non-petroleum and natural gas mining company* provide total employment figures but limited gender-specific information. Available estimates suggest that women represent around 10% of the workforce in this sector; however there is no data specifying the type of roles held by women or their representation in decision-making or technical positions.

A somewhat better scenario exists for the manufacture of basic precious and non-ferrous materials, which includes raw material processing- stage, where the country collects data on female employment (approximately 10%). However, this data does not accurately represent workers specifically involved in the battery supply chain.

For the manufacture of batteries and accumulators, including EV battery production, recent data shows approximately 13,000 workers in the industry, with women comprising around 27% of this workforce. Similarly, in the motor vehicle manufacturing sector, the latest data indicates roughly 39,000 workers, of whom 8% are women as highlighted in Figure 4.2. For other categories, there is no official disaggregated data on women employed in motor vehicle/EV sales or in battery recycling activities.

[43] JETP is a multilateral platform between developed and emerging economies designed to deliver climate finance that supports developing countries to accelerate the transition to an equitable and socially inclusive low-carbon economy.

**Figure 4.2 Gender disaggregated data in the EV battery supply chain**




*Source: (I) Mining and Quarrying sector: Annual survey of Non-Petroleum and Natural Gas Mining Company. Retrieved from BPS-Statistics Indonesia. Mining Statistics of Non-Petroleum and Natural Gas 2018-2022; (II) Manufacturing sector: BPS-Statistics Indonesia. Statistics of Indonesia Manufacturing Industry. 2022. Volume 11. 2024; (III) Wholesale and retail trade: Results of Trade, Repair of Motor Vehicles and Motorcycles Establishments Data Collection EC2016-Continued.*

Although the extractive industry remains a male-dominated sector, research indicates that the mining and energy sectors have begun introducing gender-sensitive initiatives, though implementation remains uneven.

## 4.2 Regional baselines for for social and environmental assessment: Case studies

Three regions were selected as case studies: Morowali, Central Halmahera and Karawang (as described in Section 3 since the main industrial hubs described in the previous table are located in such regions. Below, the baseline characteristics of each region are illustrated through the figure maps. These maps were developed by own elaboration using information from the following sources: KSP (2024)[44], FAO (2023)[45], WDPA (2025)[46] and BRWA[47].

### 4.2.1 Morowali

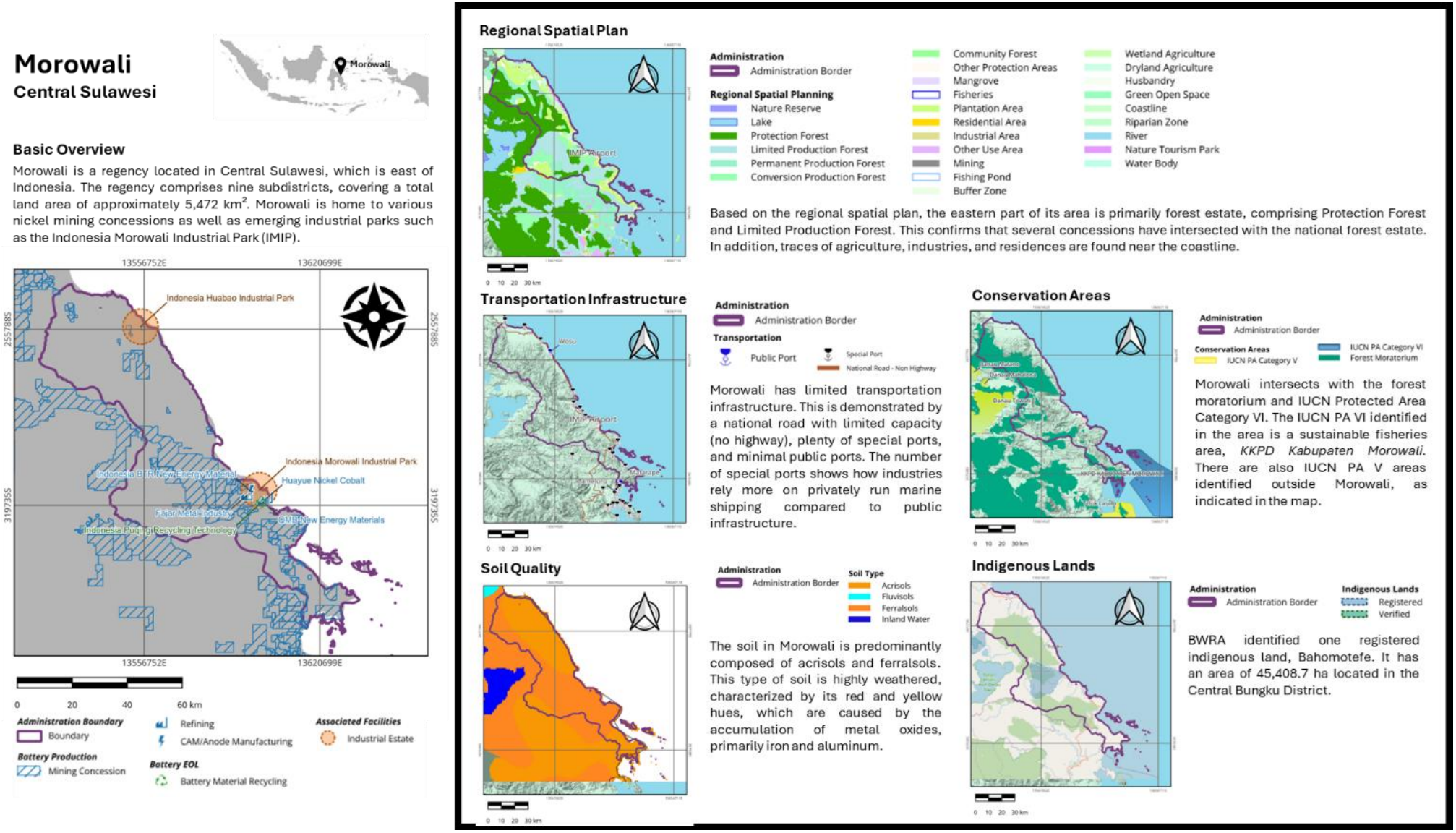
Morowali Regency, located in the Central Sulawesi Province, Indonesia, spans an area of approximately 5,472 km², comprising nine districts. The regency accounts for about 8% of Central Sulawesi's total land area. Its administrative capital is Bungku Tengah[48,49]. The region holds strategic importance due to its abundant natural resources, especially as one of Indonesia's largest nickel reserves. Today, many mining concessions and industrial estates have been established in the region, which, in the baseline, is shown to be a key cause of environmental and social issues in the area (Figure 4.3).

| Content | Description |
|---|---|
| **Industrial hub** | **PT Indonesia Morowali Industrial Park (IMIP)** |
| **Province** | Central Sulawesi |
| **Starting date of construction (est.)** | 2013 |
| **Battery supply chain facilities** | Integrated industrial zones for nickel ore mining, nickel smelting, and nickel manufacturing. Operating since 2015, includes a facility producing high-grade nickel matte (>70% Nickel content). |
| **Area characteristics** | Prior to IMIP development, Indigenous Peoples and rural communities depended on agriculture, fisheries, and forestry (BPS Central Sulawesi, 2013)[50]<br>The park´s rapid expansion has generated social concerns, including high immigration, pressure on health and housing services; documented workplace safety incidents and allegations of poor working conditions. |
| **Hub direct jobs** | 84,336 in 2024 (92% male and 8% female) |

| | |
|---|---|
| **Industrial hub** | **PT Indonesia Konawe Industrial Park (IKIP)** |
| **Province** | Southeast Sulawesi |
| **Starting date of construction (est.)** | 2022 |
| **Battery supply chain facilities** | Nickel smelters and processing facilities; home of the future Konawe Industrial Park (IKIP). |
| **Area characteristics** | Developed within the SCM mine concession to process nickel from local mines. Projected to become one of the largest nickel-based industrial zones in Sulawesi. |
| **Hub direct jobs** | Potential of 10,000 to 20,000 jobs depending on the source. |

[44] Kebijakan Satu Peta. (2024). *Kebijakan Satu Peta.* Link
[45] FAO. (2023). *Harmonized World Soil Database v2.0.* Link
[46] World Database on Protected Areas. (2025). *World Database on Protected Areas*. Link
[47] Badan Registrasi Wilayah Adat. (2025). *Badan Registrasi Wilayah Adat.* Link
[48] Badan Pusat Statistik Kabupaten Morowali. (2024). *Kabupaten Morowali dalam Angka 2024 / Morowali Regency in figures 2024* (Vol. 20). BPS-Statistics of Morowali Regency. Link
[49] Global Forest Watch (2025). *Morowali*. Link
[50] BPS Central Sulawesi. (2013, February 5). Central Sulawesi Economic Growth Q4 of 2023 [Press release]. Badan Pusat Statistik Provinsi Sulawesi Tengah. https://sulteng.bps.go.id/id/pressrelease/2024/02/05/1321/pertumbuhan-ekonomisulawesi-tengah-triwulan-iv-2023.html

**Figure 4.3 Map of Morowali: Basic Overview, Regional Spatial Plan, and Environmental and Social Parameters**



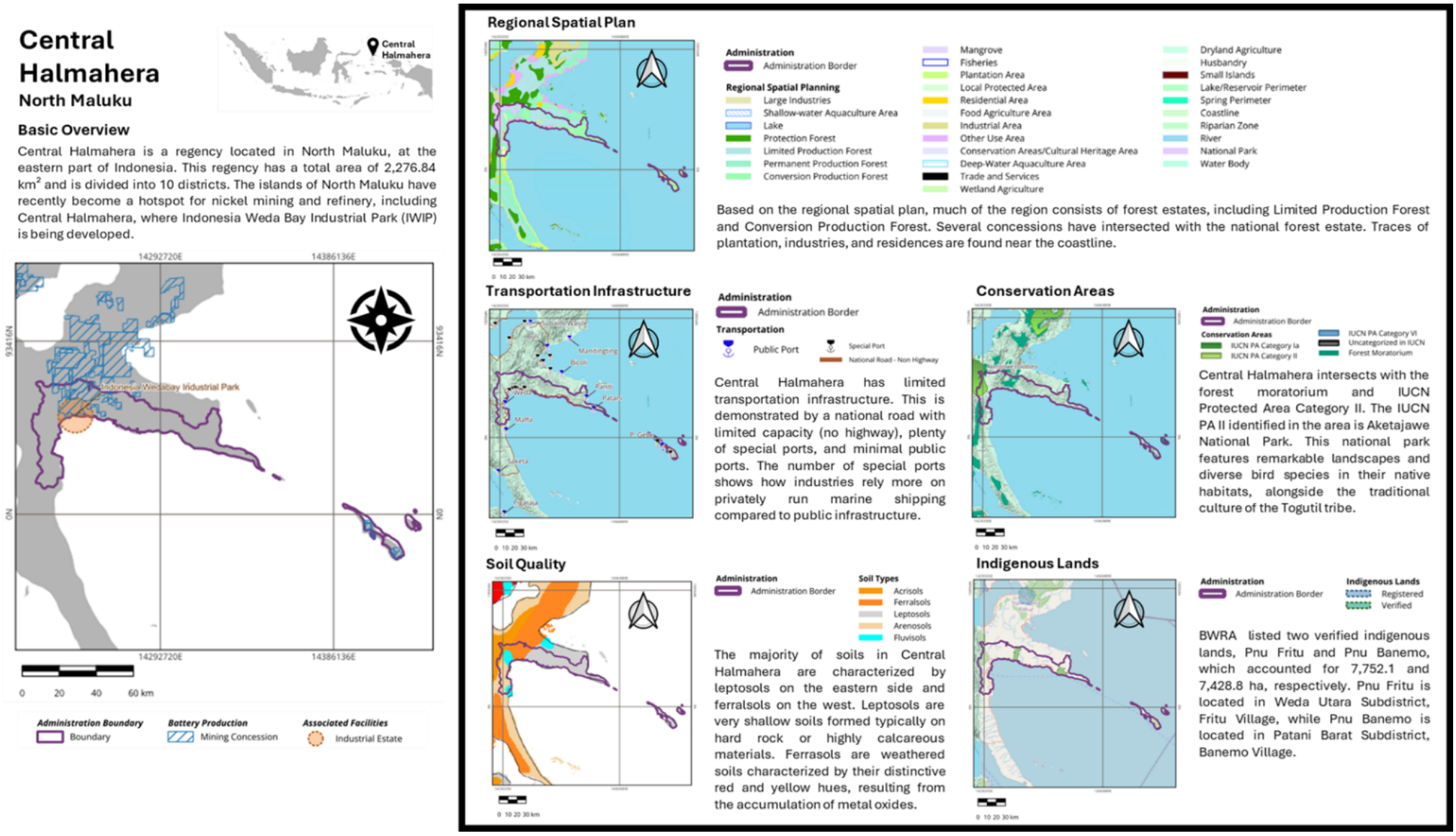
### 4.2.2 Central Halmahera

Central Halmahera Regency, situated in North Halmahera Province, Indonesia, spans an area of approximately 8,382 km². This regency consists of several islands, with the administrative capital in Weda[51]. Similar to Morowali, Central Halmahera has an emerging nickel industry, although to a slightly lesser extent, which may be attributed to its relatively isolated location[52]. The baseline data indicates that these activities have led to alterations in environmental and social parameters at the local level (Figure 4.4).

| Content | Description |
|---|---|
| **Region** | Maluku Islands |
| **Province** | North Maluku |
| **Industrial hub** | **PT Indonesia Weda Bay Industrial Park (IWIP)** |
| **Starting date of construction (est.)** | 2018 |
| **Battery supply chain facilities** | Mega-nickel integrated mining and smelter project. Since 2018, includes four pyrometallurgical production lines to produce nickel ferroalloy, expansion plans include a high-pressure acid leaching (HPLA) plant |
| **Area characteristics** | IWIP spans 5,000 ha in Lelilef Village, Central Halmahera. Indigenous communities, historically nomadic and reliant on fishing, hunting, farming, and sago-making, face resettlement pressures. Social tensions persist given past sectarian conflicts and limited trust in security forces. Weak land certification systems and limited access to cadastral data exacerbate vulnerability. |
| **Hub direct jobs** | Around 11,000 in 2020[53] to 47,000 in 2024[54] |

[51] Badan Pusat Statistik Kabupaten Halmahera Tengah. (2024). *Kabupaten Halmahera Tengah dalam Angka 2024*. Link
[52] Pemerintah Kabupaten Halmahera Tengah. (n.d.). *Kabupaten Halmahera Tengah. Link*
[53] Artikel ini telah tayang di Kompas.com dengan judul "PT IWIP Buka 12.000 Lowongan Kerja, Posisi Apa Saja?", Klik untuk baca: https://regional.kompas.com/read/2021/01/28/14341651/pt-iwip-buka-12000-lowongan-kerja-posisi-apa-saja?page=all. Kompascom+ baca berita tanpa iklan: https://kmp.im/plus6
[54] Investor ID. IWIP Targetkan Serap 100 Ribu Tenaga Kerja Lokal. Available at: https://investor.id/business/367377/iwip-targetkan-serap-100-ribu-tenaga-kerja-lokal#goog_rewarded

**Figure 4.4 Map of Central Halmahera: Basic Overview, Regional Spatial Plan, and Environmental and Social Parameters**



### 4.2.3 Karawang

Karawang Regency, located in West Java Province, Indonesia, covers an area of approximately 1,914 km²[55]. The regency accounts for about 5.4% of West Java's total land area. Its administrative capital is West Karawang[56]. It is a robust industrial hub with a strong manufacturing sector serving various industries, including battery production. Unlike Morowali and Central Halmahera, it has been a mature industrial center for several decades (Figure 4.5).

| Content | Description |
|---|---|
| **Region** | Java |
| **Province** | West Java |
| **Industrial hub** | **Karawang New Industry City (KNIC)** |
| **Starting date of construction (est.)** | 2017 |
| **Battery supply chain facilities** | Battery pack assembly plant. The facility focuses on assembling modules and packs, serving domestic EV manufacturers[57]. The plant is close to Jakarta´s automotive cluster (Toyota, Honda, Hyundai). Project Phase 2 is expected to manufacture Battery Energy Storage Systems, serving both domestic and export markets. |
| **Area characteristics** | A site with road and port infrastructure. Adjacent communities are more urbanized, with industrial estates integrated into planned spatial development. |
| **Hub direct jobs** | 1000-2000 estimated jobs |
| **Hub direct jobs** | Potential to employ 15,000 workers (local and migrant workers) |

[55] Badan Pusat Statistik Kabupaten Karawang. (2024). *Kabupaten Karawang dalam angka 2024.* Link
[56] Government of Karawang Regency. (n.d.). *General overview of Karawang Regency.* Link
[57] Karawang New Industry City website. Available at: https://knic.co.id/

**Figure 4.5 Map of Karawang: Basic Overview, Regional Spatial Plan, and Environmental and Social Parameters**

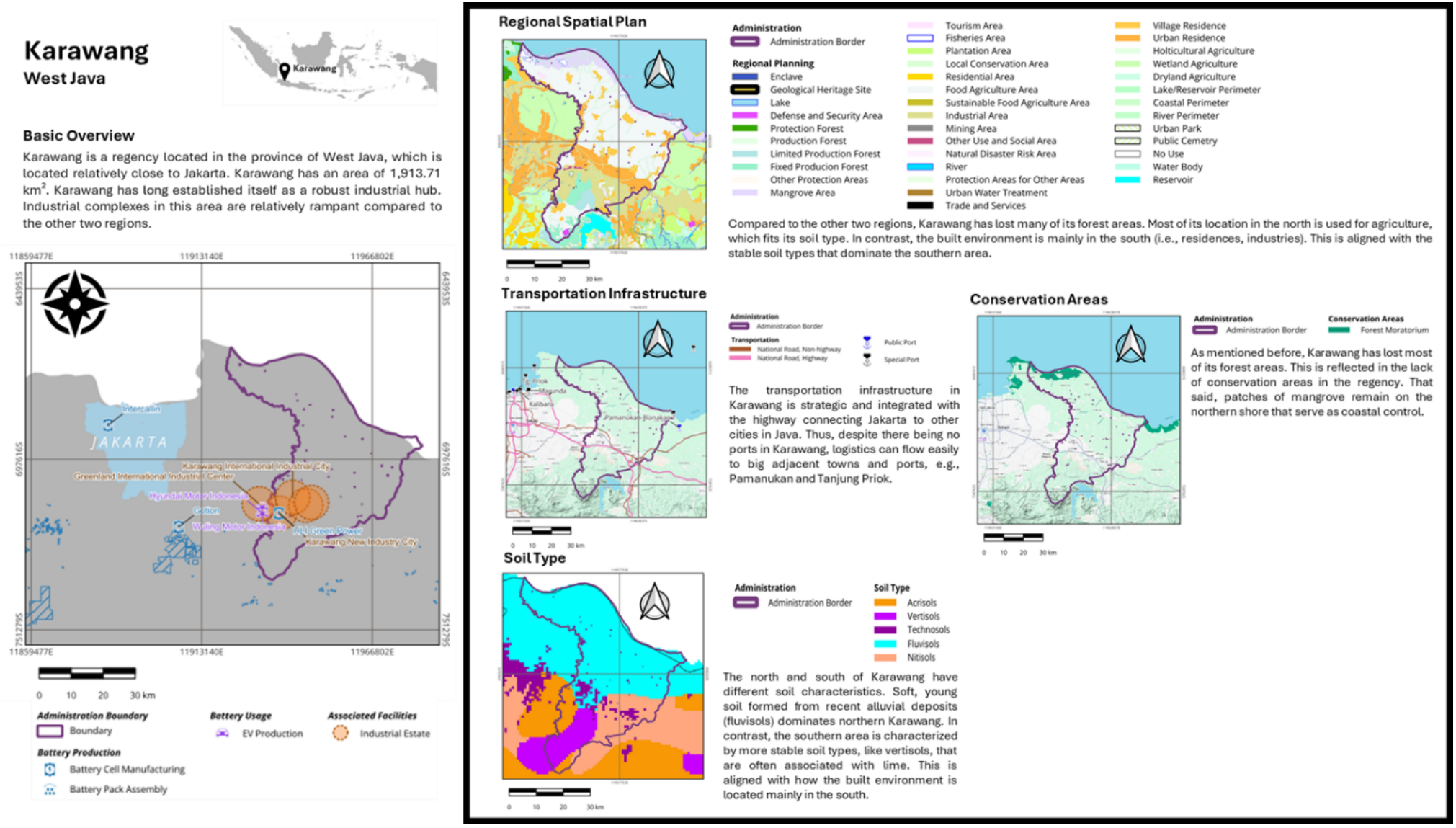


Table 4.3 presents a summary of the main baseline findings, both social and environmental, that are contextual for the impact assessment for the three case study areas. It also shows relevant aspects about the battery supply chain that are particular to each region, as well as a brief description of the companies that are located there. The complete information regarding the social and environmental baseline for all three areas can be found in Annex B: Environmental and Social Baseline Data. The Annex includes a comprehensive overview on environmental and social baseline conditions in all three regions.

**Table 4.3 Summary of Baseline Findings**

| Region | Baseline Findings | Supply Chain Highlights |
|---|---|---|
| **Morowali** | • Morowali is a regency in Central Sulawesi Province, with its administrative capital in Bungku Tengah[48].<br>• Publicly available data on water quality shows that it is still within national standards, yet high mineral content was reported in sedimentation near the IMIP area[58].<br>• Part of its territory is the forest moratorium, potentially intersecting with mining concessions in the area[59].<br>• About 73.6% of the GRDP is contributed from the manufacturing sector[60].<br>• Minimum regional wage had increased about 14% on the last three years[61].<br>• Home to the Wana People, an indigenous group occupying the customary land of Bahomotefe[62]. | • Hosts many mining concessions and smelters, including budding industrial estates.<br>• Notable companies include PT Vale Indonesia Tbk, PT Merdeka Battery Materials, and their subsidiaries.<br>• Also known for the Indonesia Morowali Industrial Park, whose tenants include PT QMB Energy Materials, PT Huayue Nickel Cobalt, PT BTR New Energy Materials, and the battery recycling company PT Indonesia Puqing Recycling Technology. |
| **Central Halmahera** | • Central Halmahera is a regency in North Maluku Province. The regency comprises several islands[51].<br>• Publicly available data on water quality shows elevated pH, TDS, and heavy metal content near the IWIP area[63].<br>• Has traces of forest moratorium and Category II Protected Area known for its distinctive species, the Standardwing Bird-of-paradise (*Semioptera wallacii*)[64].<br>• About 58.79% of the GRDP is contributed from the manufacturing sector, followed by mining and quarrying (32.23%)[52]. | • It has several mining concessions on the main island and satellite islands, such as PT Weda Bay Nickel.<br>• It also has an emerging industrial estate, i.e., Indonesia Weda Bay Industrial Park.<br>• Several nickel processing companies are under development as its tenants, i.e., PT Yashi Indonesia Investment, and PT Youshan Nickel Indonesia. |

[58] Ministry of Environment. (2025). *Status Mutu Air.* Link
[59] Global Forest Watch (2025). *Morowali*. Link
[60] BPS Sulawesi Tengah. (2024). Provinsi Sulawesi Tengah dalam Angka 2024. Vol 54. Link
[61] SPN News. (2024, December 24). *UMK Morowali 2025 Naik 6,5 Persen, Sektor Pertambangan Alami Kenaikan Tertinggi*. Link
[62] BWRA. (2025). *Peta Wilayah Adat.* Link
[63] Balbin, Abigael & Capilitan, Jobelle & Taboada, Evelyn & Tabañag, Ian Dominic. (2023). Characteristics of Nickel Laterite Mine Waste in Caraga Region, Philippines and Its Potential Utilization. Link
[64] Arini, D. I. D. & Kinho, J. 2014. Keragaman Jenis Burung di DAS Tayawi Taman Nasional Aketjawe-Lolobata. *Jurnal Wasian*. 1(1):29-37. Link

| Region | Baseline Findings | Supply Chain Highlights |
|---|---|---|
| | • Verified indigenous lands documented in the region: Pnu Fritu and Pnu Banemo[65]. | |
| **Karawang** | • Karawang is a regency in West Java Province. It is located about 74 km from Jakarta[55].<br>• Has relatively polluted air, particularly for PM2.5[66].<br>• One of the most polluted rivers in the world, the Citarum River, flows through this regency,<br>• Due to being heavily industrialized since the 1980s, it has lost much of its forest cover and has almost no area of conservation value[67].<br>• About 69.91% of the GRDP is contributed from the manufacturing sector. | • It is a robust industrial hub with a strong manufacturing sector for various industries, including batteries.<br>• Home to various industrial estates, i.e., Karawang International Industrial City (KIIC), Kawasan Industri Mitra Karawang (KIMK), and Karawang New Industrial City (KNIC).<br>• Also home to NMC battery producer PT HLI Green Power.<br>• Close to automotive companies based in Cikarang for better supply chain integration. |

[65] BWRA. (2025). *Peta Wilayah Adat.* Link.
[66] Accuweather. (2024, November 16). *Karawang, West Java.* Link
[67] Global Forest Watch (2025). *Karawang*. Link

# 5 Impact Assessment

## 5.1 Assessment Methodology

The impact assessment shall use the risk matrix[68] which considers the impact's risk and likelihood. The *risk* represents the extent to which such an impact event will affect environmental or social receptors (see Table 5.1), whereas the *likelihood* represents the possibility of the impact occurring.

**Table 5.1 Risk rating of impact**

| | |
|---|---|
| **Severe (5)** | Adverse impacts with a **very high** magnitude, where a **large number** of people are affected, and/or span over a **major spatial extent** (large geographic area, transboundary impacts). Receptors are perceived as **highly sensitive**. The impact may cause **long-term** or **permanent** effects with little to no counter-mitigation. |
| **Major (4)** | Adverse impacts with a **high** magnitude, where a **considerable number** of people are affected, and/or spans over a **significant spatial extent** (large geographic area, transboundary impacts). Receptors may be **sensitive to an extent**. The impact may be **reversible** with appropriate mitigation measures. |
| **Medium (3)** | Adverse impacts with **medium** magnitude, **limited in scale** (small area and low number of people affected) and **duration** (temporary), and relatively predictable and avoidable with appropriate mitigation measures. |
| **Minor (2)** | Adverse impacts with **minor** magnitude, **very small in scale** (very small area and very low number of people affected) and **duration** (short period of time), and relatively avoidable and manageable. |
| **Negligible (1)** | **Negligible** or **no adverse impacts** on communities, individuals, and/or on the environment. |

Source: IUCN[6868]

**Table 5.2 Rating significance of impacts**

| | | Likelihood of occurrence | | | | |
|---|---|---|---|---|---|---|
| | | **Very unlikely to occur (1)** | **Not expected to occur (2)** | **Likely – could occur (3)** | **Known to occur – almost certain (4)** | **Common occurrence (5)** |
| **Impact** | **Severe (5)** | **Moderate** | **Substantial** | **High** | **High** | **High** |
| | **Major (4)** | **Low** | **Moderate** | **Substantial** | **Substantial** | **High** |
| | **Medium (3)** | **Low** | **Moderate** | **Moderate** | **Moderate** | **Substantial** |
| | **Minor (2)** | **Low** | **Low** | **Moderate** | **Moderate** | **Moderate** |
| | **Negligible (1)** | **Low** | **Low** | **Low** | **Low** | **Low** |

Source: IUCN[6868]

The *significance of impacts* shall be determined by matching the impact (or consequence) with its likelihood (see Table 5.2). The assessment shall consider existing conditions, i.e., impacts resulting from no activity or pre-existing activities, and/or where mitigation measures are already in place, shall also be considered. The outcome of the assessment demonstrates which impacts require precedence and immediate action, which are manageable with existing conditions, and which require multi-stakeholder involvement.

[68] IUCN. (2020). *Guidance Note – ESMS Manual*. "Environmental and Social Impact Assessment (ESIA)". Link

Although there is no universally accepted definition of what constitutes a Social Impact Assessment (SIA). It is generally understood as a process that evaluates the effects—both current and anticipated—of activities on people and communities. The primary objective is to provide a structured framework for identifying, mitigating, or managing adverse or unintended social impacts, while also enhancing potential benefits for the affected populations.

For this research, the social impact analysis began with establishing a social baseline, capturing key aspects of the country and the supply chain stage at different stages, including demography, education, employment, community health, local organizations, and cultural dynamics.

## 5.2 Impact Identification

The impacts are identified using a Leopold Matrix, a tool commonly used for impact assessment in Indonesia and other countries[69]. The method works by laying out business or project activities as columns (e.g., construction, operation) and the sensitive receptors in rows. Each box of interaction (business activity vs. sensitive receptor) is used to determine if the corresponding activity has an impact on the particular receptor. If not, the box is left empty. The interaction is represented as a positive or negative impact. A positive impact is identified if the corresponding activity improves the condition of the sensitive receptor (e.g., job creation, carbon sequestration). A negative impact is identified if the corresponding activity creates a worse condition on the sensitive receptor (e.g., deforestation, pollution).

Table 5.3 shows the Leopold matrix done for this assessment. The table provides an overview of the identified impacts on all phases of the supply chain. Below are the main key points of the impact identification:

- **Upstream:** The matrix shows that many impacts are situated early in production upstream. These are mining and refining drive land conversion and landscape change, as well as risks to soil and water quality, air/noise emissions, and biodiversity pressures.
- **Midstream:** At the battery production midstream, several manufacturing steps exhibit impacts through material and energy-intensive processes that involve impacts to air emissions, hazardous and solid waste generation, and a high carbon footprint.
- **Usage:** In the battery usage phase, impacts are focused on the contribution of EV and BESS applications to Indonesia's decarbonization goals.
- **End-of-life:** The battery EOL exhibits a mixed profile: the collection, disassembly, and shredding of used batteries, as well as the battery material recycling stage, pose hazardous-waste risks. The current capacity and infrastructure for the circular economy have not yet been fully embedded with battery waste collection or scaled up recycling, which could help mitigate some of the impacts identified in the matrix.

[69] IISD. (n.d.) "Leopold Matrix". (Link)

- **Transport and logistics:** Particularly via road and sea, add incremental dust and community disturbance along roads and at ports.
- **Carbon emissions remain an issue in all activities** in some shape or form. They appear in the form of air emissions in facility operations, whereas in mining and industrial development they appear as the byproduct of deforestation.
- **Social impacts are also identified as cross-cutting**, regardless of business activity. Impacts such as community health, livelihoods, labor conditions, vulnerable groups, and indigenous people and cultural heritage intersect most strongly around extractives and industrial development, but remain relevant at facility operations and transport and logistics.

## Table 5.3 Leopold matrix

**Notes:**

**C** = Construction, **O** = Operation, **Pre-C** = Pre-construction, **Post-O** = Post-operation, **U** = Usage, **(+)** = Positive impact, **(-)** = Negative impact

| Cat-egory | Sensitive Receptors | Impact | Battery Production | | | | | | | | | | | | Battery Usage | | Battery End-of-life | | | Associated Facilities and Activities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mining | | | | Refining | | CAM/anode manufacturing | | Battery cell manufacturing | | Battery pack assembly | | EV | BESS | Battery waste | Battery recycling | | Industrial estate | | | Special port | | Transport & logistics |
| | | | Pre-C | C | O | Post-O | C | O | C | O | C | O | C | O | U | U | U | C | O | Pre-C | C | O | C | O | C&O |
| Environmental | Landscape | Land conversion | (-) | (-) | (-) | (+) | | | | | | | | | | | | | | | (-) | | (-) | | |
| | | Landscape and morphology | | (-) | (-) | (+) | | (-) | | | | | | | | | | | | | (-) | | (-) | | |
| | Soil | Soil quality | | (-) | (-) | (+) | | (-) | | (-) | | (-) | | | | | | | (-) | | (-) | | (-) | | |
| | | Soil erosion and landslide | | (-) | (-) | (+) | | (-) | | | | | | | | | | | | | (-) | | (-) | | |
| | Air | Air quality | (-) | (-) | (-) | | (-) | (-) | (-) | (-) | (-) | (-) | (-) | | | | | (-) | (-) | | (-) | (-) | (-) | | (-) |
| | | Noise | (-) | (-) | (-) | | (-) | (-) | (-) | (-) | (-) | (-) | (-) | | | | | (-) | (-) | | (-) | | (-) | | (-) |
| | Water | Surface water | | (-) | (-) | (+) | | (-) | | (-) | | (-) | | (-) | | | | | (-) | | (-) | (-) | | | |
| | | Groundwater | | (-) | (-) | (+) | | | | (-) | | (-) | | | | | | | (-) | | (-) | | (-) | | |
| | | Marine water | | | | | | | | | | | | | | | | | | | | (-) | (-) | (-) | (-) |
| | Biodiversity | Terrestrial biodiversity | | (-) | (-) | (+) | | | | | | | | | | | | | | | (-) | | (-) | | |
| | | Aquatic biodiversity | | (-) | (-) | (+) | | (-) | (-) | | | | | | | | | | | | (-) | (-) | | | |
| | | Marine biodiversity | | | | | | (-) | | | | | | | | | | | | | | (-) | (-) | (-) | (-) |
| | | Ecosystem services | | (-) | (-) | (+) | | (-) | (-) | | | | | | | | | | | | (-) | (-) | (-) | (-) | (-) |
| | Waste generation | Solid waste | | (-) | (-) | (+) | | | (-) | | | | | | | | | | (-) | | | | (-) | | |
| | | Wastewater | | (-) | (-) | | | (-) | (-) | (-) | | (-) | | | | | | | (-) | | (-) | (-) | (-) | | |

| Cat-egory | Sensitive Receptors | Impact | Battery Production | | | | | | | | | | | | Battery Usage | | Battery End-of-life | | | Associated Facilities and Activities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mining | | | | Refining | | CAM/anode manufacturing | | Battery cell manufacturing | | Battery pack assembly | | EV | BESS | Battery waste | Battery recycling | | Industrial estate | | | Special port | | Transport & logistics |
| | | | Pre-C | C | O | Post-O | C | O | C | O | C | O | C | O | U | U | U | C | O | Pre-C | C | O | C | O | C&O |
| | | Hazardous waste | | | (-) | | | (-) | | (-) | | (-) | | (-) | | | (-) | | (-) | | | (-) | | | |
| | Energy | Energy consumption | | | | | | (-) | | (-) | | (-) | | (-) | | | | | (-) | | | | | (-) | |
| | Carbon emissions | CO/CO2 (metric tonnes) | | (-) | (-) | | | (-) | | (-) | | (-) | | (-) | (+) | (+) | | | (-) | | (-) | | | (-) | (-) |
| Social | Surrounding community | Community health | | (-) | (-) | | (-) | (-) | | (-) | (-) | | (-) | | (-) | | (-) | | | | | (-) | | | (-) |
| | | Community lifestyle | (-) | (-) | (-) | | | (-) | | (-) | | | | | (-) | | | | (-) | | (-) | (-) | | | (-) |
| | | Livelihood | (+) | (+) | (+) | | | (+) | | | | | | | | | | | | (+) | (+) | (+) | (+) | | | |
| | | Human rights | (-) | | (-) | | (-) | | | | | | | | | | | | | (-) | | (-) | | | | |
| | Workers | Labor compliance | | | | (-) | | (-) | | | | | | | | | | | | | | (-) | | | | |
| | | OHS | | | (-) | | | (-) | | | | (-) | | (-) | | | | | (-) | | | (-) | (-) | | | |
| | Vulnerable people | GEDSI | (-) | | (-) | | | | | | | | | | | | | | | | | (-) | (-) | | | |
| | | IP and cultural heritage | (-) | | | | | | | | | | | | | | | | | (-) | | | | | | |

## 5.3 Environmental and Social Impact Assessment

The impact assessment is determined by assessing the significance of the identified impacts in the Leopold Matrix (Table 5.3). Using desktop research, which is then verified during stakeholder consultations (i.e., FGDs, interviews) and field investigations, the impacts are further rated by assessing the risk and likelihood (Table 5.1 and Table 5.2). The assigned risk and likelihood for each impact determine the significance of impact.

Based on the impact assessment, the following environmental and social impacts are identified in each phase of the supply chain.

1. **Battery Production:** Mining and refining generate the largest amount of impacts, including land conversion, biodiversity loss, water contamination, and carbon emissions from captive coal plants. Socially, they are associated with land conversion, livelihood shifts, Indigenous Peoples' rights, and occupational safety. Manufacturing introduces emerging challenges, including hazardous waste, chemical exposure, and gender inequities in industrial zones.
2. **Battery Usage:** While usage contributes to decarbonization, the current EV adoption rates may only reduce transport emissions by 5–6% in 2030 and 10-13% in 2034. Not much can be assessed regarding BESS usage at this point, as the available information and disclosures are limited.
3. **Battery EOL:** This stage remains the weakest link in the chain. Risks are more closely related to inadequate collection and recycling systems than to battery operation itself. Without proper collection and recycling, unmanaged waste, illegal removals, and unsafe informal practices pose risks to worker safety and community health.
4. **Associated Facilities**: In addition to these core phases, the study examines associated facilities supporting the supply chain, such as industrial estates, special terminals, and transportation and logistics, which provide essential infrastructure and energy inputs. Industrial estates, ports, and logistics hubs facilitate clustering but also create localized pressures, including pollution, waste mismanagement, displacement, and traffic-related accidents. Labor rights issues are common, particularly affecting vulnerable groups and migrant workers.

Table 5.4 presents a summary of the findings from the environmental and social impact assessment. A more detailed overview of risk rating and impact significance is shown in the subsequent sections for each assessment.

The exhaustive list of risk ratings on each sensitive receptor and activity phase is presented in the environmental and social impact assessment matrices in the subsequent tables, respectively. For more information on the assessment for each risk rating, a detailed assessment is enclosed in Annex C: Environmental and Social Impact Assessment as reference.

**Table 5.4 Summary of environmental and social impact assessment**

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| **Battery Production** | | |
| **As the most mature and developed stage, environmental and social impacts related to battery production are the most identifiable.** The country already has an established industry, particularly for the mining and refining phase, whose impacts are already widely reported. This also means that these stages have the most robust legal framework. That said, more impact assessment studies may be required for specific processes or materials, starting with the battery material, cell manufacturing, and battery pack assembly. These studies could provide a foundation for future assessments should battery production capacity scale up in the future. | | |
|  <br>**Mining**<br>⌄<br>  <br>**Refining**<br>⌄<br>  <br>**CAM/anode manufacturing**<br>⌄<br>  <br>**Battery cell manufacturing** | • **Mining is the stage of the supply chain that generates the most adverse impacts in almost all environmental aspects**. This extends to both the construction and operation phases. The sensitive receptors in question include landscape, soil, water, biodiversity, waste generation, and carbon emissions.<br>  ○ Due to its nature, mining activities will heavily alter the landscape, soil, and biodiversity through the land clearing and ore extraction process. Deforestation also contributes significantly to carbon emissions.<br>  ○ Mining operations also contribute to wastewater generation. Mining wastewater typically contains total suspended solids (TSS) and oxidized heavy metals, such as $Cr^{6+}$, which contribute to acid mine drainage[70] that can impact surface and groundwater.<br>  ○ Although the post-operation can remedy the impacts to a certain extent, it may never be able to restore the damage fully.<br>• **The refining stage will have a high impact on the following sensitive receptors: air, water, biodiversity, energy, and carbon emissions.**<br>  ○ There may be substantial impacts on the landscape and soil, particularly due to tailing and slag management. In the refining process, tailings and slag are produced as waste from hydrometallurgy and pyrometallurgy, respectively[17]. | • **Similar to the environmental assessment, mining is the most socially disruptive stage.** This is shown through the largest number of high-risk outcomes across communities, workers, and vulnerable groups.<br>  ○ **During the construction and operation phases, community health impacts are significant, as agricultural livelihoods decline when land is converted into mining sites.**<br>  ○ **Community lifestyle impacts are moderate.** They are driven by the shift from farming and fishing activities to industrial jobs, alongside the increased presence of police and military forces near mining areas.<br>  ○ **Human rights risks are substantial.** There are genuine concerns over displacement, land grabbing, inadequate compensation, and forced sales.<br>  ○ **Indigenous Peoples (IPs) and cultural heritage face high risks, as IPs lose access to land, cultural sites, and livelihoods.** Free, Prior, and Informed Consent (FPIC) is rarely implemented. Women are disproportionately affected, as land titles are often held by men, excluding women from land rights, decision-making, and equitable income opportunities.<br>• **Refining activities pose serious risks to both workers and surrounding communities, with health impacts and occupational health and safety (OHS) concerns being particularly severe.** |

[70] AEER. (2023). "Dilema Halmahera di Tengah Industri Nikel". Link

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
|  **Battery pack assembly** | ○ The high impacts from smelters are not only due to the nature of the refining process, but also due to the inclusion of a captive power plant. Ore refining is a highly energy-intensive process[71] and, in Indonesia, it relies predominantly on coal power, which contributes to NO, $SO_2$, and $PM_{2.5}$ emissions that disrupt air quality[72].<br>○ Application of captive power plants in refining also causes a substantial impact on carbon emissions. Common industry practices in Indonesian nickel smelting are reported to produce about 65 $tCO_2/Ni$[73], which falls within the higher end of industry standards[74].<br>• **The manufacturing of battery components, cells, and pack assembly is either combined into one production facility or separated into three different stages in different entities.**<br>○ The manufacturing of CAM/anode and battery cell components raises concerns about the potential air and soil contamination. These pollutants originate from dust containing heavy metals from battery materials (i.e., nickel, cobalt, lithium, graphite; depending on the product)[75]. This understudied impact warrants further analysis, as it may be amplified in the future due to the country's push for increased battery manufacturing.<br>○ In addition, all three manufacturing phases may cause a substantial impact on waste generation through the increase of hazardous waste. There have been reports of increased post- | ○ Community health risks are high due to air and water pollution.<br>○ Livelihood risks range from moderate to high, linked to environmental degradation and reduced land productivity. The use of waste storage facilities also carries moderate risks due to potential leaks that could contaminate water resources and impact community livelihoods.<br>○ Workers face high OHS risks, including respiratory problems from dust and emissions. Labor compliance issues are moderate, with reports of poor working conditions, long hours, low pay, and a lack of adequate safety measures.<br>○ Human rights violations remain a substantial risk, as reflected in reports submitted to Indonesia's National Commission on Human Rights.<br>• **Battery manufacturing presents low to moderate risks for both communities and workers.** While generally manageable, these risks can escalate if operational procedures are not followed or if incidental events occur.<br>○ Community health risks are generally low in battery manufacturing, particularly in facilities within industrial estates where geographic isolation reduces direct disturbance. However, international experiences (e.g., community opposition to the construction of lithium-ion plants in Hungary) highlight the potential for public concern regarding air pollution and waste management[76]. |

[71] Nickel Institute. (2024). "Nickel life cycle data". Link
[72] CREA & CELIOS. (2024). "Debunking the Value-added Myth in Nickel Downstream Industry". Link
[73] IEEFA. (2024). "Indonesia's Nickel Companies: The Need for Renewable Energy Amid Increasing Production". Link
[74] IFC. (2023). "Net Zero Roadmap to 2050 for Copper and Nickel Mining Value Chains ". Link
[75] Degen, F. *et al.*. (2025). "Direct emissions to air, water and soil from a battery gigafactory". *Communications Earth & Environment*, **6**(408). Link
[76] Business and Human Rights (2024). Hungary: Locals oppose construction of Chinese lithium-ion battery plant over air pollution & fear of becoming 'battery wasteland. Available at: https://www.business-humanrights.org/en/latest-news/hungary-locals-protest-against-construction-of-chinese-lithium-ion-battery-plant-over-air-pollution-fear-of-battery-wasteland/

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| | production waste in industrial areas that is not properly managed[21]. Without proper intervention, this can lead to further waste accumulation. | ○ Worker risks are moderate, primarily due to exposure to hazardous chemicals and inadequate use of personal protective equipment (PPE). |
| **Battery Usage** | | |
| **At the time of the study, battery usage in Indonesia is aimed at EV and BESS applications.** For EV usage, this analysis highlights the impact on reducing carbon emissions as well as safety risks from unauthorized battery handling and removal. As for BESS, the impact assessment is more complex due to its integration into the national electricity mix. The assessment of BESS usage is more high-leveled and seen as an integration of the overall electricity scenario compared to of BESS alone. | | |
|  **EVs**  **BESS** | • **Meeting national EV production targets would only have a low impact on carbon emission reduction.** One of the primary targets of the battery supply chain is to scale up domestic EV production as a means to meet decarbonization goals.<br>○ EV deployment is projected to increase to 10% and 2% for 2W and 4W, respectively. The current EV adoption rate is still less than 1% for either 4W or 2W[77,78]. Meanwhile, the annual production target is 13,000,000 2W and 2,000,000 4W EV units by 2030 based on information from BKPM. Targets in regulation[79] remain at 600,000 by 2030 and 1,000,000 by 2040 for 4W.<br>○ These numbers can only reduce 3-5% of carbon emissions from the transportation sector. This calculation was done by comparing the target numbers against national statistics using life-cycle GHG data[80] (see Table 3.7).<br>• **Assessing the impact of BESS applications is more complex, as they are integrated into the national electricity mix.** Using the 2025-2034 RUPTL[81] as the basis for assessment, BESS will likely be applied in new infrastructures rather than replacing existing ones. | • **The adoption of EVs has generally low risks to community health and lifestyle.**<br>○ That said, risks could escalate if EV production ramps up yet battery collection and recycling infrastructure remains inadequate. Ineffective recycling and collection systems may lead to illegal battery removal, creating hazards for EV owners (e.g., explosions, fires, or malfunctions), as well as risks of water pollution with potential impacts on community health.<br>• **BESS can support Indonesia in integrating more renewable energy, expanding energy access, and creating new employment opportunities.**<br>• However, their deployment is also associated with risks comparable to those faced by other industrial facilities. Since BESS projects are more likely to be developed within industrial estates, these risks should be assessed and managed within the context of such estates. |

[77] BPS. (2023). "Jumlah Kendaraan Bermotor Menurut Provinsi dan Jenis Kendaraan (unit), 2023". Link
[78] Ministry of Transportation. (2022). "Data Penerbitan Sertifikat Registrasi Uji Tipe (SRUT)". *Sistem Pernghubung Layanan Transportasi*. Link
[79] Peraturan Menteri Perindustrian Nomor 28 Tahun 2023 (Permenperin No 28 Tahun 2023) | catatanhukum.id
[80] Mera, Z. *et al*. (2023). "Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passeneger Cars and Two-Wheelers in Indonesia". *The International Council on Clean Transportation*. Link
[81] PLN. (2025). "Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2025-2034". Link

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| | ○ Incorporating more renewable energy technologies, including BESS, can cause moderate carbon emission reduction. The scenarios presented in the RUPTL projected carbon emission reductions of about 29-30%[81] (see Table 3.8 and Table 3.9). | |
| **Battery End-of-Life (EOL)** | | |
| **The end-of-life (EOL) stage is still in its infancy in Indonesia.** This leads to under-capacity of battery waste collection and recycling systems. However, the identification of environmental and social impacts is conducted with respect to conditions that occur in other countries. These findings can serve as references to Indonesia's battery end-of-life development. | | |
|  **Battery waste**   **Battery material recycling** | • **There is insufficient data on the projected battery waste post-EV and BESS usage.** It is reported that the Coordinating Ministry of Economic Affairs (CMEA) is preparing a dedicated study on battery waste to address this.<br>○ Inadequate battery collection may cause a moderate impact on hazardous waste generation. A similar case is reflected in China, where used EVs are abandoned and lead to illegal battery removals[82].<br>○ The current arrangement suggests that battery waste collection is insufficient even for post-production waste. Currently, battery waste from the production process is collected by the informal sector, which lacks regulation and standards. This allows an opportunity for policymakers to strengthen the current collection scheme and minimize waste generation.<br>• **Much like battery production, the battery material recycling process mirrors many of its impacts.** This includes impacts on air, soil, water, and waste generation. However, available studies specifically on battery recycling are limited. | • **Risks are generally low to moderate but depend heavily on effective management practices.**<br>○ **Community lifestyle and health:** Largely low risk; however, improper recycling or disposal practices can significantly escalate impacts.<br>○ **Recycling facilities:** Pose limited but notable safety risks, particularly from accidental chemical spills, handling of flammable or reactive reagents, and the transportation of hazardous materials.<br>○ **Battery collection:** Inadequate collection systems increase exposure of communities to toxic components, mainly when illegal or informal removals occur. This raises serious health and safety concerns in areas without formal collection infrastructure.<br>○ **Defective batteries:** A critical risk arises from the high volume of defective batteries generated during the start-up phase of new factories. Improper storage and processing of these defective units can endanger both workers and the surrounding communities. |

[82] Bloomberg. (2023). "China's Abandoned, Obsolete Electric Cars Are Piling Up in Cities". Link

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| | ○ The battery material recovery process will produce air pollutants containing heavy metals, which can further cause soil and groundwater pollution[83]. That said, this finding warrants further investigation, specifically in the context of battery recycling plants.<br>○ The dismantling process may also contribute to increased solid waste from battery packaging. This is linked to the findings regarding battery waste in general. | |
| **Associated Facilities** | | |
| **Associated facilities linked to the battery supply chain are expected to increase in capacity, which warrants the need for their own environmental and social impact assessment.** The assessment itself highlights several notable findings, such as the issue with processing waste management, which is within the full accountability of the industrial estate; human rights issues related to land displacement and social concerns from industrial development; as well as perceived impacts from the development of special ports. | | |
|  <br>**Industrial estate**<br>  <br>**Special port**<br>  <br>**Transport & logistics** | • **Industrial estates allow impacts to be contained within their premises, minimizing impact on the surrounding environment.** That said, it does not mean the impacts are less significant. High and substantial impacts are still potential within industrial estate borders, with some having a higher likelihood of spilling over into the environment.<br>○ The only time industrial estates produce impacts on their own is during the construction period. The construction phase allows high and substantial impacts on the landscape, soil, water, biodiversity, waste generation, and carbon emissions. This is from the land preparation and construction activities for preparing the industrial lots and infrastructure[70].<br>○ During the operation phase, impacts from the industrial estates are ruled mainly by their tenants. This is due to the nature of its business. Industrial estates serve as "operational hubs" where different types of industries operate in isolation from the | • **Impacts related to industrial estates are generally less severe than mining or refining, but emerging risks in industrial zones warrant close attention.**<br>○ Since the pre-construction phase, high-risk impacts to IPs have been reported due to lack of FPIC. Land has been taken or deforested without consent, with partial or inadequate compensation. They have faced loss of livelihoods, displacement, and restricted access to cultural and ancestral burial lands. Indigenous groups without government-recognized land certificates are especially vulnerable to dispossession.<br>○ Impact on human rights as there are reports document intimidation, threats, and criminalization of residents opposing projects. Compensation processes are often partial, delayed, or contested, with some leaders striking deals without broader community consent.<br>○ Once the construction and operation phases kick in, rapid immigration ensues. Thus has doubled local populations, |

[83] Xiaodong. *Et al*. (2024). "Environmental Impact Analysis of Waste Lithium-Ion Battery Cathode Recycling". *Journal of Ecological Engineering* 2024, **25**(7), 352-358. Link

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| | surrounding community. Thus, impacts at this stage are driven mainly by what the tenants do and how the estate manages them.<br>○ Air pollutants and waste generation are full responsibility of the tenants. Air pollutants are usually emitted from industrial factories, including smelters. Waste from production processes also falls within the responsibility of the industrial tenants.<br>○ The industrial estate typically manages effluent water discharge, as it provides wastewater treatment plants (WTP) for tenant usage. The industrial estate must ensure that all tenants adhere to industrial standards, as their environmental licensing is tied to the industrial estate's. The estate also has full authority to suspend tenant activities.<br>○ In addition, the industrial estate also holds full accountability to the management of processing waste i.e., nickel slag. Industrial estates such as IMIP are reported to manage their own waste storage facilities by collecting and processing waste from their tenants. Thus, any accidents related to this shall be the industrial estate's responsibility.<br>• **Special ports serve as an important infrastructure for mines, smelters, or industrial parks.**<br>○ The development of special ports seems to lack a planning and policy framework. In Java, as reflected in Karawang, many special ports are built within industrial zones, which promotes the integration of industrial zones. However, in Sulawesi—as reflected in Morowali—special ports are often scattered due to poor road infrastructure. | generating social tensions between newcomers, local residents, and companies.<br>○ Workers face substantial labor and OHS risks. This comes in the form of corruption in job placement (payments demanded for employment), wage disparities between Indonesian and migrant workers, retaliation against union activities, and limits on overtime. In addition, there are also reports of low wages, poor implementation of PPE, long working hours, passport withholding, and hazardous conditions. The Human Rights & Business Observatory reports high rate of accidents between 2015-2024 (114 incidents, 101 deaths, 240 injuries reported 2015–2024)[85].<br>• **Impacts to vulnerable communities have also been linked to industrialization.**<br>○ Women report denial of menstrual leave and assignment of night shifts during pregnancy, despite national protections. Gender-sensitive measures are largely absent.<br>○ Community Livelihoods and Lifestyle: Communities have lost access to agricultural lands, fishing grounds, and IPs have lost access to ancestral burial sites. In addition, Immigration pressures have generated tensions with residents.<br>○ Community health is compromised by pollution from industrial estate tenants, linked to respiratory and skin illnesses.<br>○ That said, opportunities and improvement of the quality of life are offered to the people. These are demonstrated through scholarships, healthcare, clean water, and support for small and medium-sized enterprises. Although the benefits are unevenly distributed and limited in scope. |

[85] Business & Human Rights Resource Centre (2024). Indonesia: Workers allege 'production first, safety later' culture at IMIP nickel complex leads to unsafe conditions & rising accidents. Available at: Indonesia: Workers allege 'production first, safety later' culture at IMIP nickel complex leads to unsafe conditions & rising accidents - Business & Human Rights Resource Centre
Reported worker deaths and injuries in Indonesia: https://www.business-humanrights.org/documents/40741/Reported-Worker-Deaths-and-Injuries-in-Indonesia-updated-11_4_1.xlsx

| Activity | Environmental Impacts | Social Impacts |
|---|---|---|
| | ○ Unsustainable development of special ports can cause a substantial impact on marine ecosystems. This comes from activities such as dredging during construction and overall terminal operations[84].<br>• **Other transport and logistics infrastructure such as roads remain key to enabling an integrated supply chain.**<br>○ There seems to be an uneven distribution of proper roadworks between Java and the rest of Indonesia. This is evident in how other parts of Indonesia, especially the east, rely more on goods hauling via sea compared to roads. | ○ Port development has disrupted ecosystems long managed by residents, displacing around 1,105 fishing households. Other impacts include: the displacement of youths shifted into low-income activities (i.e., construction, vending, parking, scavenging), and women, previously central to coastal resource management as shellfish gatherers, were excluded from project planning and decision-making.<br>• **Transport and Logistics: Moderate to high risks emerge from heavy traffic linked to industrial estates.** Large trucks and heavy equipment increase accident risks, particularly in mixed-traffic areas (pedestrians, motorcycles).<br>○ Workers face additional risks from heavy machinery and chemical exposure, worsened by inadequate safety measures and communication. |

[84] UNESCAP. (1992). "Assessment of the Environmental Impact of Port Development". Link

## Table 5.5 Environmental impact assessment matrix

**Notes:**
**C** = Construction, **O** = Operation, **Pre-C** = Pre-construction, **Post-O** = Post-operation, **U** = Usage

H High risk  S Substantial risk  M Moderate risk  L Low risk

| Sensitive Receptors | Impact | Battery Production | | | | | | | | | | | | Battery Usage | | Battery End-of-life | | | Associated Facilities and Activities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mining | | | | Refining | | CAM/anode manufacturing | | Battery cell manufacturing | | Battery pack assembly | | EV | BESS | Battery waste | Battery recycling | | Industrial estate | | | Special port | | Transport & logistics |
| | | Pre-C | C | O | Post-O | C | O | C | O | C | O | C | O | U | U | U | C | O | Pre-C | C | O | C | O | C & O |
| Landscape | Land conversion | L | H | H | S | | | | | | | | | | | | | | | S | | M | | |
| | Landscape and morphology | | H | H | S | | S | | | | | | | | | | | | | H | | M | | |
| Soil | Soil quality | | S | H | S | | L | | H | | H | | | | | | | H | | S | | M | | |
| | Soil erosion and landslide | | H | S | S | | S | | | | | | | | | | | | | H | | M | | |
| Air | Air quality | L | M | M | | L | H | L | L | L | L | L | | | | | L | L | | M | H | M | | M |
| | Noise | L | M | M | | L | M | L | M | L | M | L | | | | | L | L | | M | | M | | M |
| Water | Surface water | | H | M | S | | H | | L | | L | | L | | | | | L | | H | H | | | |
| | Groundwater | | H | H | S | | | | H | | H | | | | | | | H | | H | | M | | |
| | Marine water | | | | | | | | | | | | | | | | | | | | H | S | S | M |
| Biodiversity | Terrestrial biodiversity | | H | H | S | | | | | | | | | | | | | | | H | | M | | |
| | Aquatic biodiversity | | H | M | S | | H | M | | | | | | | | | | | | H | H | | | |
| | Marine biodiversity | | | | | | H | | | | | | | | | | | | | | H | S | S | M |
| | Ecosystem services | | H | H | M | | H | M | | | | | | | | | | | | H | H | S | S | M |
| Waste generation | Solid waste | | M | S | L | | | S | | | | | | | | | | S | | | | S | | |
| | Wastewater | | H | M | | | H | S | L | | L | | | | | | | L | | H | H | M | | |
| | Hazardous waste | | | L | | | M | | S | | S | | S | | | M | | H | | | S | | | |
| Energy | Energy consumption | | | | | | H | | M | | M | | L | | | | | M | | | | | M | |
| Carbon emissions | CO/CO2 (metric tonnes) | | H | H | | | S | | S | | S | | L | L | M | | | M | | H | | | M | L |

## Table 5.6 Social impact assessment matrix

**Notes:**
**C** = Construction, **O** = Operation, **Pre-C** = Pre-construction, **Post-O** = Post-operation, **U** = Usage

H High risk S Substantial risk M Moderate risk L Low risk

| Sensitive Receptors | Impact | Battery Production | | | | | | | | | | | | Battery Usage | | Battery End-of-life | | | Associated Facilities and Activities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mining | | | | Refining | | CAM/anode manufacturing | | Battery cell manufacturing | | Battery pack assembly | | EV | BESS | Battery waste | Battery recycling | | Industrial estate | | | Special port | | Transport & logistics |
| | | Pre-C | C | O | Post-O | C | O | C | O | C | O | C | O | U | U | U | C | O | Pre-C | C | O | C | O | C & O |
| Surrounding community | Community health | | M | H | | H | H | | M | L | | L | | L | | M | | | | | M | | | M |
| | Community lifestyle | M | M | M | | | M | | L | | | | | L | | | | L | | S | M | | | M |
| | Livelihood | S | S | H | | | H | | | | | | | | | | | | H | S | S | M | | |
| | Human rights | S | | H | | S | | | | | | | | | | | | | H | | S | | | |
| Workers | Labor compliance | | | | M | | M | | | | | | | | | | | | | | S | | | |
| | OHS | | | H | | | H | | | | M | | M | | | | | M | | | S | M | | |
| Vulnerable people | GEDSI | S | | M | | | | | | | | | | | | | | | | | M | M | | |
| | IP and cultural heritage | H | | | | | | | | | | | | | | | | | H | | | | | |

## 5.4 Sustainability Metrics

The sustainability metrics represent the overall health of the battery supply chain in Indonesia. The following metrics use sensitive receptors as the primary measures, and the indicators used as parameters that are considered major representations for each receptor. As each phase of the battery supply chain does not have the same level of maturity and scope, each sustainability metric is analyzed differently depending on the corresponding receptor and available information. Limited publicly available data also affects the depth of analysis. The rationale for each rating is also described below.

### Table 5.7 Sustainability metrics

**Notes:**
↘ = negative impact, ↗ = positive impact

High risk | Substantial risk | Moderate risk | Low risk

| Sensitive Receptor | | Indicator | Baseline | Change/Trajectory | ↘ \| ↗ | Risk Rating | Rationale |
|---|---|---|---|---|---|---|---|
| Environmental | **Landscape** | Land conversion | Morowali: 75,469 Ha of other non-forest in 2010 [86] | Morowali: 100,758 Ha of other non-forest in 2024[86] | ↘ | **Moderate** | Based on other non-forest data from the Nusantara Atlas[86], there is positive increase of land conversion. The available data does not directly link land conversion to a certain industry. That said, Morowali and Central Halmahera have mining concessions intersected to its forest areas and Karawang has been long liked with heavy industrialization[87]. These factors are sufficiently strong to indicate business practices induce land conversion in these regions. Although extractives cause heavy implication towards land cover, mining companies in Indonesia adhere to existing regulations and good business practices as standardised by MEMR. This includes enforcing companies to conduct post-mine rehabilitation and reforestation to minimize environmental impact. This practice is also reflected in the industrial visit in Morowali[18]. |
| | | | Central Halmahera: 47,515 Ha of other non-forest in 2010[86] | Central Halmahera: 59,172 Ha of other non-forest in 2024[86] | | | |
| | | | Karawang: 190,384 Ha of other non-forest in 2010[86] | Karawang: 190,385 Ha of other non-forest in 2024[86] (there is <1 kHa of forest left in Karawang) | | | |
| | **Air** | Air quality | Heightened $PM_{2.5}$ levels are observed within the local scale[88] | Noncompliant $PM_{2.5}$ levels at a regional scale by 2030 if left unchecked | ↘ | **High** | The study finds that one of the most prominent air emissions come from the refining stage. Study on air modelling from refinery plants is available for Central Halmahera[88]. Although the study identifies that air emissions are isolated from the community due to their location in |

[86] Nusantara Atlas. (2025). *Nusantara Atlas.* Link
[87] As shown in the maps presented in the **Chapter 4 Environmental and Social Baseline**.
[88] Based on data in the surrounding area of IWIP, using data from CREA & CELIOS (2024)[72].

| Sensitive Receptor | | Indicator | Baseline | Change/Trajectory | ↘ \| ↗ | Risk Rating | Rationale |
|---|---|---|---|---|---|---|---|
| | | | Visible dust is observed in the field visit in Morowali[18] | Further dust generation from logistics/transport that can increase with capacity | | | industrial estates, precautions should be taken if production capacity is scaled up in the future. The air dispersion modeling results show that regional-level dispersion impacts by 2030 is possible without mitigation measures.<br>Additionally, air emissions and dust from the transportation of goods and materials are also a significant issue. Quantitative assessments on this particular matter were not available publicly, thus analysis was done based on field visit inputs. The field visit in Morowali has shown that transportation and logistics through publicly accessible roads have caused dust and respiratory issues to the surrounding community[18]. This presents an opportunity for studies related to the impacts of battery and/or mineral extraction logistics towards communities. |
| | **Soil** | Soil quality | Potential soil contamination from processing waste that is not properly stored[89] | Further soil contamination can penetrate the groundwater | ↘ | **Moderate** | Stored processing waste in dry stacks that are dumped within industrial estates. As this impact is locally scaled, analysis is done at the local level. The main risk of stored processing is if the lining system cannot or fail to prevent pollutants from infiltrating the soil and contaminate groundwater through seepage[89]. That said, such cases (related to waste dams, not waste dumping) have not been reported or identified in Indonesia, which is a demonstration of good design and maintenance.<br>Another issue that is flagged in the assessment is the potential soil contamination from heavy metal-containing dust generated through battery production plants[75]. By the time of this study, assessments on this particular topic is still very limited. At the moment, a trajectory of soil contamination from these pollutants remain a possibility, with note that further assessment using the technologies applied in Indonesian-based battery production plants is required |
| | | | Potential soil contamination from battery manufacturing air pollutants that penetrate the soil[75] | Further soil contamination with increased production capacity | | | |

[89] Cheng, Y. *et al.* (2024). "Seepage and Deformation Analysis of Tailing Dam regarding the Upper Reservoir of Tiantai Pumped Storage Station". *Journal of Physics: Conference Series* 2024, 7736, 012021 Link

| Sensitive Receptor | | Indicator | Baseline | Change/Trajectory | ↘ \| ↗ | Risk Rating | Rationale |
|---|---|---|---|---|---|---|---|
| | **Water** | Surface and seawater quality | Heightened pH and $Cr^{6+}$ in water bodies near mining concessions | Persistent noncompliant water quality standards without proper measures | ↘ | **Substantial** | Implications towards surface water from mining activities remain a major issue that is carefully monitored by government standards and corporate responsibility[17]. Intricate studies and permitting processes have become part of the standard procedure before corporations can discharge wastewater. In addition, post-mining rehabilitation can alleviate these impacts with proper measures.<br>The stakeholder consultation with Morowali government agencies identified discharged cooling water as a major impact to seawater[18]. Cooling water discharge are tied to CPPs that power smelters in industrial estates. It is reported that the line of accountability for this particular impact is blurred in execution.<br>The development of special ports can also disrupt marine ecosystems, particularly through dredging and operational activities[84]. Rapid development of special ports, particularly in rural areas like Morowali, may be linked to uneven roadworks which leads to reliance of sea transport for shipping. Increased production capacity may lead to further development which can lead to further disruption of marine ecosystems if development is not properly regulated or planned. |
| | | | Increased seawater temperature from cooling water discharge | Persistent noncompliant seawater quality standards without proper measures | | | |
| | | | Seawater quality noncompliance due to the special port development and operation | Increased and non-regulated development of special ports can lead to further seawater quality disruption | | | |
| | **Biodiversity** | Deforestation | Morowali: 1.01 Mha of natural forest in 2020[90] | Morowali: 4.61 Ha of natural forest loss in 2024[90] | ↘ | **Substantial** | The implication on biodiversity is a byproduct of massive land conversion. Natural forest cover data from the Global Forest Watch[90] shows decline in the three snapshot regions. The available data does not directly link deforestation to a certain industry. These factors are sufficiently strong to indicate business practices induce deforestration in these regions. Changes in landscape, water, and other abiotic factors can alter ecosystems and the species that inhabit them. |
| | | | Central Halmahera: 188 kha of natural forest in 2020[90] | Central Halmahera: 700 Ha of natural forest loss in 2024[90] | | | |
| | | | Karawang: 437 Ha of natural forest in 2020[90] | Karawang: <1 Ha of natural forest loss in 2024[90] | | | |
| | **Waste generation** | Solid waste generation | Solid waste from battery dismantling is still nascent | Dismantling of batteries can increase in the future with increased capacity | ↘ | **Substantial** | Waste is generated in all stages of the supply chain. Hazardous waste is a projected potential impact from various stages of battery production. However, current studies are still limited in addressing these impacts. Slag, a byproduct of refining process, is projected to be |

[90] Global Forest Watch. n.d. *Global Forest Watch*. Link

| Sensitive Receptor | | Indicator | Baseline | Change/Trajectory | ↘ \| ↗ | Risk Rating | Rationale |
|---|---|---|---|---|---|---|---|
| | | Refining waste, i.e., slag. | Nickel slag is estimated at 13 mllion tonnes annually[91] | Refining waste can overflow with increased capacity | | | a significant impact that should be properly handled in the future. With many smelter projects in the pipeline, slag production can increase with increased should production capacity. Other potentially hazardous waste includes used batteries, which at the moment still requires a more precise projection of numbers.<br>Solid waste is also seen as a potential impact should battery production increases, particularly from battery dismantling. The government has shown interest in exploring circular economy and end-of-life battery approaches that can shed light to this issue[17]. |
| | | Battery waste | Current domestic battery waste is still nascent | Battery waste can increase in the future with prolonged EV usage and increased adoption | | | |
| | **Energy** | Energy consumption for nickel refining[92] | 65.0 ton $CO_2$/Ni | Energy consumption can spike with increased capacity | ↘ | **Moderate** | The impact assessment identified the refining process to have the highest potential for energy consumption. The assessment level for this metric is based on the energy consumption per phase using publicly available information. In essence, the most energy-intensive aspect is refining, as the process relies on high-heat in consistent rates. Battery production is also projected to cause high energy consumption due to parts of its production that also requires high consistent heat. That said, other phases of the battery supply chain are concluded to not consume the same level of energy. |
| | | Energy consumption for battery pack manufacturing[93] | 50.17 kWh/kg of battery pack produced (24 kWh capacity) | | | | |
| | **Carbon emissions** | Life-cycle GHG emissions per kWh[94] | 41-89 kg $CO_2$eq/kWh | Collective $CO_2$ emissions are expected to grow with increased capacity | ↘ | **High** | Assessment for carbon emissions are done at the macro level which gives a proportion of how GHG emissions are distributed across supply chain phases. Available studies show that the life-cycle GHG emissions for batteries are relatively high. This calculation quantifies extraction, provision, and manufacturing. There is potential for collective emissions to grow significantly with increased capacity. |
| **Social** | **People** | Population[95] | Central Sulawesi: 2,635,000 (2010) | Central Sulawesi: 3,156,100 (2025) | ↗ | **Substantial** | All hubs experienced population increases, indicating strong labor in-migration driven by industrial development. Overall, industrial parks clearly attract workers and stimulate regional population growth, particularly in Java and Sulawesi. |
| | | | North Maluku: 1,209,300 (2017) | North Maluku: 1,373,800 (2025) | | | |

[91] Tanjung, A.A.T. *et al*. (2022). "Analysis of Nickel Slag Utilisation as Shotcrete Raw Material and Handling of Nickel Slurry to Reduce the Environmental Impact". *Jurnal Migasian*. VI(2) (Link)
[92] IEEFA. (2024). "Indonesia's Nickel Companies. The Need for Renewable Energy Amid Increasing Production". (Link)
[93] Yuan, C. *et al*. (2017). "Manufacturing energy analysis of lithium-ion battery pack for electric vehicles". *CIRP Annals*, 66 (1), p53-56 (Link)
[94] Xu, C. *et al*. (2022). "Future greenhouse gas emissions of automotive lithium-ion battery cell production". *Resources, Conservation and Recycling*, (187), 106606 (Link)
[95] BPS- Statistics Indonesia. Product – Statistical Data. Income and consumption > Percentage of poor population by province and area

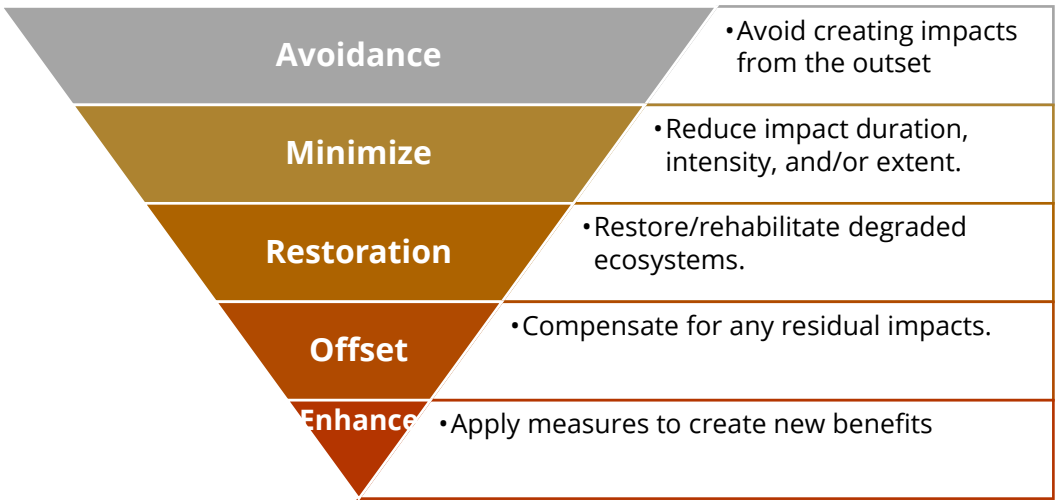
| Sensitive Receptor | | Indicator | Baseline | Change/Trajectory | ↘ \| ↗ | Risk Rating | Rationale |
|---|---|---|---|---|---|---|---|
| | | | West Java: 47,379,400 (2016) | West Java: 50,759,000 (2025) | | | |
| | **Livelihood** | Poverty Rate[96] | Central Sulawesi: 15.40% (2012) | Central Sulawesi: 10.92% (2025) | ↗ | **High** | Industrialization appears to have contributed to poverty reduction in Morowali, Weda Bay, and Karawang, where total poverty rates declined after industrial park development. |
| | | | North Maluku: 6.35% (2017) | North Maluku: 5.81% (2025) | | | |
| | | | West Java: 8.95% (2016) | West Java: 7.02% (2025) | | | |
| | **Workers** | Regency Unemployment Rate[97] | Central Sulawesi: 3.75% (2012) | Central Sulawesi: 3.02% (2025) | ↗ | **High** | Employment indicators improved in Morowali, Weda Bay, and Karawang, all showing declines in unemployment compared to pre-construction levels. Industrial hubs generally create jobs, but structural unemployment persists, particularly in regions with weaker skills or limited integration into the formal economy. |
| | | | North Maluku: 4.82% (2017) | North Maluku: 4.26% (2025) | | | |
| | | | West Java: 8.57% (2016) | West Java: 6.74% (2025) | | | |
| | **Vulnerable groups** | Gender Inequality Index[98] | Central Sulawesi: 0.469 (2023) | Central Sulawesi: 0.461 (2024) | ↗ | **Moderate** | The Gender Inequality Index (GII) reflects improvements in gender equality. Gender inequality narrowed slightly in Weda Bay, Karawang, and Morowali provinces, reflecting modest improvements in gender balance. However, this trend does not extend to supply chain related sectors, which remain largely male-dominated. Therefore, it is recommended to conduct a dedicated survey to better understand the gender dynamics within the hotspots of the supply chain. |
| | | | North Maluku: 0.519 (2023) | North Maluku: 0.508 (2024) | | | |
| | | | West Java: 0.482 (2023) | West Java: 0.458 (2024) | | | |

[96] BPS- Statistics Indonesia. Product – Statistical Data. Income and consumption > Percentage of poor population by province and area
[97] BPS- Statistics Indonesia. Product – Statistical Data. Number and percentage of employment and unemployment
[98] BPS-Statistics Indonesia. Gender Inequality Index (GII) 2024. Official statistics news. No. 45/05/Th.XXVIII, 5 May 2025.

# 6 Mitigation Strategies

Based on the impact assessment results, mitigation strategies shall be determined based on residual impacts. For environmental impacts, mitigation strategies will employ the mitigation hierarchy approach, as outlined below. Mitigation strategies related to the social effects should consider the involvement of vulnerable groups in the five domains of GEDSI, including access, decision-making, participation, systems, and well-being.

**Figure 6.1 Mitigation hierarchy**




## 6.1 Environmental and Social Mitigation Strategies

The study identifies a set of safeguards and solutions organized around five thematic priorities that cut across the battery supply chain:

1. **Governance and Compliance:** There are recurrent gaps related to governance, particularly in regional development and industrialization, land use and permitting, law enforcement, and consistent practice of Free, Prior, and Informed Consent (FPIC) are essential to avoid conflicts with communities and Indigenous Peoples. Enhanced coordination among government institutions, improved multi-stakeholder involvement, transparent land acquisition, robust grievance mechanisms, and independent audits will strengthen accountability and build trust across the sector.

2. **Social Safeguards:** Given the importance of workers and communities in sustaining the supply chain, social safeguards must focus on stronger occupational health and safety (OHS) standards, enforcement of labor rights, and inclusion of vulnerable groups. Gender-responsive workplace policies—including childcare support, protections against gender-based violence, and expanded training opportunities—will enable broader participation of women and vulnerable groups, while community investments in healthcare and education can help offset social disruption in host regions.

3. **Environmental Management:** To address the sector's environmental footprint, environmental safeguards should prioritize biodiversity protection; stricter

monitoring of air, water, and soil quality; and stronger waste management systems. At the refining stage, reducing reliance on captive coal power plants and incentivizing renewable energy use will lower the sector's carbon intensity, while aligning expansion with Indonesia's NDC commitments.

4. **Associated Infrastructure:** The facilities that enable the supply chain must also be managed responsibly. Industrial estates, ports, and logistics hubs should adopt higher environmental standards, including wastewater treatment, waste management, and green port initiatives. Logistics planning can reduce traffic and accident risks in surrounding communities, while stronger worker protections and accessible grievance systems—particularly for women and migrant workers—will address persistent labor challenges in these facilities.

5. **Circular Economy and Innovation:** As of this study, battery end-of-life is underdeveloped, requiring innovation and circular solutions. Building formal systems for collection, safe dismantling, and environmentally sound recycling will be critical, alongside expanding domestic recycling capacity. Extended Producer Responsibility (EPR) schemes and incentives for formal-sector recovery can reduce reliance on unsafe informal practices while encouraging eco-design and material efficiency.

High-level environmental and social mitigation strategies are presented in Table 6.1 and Table 6.2 respectively. The mitigation strategies are presented per supply chain phase.

**Table 6.1 Summary of environmental mitigation strategies**

| Activity | Environmental Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| **General** | | | |
| | **Although the legal framework requires studies and permits related to business activities, government enforcement should be optimized to reduce poor practices.** Indonesia has a robust set of regulations and permits related to business activities, which includes project feasibility, detailed engineering design, and environmental and social impact assessment. However, the gap remains in its implementation. Thus, **the government can leverage better standardization, coordination between central and regional institutions, and law enforcement.** | • Ministry of Investment and Downstream Industries (BKPM)<br>• Ministry of Environment (MoE)<br>• Regional governments | **Minimize** |
| | **Calculation of scope 1 and 2 carbon emissions can be mandatory to promote transparency.** Carbon calculation in Indonesia is based on internationally established standards, as outlined in ISO 14064, while regulations such as Presidential Regulation No. 98/2021 and Minister of Environment and Forestry Regulation No. 12/2024 do not yet fully mandate companies to calculate their carbon emissions. Companies typically report them as part of their commitment as publicly listed companies, required by investors, or to demonstrate sustainability and responsibility. **Including carbon emission calculation in the national legal framework can promote good practice while also ensuring alignment with the country's net-zero emission goals.** | • MoE | **Minimize** |
| **Battery Production** | | | |
| **Mining** | **Mining concessions should adhere to spatial planning regulations and conservation areas that comply with national and international frameworks.** In practice, permits are granted to mining concessions that intersect with the national forest estate with commitments i.e., mining warrant, forest inventory. However, this mainly adheres to national regulations. International frameworks provide more contextualized findings, i.e., the distribution of globally significant species, that are not limited by the national forest boundary. **The government can encourage companies to adopt these standards and promote more effective spatial planning.** | • BKPM<br>• MoE<br>• Ministry of Forestry (MoF)<br>• Ministry of Energy and Mineral Resources (MEMR)<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATRBPN) | **Avoid** |
| | **Emphasis should be placed on mine water and wastewater management.** The current national framework has taken this into account. That said, **continuous monitoring by the government and relevant stakeholders is encouraged to minimize the impacts on water bodies** both from wastewater discharge and fresh water utilization. | • BKPM<br>• MoE<br>• Regional governments | **Minimize** |
| | **Identify key biodiversity areas ahead of activities as inputs for the mine plan.** Conducting biodiversity studies ahead of mine planning can help identify potential biodiversity hotspots and species with conservation significance. The study results can provide crucial inputs to the mine plan, allowing for the avoidance of critical areas. **The government can enhance national regulations to incorporate international conservation frameworks, thereby improving conservation efforts related to mining.** | • MoE<br>• MoF<br>• Regional governments | **Avoid** |

| Activity | Environmental Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | **Where avoidance is impossible, incorporate critical habitat-based approaches to mining closure and rehabilitation.** Biodiversity studies can also provide input on the baseline condition of ecosystems in the mining concession, i.e., identification of critical habitats. These inputs can give valuable information for conservation targets. **There is an opportunity for policymakers to incorporate critical habitat-based approaches to mining closure and rehabilitation for better mining restoration.** | • MoE<br>• MoF<br>• Regional governments | **Restoration** |
| | **In cases where rehabilitation does not restore an ecosystem to its baseline condition, mining companies should opt for biodiversity offsets.** | • MoE<br>• MoF<br>• Regional governments | **Offset** |
|  <br>**Refining** | **Emphasis should be placed on air quality management from captive power plants (CPP) linked to refining.** The current national framework has taken this into account. However, the study methodology can be improved, such as through proper air dispersion modelling to identify how air pollutants disperse among the sensitive receptors[18]. That said, **continuous monitoring by the government and relevant stakeholders is encouraged to minimize the impacts on the surrounding environment**. | • MoE<br>• Regional governments | **Minimize** |
| | **Better modeling and control of cooling water discharge are required to minimize its impact on marine ecosystems.** Modelling of ballast water, or cooling water discharge from CPP cycles, is obligatory in the national framework. That said, **continuous monitoring by the government and relevant stakeholders is encouraged to minimize the impacts on the surrounding environment**. | • MoE<br>• Ministry of Marine Affairs and Fisheries (MMAF)<br>• Regional governments | **Minimize** |
| | **Policymakers should drive renewable or clean energy alternatives to coal in CPPs.** Poor air quality and high carbon emissions are linked to the use of coal. The use of renewable or clean energy technology should be encouraged to reduce reliance on coal and its subsequent impacts[18]. **Policymakers can benefit from applying incentives or other policy instruments to stimulate companies in the energy transition.** | • MEMR<br>• Regional governments | **Minimize** |
|  <br>**CAM/anode & battery cell manufacturing** | **More studies are required on the modelling of pollutants, especially air pollutants.** For battery cell manufacturing, this involves air pollutants that contain battery compounds, i.e., nickel and manganese. Subsequent impact on soil and groundwater can also be investigated for derivative impacts. **Policymakers can leverage the use of environmental licenses to make such a study an obligation.** | • MoE<br>• Regional governments | **Minimize** |
|  <br>**Battery pack assembly** | **Post-production waste, which is generally classified as hazardous, must be appropriately managed under appropriate regulations.** Currently, the handling of battery post-production waste (i.e., no-good products) at the corporate level is by storage and eventual exportation, where waste is handled overseas. However, logistic constraints allow this waste to be stored >90 days, which is above national standards[21]. In addition, post-production waste has garnered attention from the informal sector[21]. **Post-production waste can be minimized** | • MoE<br>• Regional governments | **Minimize** |

| Activity | Environmental Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | **through increasing local battery recycling capacity, allowing policy flexibility, and granting authorization to the informal sector.** | | |
| **Battery Usage** | | | |
|  **EVs** | The current EV production target and projection (see **Table 3.7**) indicates that EV adoption in 2030 may not contribute significantly to decarbonization in the transportation sector. Although EV production must be ramped up to meet decarbonization efforts effectively, other transport electrification and decarbonization strategies must be implemented. | • BKPM<br>• Ministry of Industry (MoI)<br>• Ministry of Transportation (MOT)<br>• MoE | **Enhance** |
|  **BESS** | **The 2025-2034 RUPTL indicates additional inclusion of BESS applications for renewable energy and grid stabilization up to 2034** (see **Table 3.8**). However, it is unclear if BESS applications serve as additions or replacements for existing technologies. Considering the advantages of BESS for renewable technology, **future electricity business plans could further scale the proportion of BESS usage, notably in off-grid areas.** | • BKPM<br>• MEMR<br>• PLN (*Perusahaan Listrik Negara*)<br>• MoE | **Enhance** |
| **Battery End-of-Life** | | | |
|  **Battery waste** | **There is currently not yet a sizeable amount of battery waste that warrants a battery collection system.** Considering the early adoption of EVs, there is still time for policymakers to scale up battery waste collection systems, particularly for EV users. **Setting up an authorized and official battery waste collection system enhances recycling capacity and reduces potential waste.** | • MoE<br>• MoI | **Enhance** |
|  **Battery material recycling** | **Due to the nascent stage of battery usage, the national capacity for recycling batteries is still low.** This has driven several companies to export post-production no-good battery products, which leads to costly delivery and overdue hazardous waste storage[21]. Apart from setting up a centralized battery collection system, **the development of battery recycling facilities can be scaled up in the near future to make recycling more efficient.** | • BKPM<br>• MoI<br>• MoE | **Enhance** |
| | **More studies are required on the modelling of pollutants, especially air pollutants.** For battery recycling, this involves air pollutants that contain battery compounds, i.e., nickel and manganese. Subsequent impact on soil and groundwater can also be investigated for derivative impacts. **Policymakers can leverage the use of environmental licenses to make such a study an obligation.** | • MoE<br>• Regional governments | **Minimize** |
| | **Once battery recycling has scaled up, dismantling of used batteries may give rise to solid and hazardous waste. Proper recycling approaches should be promoted and incentivized through policy instruments to minimize waste production.** | • MoE<br>• Regional governments | **Minimize** |
| **Associated Facilities** | | | |
| | **Industrial estates should adhere to spatial planning regulations and conservation areas that comply with national and international frameworks.** In practice, this mainly adheres to national laws. International frameworks provide more contextualized findings, i.e., the distribution of globally significant species, that are not | • BKPM<br>• MoE<br>• Ministry of Forestry (MoF) | **Minimize** |

| Activity | Environmental Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
|  **Industrial estate** | limited by the national forest boundary. **The government can encourage companies to adopt these standards and promote more effective spatial planning.** | • Ministry of Energy and Mineral Resources (MEMR)<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATRBPN) | |
| | **Further management is needed for the management of wastewater.** The current national framework has taken this into account. In fact, industrial estates take full accountability for the wastewater of their tenants. The fact remains that wastewater leaving industrial estates has reportedly shown noncompliant levels (see Annex A). **Continuous monitoring by the government and relevant stakeholders is encouraged to minimize the impacts on water bodies**. | • MoE<br>• Regional governments | **Minimize** |
| | **Proper management and containment of processing waste (i.e., slag).** Industrial estates (e.g., IMIP) manage the processing waste of their tenants through dumping and landfilling[18]. There is genuine concern about the risk of dumping/landfill collapse (see Annex A). **Policymakers should improve permit mechanisms for the handling of this particular waste.** | • MoE<br>• Regional governments | **Minimize** |
| | **Identify key biodiversity areas ahead of activities as inputs for the mine plan.** Conducting biodiversity studies before development can help identify potential biodiversity hotspots and species of conservation significance. The study results can provide crucial inputs to the mine plan, allowing for the avoidance of critical areas. **The government can enhance national regulations to incorporate international conservation frameworks, thereby improving conservation efforts related to industrial development.** | • MoE<br>• MoF<br>• Regional governments | **Minimize** |
|  **Special port** | **Special or logistics ports should adhere to spatial planning regulations and conservation areas that comply with national and international frameworks.** In practice, this mainly adheres to national laws. International frameworks provide more contextualized findings, i.e., mangroves, the presence of migratory species, that are not limited by the national forest boundary. **The government can encourage companies that develop or utilize special ports to adhere to these standards and promote better spatial planning.** | • BKPM<br>• MoE<br>• MoF<br>• MMAF<br>• MoT<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATRBPN) | **Minimize** |
| | **Incorporating critical habitat-based approaches to the surrounding terrestrial and marine ecosystems can provide valuable input for conservation efforts.** Biodiversity studies can also provide input on the baseline condition of ecosystems in the port area, i.e., identification of critical habitats. These inputs can give valuable information for conservation targets, which can be demonstrated through rehabilitation. **There is an opportunity for policymakers to incorporate critical habitat-based approaches to port development to exhibit good practices.** | • MoE<br>• MoF<br>• MMAF | **Restoration** |

| Activity | Environmental Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | **In cases where rehabilitation does not restore an ecosystem to its baseline condition, port management should opt for biodiversity offsets.** | • MoE<br>• MoF<br>• MMAF | **Offset** |
| | **Implement proper sorting and containment of dredged materials from port development. Policymakers can push for better implementation through monitoring and evaluation.** | • MoE<br>• MMAF | **Minimize** |
|  <br>**Transport & logistics** | **Policymakers should drive the implementation of green shipping principles.** This includes encouraging shipping routes to adhere to Green Shipping Corridors[99]. This is to minimize disturbance to routes that intersect with areas of conservation or socioeconomic significance. **Policymakers can enforce this further by including this in legal frameworks.** | • MoT<br>• MMAF | **Minimize** |
| | **Transport and logistics should adhere to the Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[100]. Policymakers can push the inclusion of these principles in policies related to transport and freight.** | • MoT | **Enhance** |

[99] UNESCAP. (2023). "A Study on the Implementation Strategy of the Green Shipping Corridor in Asia and the Pacific". (Link)
[100] UNESCAP. "Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific". (Link)

**Table 6.2 Summary of social mitigation strategies**

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| **General** | | | |
| | **Human rights and business conduct in businesses must be strengthened.** Policymakers should implement nationwide awareness campaigns for companies on the UN Guiding Principles on Business and Human Rights (UNGPs)[101] and mandate stricter human rights due diligence to identify harms caused by company operations, as well as require mediation with affected communities. In doing so, companies can benefit from third-party audits to increase objectivity. To improve this, **the government can improve standardization, implementation, and law enforcement. The IFC Performance Standards on Environmental and Social Sustainability[102] can be used as a guideline to improve regulations.** | • BKPM<br>• Ministry of Law and Human Rights (MoLHR)<br>• Ministry of Mandpower (MoM)<br>• Regional governments | **Minimize** |
| | **Corporate community development and benefit sharing[103] should be improved.** Indonesia already has a set of regulations that encourage companies to exercise corporate social responsibility. However, in practice, the implementation still leaves inequalities in benefit sharing. The government can amend fiscal rules to ensure tax revenues and royalties from industrial parks flow directly to host communities, not just central or provincial governments. Companies can also be required to support local MSMEs through procurement, financial training, and micro-loans, particularly for entrepreneurs from vulnerable groups. **Governments can push for better implementation and benefit sharing by companies for the people.** | • Ministry of National Development Planning (BAPPENAS)<br>• Ministry of Finance<br>• Ministry of Micro, Small, and Medium Enterprises | **Enhance** |
| | **Initiate the recognition of vulnerable groups.** To date, recognizing vulnerable groups (i.e., women's groups, disability groups) is voluntary mainly on the corporate side. GoI and Companies can begin by gathering data about vulnerable groups, such as disabled groups, women´s groups, the elderly, children, and IP, as well as their relationships to land-use systems, to increase gender-sensitive and intersectional participation in land use management.<br>**Although the current regulatory framework—conducted through AMDAL and UKL/UPL procedures—mandates the inclusion of social groups, vulnerable groups are often not addressed properly.** These vulnerable groups are often limited to IP. Inclusion of women and children groups as well as disabled groups are usually voluntary by the company. Thus, mitigation strategies targeted to these groups tend to be not optimum. | • MoLHR<br>• Ministry of Women's Empowerment and Child Protection (MoWECP) | **Enhance** |

[101] UN. Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework. Available at: Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework | OHCHR

[102] IFC's Performance Standards on Environmental and Social Sustainability. Available at: https://www.ifc.org/en/insights-reports/2012/ifc-performance-standards

[103] In this context, benefit sharing extends beyond the direct transfer of revenues to local communities. It encompasses a broader range of practices designed to foster inclusive and sustainable development. These practices include engaging local communities as vendors or suppliers of goods and services, and implementing capacity-building programs to enhance local skills and strengthen livelihoods. Additionally, some companies may offer financial literacy training and facilitate access to small loans for women, thereby supporting community-based entrepreneurship through local organizations and cooperatives..

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | **This is an opportunity for multi-stakeholder collaboration to improve the lives of vulnerable groups and promote social inclusion.** | | |
| | **Improve OHS standards and labor rights in the industry.** Although Indonesia already has a legal framework for labor rights and OHS standards, disparity remains across different companies. Some of the aspects that the company can highlight are:<br>• Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>• Proper PPE use, workplace hygiene, and worker health education programs.<br>• Ensure women's rights in the workplace, including maternity protections and gender-sensitive policies.<br>**Policymakers can push for the improvement of OHS standards and labor rights using policy instruments that companies must adhere to.** | • MoM<br>• MEMR<br>• Ministry of Women's Empowerment and Child Protection (MoWECP) | **Enhance** |
| **Battery Production** | | | |
| **Mining** | **Companies can benefit from disclosure on environmental protection and pollution control.** This becomes particularly important in the face of public scrutiny of the mining industry, especially regarding land conversion and wastewater[18]. This can be done through:<br>• Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. International Standards provided by Multilateral Development Banks or the IFC Performance Standards on Environmental and Social Sustainability[104] can be used as a guidelines to improve corporate standards.<br>**Public disclosures can be used as a tool for companies to demonstrate good corporate governance as well as for policymakers to monitor companies' conduct**. | • MoE<br>• MEMR<br>• Regional governments | **Minimize** |
| | **Involvement of the community in business conduct, land governance, and social inclusion should be upheld.** Although Indonesia's mining sector has emphasized this matter, on top of having a robust legal framework on corporate responsibility (i.e. the mining related Law No. 11/2020 for the Community Development Program with an allocated budget through the Mining Work Plan), the fact remains that implementation has been imbalanced across different companies. To improve implementation, **the government can push for third-party audits with respect to the rights of local, women, and indigenous communities, as well as improved communication channels (i.e., grievance mechanisms, usage of local languages).** Implement just compensation schemes and involve communities in decision-making processes is key. | • BKPM<br>• MEMR<br>• ATRBPN<br>• Regional governments | **Enhance** |

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | **Improvement of land governance to smooth land acquisition processes.** Indonesia has a set of policy instruments and tools that can improve land governance, such as the One Map Policy (OMP) and ATR/BPN mechanism. Indigenous and customary lands should be recognized in these tools to promote transparency. Additionally, improved implementation of Free, Prior, and Informed Consent (FPIC) should be enforced to safeguard communities (Including safeguards against bribery). **The land acquisition process as a whole should be better implemented with pro-community regulations.** | • BKPM<br>• MEMR<br>• ATRBPN | **Enhance** |
| | **Strengthen the recognition of indigenous communities in mining concessions.** One of the main gaps in Indonesia's policy framework on IPs is that Indonesia has not ratified ILO Convention 169 and fully implemented the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). Thus, there is a low ceiling for improving IP involvement in business conduct. **Ratifying these international treaties and incorporating them into actionable national regulations is a key step to enhancing IP involvement in Indonesia.** | • MoLHR | **Enhance** |
|  <br>**Refining** | **Companies can benefit from disclosing their environmental protection and pollution control measures.** This becomes particularly important in the face of public scrutiny of the refining industry, especially regarding its use of CPP. This can be done through:<br>• Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards.<br>• Prioritize best available techniques (backfilling and dry stacking) with third-party oversight, to minimize the need for deep-sea tailings disposal. As well as establishing early warning systems for coastal communities located near tailings storage facilities (TFS). In this sense, every tailing management process must be closely monitored and checked for feasibility periodically by third parties, prioritizing safety and the interest of local communities.<br>• Preparation of an Emergency Response Plan that is well communicated to communities[105].<br>**Public disclosures can be used as a tool for companies to demonstrate good corporate governance as well as for policymakers to monitor companies' conduct**. | • MoE<br>• MoI<br>• Regional governments | **Minimize** |
| | **Promote energy transition to replace coal with clean and/or renewable energy technology.** Poor air is linked to the use of coal, which also contributes to detrimental public health issues. By encouraging companies to switch to clean and/or | • MEMR<br>• Regional governments | **Minimize** |

[105] IFC suggest the ERP should be prepared in accordance with the guidance of the APELL for Mining, Awareness and Preparedness for Emergencies at Local Level, Technical Report No. 41, UNEP 2001. The report provides a framework for preparation of an Emergency Response Plan involving the mine, emergency response agencies, local authorities and communities. Available at: APELL for mining: guidance for the mining industry in raising awareness and preparedness for emergencies at local level

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | renewable energy, not only are decarbonization targets being met, but a better quality of life for the surrounding community is promoted. This can be done by:<br>• Monitor the Nickel decarbonization roadmap project led by Bappenas and draft of a governor´s regulation requiring industries to use a minimum of 10% energy from renewable sources[17,18].<br>• Conducting feasibility studies on alternative energy scenarios - such as the early retirement of coal-fired power plants (CFPPs) and the phaseout of internal combustion engines – while assessing implications for workers, reskilling needs, and social protection measures.<br>• If needed, engage international partners to mobilize financial and technical support for a just energy transition.<br>**The government can leverage the national net-zero emission goals to accelerate the energy transition in refining processes.** | | |
|  <br>**CAM/anode manufacturing** | **To minimize social conflicts, companies should enhance transparency and foster community trust by disclosing their environmental protection and pollution control measures.** Battery production itself is a relatively new industry in Indonesia. Companies can benefit from transparent disclosure to the public on the activities, potential impacts, and once activities have commenced. By current regulations, public disclosure before company activities as well as regular reporting to regional government institutions. That said, this can be improved by:<br>• Regular public disclosure of environmental parameters and/or waste generation from production plants to ensure transparency and build community trust. Regular monitoring reports are usually only disclosed to government institutions and not disclosed to the public.<br>• Involve community participation by establishing multi-stakeholder monitoring units within companies to oversee compliance with environmental protection and human rights standards as well as promote corporate accountability.<br>**Public disclosures can be used as a tool for companies to demonstrate good corporate governance as well as for policymakers to monitor companies' conduct**. | • MoE<br>• Regional governments | **Minimize** |
|  <br>**Battery cell manufacturing** | **Companies can benefit from disclosing their environmental protection and pollution control measures.** Battery production itself is a relatively new industry in Indonesia. Companies can benefit from transparent disclosure to the public on the activities, potential impacts, and once activities have commenced. By current regulations, public disclosure before company activities as well as regular reporting to regional government institutions. That said, this can be improved by:<br>• Regular public disclosure of environmental parameters and/or waste generation from production plants to ensure transparency and build community trust. Regular monitoring reports are usually only disclosed to government institutions and not disclosed to the public.<br>• Involve community participation by establishing multi-stakeholder monitoring units within companies to oversee compliance with environmental protection and human rights standards as well as promote corporate accountability.<br>**Public disclosures can be used as a tool for companies to demonstrate good corporate governance as well as for policymakers to monitor companies' conduct**. | • MoE<br>• Regional governments | **Minimize** |

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| **Battery Usage** | | | |
|  **EVs** | **The transition from ICEVs to EVs may cause issues in job displacement.** There is genuine concern among the workers' union that increased EV capacity may cause displacement of ICEV employment[21]. Although the current EV production target and projection (see **Table 3.7**) do not significantly contribute to the vehicle market, caution should still be exercised if Indonesia intends to ramp up EV production in the distant future. This can be done through:<br>• Conducting feasibility studies on alternative energy scenarios that take into account implications for ICEV workers, reskilling needs, and social protection.<br>• If needed, engage international partners to mobilize financial and technical support for a just energy transition.<br>**The government can leverage the national net-zero emission goals to accelerate the energy transition in refining processes.** | • MoI<br>• MoM<br>• MoT | **Minimize** |
|  **BESS** | **As the 2025-2034 RUPTL ties BESS applications to renewable energy** (see **Table 3.8**)**, job displacement linked to energy transition is seen as a risk that needs to be mitigated.** At a high-level view, job displacement is a genuine issue in energy transition. Addressing this early on is beneficial for policymakers as well as companies to develop corrective mitigation measures. This can be done through:<br>• Conducting feasibility studies on alternative energy scenarios that take into account implications for displaced workers, reskilling needs, and social protection.<br>• If needed, engage international partners to mobilize financial and technical support for a just energy transition.<br>• Promote multi-stakeholder collaboration among different government institutions and businesses.<br>• Draw on recommendations from the Report ""Specialized workforce for Indonesia´s Future Transition (SWIFT) Roadmap 2025-2060" to guide workforce development strategies aligned with Indonesia´s long-term transition objectives[106]. Such as: Adopting Indonesian National Work Competency Standards (SKKNI) as the main reference for training design.<br>**The government can leverage the national net-zero emission goals to accelerate the energy transition in refining processes.** | • BKPM<br>• MEMR<br>• PLN (*Perusahaan Listrik Negara*)<br>• MoM | **Enhance** |
| **Battery End-of-Life** | | | |
|  **Battery waste** | **Due to the limited availability of battery waste in Indonesia, measures will be more relevant in the future when EV adoption has ramped up.** Considering the early adoption of EVs, there is still time for policymakers to scale up battery waste collection systems, particularly for EV users. Some aspects that can be highlighted for policy makers are: | • MoE<br>• MoI | **Enhance** |

[106] UNOPS (2025). "Specialized Workforce for Indonesia's Future Transition (SWIFT) Roadmap 2025–2060". Available at: https://www.energytransitionpartnership.org/wp-content/uploads/2025/08/SWIFT_National-roadmap_v5_EN_clean_removed.pdf

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | • Set minimum recycled content requirements for EV batteries produced domestically. This may decrease the demand for raw materials and increase the life of the country reserves until renewable energy sources are boost regionally to supply the mineral extraction and industrial parks. Overall, it is aligned with the plan of the Ministry of Industry to increase from 40% to 60% by 2027 the domestic component level for electric vehicles.<br>• Adopt national extended producer responsibility mechanism and a safe battery collection network.<br>• Promote development of EV battery recycling facilities to reduce demand for raw minerals.<br>• Encourage companies to adopt transparent reporting along their supply chain.<br>From the FDGs it is known that the Coordinating Ministry for Economic Affairs is preparing a dedicated study on battery waste, while urban mining has been positioned by Bappenas as part of the national circular economy agenda. These efforts reflect Indonesia's broader commitment to building a sustainable and resource-efficient battery value chain.<br>In this sense, **setting up an authorized and official battery waste collection system enhances recycling capacity and minimizes the risk of danger from unauthorized handling of battery waste.** | | |
|  <br>**Battery material recycling** | **Due to the nascent stage of battery usage, the national capacity for recycling batteries is still low.** Apart from setting up a centralized battery collection system, **the development of battery recycling facilities can be scaled up in the near future to make recycling more efficient and reduce the risks from unauthorized waste handling.** | • BKPM<br>• MoI<br>• MoE | **Enhance** |
| | **Companies can benefit from disclosing their environmental protection and pollution control measures.** Battery recycling is a relatively new industry in Indonesia. Companies can benefit from disclosing early to the public before the damage is done. This can be done through:<br>• Mandate public disclosure of air and soil quality data from production plants to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards.<br>**Public disclosures can be used as a tool for companies to demonstrate good corporate governance as well as for policymakers to monitor companies' conduct**. | • MoE<br>• MoI<br>• Regional governments | **Minimize** |
| **Associated Facilities** | | | |
|  <br>**Industrial estate** | **Involvement of the community in business conduct, land governance, and social inclusion should be upheld.** Although Indonesia's industry sector has emphasized this matter, on top of having a robust legal framework on corporate responsibility, the fact remains that implementation has been imbalanced across different companies. To improve implementation, **the government can push for third-party audits with respect to the rights of local, women, and indigenous communities, as well as improved communication channels (i.e., grievance mechanisms, usage of local languages).** | • BKPM<br>• MoI<br>• ATRBPN<br>• Regional governments | **Enhance** |
| | **Improvement of land governance to smooth land acquisition processes.** Indonesia has a set of policy instruments and tools that can improve land governance, such as the One Map Policy (OMP). Indigenous and customary lands should be | • BKPM<br>• ATRBPN | **Enhance** |

| Activity | Social Mitigation Strategies | Governing Institutions | Mitigation Hierarchy |
|---|---|---|---|
| | recognized in these tools to promote transparency. Additionally, improved implementation of Free, Prior, and Informed Consent (FPIC) should be enforced to safeguard communities. **The land acquisition process as a whole should be better implemented with pro-community regulations.** | | |
| | **Strengthen the recognition of indigenous communities in mining concessions.** One of the main gaps in Indonesia's policy framework on IPs is that Indonesia has not ratified ILO Convention 169 and fully implemented the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). Thus, there is a low ceiling for improving IP involvement in business conduct. **Ratifying these international treaties and incorporating them into actionable national regulations is a key step to enhancing IP involvement in Indonesia.** | • MoLHR | **Enhance** |
|  **Special port** | **Involvement of the community in business conduct, land governance, and social inclusion should be upheld.** This step is to include communities, particularly those living from fishing and marine livelihoods, in the decision-making process. To improve implementation, **the government can push for third-party audits with respect to the rights of local, women, and indigenous communities, as well as improved communication channels (i.e., grievance mechanisms, usage of local languages).** | • BKPM<br>• ATRBPN<br>• MMAF<br>• Regional governments | **Enhance** |
| | **Improvement of land governance to smooth land acquisition processes.** Indonesia has a set of policy instruments and tools that can improve land governance, such as the One Map Policy (OMP). Indigenous and customary lands should be recognized in these tools to promote transparency. Additionally, improved implementation of Free, Prior, and Informed Consent (FPIC) should be enforced to safeguard communities. **The land acquisition process as a whole should be better implemented with pro-community regulations.**<br>Develop national standards for EV fire safety in ports and logistics hubs, including evacuation drills and specialized extinguishers. Policymakers should strengthen the monitoring of current OHS regulations to protect workers. | • BKPM<br>• ATRBPN<br>• MMAF | **Enhance** |
|  **Transport & logistics** | **Transport and logistics should adhere to the Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[107].** Some of the social aspects highlighted are increased rural access to make logistics more efficient and promote even benefit sharing, promote women's participation in freight transport, and strengthen governance and capacity. **Policymakers can push the inclusion of these principles in policies related to transport and freight.** | • MoT | **Minimize** |

[107] UNESCAP. "Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific". (Link)

## 6.2 Mainstreaming Social and Gender Considerations into the Development of the Supply Chain

According to manufacturers, Indonesia faces challenges related to limited availability of local talent, including engineers and scientists, as well as technological knowledge critical for ensuring operational excellence and cost competitiveness in the manufacturing of battery cells[108].

The country could benefit from developing a monitoring system to track the workforce in the mining and battery industry, particularly within nickel mining. This should include the collection of disaggregated gender data to identify the number of female workers and understand their conditions in the sector. Key areas to assess include decision-making roles, job types, gender pay gaps, caregiving responsibilities, access to childcare services, and differential health impacts. Focusing on the mining sector is essential due to the workforce's exposure to health risks, labor rights issues, limited access to services and education, and risks of gender-based violence. Key Ministries involved are Ministry of Manpower in coordination with Ministry of Energy and Mineral Resources, Minister of Women's Empowerment and Child Protection.

For women in the manufacturing sector and materials recovery subsector, a targeted survey is recommended to gather both quantitative and qualitative data on women's participation in the EV battery supply chain. This survey, inspired by international studies, aims to establish a baseline for women's participation and to identify challenges faced by women in the sector. Insights from this data could inform a specific action plan to improve conditions for women and other disadvantaged groups. The survey should be directed both to individuals, capturing personal details, perceptions, and challenges, and to organizational representatives to gather workforce gender distribution data as well as existing policies and measures that support gender equality.

In this context, potential organizations to disseminate the survey might comprise large unions, company level unions, Mining Industry Indonesia (MIND ID), Indonesia Battery Corporation (IBC), Indonesian Nickel Miners' Association (APNI), Electric Mobility Ecosystem Association (AEML), Gaikindo (Association of Indonesian Automotive Industries).

Key survey questions should cover areas such as gender, family status, educational background (technical or non-technical), involvement in the supply chain, organization type and size, access to employment benefits, barriers faced, and levels of decision-making authority. These insights will support stakeholders in developing a comprehensive gender action plan for the industry.

According to the Women Empowerment and Child Protection Agency of Karawang (DP3A) there is a limited availability of adequate social services and public facilities for women. Most gender-related initiatives are currently voluntary, depending on the individual commitment of companies or business actors, without a binding standard or obligation

[108] Asian Development Bank (ADB). (2023, August). Renewable Energy Manufacturing: Opportunities for Southeast Asia. Available at: https://www.adb.org/sites/default/files/publication/901536/renewable-energy-manufacturing-opportunities-southeast-asia.pdf

to implement them more broadly. This situation underscores the need for structured and integrated policies and regulations. Such regulations would serve as both a guideline and a driver to encourage all business actors to implement women and child protection programs as part of their corporate responsibilities[21].

Globally, few countries have established national certification systems that explicitly link gender equality, occupational safety and management practices. As mentioned, most rely on voluntary corporate commitments, such as the UN Women´s Empowerment Principles (WEPs) and the Swiss EDGE Certification, or on regulatory oversight mechanisms without standardized assessment tools.

A relevant international example is Mexico's Labor Equality and Non-Discrimination Standard, introduced in 2015[109]. This is a voluntary national certification system, jointly developed by the Ministry of Labor and Social Welfare (STPS), the National Institute of Women (INMUJERES) and the National Council to Prevent Discrimination (CONAPRED).

Rather than serving as an Index, the standard provides a certifiable framework applicable to both public and private sector entities, recognizing organizations that promote equal employment opportunities, workplace inclusion and gender responsive safety conditions. The Mexican standard evaluates compliance in four main areas:

1. Equal access to employment and professional development.
2. Work-life balance and co-responsibility between women and men
3. Prevention and attention to workplace violence and sexual harassment
4. Inclusive and safe work environments, including accessible and gender-responsive facilities such as lactation rooms.

Organizations that meet these criteria can obtain the "Labor Equality and Non-Discrimination" certification, verified through external audits. This model demonstrates how voluntary certification mechanisms, when backed by public sector oversight, can institutionalize gender equality and ensure accountability within organization, as it provides legal and national recognition, while ensuring policy alignment.

For Indonesia, adopting a similar structured and certifiable standard could help formalize corporate gender equality commitments and mainstream gender-responsive safety and inclusion across national industries.

**Challenges and opportunities for disability inclusion.** The Focus Group Discussion (FGD) highlighted significant challenges and opportunities for advancing disability inclusion. A key finding is the need for Corporate Social Responsibility (CSR) programs to adopt a more inclusive approach, particularly through partnerships with non-governmental organizations (NGOs). Such collaborations can help address barriers to employment, workplace accommodation, and limited accessibility in public spaces.

Companies should be encouraged to integrate disability awareness into their CSR strategies, targeting not only employees but also parents and caregivers. Beyond

[109] STPS (2015) Labor Equality and Non-Discrimination Standard . Available at: https://nmx.conapred.org.mx/

workplace measures, interventions to improve the inclusivity of public infrastructure would generate broader benefits for local communities.

Legally, Law No. 8/2016 on People with Disabilities, Article 53, mandates a minimum 1% employment quota for people with disabilities. However, implementation remains weak, with limited uptake in workplace culture. To strengthen compliance, companies could adopt skills-based hiring practices that prioritize competencies over formal academic qualifications, thereby expanding opportunities for vulnerable groups. On the government side, the formal recognition of people with disabilities remains a critical gap. Establishing and institutionalizing this recognition process is a necessary first step toward enabling effective policy enforcement, resource allocation, and the fulfillment of disability rights. Selected country examples are presented in the following table:

**Table 6.3 Selected countries that operate formal recognition processes for people with disabilities.**

| Country | Brief description of formal registration process for people with disabilities[110] |
|---|---|
| **Australia** | • Applicants submit evidence (medical reports, assessments) to a National Disability Insurance Scheme to receive an individualized plan. The scheme covers permanent intellectual, cognitive, neurological, sensory, physical and psychosocial disabilities. |
| **Canada** | • Applicants submit forms with a medical practitioner certifying disability included in a governmental list. |
| **India** | • Government issues disability certificate under the Rights of Persons with Disabilities (RPwD) Act, 2016 |
| **Japan** | • Japan issues formal certificates/booklets through municipal authorities after medical assessment. |
| **Mexico** | • Mexico issues a national credential and local certificates to prove a person's disability and functional limitations; applicants provide identity documents and medical/functional assessments and are evaluated by designated health/public authorities. |
| **United States** | • Individuals apply to the Social Security Administration (SSA). Medical evidence is reviewed by state Disability Determination Services against SSA's medical listings |

[110] Australia – National Disability Insurance Agency. https://www.ndis.gov.au/; Canada – Disability Tax Credit. https://www.canada.ca/en/revenue-agency/services/tax/individuals/segments/tax-credits-deductions-persons-disabilities/disability-tax-credit/eligible-dtc.html#wb-cont; India – Department of Empowerment of Persons with Disabilities. https://depwd.gov.in/en/; Japan – Disability certificate. ttps://www.pref.chiba.lg.jp/cate/kfk/fukushi/shougaisha/techou/index.html; Mexico – Disability certificate. https://sitios1.dif.gob.mx/Rehabilitacion/?page_id=450; United States – Social Security, Disability Determination Process. https://www.ssa.gov/disability

# 7 Sustainability in the Battery Supply Chain in Indonesia

The battery supply chain development in Indonesia has been in constant development, with regulations, incentives and investments being made across all sectors. This poses an opportunity for the country to make this development sustainable, guaranteeing that the country captures value from its resources today while safeguarding its environment and prosperity for future generations.

Indonesia holds the world's largest nickel reserves, placing it in a strategic role in the global energy transition. But without strong ESG safeguards, the battery industry risks social conflict, environmental degradation, and trade barriers from export markets with strict sustainability standards, such as the EU.

The impacts of not complying with ESG indicators or requirements go from reputational issues to material financial risks. Batteries are vital transition to electric vehicles and renewable energy storage, but its value is directly tied to access to critical minerals, regulatory environments that are constantly evolving, and environmental and social licenses to operate. Companies that fail to manage their ESG risks face supply disruptions, regulatory penalties, and brand erosion among their customers. Conversely, firms that embed ESG intro their business are better positioned to secure long-term contracts, attract green capital, and maintain resilience against tightening global regulations

## 7.1 ESG Standards in the battery supply chain

Environmental, Social and Governance (ESG) standards have become a widespread tool used by organizations to identify and communicate their impact according to the three areas. It can also be used as an indicator for investors to signal whether a company or sector is worth investing in. It allows organizations to identify potential risks and opportunities for improvement. It could also be used to measure the sustainability of the companies that participate in the battery supply chain in Indonesia.

Companies in the battery supply chain will face increasing scrutiny over ESG issues as regulations tighten internationally. Issues like carbon intensity, human rights, supply chain transparency, and waste management will need to be addressed and reported according to established ESG and sustainability frameworks. Extended battery producer responsibility (EPR) trends will also reshape ESG reporting in the battery sector. The next section provides an overview of the most common ESG reporting frameworks, and which ones could be used across the battery supply chain stages (mining, refining, cell manufacturing, EVs and BESS, and recycling).

### Why should Indonesian companies implement ESG standards?

LG's decision to withdraw investments from Indonesia adds to a growing list of foreign investors who have either cancelled or postponed their investments in the country. Previously, two major investors — Eramet and BASF — had also withdrawn from the Sonic Bay Indonesia project, a nickel/cobalt refining plant based on High-Pressure Acid Leach (HPAL) technology. Their decision was driven by uncertainties surrounding the balance between project development and the availability of critical supporting resources, including ore, water, land, and energy[1]. Tesla, Britishvolt, and Foxconn are other examples of companies that withdrew early on, citing Indonesia's underdeveloped green industrial ecosystem, which still heavily relies on fossil fuels. This situation is further compounded by regulatory gaps and the lack of readiness in implementing ESG (Environmental, Social, and Governance) principles[1].

Currently, LG announced its withdrawal from the Titan battery project in Indonesia, along with its consortium partners LG Chem and LX International Corp. Initially, they had planned to build an electric vehicle (EV) battery supply chain project valued at 11 trillion won or approximately US$ 7.7 billion (around IDR 129 trillion, assuming an exchange rate of IDR 16,841 per US dollar).

As of April 18, 2025, the group officially announced the cancellation of this investment plan. LG stated that their withdrawal from the megaproject was due to "changes in market conditions. According to LG, "*After careful consideration of the evolving global EV market landscape, we have determined that this particular project no longer aligns with our strategic priorities. We are taking a more selective approach to investment in the current market environment*[1]."

While lack of ESG standards compliance cannot be said to be the only reason these investments have been cancelled, it did play a significant role in the decisions made.

### 7.1.1 Common international frameworks

There are several frameworks that can be used to measure ESG indicators. Some are voluntary and can be generically applied to any organization, such as the Global Reporting Initiative (GRI). Others, like the European Sustainability Reporting Standards (ESRS) are only applicable in certain regions or for certain sectors, like the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals, the Sustainability Accounting Standards Board (SASB) that focuses on financial materiality, or the Science Based Targets (SBT) that focus on emissions reduction. This section provides a brief overview of common international frameworks that provide guidance for companies to communicate their ESG effort, or to offer guidance to apply ESG principles into their businesses.

**The GRI framework** has Universal, Sector, and Topic Standards that companies can use to report their ESG indicators and can "report on the organization's impacts in a credible way that is comparable over time and in relation to other organizations".[111] The Standards are based on

[111] a-short-introduction-to-the-gri-standards.pdf

structured disclosures, where organizations report information about themselves and their impacts. These disclosures have requirements (mandatory information to be disclosed) and recommendations (suggested information to be disclosed). Although there is no Sector Standard for batteries[112], companies in the supply chain could use the Universal Standards for reporting. Verification is done by the GRI organization after submitting the reports on their webpage.

**The Carbon Disclosure Project (CDP)** is a private, non-profit initiative that focuses mostly on emissions like the SBTs, but rather than offering technical guidance, it rates companies (letter based) based on their environmental performance and actions taken. It supports environmental disclosure systems for companies, capital markets, cities, states and regions. It is aligned with the GHG Protocol, GRI, ESRS and International Financial Reporting Standards (IFRS) Climate-related disclosures.[113] The platform highlights transparency as the main advantage of using their framework for ESG reporting. According to CDP, "companies on STOXX's (CDP) A List based index have outperformed their benchmark by nearly 6% per year, for the past decade"[114]

**The Science Based Targets initiative** builds on the Greenhouse Gas Emissions Reporting Protocol (GHG Protocol) to offer companies guidance to achieve Net Zero Emissions by 2050, in line with the Paris Agreement. It offers sectorial guides aligned with reductions in emissions by scope. Scope 1 refers to direct emissions resulting from an organization's activities; Scope 2 refers to emissions from electricity consumption, and Scope 3 refers to emissions derived from the activities of the organization's supply chain (indirect emissions). For example, if a company's emissions are mostly Scope 3 (over 40%) then the company must set a reduction target of at least 67% to be in line with the SBT initiative.[115]

The following initiatives are not frameworks per se, but rather guidelines that organizations can use to implement ESG principles into their planning and/or business strategies. The United Nations Environment Programme (UNEP) has its **Environmental and Social Sustainability Framework** that highlights eight safeguard standards: Biodiversity Conservation, Natural Habitats, and Sustainable Management of Living Resources; Climate Change and Disaster Risks; Pollution Prevention and Resource Efficiency; Community Health, Safety and Security; Cultural Heritage; Displacement and Involuntary Resettlement; Indigenous Peoples and Labor and Working Conditions.[116] It is mainly used by multilateral banks, and borrowers must comply with them. The UN Global Compact initiative takes the 17 **Sustainable Development Goals (SDGs)** included in the "Agenda 2030" and provides guidance and tools for businesses to contribute to them, with the goal of asking companies "to first do business responsibly and then pursue

[112] GRI - GRI Standards English Language
[113] Alignment with Disclosure Frameworks and Standards - CDP
[114] Why Disclose? - CDP
[115] Standards and guidance - Science Based Targets Initiative
[116] Environmental, social and sustainability framework | UNEP - UN Environment Programme

opportunities to solve societal challenges through business innovation and collaboration."[117]

### 7.1.2 Applying ESG frameworks by battery supply chain segment

Companies across the battery supply chain may choose to adapt their sustainability report to mandatory frameworks or adopt voluntary frameworks when there are no regulations in place, or when they have operations across different geographies and regulation is asymmetrical. One of the recommendations this document makes in Table 6.1 is to make calculations of Scope 1 and Scope 2 mandatory. In the absence of this mandate, companies can and should voluntarily communicate their impact through sustainability reports, offering investors a clearer picture of actions being taken under ESG frameworks. This section briefly describes how to elaborate an ESG report and provides information for companies on how to select which framework to work under.

#### ESG reporting requirements

A central concept in ESG reporting is materiality. Originating from accounting, materiality refers to the significance of specific data for an organization. In financial terms, information is considered *material* if its omission could influence the decisions of investors or other stakeholders[118]. Similarly, in ESG reporting, materiality determines which environmental, social, and governance issues are most relevant to the company and its stakeholders. Identifying and engaging key stakeholders—those who impact or are affected by the organization's activities—is therefore essential to understanding expectations and defining material topics.

The materiality assessment should be conducted every two to three years to ensure that ESG priorities remain aligned with evolving stakeholder interests and business strategy. This process informs the definition of short-, medium-, and long-term goals, as well as the content to be disclosed in ESG reports. It may include a gap analysis of impacts, actions, and data, as well as benchmarking against industry peers to identify opportunities for improvement. Ultimately, ESG objectives should reinforce the company's purpose, strategy, and stakeholder priorities.

Once material topics are defined, organizations can proceed to select an appropriate reporting framework. A thorough understanding of ESG reporting standards and emerging trends is crucial. Decision-makers and relevant teams should receive targeted training to ensure consistency between company actions, disclosures, and overall strategy. The chosen framework should reflect the organization's size, stakeholder expectations, and strategic goals. Evaluating disclosure requirements in advance helps ensure transparency, accuracy, and comparability—both across time and with peer organizations. The Global Reporting Initiative (GRI) remains the most widely used framework, though many companies now report across multiple standards to meet diverse stakeholder demands.

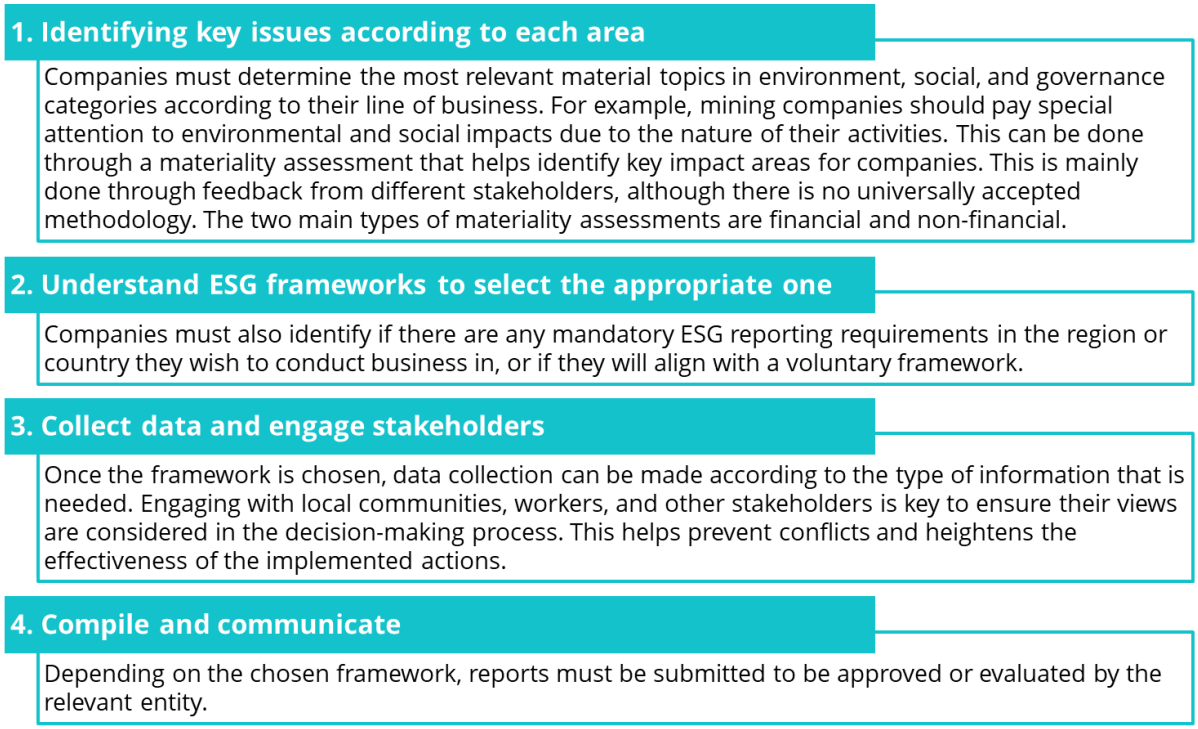
[117] The SDGs Explained for Business | UN Global Compact
[118] What Is Materiality in Accounting? | HBS Online

The next phase involves data collection and processing. Implementing the selected framework, gathering relevant data, reviewing it for accuracy, and interpreting it for insights form the backbone of the ESG reporting process. Data sources should be clearly documented, and data management systems—ranging from spreadsheets to specialized ESG software—must be properly secured. The complexity of this stage depends on the reporting framework and applicable regulatory requirements. Establishing robust verification and quality control mechanisms streamlines reporting and enhances credibility.

When drafting the report, the collected data and insights should be transformed into a coherent and engaging narrative. Executive statements, ESG goals, progress updates, and illustrative case studies should highlight the company's sustainability journey. Appointing a lead writer helps ensure a unified tone and consistent messaging. The visual design of the report is also critical: clear layouts, infographics, charts, and visuals enhance comprehension and engagement. Adhering to brand standards and adopting a logical structure with intuitive navigation allows readers to easily explore the information. Some companies opt for landscape formats or interactive digital reports for improved online accessibility.

Upon completion, the report must be distributed among rating agencies, stakeholders, and partners to support external assessment and stakeholder engagement. Disseminating the report effectively amplifies its visibility and reinforces the organization's commitment to transparency and sustainability. The following figure summarizes the key stages involved in developing a comprehensive ESG report.

**Figure 7.1 General steps for conducting an ESG assessment for reporting**



## ESG frameworks used by companies along the battery supply chain

ESG standards have been and continue to increase being adopted by companies across the battery supply chain, like Northvolt a swedish battery developer and manufacturer, or Rio Tinto, a mining company that has committed itself to sustainability frameworks and ESG standards in spite of being in a highly observed and complex industry.

**Rio Tinto** adheres to the Global Reporting Initiative (GRI) standards and has developed its own Sustainability Framework, informed by a comprehensive stakeholder assessment and aligned with the United Nations Sustainable Development Goals (SDGs). As a member of the International Council on Mining and Metals (ICMM), the company is committed to the 10 ICMM Principles for Sustainable Development and integrates the mandatory requirements from ICMM position statements into its corporate policies, standards, and practices.

In 2022, Rio Tinto published a Sustainability Glossary that defines key ESG-related terms. The most significant component of this publication is the section on Materiality Descriptors, which identifies material ESG topics and explains their relevance to the company's operations. Examples include:

- **Biodiversity and Ecosystems:** Mining inherently disturbs land and environmental systems—including air, water, and biodiversity—and can impact surrounding communities.
- **End-to-End Materials Management:** Reflects increasing consumer and investor expectations regarding sustainable production practices, encompassing the entire value chain from responsible sourcing and waste management to product certification and accreditation.
- **Business Performance:** Captures the company's economic contributions, including taxes and royalties, employee compensation, community development investments, and supplier payments.

In addition to its annual sustainability disclosures, Rio Tinto publishes a Sustainability Fact Book and a Conflict Minerals Disclosure to comply with Section 1502 of the U.S. Dodd-Frank Wall Street Reform and Consumer Protection Act, reinforcing transparency in its supply chain and operational accountability.

**Northvolt** publishes an annual Sustainability Report aligned with both the GRI and the Task Force on Climate-related Financial Disclosures (TCFD) standards. Northvolt's materiality assessment identifies several core ESG topics, including:

- **Climate Change and Climate Risk Management:** Recognizing that batteries are essential for the decarbonization of transport, energy, and industry, while acknowledging that unsustainable production practices can impose significant environmental and resource costs.
- **Responsible Sourcing:** Ensuring ethical and sustainable procurement of raw materials by adhering to the OECD Due Diligence Guidance for Responsible Supply Chains, the International Finance Corporation (IFC) Performance Standards, and the United Nations Guiding Principles on Business and Human Rights (UNGPs).

Northvolt's proactive ESG strategy and transparent reporting have earned it high sustainability ratings from Sustainalytics and CICERO/S&P Global, underscoring its leadership in responsible manufacturing and climate-aligned innovation within the clean energy sector.

Companies have the flexibility to select the reporting framework that best aligns with their operations, stakeholder expectations, and strategic objectives. However, certain frameworks are specifically designed to address particular supply chain stages or thematic areas. For example, Northvolt's adoption of multiple reporting standards reflects its commitment to responsible sourcing across its raw materials supply chain.

The following section presents a range of ESG reporting frameworks that may be suitable for organizations operating at different stages of the battery value chain, aligned with prevailing international sustainability and disclosure trends.

## Extraction and refining

### OECD Due Diligence Guidance

This risk-based guideline was developed "to help companies avoid contributing to conflict, serious human rights impacts and financial crime through their operations or mineral sourcing practices."[119] The guidance has five steps and can be applied to all minerals. Step 1 consists of establishing strong management systems across the company's activities to collect data and ensure transparency in the information. Step 2 entails reviewing the collected information to identify and prioritize risks that need to be solved. Annex II of the Guidance offers a tool to do this prioritization. The risks that require urgent action are serious human rights abuses, support to armed groups, security contracting, bribery and fraud, money laundering, and non-payment of dues. Step 3 refers to risk management and indicates the need of communicating findings to senior management to take proper actions. It also suggests disengaging from suppliers associated with the most harmful impacts. Step 4 highlights the importance of having audit control points made by independent third parties to validate the actions taken to control risks. Finally, Step 5 is to communicate and report on due diligence.

### International Financial Reporting Standards (IFRS) Standard 2 - Climate Related Disclosures

Standard 2 (S2) of the IFRS is intended to provide investors with all the necessary information regarding an organization's sustainability metrics. Launched in 2023, S2 covers the climate-related risks and opportunities that could "reasonably be expected to affect the entity's prospects are those that could reasonably be expected to affect its cash flows, its access to finance or cost of capital over the short, medium, and long term."[120] Although the scope of the report is not stated in the Standard, most companies report risks across all their supply chain. S2 does mention that climate-related risks can be physical or transition risks. The IFRS S2 aims to provide a global baseline for sustainability reporting, building on and replacing the phased-out Task Force on Climate-Related

[119] OECD - Mineral Supply Chain
[120] Applying IFRS - Introduction to IFRS S1 and IFRS S2 (Updated June 2025)

Financial Disclosures (TCFD). It also uses the GHG Protocol as basis for emissions disclosure.[121]

According to a 2024 report made by SGS[122], most mining companies use GRI and SDG as basis for disclosure and reporting frameworks. The phased-out TCFD and the Sustainability Accounting Standards Board (SASB) are also common frameworks and are now under the IFRS supervision. This means that they are likely to undergo a revision to harmonize the three frameworks. CDP was also cited as a common option.

## Assembly, end-use and end-of-life

### GRI and SBTs

Both initiatives are flexible enough to adapt to any type of organization, which makes them appropriate for the companies that are in the middle and at the end of the supply chain, since they need to monitor activities both upstream and downstream. Both frameworks use the GHG Protocol as basis for emissions reporting, with the SBT initiative providing guidance on how to set targets and actions to comply with them, while GRI goes beyond the environmental indicators and provides support for the other two areas of ESG reporting.

### GBA's upcoming Battery Passport

Although the Global Battery Alliance's Battery Passport is not strictly a reporting framework, it is a tool that focuses on traceability, responsible sourcing, and lifecycle carbon footprint of batteries. It also addresses a key factor when it comes to ESG reporting: verification. This is done automatically by registering information directly into the digital passport, and can be swiftly accessed by anyone who scans the QR code. The GBA Battery Passport "defines a measurement framework for site- and facility-level sustainability performance, and sets rules for how associated data is passed between organizations, how supply chains are made visible and how the trustworthiness of data is assured."[123] The roadmap in Deliverable 3 of this series of reports delves deeper into this and suggests actions for Indonesia to align with this future requirement.

### European Sustainability Reporting Standards (ESRS)

On Article 40a of the Corporate Sustainability Reporting Directive (CSRD), it is stated that "non-EU companies generating over €150m in the EU and that have at least one entity in the group in scope of the CSRD, or at least one EU branch with revenue of over €40m, shall publish sustainability-related information by 1 January 2028".[124] For EU companies, this reporting is mandatory for organisations with +500 employees, and Small and Medium-sized Entities can participate voluntarily, although some of them may be obligated to after 2026[125]. The ESRS cover four areas: governance; strategy; impact, risk and opportunity management; and metrics and targets. These standards take a double materiality approach, meaning they cover both direct impacts to the environment and to the people, and how these impacts create financial risks and opportunities.[126]

---

[121] IFRS Sustainability Disclosure Standards – Guidance, insights and where to begin
[122] Sustainability Trends in Mining and Minerals
[123] Battery Passport
[124] European Sustainability Reporting Standards (ESRS) | ICAEW
[125] Q&A adoption of European Sustainability Reporting Standards
[126] European Sustainability Reporting Standards (ESRS) – United Nations Environment – Finance Initiative

Mandatory ESG is not exclusive to the EU. Similar to the US, Indonesia mandates public companies and financial institutions to submit an annual sustainability report, according to the Financial Services Authority (Otoritas Jasa Keuangan; OJK in Indonesian) OJK Regulation No. 51/2017 and OJK Circular Letter No. 16/2021. However, in 2024, the United States' Securities and Exchange Commission adopted rules to enhance and standardize climate-related disclosures made by public companies. This was in response to "investors' demand for more consistent, comparable, and reliable information about the financial effects of climate-related risks on a registrant's operations and how it manages those risks while balancing concerns about mitigating the associated costs of the rules"[127]. Now, companies are also obliged to disclose information related to climate risks, mitigation strategies, transition plans, and more, going beyond simple Key Performance Indicators (KPI) or impact reporting. Also in the US, the State of California is making annual disclosure of scope 1, 2 and 3 GHG emissions for the prior fiscal year mandatory for "business entities formed under the laws of California, with total annual revenues in excess of one billion dollars that do business in California ("reporting entities")"[128]. In 2022, Japan established their Sustainability Standards Board (SSBJ). In 2025, the SSBJ issued three Sustainability Disclosure Standards, with the vision of these eventually becoming mandatory for companies listed under the Prime Market of the Tokyo Stock Exchange. The SSBJ Standards are aligned with the IFRS Sustainability Disclosure Standards[129].

Still, most companies mandated to disclose ESG data are very large, while Small and Medium Enterprises do so only on a voluntary basis. The following section shows three examples of international best practices when it comes to voluntary ESG reporting,

### 7.1.3 Examples of best practices

#### Aquila Clean Energy and Nippon Koei BESS plant in Belgium: ESG embedded into project design

Aquila Clean Energy is an investment firm from Hamburg, Germany. It developed a 25MW/100MWh BESS plant in partnership with Nippon Koei Energy.[130] The storage facility is located in Ruien, East Flanders, and was built on the site of a retired 800MW coal-fired power plant site. Aquila credits its high ESG standards and previous expertise for its success in implementing them from the start and during the construction of the project. This is why the BESS plant was able to leverage the site's existing infrastructure of the old coal power plant, including the connection point to the Belgian high-voltage grid.[131] This reduced the environmental impact of constructing a new facility from scratch and extended the life cycle of the old infrastructure. Additionally, the project contributes to the overall energy transition of Europe by enhancing grid flexibility, thus enabling more penetration of renewables. The project was awarded a 15-year capacity market contract by the Belgian TSO Elia.[153]

[127] SEC.gov | SEC Adopts Rules to Enhance and Standardize Climate-Related Disclosures for Investors
[128] California Corporate Greenhouse Gas (GHG) Reporting and Climate Related Financial Risk Disclosure Programs
[129] SSBJ issues Inaugural Sustainability Disclosure Standards to be applied in Japan | Sustainability Standards Board of Japan
[130] Nippon Koei Energy Europe and Aquila Clean Energy start BESS in Belgium
[131] 2024-06-24_Aquila-Capital_Whitepaper_BESS_EN.pdf

### CATL's increasing ESG voluntary disclosure

As one of the world's leading battery manufacturing companies, CATL has a strong impact on the global supply chain, meaning it is also exposed to more risks. However, the company has published ESG reports since 2018, with the amount of information increasing each year. A study found that the length of its ESG report increased by 324% in 2022 when compared to the previous year's report.[132] Additionally, CATL has established "a top-down ESG management structure to ensure the efficient implementation of ESG work."[133] All managers are part of the executive personnel to ensure implementation of ESG into the company's work.

### Malmö's 'Better Batteries: Malmö's roadmap toward ethical and climate-smart public procurement of e-vehicle batteries' project

The city of Malmö in Sweden has a target of becoming a net-zero carbon municipality by 2030. One of the strategies to achieve this is the electrification of vehicle fleets, particularly EVs and e-bikes. The published roadmap intends to be a living document to "provide a solid understanding of ways of managing risks in relation to the lifecycle of batteries" to ensure "the batteries used in its fleet of e-vehicles and e-bikes meet expectations relating to environmental, social and governance (ESG) performance" .[134] Published in 2022, the roadmap intended to provide input's for the city's upcoming tenders, and identified upstream and downstream risks of battery supply chain. In the end, Malmö aims to "procure e-vehicles with ethically certified batteries and GHG data fully disclosed."[135]

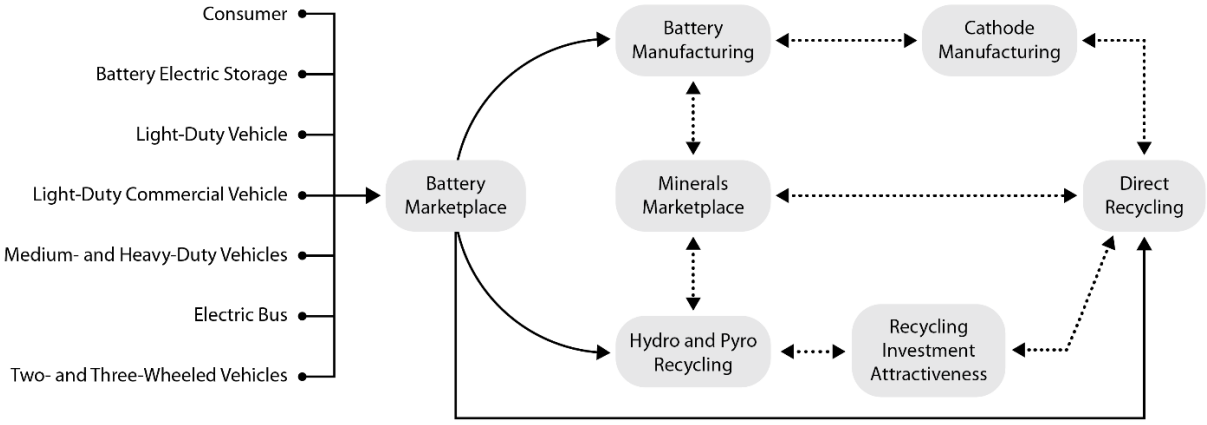
## 7.2 The battery recycling sector

The Indonesian government has informally stated on several occasions its intention of becoming an important battery exporter. This means that batteries manufactured in Indonesia must comply with the latest regulations from each of the markets it wishes to export to. The EU in particular is tightening requirements for batteries that enter the territory. One of the regulations that will become stricter in coming years is the recovery and recycling of batteries and their components. This has implications across all stages of the supply chain due to how each segment interacts with the others. For example, technological trends and improvements can have long term implications in availability of materials for batteries, as well as market trends (e.g. LFP vs. NMC batteries). Another factor is the constant monitoring of Chinese investments abroad, especially with regards to western LIB supply chains.

The US National Renewable Energy Laboratory (NREL) has developed a system dynamics model for the battery supply chain. The Lithium-Ion Battery Resource Assessment Model (LIBRA) shows how lithium-ion (Li-ion) battery manufacturing, reuse, and recycling across the supply chain interact with each other under dynamic conditions.

[132] ESG Information Disclosure and Innovation in New Energy Enterprises: A Case Study of CATL | Advances in Economics, Management and Political Sciences
[133] 20230412124803_hwtda8d0cl.pdf
[134] 20220707_Better-batteries_20pager_Final.pdf
[135] BetterBatteries - Standards Map

**Figure 7.2 Dynamics of battery recycling**



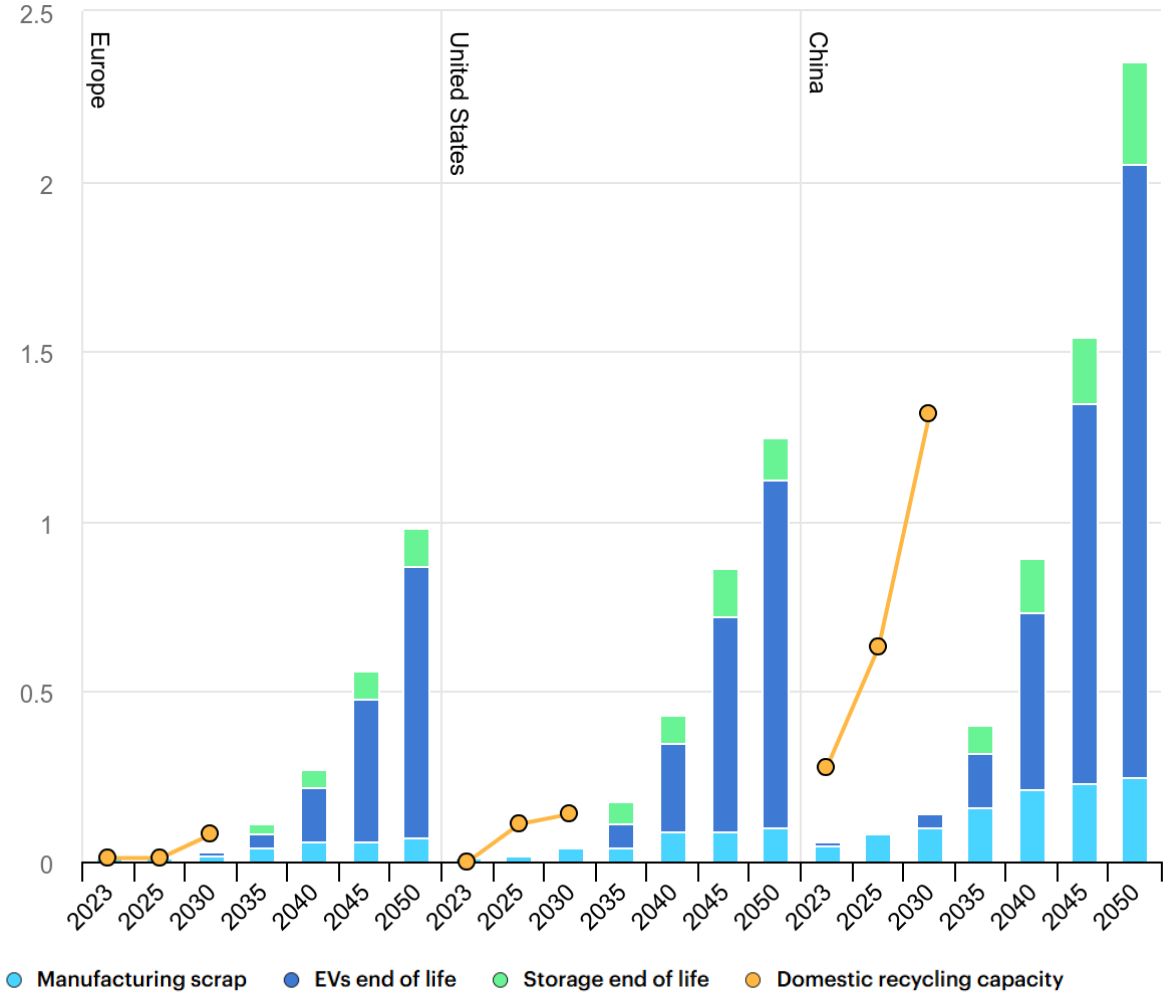

*Graphic by NREL*[136]

As seen in Figure 7.2 battery recycling has a direct effect on the number of materials available for manufacturing batteries. As the world's largest exporter of nickel, Indonesia is directly affected by developments in battery recycling abroad, which influence demand for nickel and other minerals. This makes it important to examine the country's battery recycling sector, its current state, and future trends. Battery recycling also offers a pathway for Indonesia to reduce dependence on traditional raw material mining for lithium and to mitigate risks of future supply disruptions.

The current size of the battery recycling market varies widely across sources (in ranges from 12.22 billion USD in 2024[137] to 26.9 billion USD in the same year[138]). However, they all report high Compound Annual Growth Rates of at least 7.8%, with some going as high as 37.6%[139]. China retains most of the global recycling capacity, as seen on Figure 7.3 below.

[136] LIBRA: Lithium-Ion Battery Resource Assessment Model | Transportation and Mobility Research | NREL
[137] Battery Recycling Market Size, Share & Outlook Report 2034
[138] Battery Recycling Market Size, Share & Growth Report - 2034
[139] Battery Recycling Market Size & Share Analysis Report, 2030

**Figure 7.3 Global available battery recycling feedstock and recycling capacity, 2023-2050 (TWh)**




*Graphic by IEA*[140]

The figure also shows that most of the recycling feedstocks will come from EV batteries in all geographies.

### 7.2.1 Main regulations and international initiatives

The regulations that have an impact on battery recycling are Extended Producer Responsibility (EPR) obligations, hazardous waste management rules, recycled content requirements for new batteries, and end-of-life requirements that stem from circular economy strategies. The European Union (EU), the United States (US) and China have all implemented one or more of these regulations.

The EU's New Battery Regulations published in 2023 state a minimum lithium recovery from waste batteries of 50% by the end of 2027 and 80% by the end of 2031. In parallel, it sets targets for minimum recycled lithium content in lithium-ion batteries at 6% by 2031 and 12% by 2036. For nickel, the minimum recycled contents are 6% by 2031 and 15% by

[140] IEA (2024), Global available battery recycling feedstock and recycling capacity, 2023-2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/global-available-battery-recycling-feedstock-and-recycling-capacity-2023-2050, Licence: CC BY 4.0

2036.[141] Additionally, a carbon footprint declaration will also be mandatory for all EV batteries that enter the territory starting February 2025.[142]

The US Resource Conservation and Recovery Act (RCRA) has no specific handling for batteries and instead follows universal hazardous waste guidelines for them. Some states like California have implemented bans on landfill disposal for batteries. However, the most significant regulation is the country's 2022 Inflation Reduction Act (IRA) that includes tax credits (for investment or for production) for battery manufacturers. In short, battery and EV manufacturers who produce and assemble their products in the US can get "$35 per kilowatt-hour (kWh) in subsidies for domestically produced battery cells, $10/kWh subsidies for domestically produced battery modules, and a 10% production cost credit for mining critical minerals and producing electrode active materials, which include cathode and anode active materials."[143] The IRA also includes a clause that classifies EV batteries recycled materials inside the U.S. as American-made, making them qualifiable for subsidies, regardless of the origin of the battery. This means manufacturers who use recycled materials for production can apply for the production tax credits.[144] This has made investments in recycling plants surge significantly.

In China, the Ministry of Industry and Information Technology (MIIT) introduced mandatory EPR standards for EV batteries and banned solid waste imports since 2020.[145] It has also put in place several regulations related to circular economy and traceability of batteries. The most recent one is the Specifications for the Comprehensive Utilisation of Waste EV Batteries published in 2024. It sets new rules and updates the 2019 requirements. For example, it includes recovery rate requirements for materials like copper and aluminium (98%) and lithium (90%); a minimum 3% of revenue to be spent on R&D annually; and enterprise positioning and project location.[146]

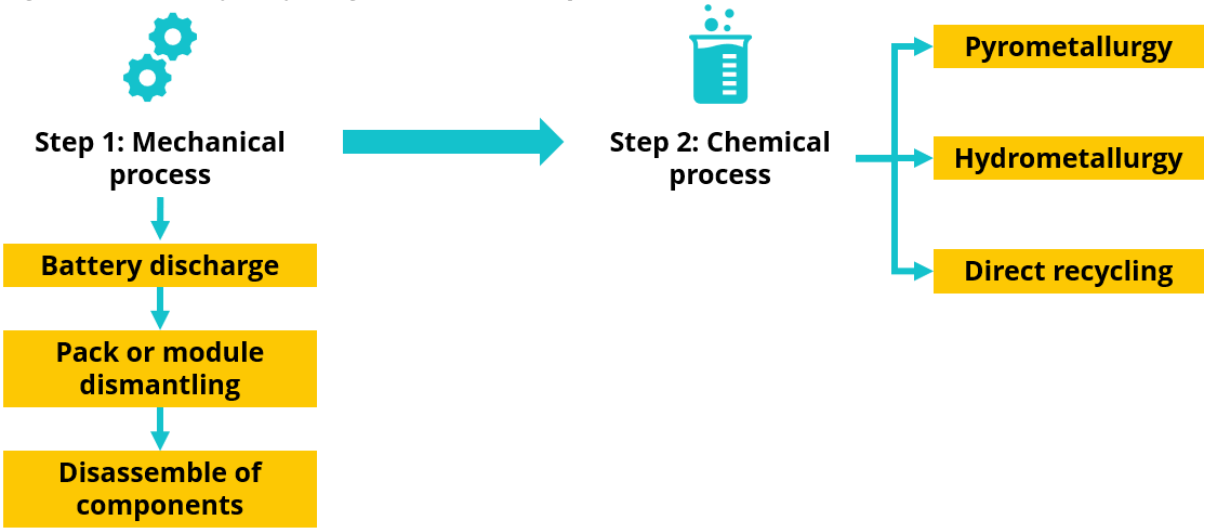
India and South Korea have also announced some rules related to this. India's Ministry of Environment, Forest and Climate Change published in 2022 the Battery Waste Management Rules that take EPR mandates as basis. The rules prohibit batteries from being disposed of into landfills or being incinerated. South Korea is also planning to extend EPR to all electronic products in 2026, and will introduce a recycled material certification system, as well as a recycled material usage target system for batteries manufactured in or imported to Korea.[147]

[141] Battery recycling report
[142] EU Battery Regulation 2025: Key Timelines & Compliance Requirements
[143] The IRA and the US Battery Supply Chain: One Year On - Center on Global Energy Policy at Columbia University SIPA | CGEP
[144] Dead EV batteries turn to gold with US incentives | Reuters
[145] Lithium-ion battery recycling report | CAS and Deloitte
[146] Specifications for the Comprehensive Utilisation of Waste EV Batteries 2024 – Policies - IEA
[147] Korea to launch recycled battery certification system targeting 2027 - CHOSUNBIZ

### 7.2.2 Recycling technologies by battery type

After collection and sorting, all EV and BESS batteries are recycled by conducting two main steps, as seen on Figure 7.4 below.

**Figure 7.4 Battery recycling: traditional steps**



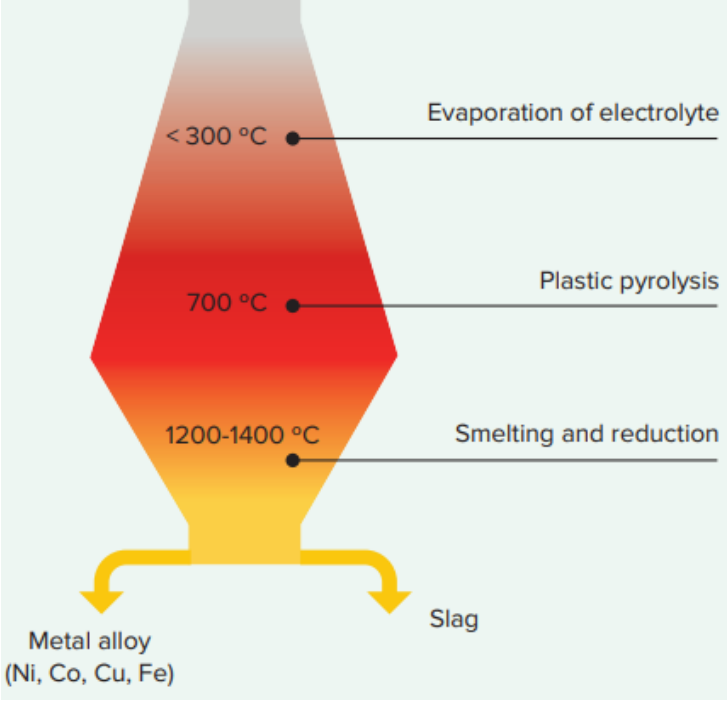

The mechanical process, often referred to as pre-treatment, varies depending on the recycling strategies, but usually follows the same steps. Batteries are disassembled, or crushed, to separate plastics, metals and other components. This step usually requires batteries to be sorted by type or size in order to be handled properly. Some facilities also crush batteries under a nitrogenized atmosphere to prevent fire hazards. Minerals from the electrode, cathode and anode are then processed via pyrometallurgy, hydrometallurgy or a hybrid process that uses both methods. There is a third emerging method called direct recycling, and most facilities have hybrid pathways that implement both pyrometallurgy and hydrometallurgy strategies.[148]

#### Pyrometallurgy

This method uses heat to melt and separate the battery's components, taking advantage of the different melting points of each material. The resulting mix of phases is then refined to recover each mineral. Heavier metals sink to the bottom (cobalt, nickel, iron) while lighter components float to the top (like lithium). This lighter phase is called slag.
The separator, all plastic pieces and aluminum plates are all removed during the mechanical process before pyrometallurgy can be conducted. Figure 7.5 below shows Brussels-based Umicore's pyrometallurgy process.

[148] Paul, S., & Shrotriya, P. (2025). Efficient Recycling Processes for Lithium-Ion Batteries. *Materials (Basel, Switzerland)*, *18*(3), 613. https://doi.org/10.3390/ma18030613

**Figure 7.5 Pyrometallurgy process from Umicore**




*Graphic by giz*[149]

Pyrometallurgy is successful in recovery of heavier metals like copper, nickel and cobalt. However, the lithium both in the cathode and in the electrolyte are lost due to incineration. The concentration of the recovered material is usually low due to the need of extra refining or processing to recover it.[150] Additionally, this method is very energy-intensive due to the amount of heat required to reach the melting points (around 1,200 °C at minimum). The process releases hazardous gases, making it necessary to add capture technologies to the exhaust, to prevent release of toxic fumes.[151]

## Hydrometallurgy

This method has a higher rate of mineral recovery than pyrometallurgy, at least for lithium. Hydrometallurgy is particularly useful when it comes to lithium recovery, which is something Indonesia could take advantage of to reduce its dependence on imports. Hydrometallurgy relies on chemical processes for metals separation like acid leaching, chemical precipitation, solvent extraction, electrochemical separation, etc. This allows for processes to be tailored to the battery's chemistry, allowing to recover metals with a high level of purity.[4] It does not require low-temperature operation like pyrometallurgy, and therefore has virtually no GHG emissions.[5] The hydrometallurgy process results in salts that can be directly sold as raw materials for batteries. However, it requires large amounts of water and chemicals, and it produces wastewater that needs to be managed to prevent pollution. Some companies (like Umicore) use hydrometallurgy after a moderate heating to separate metals after smelting.[5]

---

[149] GIZ-Battery-Recycling-Report.pdf

[150] Paul, S., & Shrotriya, P. (2025). Efficient Recycling Processes for Lithium-Ion Batteries. *Materials (Basel, Switzerland)*, *18*(3), 613. https://doi.org/10.3390/ma18030613

[151] Toro, L., Moscardini, E., Baldassari, L., Forte, F., Falcone, I., Coletta, J., & Toro, L. (2023). A Systematic Review of Battery Recycling Technologies: Advances, Challenges, and Future Prospects. Energies, 16(18), 6571. https://doi.org/10.3390/en16186571

### Direct recycling or refurbishing

This method is still in its early stages of development, and most research is still focused on how to scale it and make it commercially available. It consists of restoring the functionality (refurbishing) of the battery components instead of fully breaking down its components into raw material like metals, thus prolonging the life cycle of the battery. This is usually made by reintroducing lithium into the cathode (re-lithiation process).[5] Other components need to be treated and restored as well, such as the anode, the electrolyte, the separator (between the cathode and the anode) and the plastic shell of the battery.[4] However, this method has only been tested with certain battery technologies in a lab environment and has limitations regarding cathode degradation and structural state of the battery.

## Recycling vs. reuse

The consensus is that NMC batteries show higher immediate recycling returns (due to more lithium being recovered from them, and the possibility of selling the black mass or recovered salts directly as input for cathode manufacturing), while LFP batteries present higher long-term benefits through reuse before recycling.[152] This is because LFP batteries have a higher life cycle than NMCs, so it is better to use them on second life applications like grid services or ups

In theory, there is no need for incentives for second life uses for batteries as ESS because they generate revenue just like a new battery used for this purpose (usually grid services payments like frequency regulation or firm capacity). However, this is not applicable to Indonesia due to lack of regulation that recognizes these services. Still, PLN and IBC could enter into an agreement for battery collection and purchase of end-of-life batteries. Even if there are no payments made directly to the batteries for the grid services, PLN could acquire batteries at a cheaper price than new ones in the market. IBC could also benefit from securing a sale from the recovered batteries after evaluating the batteries' SoH and determining which ones are good for reuse, and which ones must be recycled.

Heterogeneous feedstock of batteries and uncertainty about their State of Health (SoH) may prevent reuse of batteries. However, there have been several small-scale projects that have piloted this solution. Car manufacturers in particular present an interesting opportunity for this. The Johan Cruijff Arena in Amsterdam uses 250 retired Nissan Leaf battery packs alongside solar PV to provide energy during events[153]. Toyota and Chubu Electric Power have a partnership to reuse the car manufacturer's EV batteries as ESS for grid services in Japan[154]; BMW, Bosch and Vattenfall have a similar partnership, with second-hand EV batteries being used as ESS in the city of Hamburg, Germany[155].
This reuse option is particularly attractive for LFP batteries as previously mentioned due to the higher energy density of these batteries. Generally, when a battery's energy density

[152] Ma, R., Tao, S., Sun, X. et al. Pathway decisions for reuse and recycling of retired lithium-ion batteries considering economic and environmental functions. Nat Commun 15, 7641 (2024). https://doi.org/10.1038/s41467-024-52030-0
[153] Storage system in Amsterdam stadium shows potential for used batteries
[154] Chubu Electric Power and Toyota to Commence Electrified Vehicle Battery Reuse and Recycling Verification Project | Corporate | Global Newsroom | Toyota Motor Corporation Official Global Website
[155] A second life for used batteries - Bosch Media Service Belgium

falls under 80% of its original value, they are not suitable for EV usage. This is because the battery's capacity to deliver energy across long distances is vital for driving, and when a battery's capacity to retain energy lowers, this derives in lower driving ranges. However, this capacity is not as important when it comes to ESS. For providing firm capacity for renewable energy power plants, total storage power is more important than maximum power discharge. For grid frequency regulation, maximum power discharge can be incremented by grouping used batteries, since there are no space and portability restrictions like in an electric car. However, if the power delivery of a used battery is less than about 40%, then they are no longer suitable for any commercial use.[156]

### 7.2.3 Battery recycling by region

As previously mentioned, most of the global battery recycling capacity is in China, the US and the European Union (Figure 7.3). However, the regulations that incentivize sector growth are different in the three regions. For example, the US has no recycling targets to mobilize investments, and rather relies on fiscal incentives and direct subsidies. Still, China more than doubles the US' recycling capacity, and, according to the IEA, this trend will continue until 2030. The EU on the other hand, has a smaller recycling capacity, which is reflected in the smaller size of the facilities in the region. While the US and China have facilities of 20,000 ton/year or above, the EU tends to have facilities below 7,000 ton/year. The following tables show a snapshot of the status of battery recycling in the three regions.

**Table 7.1 Battery recycling in China**

| **China** | |
|---|---|
| **Policies in place** | Specifications for the Comprehensive Utilisation of Waste EV Batteries |
| **Targets** | Minimum 60% annual repurposing volume of recovered battery weight; Copper and aluminum recovery rates should be no less than 98%, with electrode powder recovery after crushing and separation also at 98%. Lithium recovery during smelting should be no less than 90%, with nickel, cobalt, and manganese no less than 98%. Recovery of rare earth and other valuable metals should not be less than 97%. Recovered materials should comprise at least 99% of the target materials in the battery.[157] |
| **Characteristics of recycling facilities** | Collective annual recycling capacity of over 188,000 tons.[158]<br>Brunp Recycling Technologies operates a 100,000 ton/year facility with a hydromet+pyromet combo in Hunan.<br>GEM operates a 30,000 ton/year plant in Jingmen using hydrometallurgy.[159]<br>Quzhou Huayou in Quzhou operates a 40,00 ton/year recycling plant with pyromet. |
| **Source of recycling feedstock** | Local; imports of used batteries are banned, and exports are tightly restricted |

[156] A Future Perspective on Waste Management of Lithium-Ion Batteries for Electric Vehicles in Lao PDR: Current Status and Challenges
[157] China used EV batteries recycling standards 2019 vs. 2024 | Mysteel
[158] China Leads EV Battery Recycling: Insights on BYD, Tesla & LFP Batteries
[159] Lithium-Ion Battery Recycling—Overview of Techniques and Trends | ACS Energy Letters

**Table 7.2 Battery recycling in the US**

| **United States** | |
|---|---|
| **Policies in place** | Inflation Regulation Act |
| **Targets** | No targets |
| **Characteristics of recycling facilities** | Redwood Materials has a capacity of 40,000 ton/year in its facility in Nevada, using hydromet processes.[160]<br>Li-Cycle (acquired by Glencore) operates 3 facilities across the US in New York, California and Arizona. All of them use hydromet processes and have a collective recycling capacity of around 25,000 ton/year.[159]<br>Cirba Solutions operates a 20,000 ton/year facility in Ohio primarily with pyromet and some hydromet processes.[161] |
| **Source of recycling feedstock** | Mostly local, but imports and exports are not banned as the US has not ratified the Basel Convention |

**Table 7.3 Battery recycling in the EU**

| **European Union** | |
|---|---|
| **Policies in place** | New Battery Regulations |
| **Targets** | By the end of 2030, lithium-based batteries must have a 70% overall recycling efficiency (weight basis); by the end of 2031, 95% recovery of cobalt, copper, lead, nickel, and 80% recovery of lithium; from August 18, 2031, all batteries that enter the EU market must have at least the following percentages of recycled content per metal: 16% cobalt, 85% lead, 6% lithium and 6% nickel |
| **Characteristics of recycling facilities** | Umicore in Brussels, Belgium has a capacity of 7,000 ton/year. It uses pyromet+hydromet processes.<br>Fortum Battery Recycling in Finland claims to be the largest commercial hydromet li-ion recycling facility[162].<br>Mercedes Benz opened its own hydromet recycling factory with 2,500 ton/year capacity in Germany.[163]<br>Accurec operates a 4,000 ton/year facility in Germany with a pyromet+hydromet combo.[159]<br>Veolia is currently running demos for a 7,000 ton/year facility in France with hydromet processes.[164]<br>Northvolt "Revolt Ett" in Sweden had a recycling capacity of 22,000 ton/year using hydromet[165] but announced it was closing in May 2025 after the company filed for bankruptcy in Sweden and Quebec[166]. |
| **Source of recycling feedstock** | Mostly local; exports to non-OECD countries are banned under the Basel Convention; imports are allowed as long as they comply with the Basel Convention and the Waste Shipment Regulation |

[160] Redwood Materials announces technical advancements in recycling - electrive.com
[161] US battery recycling capacity increases as Cirba Solutions expands facility (Industry update) - Rho Motion
[162] Fortum Battery Recycling opens Europe's largest closed-loop hydrometallurgical battery recycling facility in Finland | Fortum
[163] Mercedes-Benz opens own recycling factory to close the battery loop | Mercedes-Benz Group > Company > News
[164] Solvay and Veolia set up a recycling battery metals demo plant
[165] Revolt: closing the loop on batteries | Northvolt
[166] Northvolt files for bankruptcy in Sweden | Northvolt

# 8 Recommendations

One of the main risks Indonesia faces when it comes to the battery supply chain, is the lack of key raw materials like Lithium and Manganese. As recommended in Deliverable 3 of this study, Indonesia could implement strategic stockpiling measures to safeguard battery material feedstock and enhance the security of resource supply. Complementing this approach, a regulatory mandate requiring a minimum percentage of recycled content in domestically manufactured EV batteries could reduce reliance on primary raw materials while reinforcing stockpiling efforts. Coupling these measures with the accelerated deployment of renewable energy to power mineral extraction and industrial park operations would further align the sector with national sustainability objectives.

This integrated strategy would not only strengthen Indonesia's long-term resource security but also help mitigate potential livelihood and public health risks for local communities by slowing the pressure for new land exploration and reducing the pace of industrial facility expansion. While prior analyses caution that local content requirements can raise production costs in emerging markets, these trade-offs must be balanced against the significant social and environmental costs of inaction.

The Ministry of Industry has set a target for having an operational recycling battery sector by 2030. However, this is an ambiguous target because it is not numerical, and it does not describe how "operational" will be measured. Additionally, although the Government of Indonesia recently announced intentions of making EPR mandatory for plastic waste[167], there have not been similar announcements for EV or BESS. There are no incentives or subsidies for recycling them, and regulations for handling retired batteries due to their classification as hazardous material, which fall under B3 licensing process, are complex and oftentimes lack clear rules regarding used batteries handling. Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management establishes used batteries as waste under the non-specific list (*Aki/baterai bekas*)[168]. This means that end-of-life Li-ion packs and modules fall under B3 regulation. Thus, this forces any entity that collects, transports, treats, and/or uses B3 waste to have a B3 waste license issued by the Ministry of Environment & Forestry. Collectors and transporters may need to get additional licenses by emitted by district/provincial authorities.[169]

Although Presidential Regulation No. 55 Year 2019 regarding Acceleration of Battery-Based Electric Vehicle Program for Road Transportation mentions two points regarding EV and BESS recycling:

- Handling of battery waste from battery-based electric vehicles (BEV) must be carried out by recycling and/or waste management.

[167] Indonesia to make Extended Producer Responsibility mandatory in 2025 - ANTARA News
[168] PP No. 22 Tahun 2021
[169] Indonesia's EV ambitions highlight urgent battery recycling challenges | Dialogue Earth

- Handling of battery waste is carried out by institutions, the BEV industry, and/or the domestic BEV component industry that has a battery waste management license from a BEV that own licenses in accordance with regulations in the field of waste management.

However, there is no "battery waste management license" specifically for BEV. As previously mentioned, no matter the type or their composition, batteries fall under hazardous waste according to B3 regulation. Therefore, any company that wishes to recycle batteries must comply with B3 and obtain a license. Based on this information, and the findings of the ESIA, the following recommendations are made for the battery supply chain in Indonesia:

**Unify municipal and regional criteria under a national standard for battery management.** The classification of batteries exclusively as hazardous waste prevents taking coordinated action at a national level. As mentioned before, the battery supply chain is intrinsically connected across its links and cannot be managed in silos. therefore, to achieve the target of having an operable recycling sector by 2030, the Government of Indonesia should set either mandatory recycled content for new batteries or set mandatory Extended Producer Responsibility mandates. This would also ensure the market can operate with local feed stock, given the ban on end-of-life battery imports and exports. Additionally, the high level of EV imports seen in recent years (particularly 2024 and 2025) means there will be more EV batteries than only those manufactured locally. Therefore, Indonesia needs to start planning for the first wave of retirement of batteries 6-8 years from now. This means setting rules to prevent these batteries from ending up in landfills, as well as sending demand signals for investors. At the same time, the current recycling plants need to have enough feed stock to operate. A progressive mandate (similar to the EU regulation) could be implemented, with EPR and recycled content percentages increasing over time.

**Keep up with China and EU regulations.** All of China's current actions will derive in a decrease of its nickel imports, particularly the increasing domestic recycling pressure. By law, China enforces EPR and mandatory collection, so a growing fraction of Ni (and Co, Li) is recovered domestically and looped back into China's domestic cathode supply. That reduces net import demand growth for primary nickel over time. At the same time, increasing mandates for recycled content in batteries across different regions e.g., China and the US, could potentially open new revenue streams for recycled Nickel to be exported from Indonesia. Therefore, it is worth keeping up with international regulations to identify opportunities early. Indonesia could start offering recycled nickel and other components to international markets, which could be interesting for complying with tightening regulations in large markets like the European Union.

Recycling could also help companies with complying with the domestic component level (TKDN) requirements stated by law. Reuse could open new lines of business and create new jobs as part of the energy transition. Even if mining jobs go down due to the increase of recycled minerals in the supply chain, the workers could enter this new sector, which would also represent less health impacts for workers, and potentially less environmental impacts overall.

Additionally, the study identified substantial social risks—including land dispossession, weak labor protections, gender inequities, and governance gaps—that, if left unaddressed, could undermine the just and sustainable development of Indonesia's battery supply chain. In addition to the previous mitigation strategies and recommendations, the following key actions are proposed:

**Implement targeted surveys to monitor social issues in industrial growth poles**

While nickel industrialization has the potential to reduce poverty through labor absorption and higher wages, monitoring its impact requires careful attention to data quality and scope. Official indicators such as the regency-level poverty rate and unemployment rate provide a useful overview of welfare trends but do not capture whether economic gains are equitably distributed across different population groups. Moreover, reliance on provincial-level statistics obscures intra-regional disparities and limits the ability to assess differentiated impacts across sub-groups, including Indigenous Peoples, migrants, women, and youth.

To strengthen evidence-based policymaking, it is recommended to design and implement targeted surveys in industrial growth poles. These should collect disaggregated data on key indicators such as employment and poverty levels, the share of local versus migrant labor, workforce upskilling and training efforts, alignment of local education with industrial demands, and the participation of women and men in the labor force. Such granular data would enable policymakers to better evaluate the inclusiveness of industrial development and inform strategies that ensure equitable distribution of benefits.

**Strengthen the implementation of international standards in foreign investments**

Even though the country has developed substantial ESG related regulations covering environmental, social and governance principles. The Ministry of Finance should further develop sustainable investment regulations requiring companies to identify, avoid, mitigate, and manage environmental and social risks in line with international standards. Reference frameworks include the IFC Performance Standards, the OECD Guidelines for Multinational Enterprises, and the Equator Principles. Stronger alignment with these standards will enhance the accountability of foreign investments and safeguard communities and ecosystems.

**Implement a Just Transition Framework to address emerging worker concerns**

During the focus group discussion with *Konfederasi Serikat Pekerja Indonesia* (KSPI) Karawang[170], participants highlighted the importance of implementing a Just Transition framework to address worker concerns arising from two structural shifts (i) the transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs), and (ii) the impact on coal workers directly affected by the early retirement of coal-fired power plants (CFPPs) as part of the shift to renewable energy. To support a just and inclusive transition, policymakers should consider the following priority actions:

[170] Detailed information can be consulted in the FGD with Konfederasi Serikat Pekerja Indonesia (KSPI) as part of the Karawang Stakeholder Consultation and Field Verification Report in Annex A.

a) **Differentiated retirement strategies for on-grid and captive coal plants**: In Indonesia, many nickel and smelter projects in Sulawesi and Maluku depend on captive coal power plants, which average around 10 years of operation. This makes early retirement strategies less feasible compared to on-grid CFPPs, which average around 20 years of operation and are therefore more suitable for accelerated phase-out. It is recommended that this information be communicated transparently to workers, together with clear updates on global trends in ICE vehicle manufacturing, to ensure they are informed about long-term employment prospects.

b) **Leveraging just transition initiatives and existing ESG framework**: PT Sarana Multi Infrastruktur (Persero) (PT SMI) is participating in the Climate Investment Funds-Accelerated Coal Transition project to coordinate and implement a national just transition framework. The insights from this work can be applied to address just transition challenges in the battery supply chain – particularly those linked to captive power plants (CPP) in the refining stage of the battery supply chain.

c) **Anticipating cost and designing comprehensive transition packages for workers:** International experience shows that reskilling alone does not capture the full scope of costs and social implications for the coal labor force when transitioning to the renewable sector. In addition to the Effective just transition programs also include early retirement schemes, pension protections, compensation mechanisms, and community-level investments. Annex F highlights measures adopted by different countries on this matter.

# 9 Conclusion

The findings from the ESIA show that the sustainability challenges and opportunities in the battery supply chain are unevenly distributed across its stages, with the most acute impacts occurring in upstream extraction and midstream processing. Mining and refining drive extensive land conversion, threaten water and soil quality, generate air and noise emissions, and place pressure on biodiversity. These impacts are combined with risks to community health, agricultural livelihoods due to changes in land use, and vulnerable groups such as women and disabled people. This presents an opportunity for the Government of Indonesia to enhance national frameworks across different areas. For example, incorporating international conservation frameworks and habitat-based approaches to mining plans, closures and rehabilitation for better mining restoration, and to mitigate impacts.

Air pollutants have a significant impact on both the upstream and downstream sections of the battery supply chain, particularly from captive coal power plants. Midstream production is characterized by material and energy-intensive processes that carry a high carbon footprint and generate hazardous waste. Industrial estates are major contributors to emissions and local pollution. At this stage, occupational health and safety standards, labour rights, and gender-sensitive workplace policies become central to minimizing risks for workers.

When it comes to the end-use sector, it was found that batteries are enablers for decarbonization, but not drivers of it. The current EV manufacturing targets for Indonesia only reduce 3-5% of carbon emissions from the transportation sector. For BESS, the 2025 RUPTL considers reductions of around 29-30%. However, BESS will likely be applied to new infrastructure (renewable power plants) rather than replacing existing one (captive power plants, for example). But given that EV's are still on the early adoption phase, there is time for policymakers to set up regulations for battery waste collection before thinking about scaling up recycling capacity. However, guaranteeing the full climate benefit of both EVs and BESS requires lowering the embedded carbon in batteries through cleaner manufacturing, more efficient logistics, and the development of a strong recycling ecosystem. Transport and logistics, though a smaller contributor, still add incremental community disturbance and emissions, underscoring the need for sustainable freight practices and green shipping corridors.

End-of-life (EOL) management is both a challenge and an opportunity. Although current volumes of battery waste are small, the rapid growth of EVs and BESS markets means that battery waste will scale sharply in the next decade. Without formalized collection systems, communities risk exposure to toxic components through informal dismantling and disposal. Scaling up authorized collection networks and adopting extended producer responsibility mechanisms will be essential. In addition, battery recycling could reduce pressure on raw mineral extraction, cut waste, and lower lifecycle emissions. The results of the study conducted by the Coordinating Ministry for Economic Affairs will be key to guide end-of-life and circular economy policies.

In Indonesia, industrial estates are responsible for managing and processing waste, including nickel slag and wastewater. Reported noncompliance underscores the need for stronger oversight. To reduce environmental and social risks, continuous government

monitoring of wastewater discharge and stricter enforcement of occupational health and safety (OHS) standards are critical. Policymakers can support improvements through binding regulations, while companies can strengthen trust by disclosing their environmental protection and pollution control measures, particularly given global scrutiny of battery supply chains from cradle to cradle.

Finally, cross-cutting social impacts must remain central in any mitigation strategy. Communities living near mines, industrial estates, and transport corridors often bear the heaviest burdens from pollution, displacement, and disrupted livelihoods. Vulnerable groups e.g., women, indigenous peoples, children, and people with disabilities, require structured recognition in policymaking and corporate practice. Participation, consultation in local languages, grievance mechanisms, and accessible social services are integral to securing social license to operate.

Companies in the battery supply chain will face increasing scrutiny over ESG issues as regulations tighten internationally. Issues like carbon intensity, human rights, supply chain transparency, and waste management will need to be addressed and reported according to established ESG and sustainability frameworks. This means that batteries manufactured in Indonesia must comply with the latest regulations from each of the markets it wishes to export to. Alignment with the latest sustainability requirements could give Indonesian companies credibility in global markets and reduce long-term export risk.

# Annex A: Stakeholder Consultation and Field Verification Reports

| Activity | Stakeholders | Activity Description | Date |
|---|---|---|---|
| FGD with Policymakers | 17 directorates under 7 ministries | A collective discussion was conducted with institutions from the Government of Indonesia to gather input on industry and policy insights. | Jul 10th 2025 |
| Karawang Stakeholder Consultation and Field Verification | Regional government institutions, businesses, local communities | • A series of collective discussions with regional government institutions, CSOs, and worker union.<br>• Interview with local communities.<br>• Field verification at locations near industrial development. | Jul 17th – Sep 3rd 2025 |
| Morowali Stakeholder Consultation and Field Verification | Regional government institutions, businesses, local communities | • A series of collective discussions with regional government institutions, CSOs, and worker union.<br>• Interview with local communities.<br>• Field verification at locations near industrial development. | Aug 11th – 28th 2025 |
| Discussion with PT Sarana Multi Infrastruktur | PT Sarana Multi Infrastruktur (financial institution) | In-depth interview with PT Sarana Multi Infrstruktur as a financial institution with interest in the battery sector and energy transition in general. | Aug 5th 2025 |
| Discussion with Bank Mandiri | Bank Mandiri (financial institution) | In-depth interview with Bank Mandiri as a state-owned financial institution that is committed to provide financing for infrastructure development. | Aug 11th 2025 |

# Annex B: Environmental and Social Baseline Data

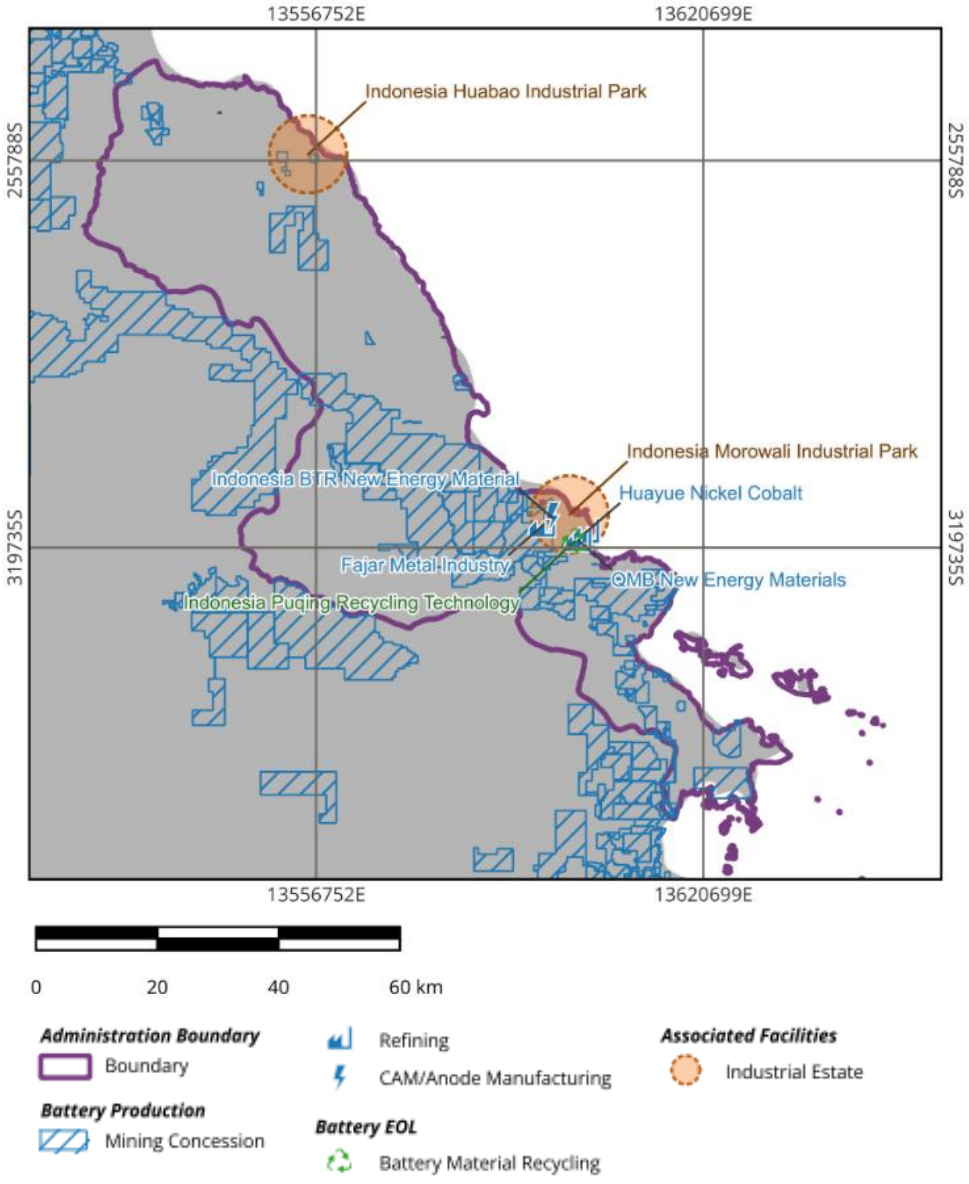
## B.1 Morowali

Morowali is a regency located in Central Sulawesi Province, Indonesia. Below is an overview of the region's location, environment, and demographics.

### B.1.1 Location and Climate

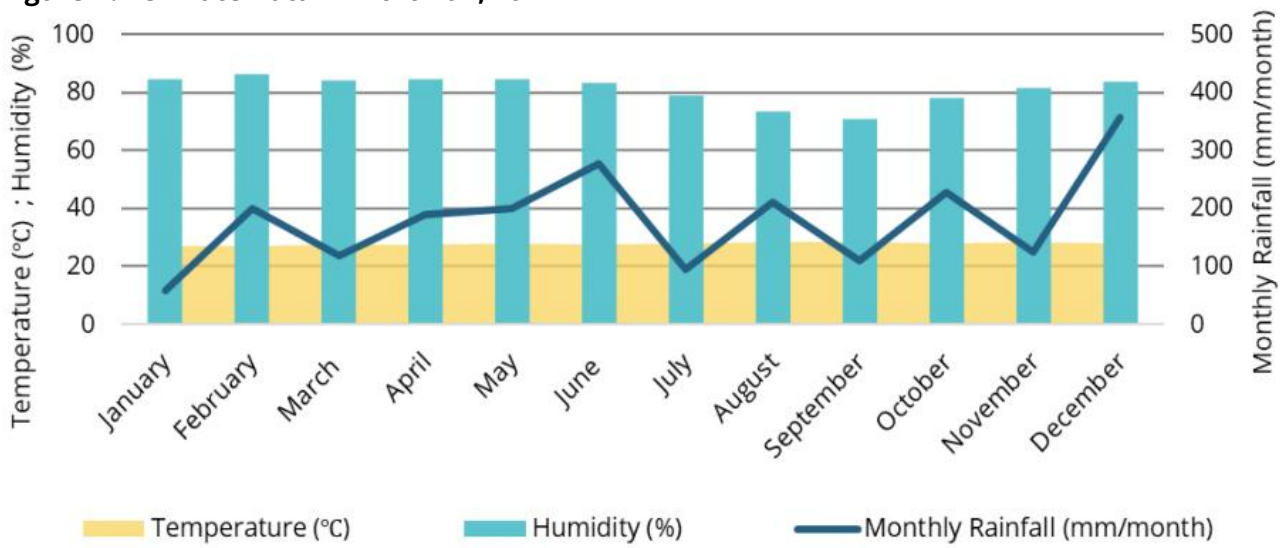
Morowali is a regency located in Central Sulawesi Province, Indonesia, with its administrative capital in Bungku Tengah **Figure B.1**. The regency comprises nine sub-districts, covering a total land area of approximately 5,472 km², consisting of 7 urban villages and 126 rural villages. This area accounts for approximately 8.04% of the total landmass of Central Sulawesi Province. Morowali has a tropical climate with an average annual temperature of around 28ºC, high humidity (81%), and moderate rainfall (±179 mm/month), as shown in **Figure B.2.**

**Figure B.1 Locality of Morowali, South Sulawesi**




*Sources: Own elaboration, with maps from KSP (2024)[44], MEMR (2025) [15]*

**Figure B.2 Climate Data in Morowali, 2024**




*Sources: BPS Morowali (2024)*[171]

Geographically, Morowali Regency shares its northern border with North Morowali Regency, its southern border with the provinces of Southeast Sulawesi and South Sulawesi, its western boundary with the provinces of South and Southeast Sulawesi. To the east, it faces the coastal waters of Tolo Bay. Positioned along the coastline of Tolo Bay, Morowali holds significant strategic value due to its abundant natural resources, most notably, its substantial nickel reserves, which are among the largest in the country.

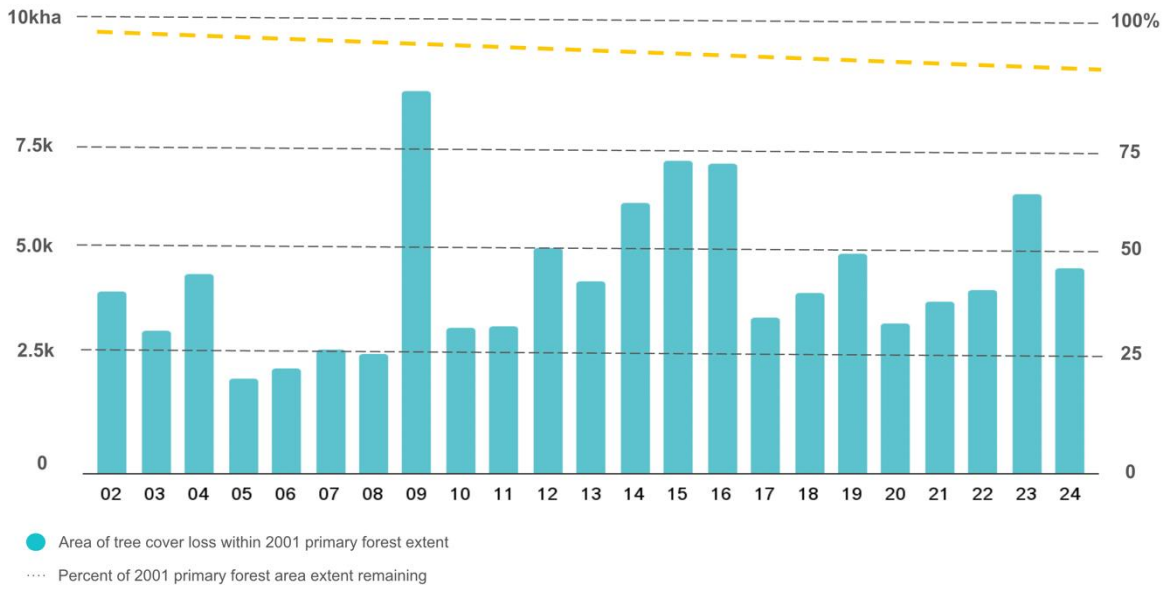
## B.1.2 Landscape

### Land Conversion

Based on Global Forest Watch, between 2002 and 2024, Morowali lost around 101 thousand hectares of humid primary forest, accounting for 59% of the total tree cover loss (see Figure B.3 ). As a result, the extent of humid primary forest decreased by 10%. Overall, Morowali recorded a loss of 174 thousand hectares of tree cover, equivalent to 14% of the total area in 2000, which is estimated to have generated 120 million tons of $CO_2e$ emissions.

[171] Badan Pusat Statistik Kabupaten Morowali. (2024). *Kabupaten Morowali dalam Angka 2024 / Morowali Regency in figures 2024* (Vol. 20). BPS-Statistics of Morowali Regency. Link

**Figure B.3 Primary Forest Loss In Morowali, 2002-2024**

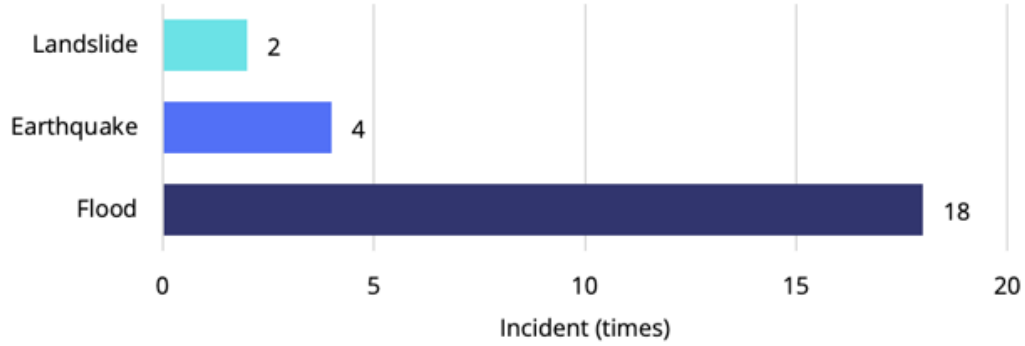



*Sources: Global Forest Watch (2025)*[172]

## Natural Disasters

Regarding natural disasters, earthquakes were reported to be the most prevalent threat in Morowali. Statistics in 2024 reported 18 flood incidents (Figure B.4). Earthquakes were the second most common hazard, with four incidents reported, while only two landslide incidents were reported.

**Figure B.4 Natural Disasters in Morowali, 2024**



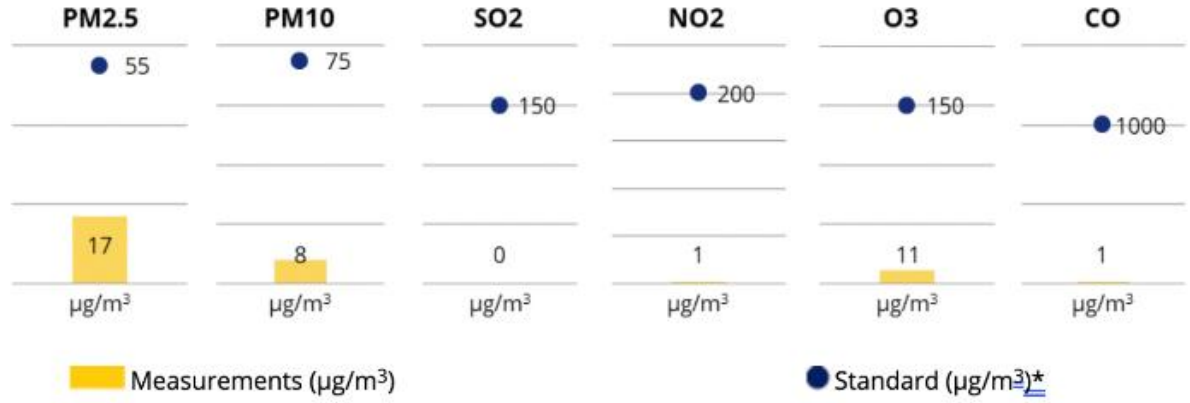

*Source: BPS Morowali (2024)*[171]

## B.1.3 Air

Publicly available data is available from the Keurea District Weather Station[173]. The data shows air quality within standard regulations. It is important to note that this data is based on modeling and only the Keurea District, which is located approximately 15 km from the Indonesia Morowali Industrial Park. Thus, data may not be well represented.

[172] Global Forest Watch (2025). *Morowali.* Link
[173] Accuweather. (2024). *Keurea, Central Sulawesi.* Link

**Figure B.5 Ambient Air Quality in Keurea District, 2024**

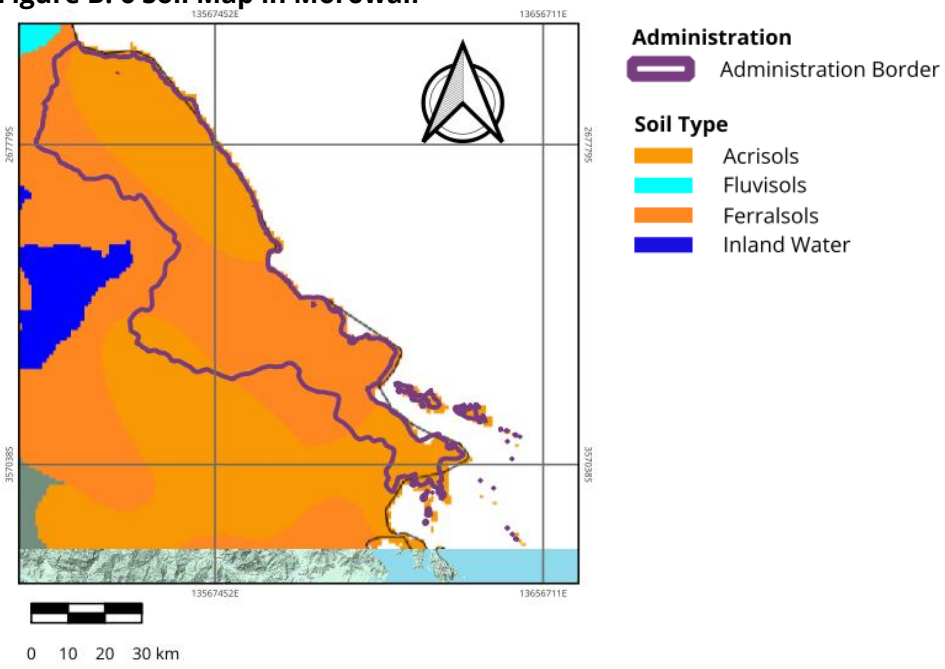



*Source: Accuweather (2024)*

## B.1.4 Soil

Geologically, the majority of soils in Morowali Regency are dominated by ferralsols[174]. This type of soil is highly weathered, characterized by its red and yellow hues, which are caused by the accumulation of metal oxides, primarily iron and aluminum. These elements are the reason why the soil group is called Ferralsols[175].

**Figure B. 6 Soil Map in Morowali**




*Source: FAO (2023)*[174]

[174] Harmonized World Soil Database. (2023). Link
[175] Britannica. (2025). *Ferrasols.* Link

## B.1.5 Water

### Surface Water

Public surface water data is only available for the Ungkaya River (see figure below). Satellite imagery shows that this area has undergone land clearing from what seems like mining activities. For most parameters, the surface water quality demonstrates standard quality with elevated ammonia, BOD, and TSS concentration[176]. The higher BOD values reflect an increased presence of organic waste in the water caused by human activities. Additionally, elevated ammonia levels can be generated by agricultural, industrial, domestic, and livestock sources[177]. Meanwhile, heightened TSS is often associated with extensive land clearing[178].

**Figure B.7 Surface Water Quality of Ungkaya River, 2025**

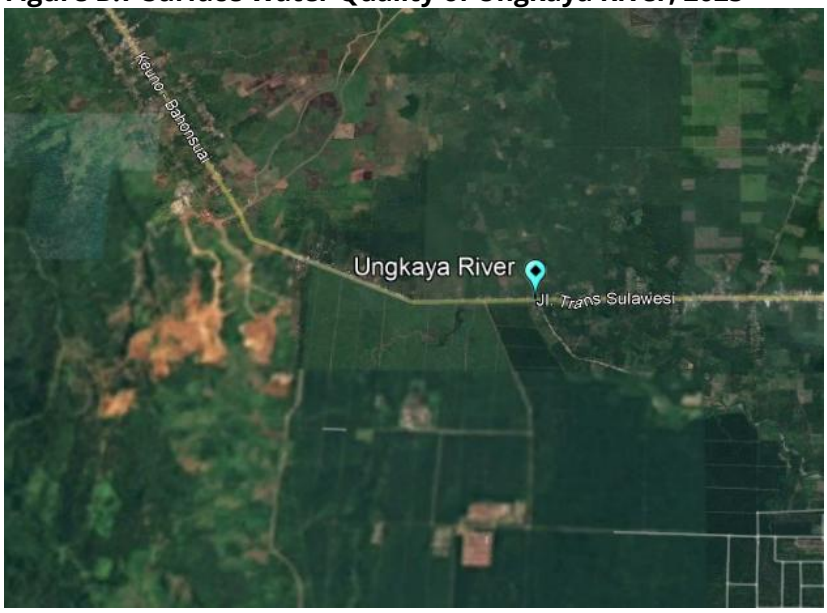



Photo source: Google Earth, 2025

| River | $NH_3$ | BOD | COD | DO | $NO_3^-$ | pH | TDS | TSS |
|---|---|---|---|---|---|---|---|---|
| **Ungkaya** | Noncompliant | Noncompliant | Standard | Standard | Standard | Standard | Standard | Noncompliant |

*Ministrial Regulation of The Minister of Environment and Forestry No. 27/2021[179]

*Source: MoE (2025)*[176].

### Marine Water and Sedimentation

Marine water quality data is also shown to be within government standards, with elevated heavy metal content[180] (see figures below). This is based on a 2024 research done in Jetty Siumbatu. pH, TSS, and $Cr^{6+}$ were shown to be within national standards. Jetty Siumbatu is reportedly located at the receiving marine water body for operational mining activities

[176] Ministry of Environment. (2025). *Status Mutu Air.* Link
[177] Ibrahim, A., Syawal, M. S., Sjarmidi, A., Aisyah, S., Sugiarti, Rahmadya, A., Waluyo, A. 2023. Assessment of Cihampelas River Water Quality Status using STORET Method and Pollution Index. *Jurnal Presipitasi.* 20(3): 644-654. Link
[178] Noor, R. J., Lanuru, M., Faizal, A., Fathuddin. 2020. Kapasitas Asimilasi TSS di Muara Sungai Mamuju. *Journal of Fisheries and Marine Research*, 4(3): 324-331. Link
[179] Ministrial Regulation of The Minister of Environment and Forestry No. 27/2021, Appendix I - Water Quality Index.
[180] Siharis, A. A., Amin, F., Abriansyah, Aldiansyah, Shaddad, A. R., Ladianto, H. Z., Saleh, F. (2024). Pengujian Kualitas Air Laut di Kecamatan Bahadopi, Kabupaten Morowali, Sulawesi Tengah berdasarkan Nilai TDS dan TSS. *Jurnal Pengabdian Masyarakat,* 3(1), 1-6. Link

by PT Cahaya Ganda Gindi. Meanwhile, sedimentation sampling[181] near Indonesia Morowali Industrial Park showed very high nickel content, exceeding the standards of IADC/CEDA (International Association of Drilling Companies/Central Dredging Association).

**Figure B.8 Marine Water Quality of Jetty Siumbatu, 2024**


Photo source: Google Earth, 2025

| Location | pH | TSS | $Cr^{6+}$ |
|---|---|---|---|
| **North side of Jetty Siumbatu** | Standard | Standard | Standard |
| **South side of Jetty Siumbatu** | Standard | Standard | Standard |

*Government Regulation No. 22/2021 – marine water quality for port (pH = 6.5-8.5 ; TSS = 80 mg/L ; $Cr^{6+}$ = no quality standards)[182]

[181] Lestari, D. W., Umar, M. R., Priosambodo, D. (2024). Analisis Kadar Nikel dan Besi pada Sedimen Perairan Pesisir Desa Fatufia, Kecamatan Bahodopi, Kabupaten Morowali, Sulawesi Tengah. *Jurnal Biologi Makassar*, 9(1), 119-127. Link

[182] Government Regulation No. 22/2021 on Environmental Protection and Management, Appendix VIII on Seawater Quality Standard.

**Figure B.9 Sediment Quality Near Indonesia Morowali Industrial Park, 2024**

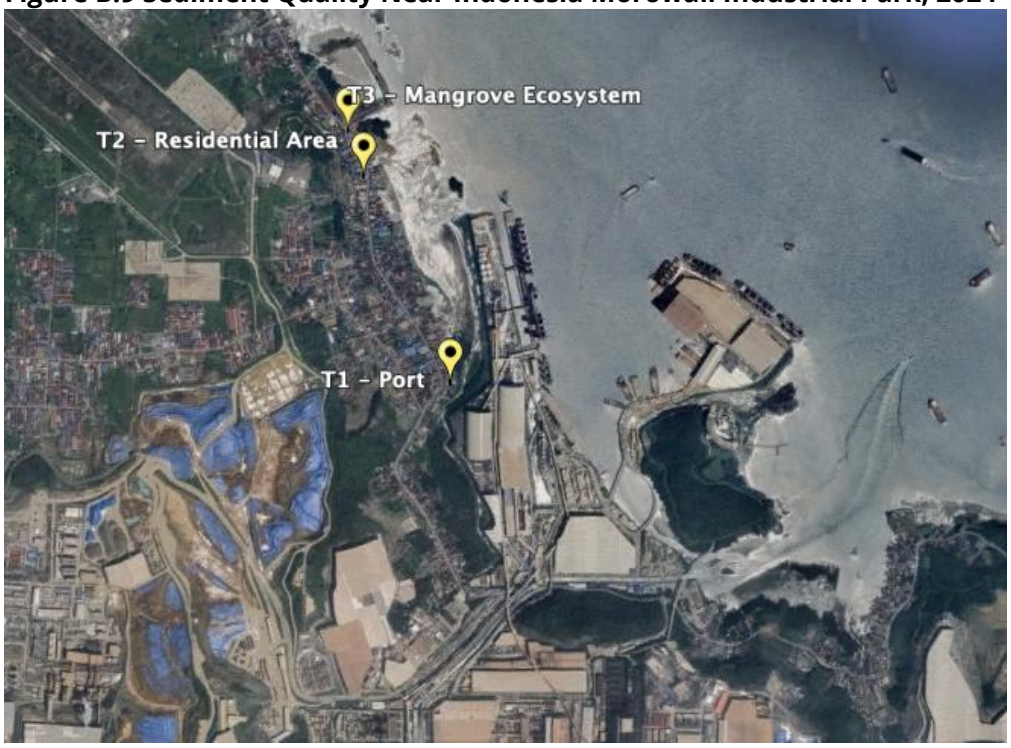



*Photo source: Google Earth, 2025*

| Location | Ni | Fe |
|---|---|---|
| **Port Area** | Noncompliant | Standard |
| **Residential Area** | Noncompliant | Standard |
| **Mangrove Ecosystem** | Noncompliant | Standard |

*IADC/CEDA 1997 – standard (max) for Ni = 300 µg/g ; standard (max) for Fe = 40,000 µg/g[183]. *Source: Lestari et al. (2024)*[181]

## B.1.6 Biodiversity

The Morowali administrative area intersects with several areas of conservation importance, including an IUCN Protected Area (IUCN PA)[184]. The list of areas is shown in **Table B.1.**

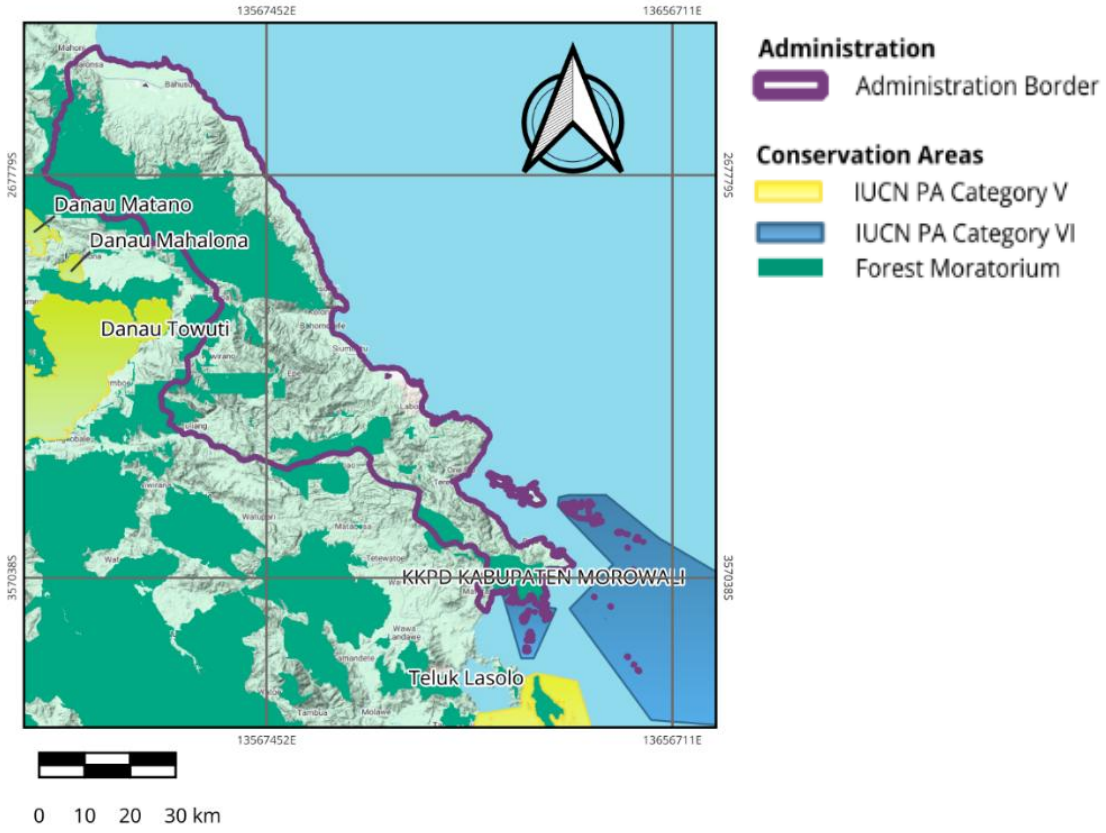
**Table B.1 List of Conservation Areas in Morowali**

| Name | Type | Description |
|---|---|---|
| **Forest moratorium** | Forest moratorium | Forest moratorium as regulated by the Indicative Map of Suspension of New Permits and Improvement of Forest Governance[185]. |
| **KKPD[186]** | IUCN Protected Area Category VI | IUCN PA Category VI areas protect nature while allowing traditional and sustainable use of natural resources[187]. They are large, mostly natural, and support low-impact activities that help conserve the environment. |

[183] The IADC/CEDA (International Association of Drilling Companies/Central Dredging Association) standards are typically applied to dredging projects and the disposal of dredged material in marine ecosystems.
[184] UNEP-WCMC & IUCN. (2025). World Database of Protected Areas. Link
[185] Minister of Forestry Decree No. 554/2025 on Determination of Indicative Map of Suspension of New Permits and Improvement of Forest Governance or Changes in the Designation of New Forest Areas in Primary Natural Forests and Peatlands
[186] *Kawasan Konservasi Perairan Daerah*, or Regional Marine Conservation Area
[187] IUCN. (2008). Guidelines for Applying Protected Area Management Categories. Link

The figure shows that on the west side of Morowali, although not within the administrative area, are the Matano, Mahalona, and Towuti Lakes. These areas are classified as KBA and IUCN PA Category V[187], referring to landscapes or seascapes shaped by the long-term interaction between people and nature. These areas possess significant ecological, cultural, and scenic value, and protecting this balance is crucial to preserving their unique character and benefits.

**Figure B.10 Map of Conservation Areas in Morowali**




*Source: WDPA (2025)[46]*

## B.1.7 Power and Electricity

### Captive Power Plants

Nickel industries in Morowali rely on captive power plants—privately owned facilities that generate electricity exclusively for smelting and processing operations. Two major companies, PT Gunbuster Nickel Industry and PT Sulawesi Mining Investment, operate plants with a combined capacity of around 2.8 GW, with an additional 2.8 GW currently under construction. **Table B.2** presents the list of captive power plants in Morowali, including their operational and under-construction capacities (MW).

**Table B.2 List of Captive Power Plants in Morowali**

| Name of Captive Power Plant | Owner of Captive Power Plant | Operational Capacity (MW) | Under Construction Capacity (MW) |
|---|---|---|---|
| Delong Nickel Phase III Unit 02, 03, 04, 05, 06 and 07 | PT Gunbuster Nickel Industry | 945 | 1350 |
| Sulawesi Labota Unit 5, 6, 7, and 8 | PT Sulawesi Mining Investment | 1900 | 1500 |

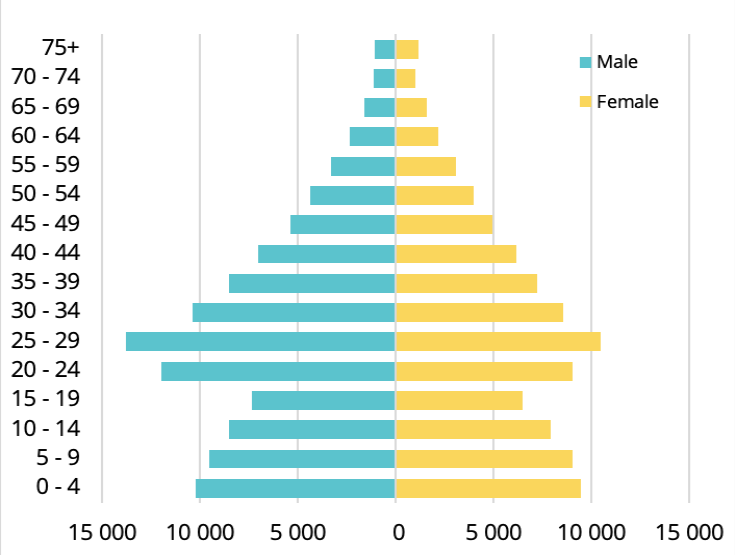
*Sources: ADB (2023)[188] CREA (2024)[189]*

## B.1.8 People

### Population

Based on population projections for 2024, Morowali Regency is estimated to have 198,968 people, consisting of 106.950 males and 92,378 females ()**.** The population has continued to increase annually, with a recorded population growth rate of 1.93% from 2020 to 2023. In 2024, population density reached 36 people per square kilometer. The density varies across the nine sub-districts, with the highest density recorded in Menui Kepulauan District at 75 people/km², and the lowest in Bungku Pesisir District at 10 people/km²[171].

**Figure B.11 Population Pyramid by Age Group and Sex in Morowali, 2024**




*Source: BPS Morowali (2024)[171]*

In terms of sex ratio, the male population outnumbers the female population, with a sex ratio of 115. However, life expectancy is higher among females than males. Overall, the population of Morowali is largely composed of individuals within the productive age group, accounting for 68.8% of the total population.

[188] ADB (2024) Captive Power Landscape Assessment for the Energy Transition in Indonesia – Final Report. Link
[189] Centre for Research on Energy and Clean Air (2024) Indonesia's captive coal on the uptick: Capacity tripled in five years, on track to cost USD 20 billion in public health burden. Link

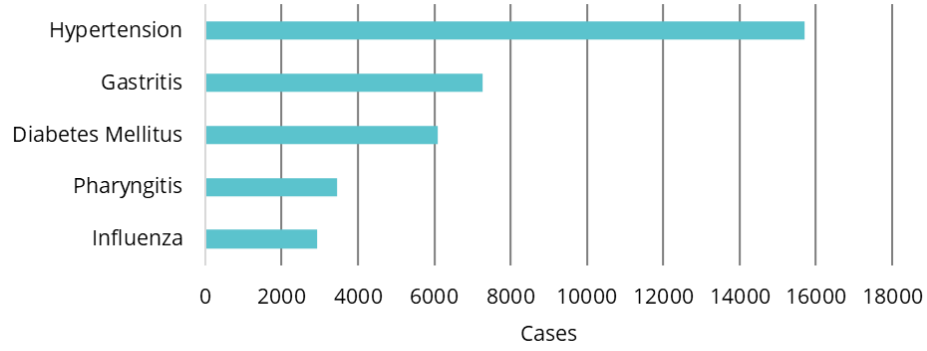
### Community Health

The figure below shows an overview of public health facilities in the region. Hypertension is reported as the top disease, affecting 16.7% of the population. This is followed by gastritis and diabetes mellitus. There is also an imbalance in the number of health facilities and medical workers, indicating poor medical access. This needs to be improved, especially as occupational health and safety accidents in Morowali have become highlighted in recent years[190].

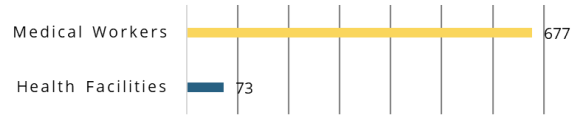
Lastly, data about sanitation depicts that 86% of sanitation facilities are privately owned, meaning that the majority of people have access to sanitation[191].

**Figure B.12 Public Health Figures in Morowali: (a) Top 5 Diseases, (b) Health Facilities, and (c) Sanitation Facilities**

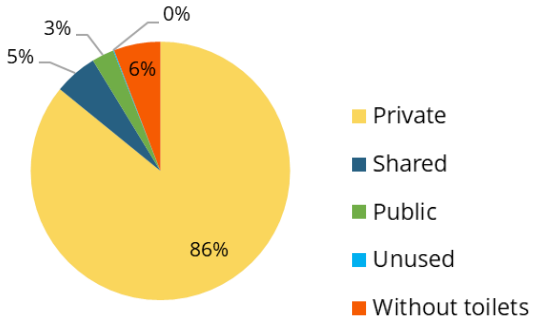
**(a) Top Diseases**




**(b) Health Facilities**




**© Sanitation Facilities**




*Source: BPS Morowali (2025)*[171]

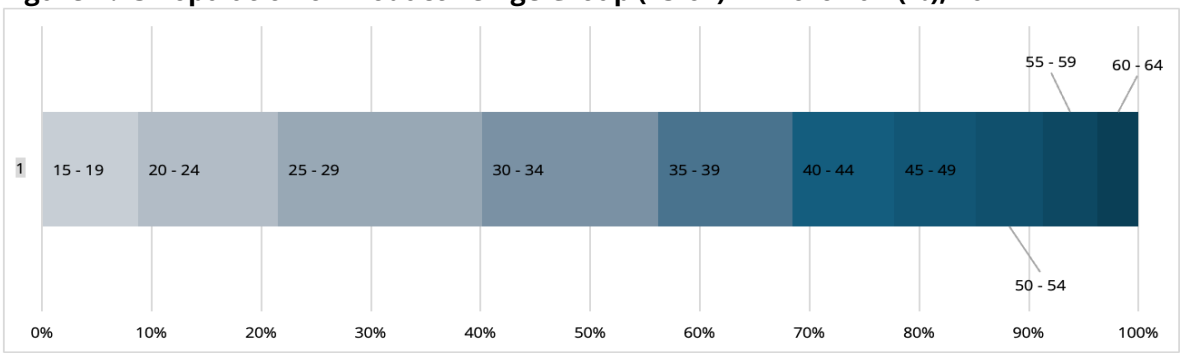
## B.1.9 Livelihood

### Productive Age Group

Morowali sees a large number of people from the productive age group. As shown in the (**Figure B.13**), the 25-29 age range is the largest group in the region, indicating high employment opportunities. The workforce figures further detail this, where the 25-29 age group demonstrated the highest percentage (19%), followed closely by the 20-24 age bracket (16%), and the 30-34 age bracket (13%). This represents the high number of fresh graduates or migrants seeking opportunities in the region's growing industries.

[190] CNBC. (January, 2024). Kecelakaan Kerja di Smelter Berulang, Pemerintah Didesak Lakukan Ini!. Link
[191] Central Bureau of Statistic of Central Sulawesi Province. (2023). Distribusi Persentase Rumah Tangga Menurut Kabupaten/Kota dan Peggunaan Fasilitas Tempat Buang Air Besar di Provinsi Sulawesi Tengah, 2019. Link

**Figure B.13 Population of Productive Age Group (15-64) in Morowali (%), 2024**

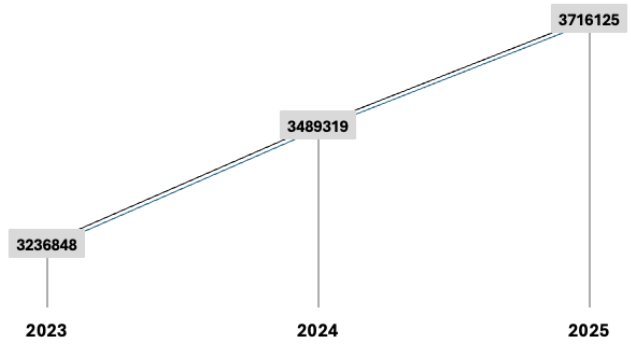



*Source: BPS Morowali (2025)*[171]

## Minimum Regional Wage

The minimum regional salary in Morowali is Rp 3,716,125[192] in 2025. There has been a positive growth in the minimum regional wage, as shown in **Figure B.14.**

**Figure B.14 Trends in Minimum Regional Wage in Morowali, 2023–2025**




*Source: SPN (2024)*[192]

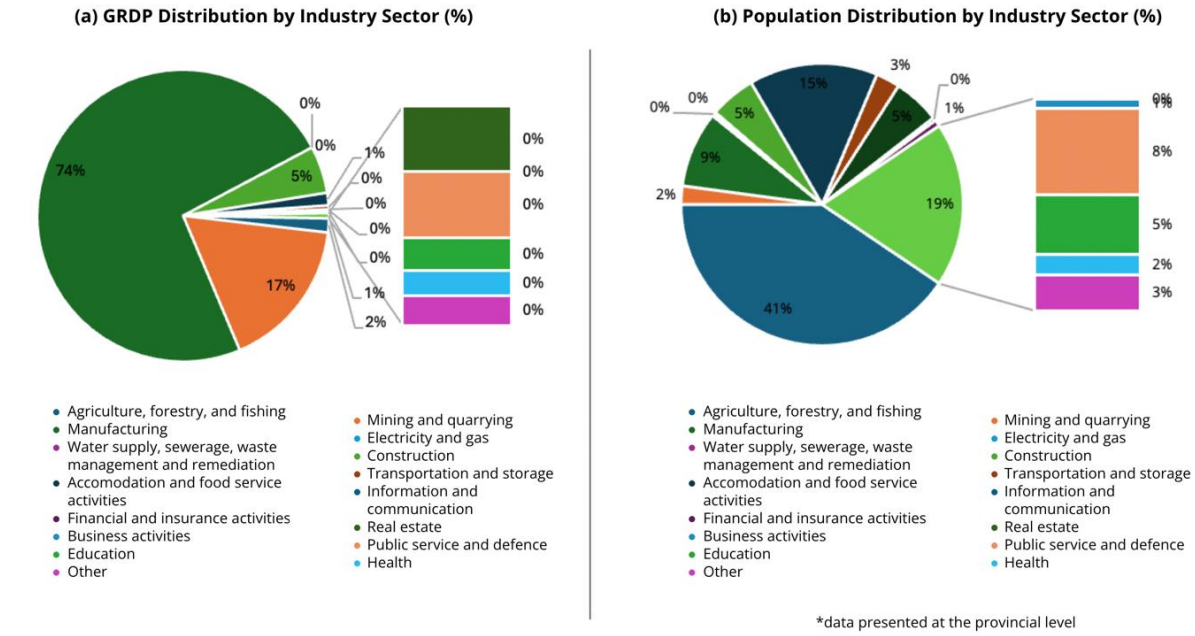
## GRDP

The economic growth of Morowali Regency has shown a remarkable increase over the past decade. In 2024, the Gross Regional Domestic Product (GRDP) of Morowali was recorded at IDR 173,864,99 million. Increases were also observed in real GRDP, GRDP per capita, and the overall economic growth rate. Over the past five years, Morowali's economic growth rate has consistently exceeded 20% annually.

The most significant contributor to Morowali's GRDP is the manufacturing industry, accounting for 73.6% of the total, followed by the mining and quarrying sector (16.80%), and construction (5.23%) (**Figure B.15**). The dominance of the manufacturing industry, particularly in basic metals, indicates that Morowali's regional economy relies heavily on industrial processing, which serves as the primary driver of its economic output.

[192] SPN News. (2024, December 24). *UMK Morowali 2025 Naik 6,5 Persen, Sektor Pertambangan Alami Kenaikan Tertinggi*. Link

**Figure B.15 GRDP and Population Distribution by Industry Sector (%) in Morowali, 2024**




*Source: BPS Morowali (2025)*[171] *and BPS Sulawesi Tengah (2024)*[193]

## Industrialization and Driving Forces

### *Establishment of Indonesia Morowali Industrial Park (IMIP) Industrial Zone*

The formation of the Indonesia Morowali Industrial Park (IMIP) began in 2009, when Tsingshan Group, through its subsidiary Shanghai Decent, partnered with PT Bintang Delapan Investama to form a joint venture company, PT Sulawesi Mining Investment (SMI)[194]. The venture aimed to invest in smelter development in Morowali. The region was identified as a location with substantial potential for natural resources. PT SMI was granted an exploration license and began developing a laterite nickel mine covering nearly 47,000 hectares. Recognizing the immense potential, the company established its first processing plant in Bahodopi, Morowali[195].

The year 2013 marked the beginning of IMIP's establishment, as PT SMI held a groundbreaking ceremony for the construction of a nickel smelter in Morowali. This development coincided with President Xi Jinping's announcement of the 21st Century Maritime Silk Road (MSR) initiative and the signing of a Memorandum of Understanding (MoU) with President Susilo Bambang Yudhoyono to support the development of the industrial zone[196].

The IMIP Industrial Zone was officially inaugurated in 2015 by President Joko Widodo. In 2019, it was designated as a National Strategic Project and classified as a National Vital

[193] BPS Sulawesi Tengah. (2024). Provinsi Sulawesi Tengah dalam Angka 2024. Vol 54. Link
[194] Indonesia Morowali Industrial Park. (n.d.). Link
[195] Departemen Health and Safety PT Indonesia Morowali Industrial. (2024). *Majalah Klaster* (Edisi ke-15). Yayasan IMIP Peduli. Link
[196] Nickel Industries. (n.d.). *Indonesia Morowali Industrial Park (IMIP)*. Link

Object (*Objek Vital Nasional/Obvitnas*). The park currently spans approximately 3,000 hectares, with planned expansion up to 6,000 hectares[197].

***High global demand and foreign investment influx***

The Morowali region's industrial development was accelerated by the Belt and Road Initiative (BRI), which positioned Indonesia, particularly Morowali, as a key partner in China's international investment strategy. Through the BRI framework, multiple Chinese financial institutions, including the China-ASEAN Investment Cooperation Fund, Export-Import Bank of China, and HSBC China, provided capital for IMIP's infrastructure and industrial development[198]. In 2015, world-leading stainless steel producer Tsingshan Holding Group invested approximately USD 3.3 billion into IMIP. The park generated USD 187 million in export revenues and contributed over IDR 306.8 billion in taxes and royalties[199]. The influx of Chinese industrial capital, facilitated by diplomatic and financial mechanisms under the BRI, has created a high-growth industrial hub centered on nickel and downstream processing. Foreign investment and sustained export demand establish a long-term industrial trajectory, positioning Morowali as a global player in mineral processing and green industrial development.

## B.1.10 Workers

### Workplace Accidents

IMIP recorded several serious workplace accidents between 2015 and 2022. During this period, there were 18 incidents, resulting in 15 fatalities and 41 workers injured (see **Table B.3**).

**Table B.3 Workplace Accident in IMIP, 2015-2022**

| Victims | | Total Incidents |
|---|---|---|
| Death | Injuries | |
| 15 | 41 | 18 |

*Source: Trend Asia (2024)*[200]

## B.1.11 Vulnerable Groups

### Women and Children's Violence

Across these two vulnerable groups, a total of 22 victims were recorded, categorized into different types of violence experienced (**Table B.4**)**.** This highlights the heightened vulnerability of women and children, as well as the need for stronger protection measures within the industrial area.

[197] IMIP. (2023). *Laporan perkembangan berkelanjutan kawasan IMIP 2023*. Indonesia Morowali Industrial Park. Link
[198] Tritto, A. (2023, April 11). *How Indonesia used Chinese industrial investments to turn nickel into the new gold*. Carnegie Europe. Link
[199] Camba, A. (n.d.). *Indonesia Morowali Industrial Park: How industrial policy reshapes Chinese investment and corporate alliances*.
[200] Trend Asia (2024). Recurring Workplace Accidents at IMIP. Link

**Table B.4 Number of Women and Children Violence, 2022**

| Type of Violence | Number of Victims |
|---|---|
| Physical | 9 |
| Psychological | 5 |
| Sexual | 7 |
| Exploitation | 0 |
| Human Trafficking | 0 |
| Neglect | 0 |
| Others | 1 |

*Source: Ministry of Women's Empowermen and Child Protection (2023)*[201]

## Disability Groups

Based on data records in Morowali, there are 583 people with disabilities, categorized into various types. **Table B.5** presents the number and types of disabilities in Morowali.

**Table B.5 Number of Disabilities in Morowali, 2020**

| Type of Disability | Number (2020) |
|---|---|
| Physical Disability | 128 |
| Blind/Visually Impaired | 105 |
| Deaf/Hearing Impaired | 41 |
| Speech Impairment | 51 |
| Deaf and Speech Impairment | 17 |
| Blind & Physical Disability | 22 |
| Blind, Deaf & Speech Impairment | 9 |
| Deaf, Speech Impairment & Physical Disability | 7 |
| Deaf, Speech Impairment, Blind & Physical Disability | 11 |
| Intellectual Disability | 84 |
| Former Mental Health Patients | 25 |
| Physical and Mental Disability | 83 |
| **Total Disabilities** | **583** |

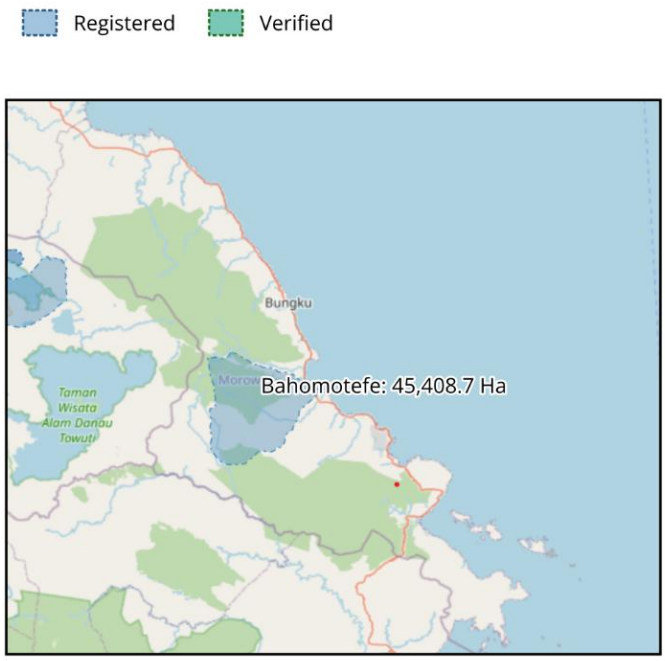
*Source: LAKIP-Social Service Office*[202]

## Indigenous People

BWRA[203] has listed one registered indigenous land, Bahomotefe, which has an area of 45,408.7 ha located in the Central Bungku District. Information regarding this is very scarce. **Figure B.16** shows the location of the registered land. The Regent of Morowali has mandated the Wana People (the indigenous group of Bahomotefe) as a group whose existence and culture must be recognized and protected[204].

[201] SIGA – Gender and Child Information System, Ministry of Women's Empowerment and Child Protection (PPPA). Link
[202] Social Service Office of Central Sulawesi Province. (2023). Performance Accountability Report (LAKIP) of the Social Service Office of Central Sulawesi Province 2022. Link
[203] BWRA. (2025). *Peta Wilayah Adat.* Link
[204] Morowali Regional Regulation 13/2012 on Recognition and Protection of the Indigenous Group of the Wana Tribe

**Figure B.16 Map of Indigenous Lands in Morowali**




Sources: BRWA (2025)

## B.2 Central Halmahera

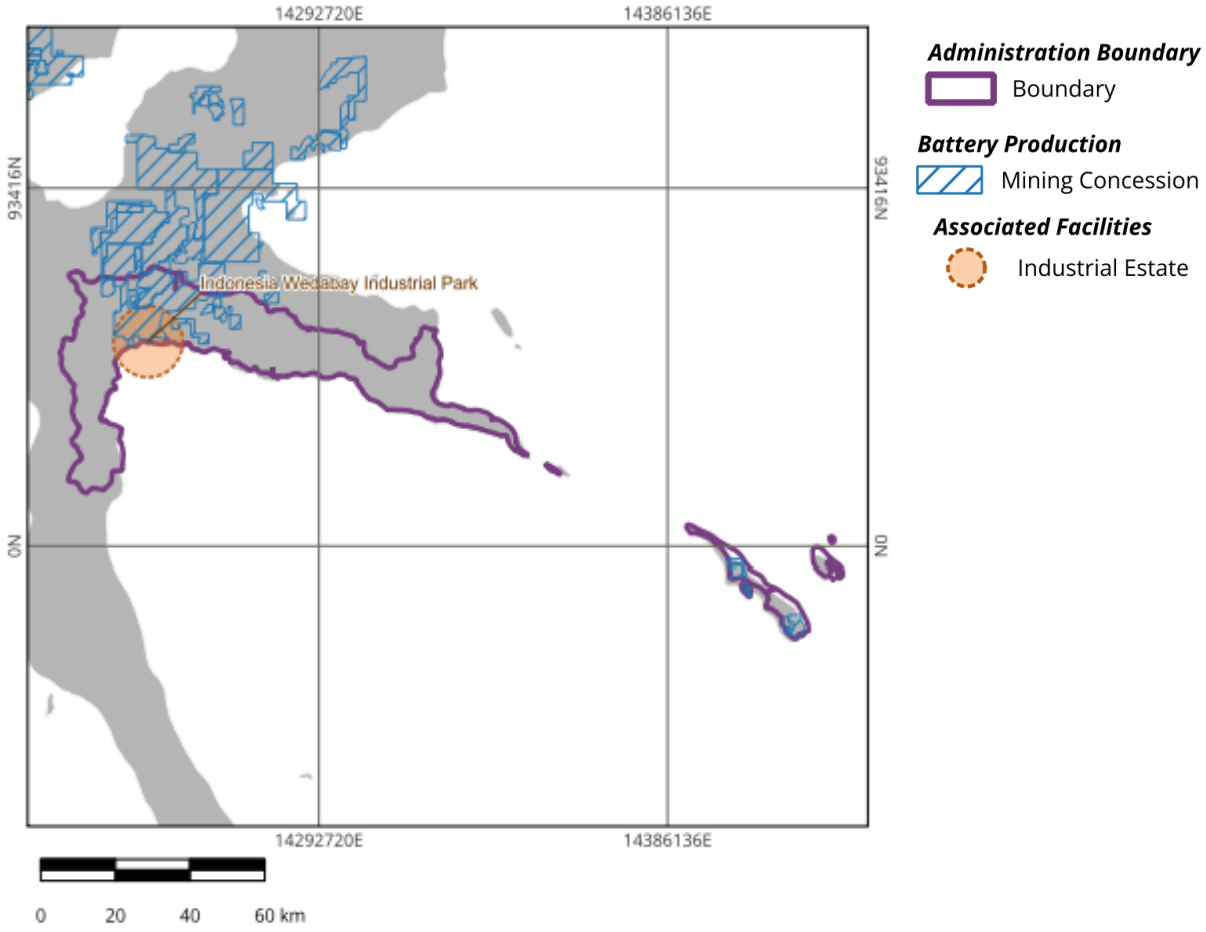
Central Halmahera is a regency situated in the province of North Maluku, Indonesia. Below is an overview of the region's location, environment, and demographics.

### B.2.1 Location and Climate

This regency, with a total area of 2,276.84 km², is located in the province of North Maluku[205]. The area is divided into 10 districts, comprising 61 villages and two transitional (preparatory) villages (see **Figure B.17**). The largest district in terms of land area is East Weda (13.72%), while the smallest is East Patani (4.78%). Central Halmahera Regency borders with East Halmahera Regency to the north, Southwest Papua Province to the east, Tidore Islands City to the west, and Halmahera Sea to the south. Previously, the capital of Central Halmahera was in Soasiu, but since 2002, it has been relocated to Weda[206].

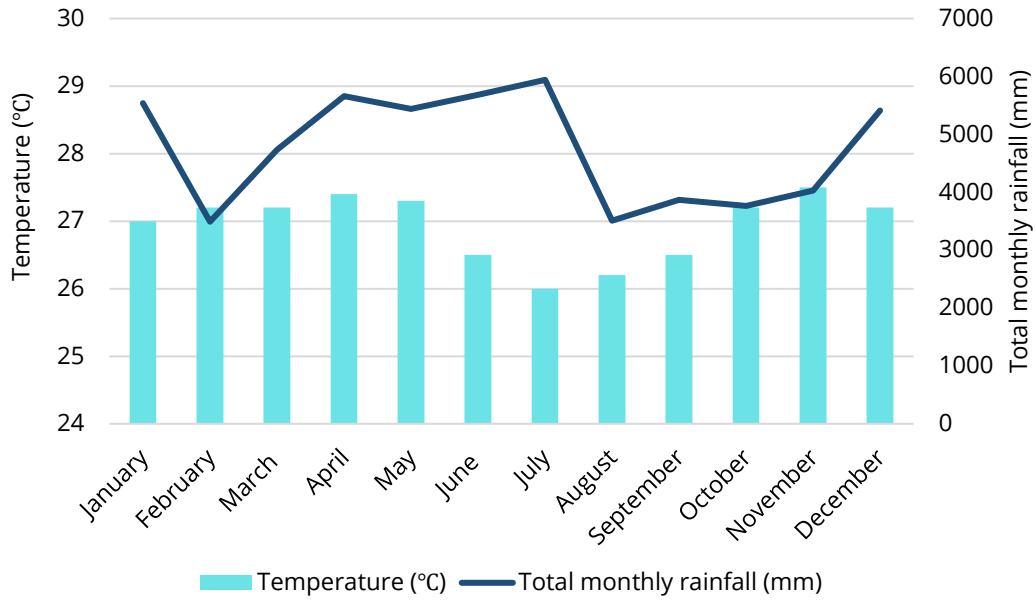
**Figure B.17 Locality of Central Halmahera, North Maluku**

[205] Badan Pusat Statistik Kabupaten Halmahera Tengah. (2024). *Kabupaten Halmahera Tengah dalam Angka 2024*. Link
[206] Pemerintah Kabupaten Halmahera Tengah. (n.d.). *Kabupaten Halmahera Tengah*. *Link*




*Sources: Own elaboration, with maps from KSP (2024)[44], MEMR (2025) [15]*

**Figure B.18 Climate Data in Central Halmahera, 2024**




*Source: Nasa (2024)[207]*

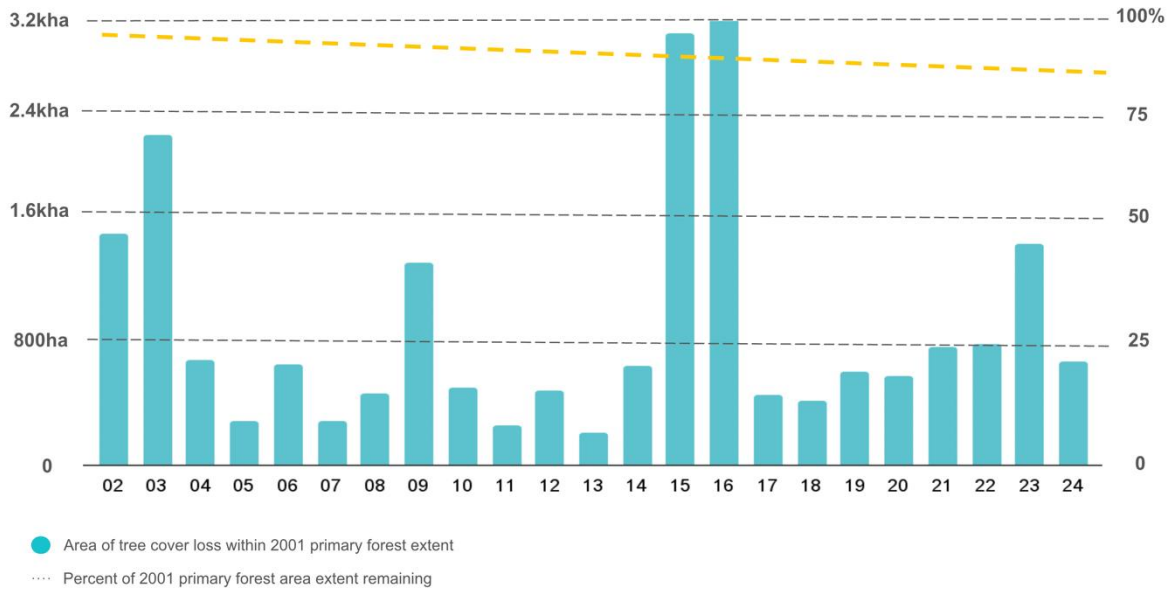
Central Halmahera has a tropical climate with an average annual temperature of around 26.93ºC and total precipitation in a month around 4756 mm[207]. The humidity level is reportedly ranged between 76-98%[208]. shows an overview of the local climate all-year round.

## B.2.2 Landscape

### Land Conversion

Based on Global Forest Watch, Central Halmahera lost approximately 21.9 thousand hectares of humid primary forest, accounting for 77% of the total tree cover loss between 2002 and 2024 (see **Figure B.19**). The extent of humid primary forest decreased by 12%, indicating significant pressure on these ecosystems. Central Halmahera also recorded a loss of 28.8 thousand hectares of tree cover, equivalent to 13% of the tree cover area in 2000, which is estimated to have generated 19.8 million tons of $CO_2e$ emissions. Notably, 34% of the tree cover loss occurred in areas where the dominant drivers led to deforestation, highlighting the significant impact of land conversion on primary forest ecosystems.

**Figure B.19 Primary Forest Loss In Central Halmahera, 2025**




*Sources: Global Forest Watch (2025)[209]*

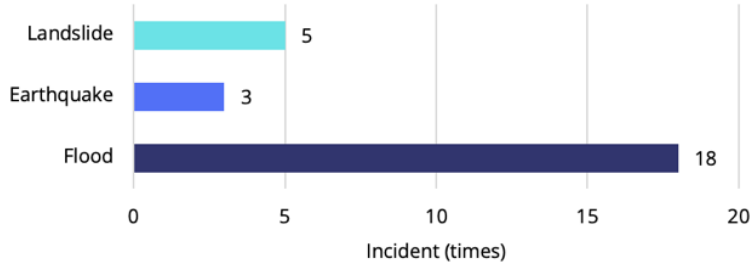
### Natural Disasters

Regarding natural disasters, floods were reported to be the most prevalent threat in Central Halmahera. In 2024, a total of 18 flood incidents were reported. Landslides are

[207] Nasa. (2024). *Nasa Power | Dav.* Link
[208] BMKG. (2025). Prakiraan Cuaca Kabupaten Halmahera Tengah. Link
[209] Global Forest Watch (2025). *Central Halmahera*. Link

the second most common hazard (five incidents), while earthquakes were only three incidents[208]

**Figure B.20 Natural Disasters in Central Halmahera, 2024**

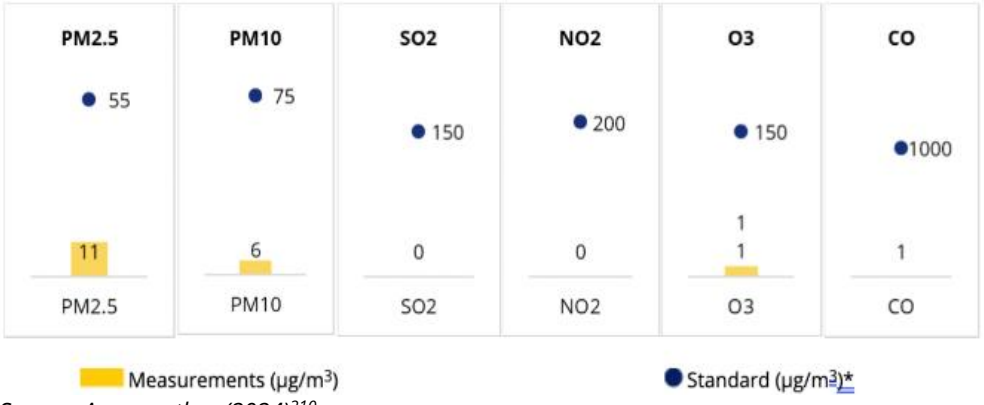



*Source: BPS Central Halmahera (2024)[208]*

## B.2.3 Air

Public data is available from the Lelilef Sawai District, which is where Indonesia Weda Bay Industrial Park is located. The data indicates that the district has relatively clean air[210]. The current industrial activities reported in the region are mining and smelter development, which may not warrant enough smoke to be fully captured as potential air pollution. In addition, this data is based on modelling and not real-time sampling.

**Figure B.21 Ambient Air Quality in Lelilef Sawai District, 2024**



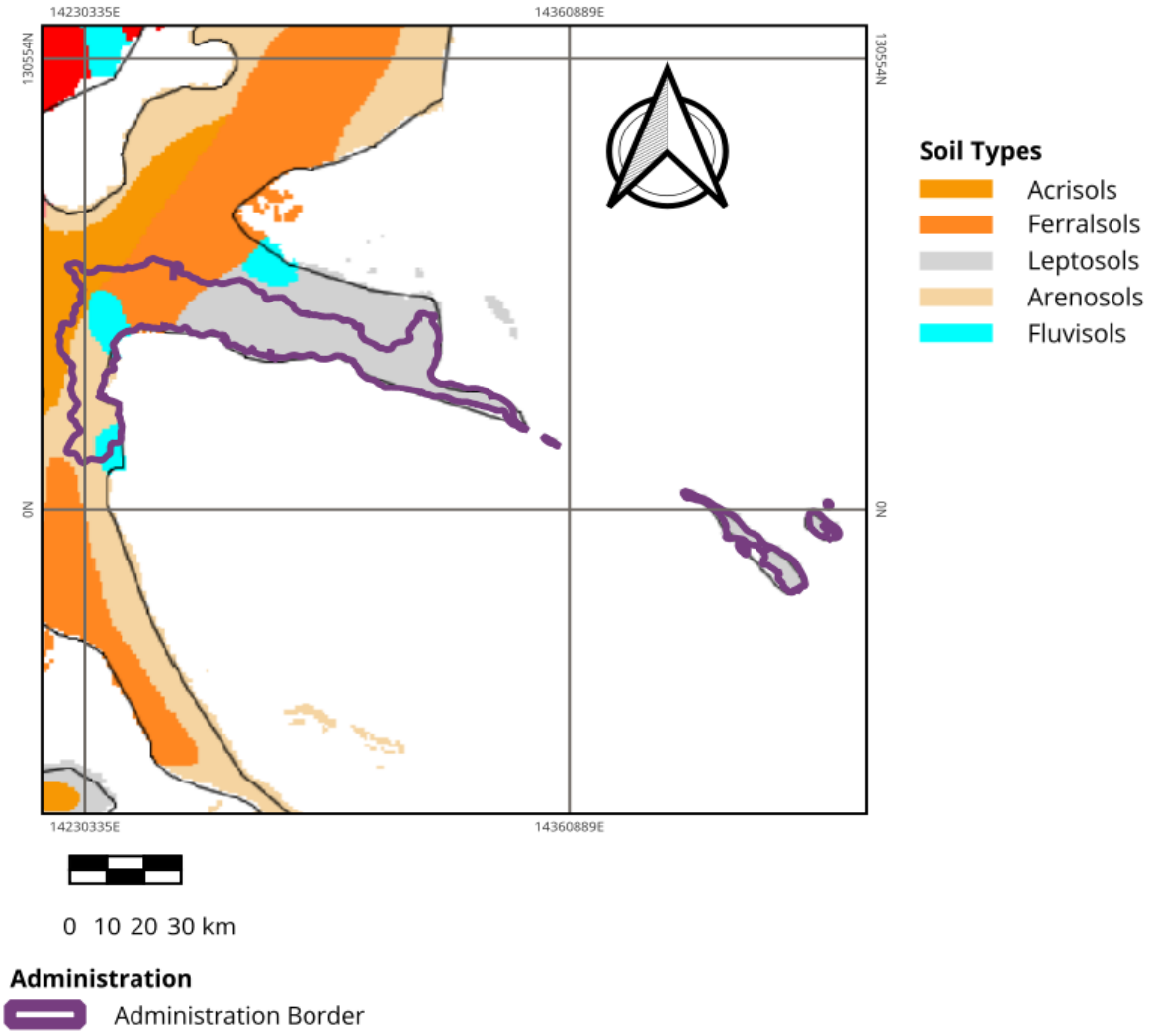

*Source: Accuweather (2024)[210]*

## B.2.4 Soil

Geologically, the majority of soils in Central Halmahera are characterized by leptosols on the eastern side and ferralsols on the western side[211]. Leptosols are very shallow soils with minimal development, formed typically on hard rock or highly calcareous materials. They can also be found in deeper soils, but are composed chiefly of gravel or stones, with little fine soil[212]. Meanwhile, Ferrasols are highly weathered soils characterized by their distinctive red and yellow hues, which result from the accumulation of metal oxides, primarily iron and aluminum. Thus, it is evident that many mineral mining concessions are located on the west side of Central Halmahera.

[210] Accuweather. (2024). Lelilef Sawai, North Maluku. Link
[211] Harmonized world soil database v2.0 | FAO SOILS PORTAL | Food and Agriculture Organization of the United Nations
[212] Springer. (2016, January 16). *Leptosols.* Link

**Figure B.22 Soil Map in Central Halmahera**




*Source: FAO (2023)*[45]

## B.2.5 Water

### Surface Water

A study by AEER (2023) indicated that the surface water is slightly polluted[213]. Elevated pH, TDS, and $Cr^{6+}$ levels demonstrate increased eroded soil particles in the water and heavy metals usually associated with mining activities[214]. These are rivers located within the vicinity of the Indonesia Weda Bay Industrial Park (IWIP). **Figure B.23** shows the sampling locations.

[213] AEER. (2023). Dilema Halmahera di Tengah Industri Nikel. Jakarta: AEER. Link
[214] Gunkel-Grillon, Peggy & Christine, Laporte-Magoni & Lemestre, Monika & Bazire, Nicolas. (2014). Toxic chromium release from nickel mining sediments in surface waters, New Caledonia. Environmental Chemistry Letters. 12. Link

**Figure B.23 Surface Water Quality of Selected Rivers in Central Halmahera, 2023**

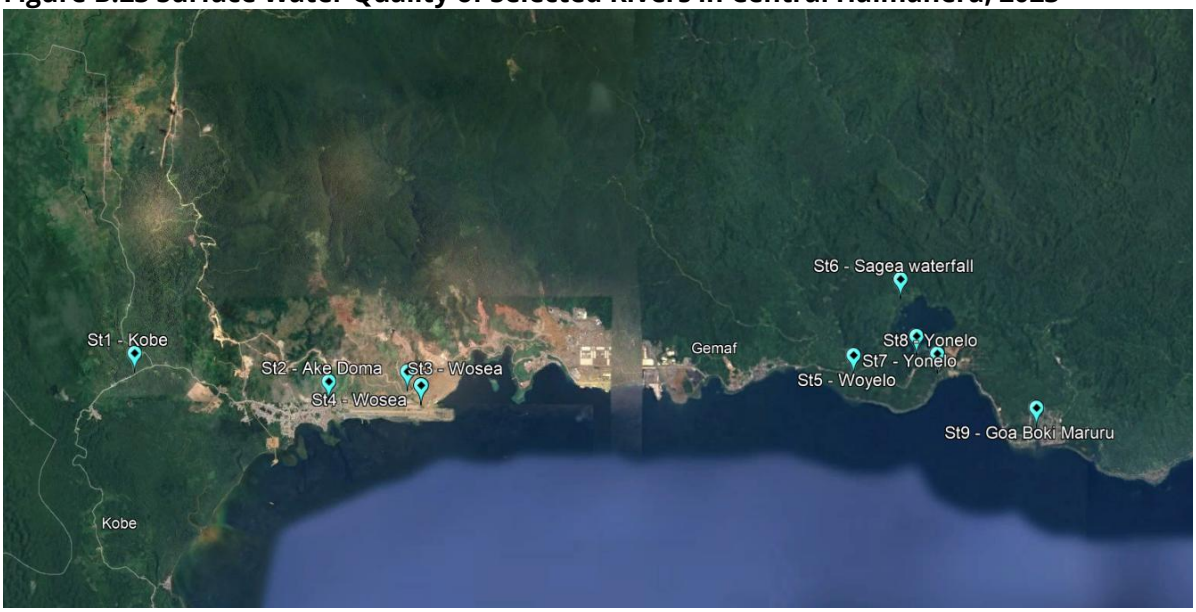



*Photo source: Google Earth, 2025*

| River | pH | TDS | $Cr^{6+}$ |
|---|---|---|---|
| **Kobe** | Standard | Standard | Standard |
| **Ake Doma** | Standard | Standard | Standard |
| **Wosea** | Noncompliant | Standard | Noncompliant |
| **Wosea** | Standard | Standard | Noncompliant |
| **Woyelo** | Standard | Standard | Standard |
| **Danah Sagea Waterfal** | Noncompliant | Standard | Standard |
| **Yonelo** | Standard | Noncompliant | Standard |
| **Yonelo** | Standard | Noncompliant | Standard |
| **Goa Boki Manuru** | Standard | Noncompliant | Standard |

*Government Regulation No. 22/2021 – class 2 river (pH = 6-9 ; TDS = 1000 mg/L ; $Cr^{6+}$ = 0.05 mg/L)[215]

*Source: AEER (2023)[213]*

## Marine Water

The same study also shows marine water parameters. The marine water quality exhibits noncompliant parameters, including elevated pH (above pH 8) and $Cr^{6+}$ levels in several areas. The sampling locations used in this study are located at several outlet points of IWIP and coastal villages surrounding the industrial complex. Elevated pH near nickel extraction and refining is linked with alkaline reagants that are commonly used in laterite nickel processing[216]. **Figure B.24** shows the sampling locations for marine water parameters.

[215] PP No. 22 Tahun 2021

[216] Balbin, Abigael & Capilitan, Jobelle & Taboada, Evelyn & Tabañag, Ian Dominic. (2023). Characteristics of Nickel Laterite Mine Waste in Caraga Region, Philippines and Its Potential Utilization. Nature Environment and Pollution Technology. 22. Link

**Figure B.24 Marine Water Quality of Selected Estuaries in Central Halmahera, 2023**

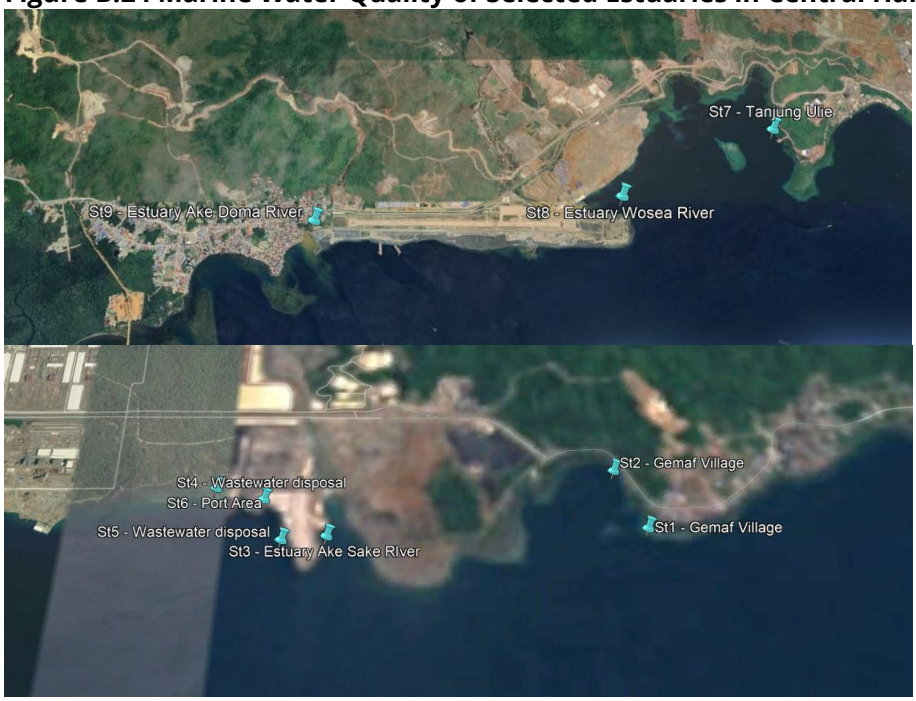



*Photo source: Google Earth, 2025*

| Location | pH | $Cr^{6+}$ |
|---|---|---|
| **Batepo, Gemaf Village** | Noncompliant | Borderline |
| **Lolaro, Gemaf Village** | Standard | Standard |
| **Estuary Ake Sake River** | Noncompliant | Standard |
| **Estuary wastewater disposal** | Noncompliant | Noncompliant |
| **Estuary wastewater disposal** | Noncompliant | Noncompliant |
| **Port area** | Noncompliant | Standard |
| **Tanjung Ulie** | Noncompliant | Noncompliant |
| **Estuary Wosea River** | Noncompliant | Standard |
| **Estuary Ake Doma River** | Noncompliant | Noncompliant |

*Government Regulation No. 22/2021 – marine water quality for aquatic biota (pH = 7.0-8.5 ; $Cr^{6+}$ = 0.005 mg/L) [215]

*Source: AEER (2023)[213]*

## B.2.6 Biodiversity

Central Halmahera intersects with a forest moratorium area as well as an IUCN Protected Area (IUCN PA). The list of areas is shown in **Table B.26** and an overview is shown in Figure B.25

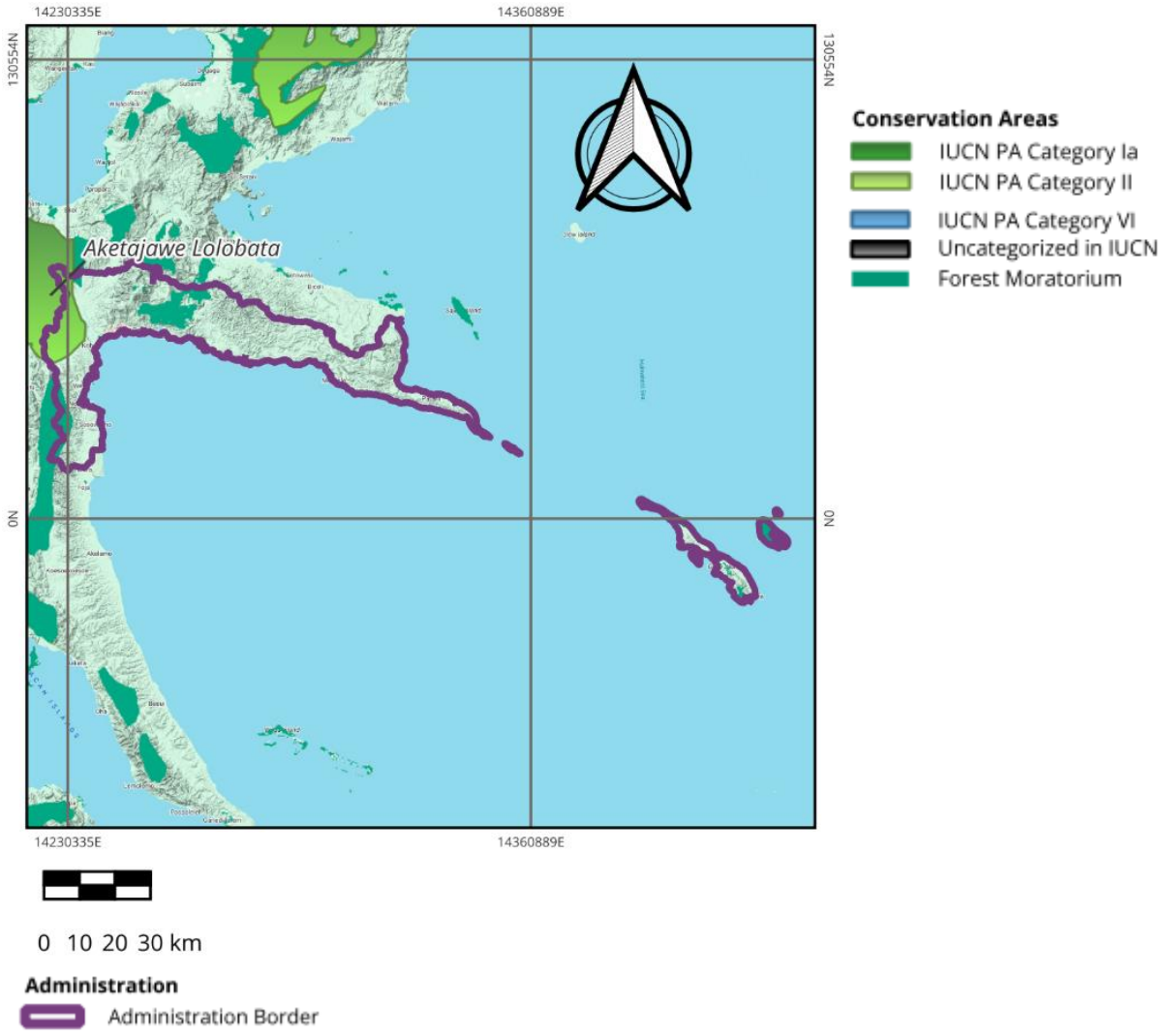
**Table B.26 List of Conservation Areas in Central Halmahera**

| Name | Type | Description |
|---|---|---|
| **Forest moratorium** | Forest moratorium | Forest moratorium as regulated by the Indicative Map of Suspension of New Permits and Improvement of Forest Governance[217]. |
| **Aketajawe National Park** | IUCN Protected Area Category II | IUCN PA Category II areas protect large-scale ecological processes, characterized by unique species and ecosystems, which also offer environmentally and culturally compatible opportunities for spiritual, |

[217] Minister of Forestry Decree No. 554/2025 on Determination of Indicative Map of Suspension of New Permits and Improvement of Forest Governance or Changes in the Designation of New Forest Areas in Primary Natural Forests and Peatlands

| Name | Type | Description |
|---|---|---|
| | | scientific, educational, recreational, and visitor experiences. The national park features remarkable landscapes that attract visitors with its natural panoramas, waterfalls, and diverse bird species in their native habitats, alongside the traditional culture of the Togutil tribe. It is recognized as a critical habitat for four of the five globally endangered endemic bird species, including economically significant birds such as the Halmahera Paradise-crow (*Semioptera wallacii*) and the white cockatoo (*Cacatua alba*).[218] |

**Figure B.25 Map of Conservation Areas in Central Halmahera**




*Source: WDPA (2025)*[46]

## B.2.7 Power and Electricity

### Captive Power Plants

In IWIP, there are numerous captive power plants owned by various tenants. The total installed capacity of these captive power plants in the area reaches approximately 3.7

[218] Arini, D. I. D. & Kinho, J. 2014. Keragaman Jenis Burung di DAS Tayawi Taman Nasional Aketjawe-Lolobata. *Jurnal Wasian*. 1(1):29-37. Link

GW, with the largest share owned by Tsingshan Holding Group through PT Weda Bay Industrial Park.

**Table B.7 List of Conservation Areas in Central Halmahera**

| Owner of Captive Power Plant | Capacity (MW) |
|---|---|
| PT Weda Bay Energi | 250 |
| PT Yashi Indonesia Investment | 250 |
| PT Youshan Nickel | 250 |
| PT Libai Indonesia Metal | 250 |
| Huayue Nickel Cobalt | 250 |
| PT Huake Nickel Indonesia | 250 |
| PT Sunny Metal Industry | 380 |
| PT Angel Nickel Industry | 380 |
| PT Angel Nickel Industry | 380 |
| PT Indonesia Weda Bay Industrial Park | 380 |
| PT Indonesia Weda Bay Industrial Park | 380 |
| PT Indonesia Weda Bay Industrial Park | 380 |

*Source: CRI (2024)*[219]

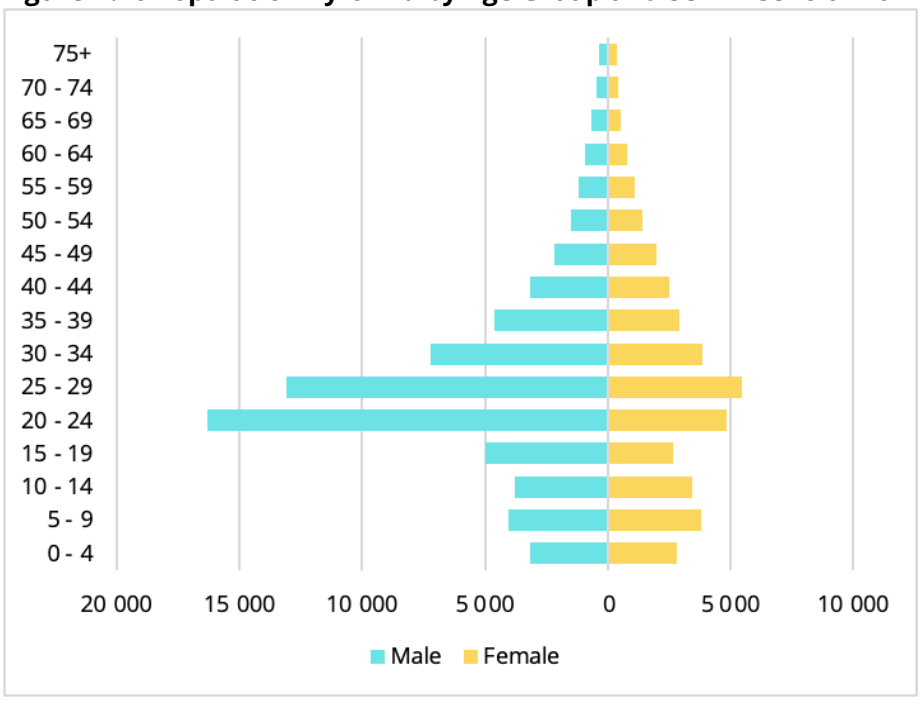
## B.2.8 People

### Population

The population of Central Halmahera Regency totals 96,977 people, spread across ten districts. The regency has a population density of around 25 people per square kilometer, with the highest density found in South Kayoa at approximately 257 people/km², and the lowest in East Obi with only about 13 people/km². The male population is significantly larger than the female population, with 59,884 males compared to 37,093 females. The Labor Force Participation Rate stands at 70.7%, or 30,452 individuals. Of these, 18,715 are male workers, while 10,533 are female workers.

[219] CRI (2024). Nickel Unearthed, The Human and Climate Costs of Indonesia's Nickel Industry. Link

**Figure B.26 Population Pyramid by Age Group and Sex in Central Halmahera, 2025**




*Source: BPS Central Halmahera (2025)*[220]

## Community Health

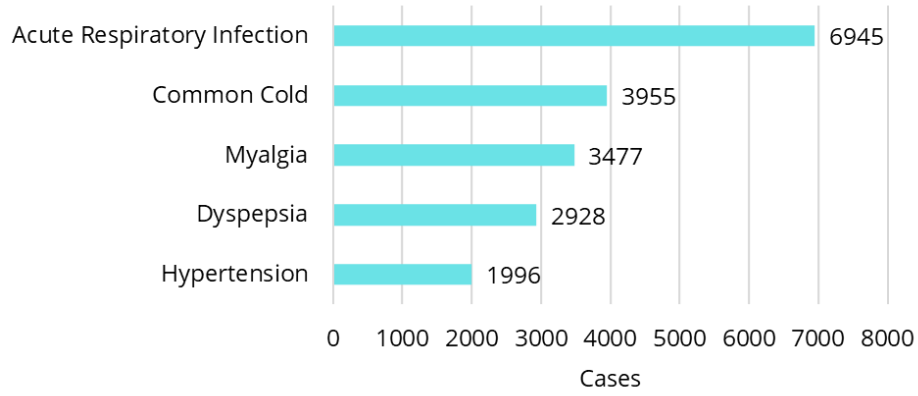
The figure below underlines key aspects of public health in Central Halmahera. Acute respiratory infection is reported as the top disease, affecting 11.8% of the population. This is followed by common cold and myalgia. There is also an imbalance in the number of health facilities and medical workers, indicating poor medical access. This needs to be improved, especially as occupational health and safety accidents in Central Halmahera have become highlighted in recent years[221].

Lastly, data about sanitation depicts that 86% of sanitation facilities are privately owned, meaning that the majority of people have access to sanitation[222].

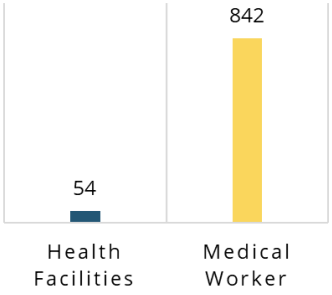
[220] Badan Pusat Statistik Kabupaten Halmahera Tengah. (2025). *Kabupaten Halmahera Tengah dalam Angka 2025*. Link
[221] Didi, F. (2025). *Dua Karyawan Meninggal Dunia, Polres Halmahera Tengah Lidik Kecelakaan Kerja di Perusahaan Tambang.* Link.
[222] Badan Pusat Statistic Provinsi Maluku Utara. (2023). *Distribusi Persentase Rumah Tangga Menurut Kabupaten/Kota dan Penggunaan Fasilitas Tempat Buang Air Besar di Provinsi Maluku Utara, 2023*. Link.

**Figure B.27 Public Health Figures in Central Halmahera: (a) Top 5 Diseases, (b) Health Facilities, and (c) Sanitation Facilities**

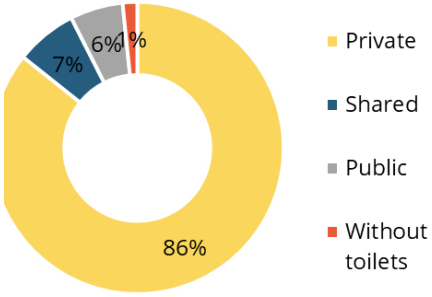
**(a) Top Diseases**




**(b) Health Facilites**




**© Sanitation Facilites**



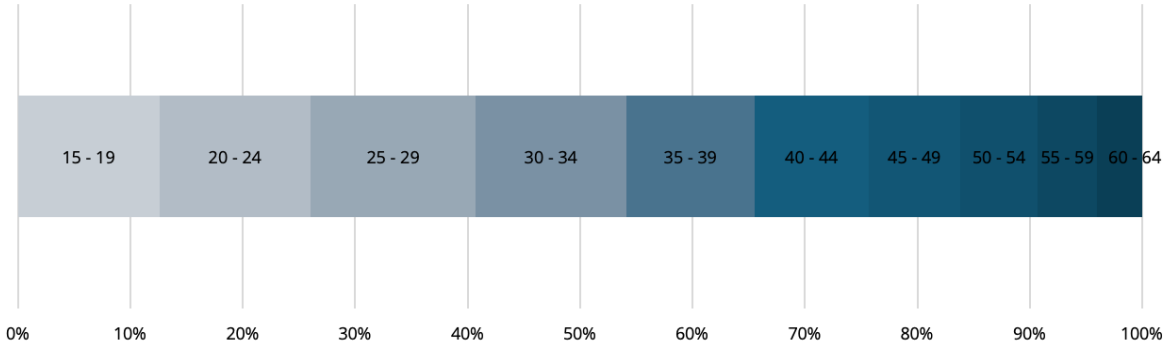

*Source: BPS Central Halmahera (2024)*[220]

## B.2.9 Livelihood

### Productive Age Group

In general, Central Halmahera sees a large number of people from the productive age group. As shown in Figure B.28, the 25-29 age range is the largest group in the region, indicating high employment opportunities. The 25-29 age group illustrates the highest percentage (15%), followed closely by the 20-24 and 30-34 age bracket (13%). The largest type of employment in Central Halmahera is as employees/workers/laborers, which accounts for 41% of the working population. This significant proportion suggests that a majority of individuals are engaged in formal or informal labor-intensive jobs, likely driven by the presence of industrial, mining, and service sectors.

**Figure B.28 Working-Age (15–64) Population in Central Halmahera (%), 2025**

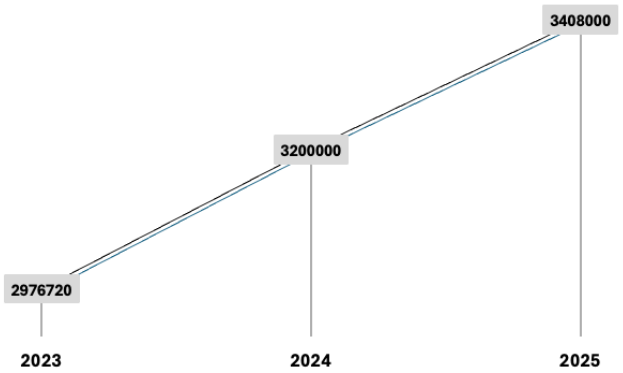



*Source: BPS Central Halmahera (2025)*[222]

## Minimum Regional Wage

The minimum regional wage in Central Halmahera is expected to Rp 3,408,000 in 2025[223]. Further details on wage developments can be seen in the figure below.

**Figure B.29 Trends in Minimum Regional Wage in Central Halmahera, 2023–2025**




*Source: Ternate Tribun News (2024)[223]*

## GRDP

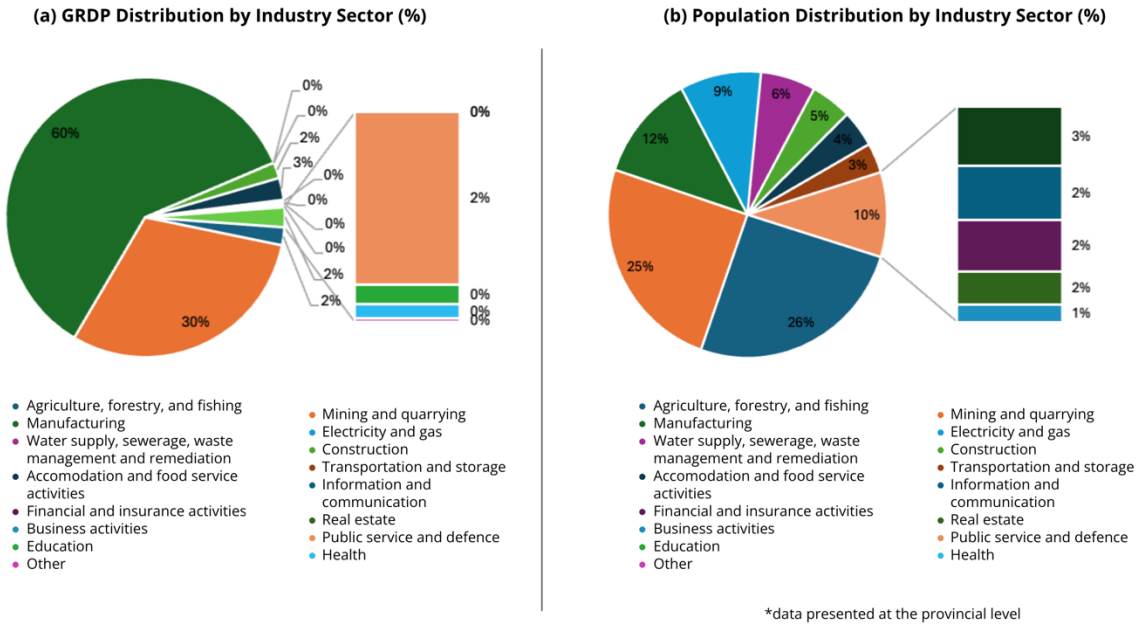
Central Halmahera recorded a Gross Regional Domestic Product (GRDP) at current prices of IDR 28.358 trillion. The sectors with the most significant contributions to the GRDP are manufacturing (58.79%) and mining and quarrying (32.23%). These two sectors are the main economic drivers of the regency, given Central Halmahera's abundant mineral resources[224]. In 2023, Central Halmahera achieved an impressive economic growth rate of 42.41%, making it the fastest-growing regency or municipality in North Maluku.

As for livelihood, which is presented at the provincial level, agriculture is the primary source of livelihood in North Maluku, accounting for 26%. This is followed by processing industries (25%) and the trade sector (12%). **Figure B.30** shows an overview of the GRDP and population distribution based on industry sector.

[223] Ternate Tribun News. (2025). Upah Minimum Naik 6,5 Persen, UMP Maluku Utara Jadi Berapa? Berikut Proyeksinya. Link

[224] Pemerintah Provinsi Maluku Utara. (2024). *Halmahera Tengah*. Link

**Figure B.30 GRDP and Population Distribution by Industry Sector (%) in Central Halmahera, 2024**




*Sources: BPS Central Halmahera (2024)[220], Pemprov Maluku Utara (2024)[222]*

## Industrialization and Driving Forces

### *Establishment of Indonesia Weda Bay Industrial Park (IWIP)*

Indonesia Weda Bay Industrial Park (IWIP) is an integrated industrial zone for heavy metal processing located in Lelilef Village, Weda Subdistrict, Central Halmahera Regency, North Maluku Province. The discovery of nickel deposits in the Weda Bay area marked the beginning of the region's transformation into an industrial zone. These nickel deposits were first discovered in 1996, followed by the establishment of a joint venture between Weda Bay Minerals and ANTAM in 1997. However, due to a decline in mineral prices, the mining project was halted in 2006 and remained inactive until 2013[225].

A new phase began in 2017 when China's Tsingshan Group signed an agreement and acquired a 57% stake in Weda Bay Minerals. Tsingshan then formed a joint venture with Huayou and Zhenshi, with a portion of the shares later acquired by CATL[226]. The development of the industrial park officially began on August 30, 2018, and mining operations commenced in October 2019. The area has since continued to grow and was designated a National Strategic Project through Presidential Regulation (Perpres) No. 109 of 2020, which amended Perpres No. 3 of 2016 on the Acceleration of National Strategic Projects. IWIP is also classified as a National Vital Object.

### *Entry of major investments*

Tsingshan, Huayou, Zhenshi are among the major companies that have committed substantial capital investments in this industrial area. Their involvement has significantly increased the interest of other companies in investing as well. The initial joint venture

[225] Indonesia Weda Bay Industrial Park. (n.d.). *About IWIP.* Link
[226] Reuters. (2020, April 30). *Indonesia's Weda Bay nickel project by Tsingshan and Eramet starts production.* Link

established by Tsingshan served as a catalyst, triggering a domino effect that led to increased investment inflows into the region[227].

## B.2.9 Workers

### Workplace Accidents

Based on 2022 data, a total of 131 workplace accident cases were reported, with 125 cases occurring within company premises, while traffic accidents caused the remaining cases (**Table B.8).**

**Table B.8 Workplace Accidents in Central Halmahera, 2022**

| Type | Number |
|---|---|
| Traffic | 6 |
| Company Area | 125 |
| Total Cases | 131 |

*Source: Jazirah Indonesia (2022)[228]*

## B.2.10 Vulnerable Groups

### Women and Children's Violence

According to Satu Data, incidents of violence against women and children in Central Halmahera are relatively rare. The latest reports and available data indicate that only one case involving a woman has been recorded (**Table B.9**). This may also be an indication that cases like this are often under-reported.

**Table B.9 Number of Women and Children Violence, 2022**

| Province | Male | | Female | | Total |
|---|---|---|---|---|---|
| | Child | Adult | Child | Adult | |
| Central Halmahera | 0 | 0 | 0 | 1 | 1 |

*Source: Satu Data (2022)[229]*

### Indigenous People

BWRA[230] listed two verified indigenous lands, Pnu Fritu and Pnu Banemo, which accounted for 7,752.1 and 7,428.8 ha, respectively. Available information for both of these areas is scarce. **Figure B.31** shows the location of the registered land.

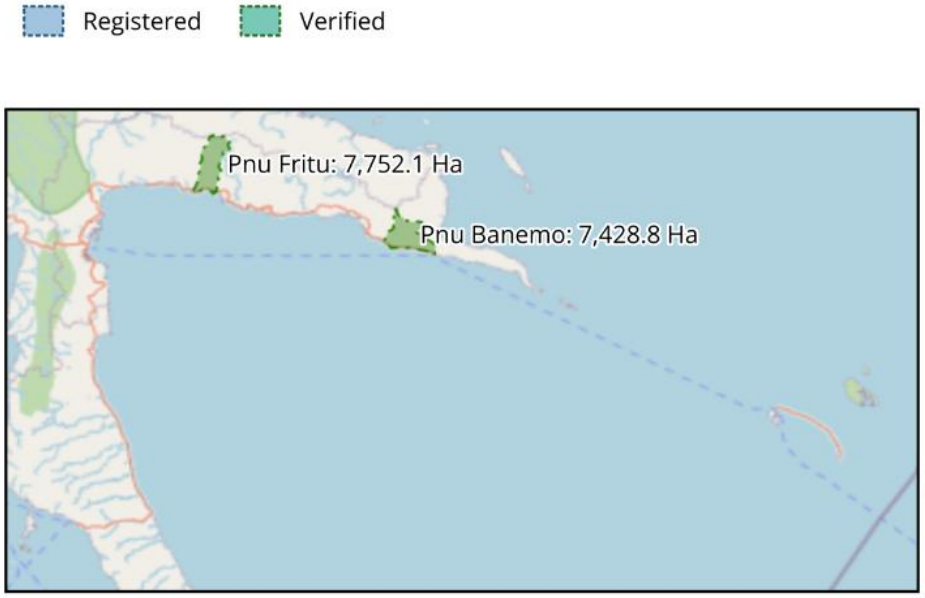
Pnu Fritu is located in Weda Utara Subdistrict, Fritu Village, while Pnu Banemo is located in Patani Barat Subdistrict, Banemo Village. Both territories share a southern boundary with Weda Bay, one of the key coastal areas in Central Halmahera. The term "Pnu" refers to settlement areas and living spaces that have been inhabited across generations. A Pnu encompasses not only residential areas but also buffer zones, including mountainous

[227] Channel News Asia (2023, March 27). *North Maluku is one of Indonesia's top nickel producers – but are its people prospering.* Link
[228] Jazirah, Indonesia (2022) Workplace Accidents in Central Halmahera (2015–2022). Link
[229] Satu Data (2022). Link
[230] BWRA. (2025). *Peta Wilayah Adat.* Link.

regions, lowlands, coastal areas, and marine waters that serve as vital sources of livelihood.

Indigenous communities in these territories rely heavily on local natural resources, with primary economic activities including plantation and capture fisheries in the surrounding waters of Weda Bay. Moreover, these territories hold important socio-cultural values, serving as spaces of identity, customary practices, and the continuity of community life.

**Figure B.31 Map of Indigenous Lands in Central Halmahera**



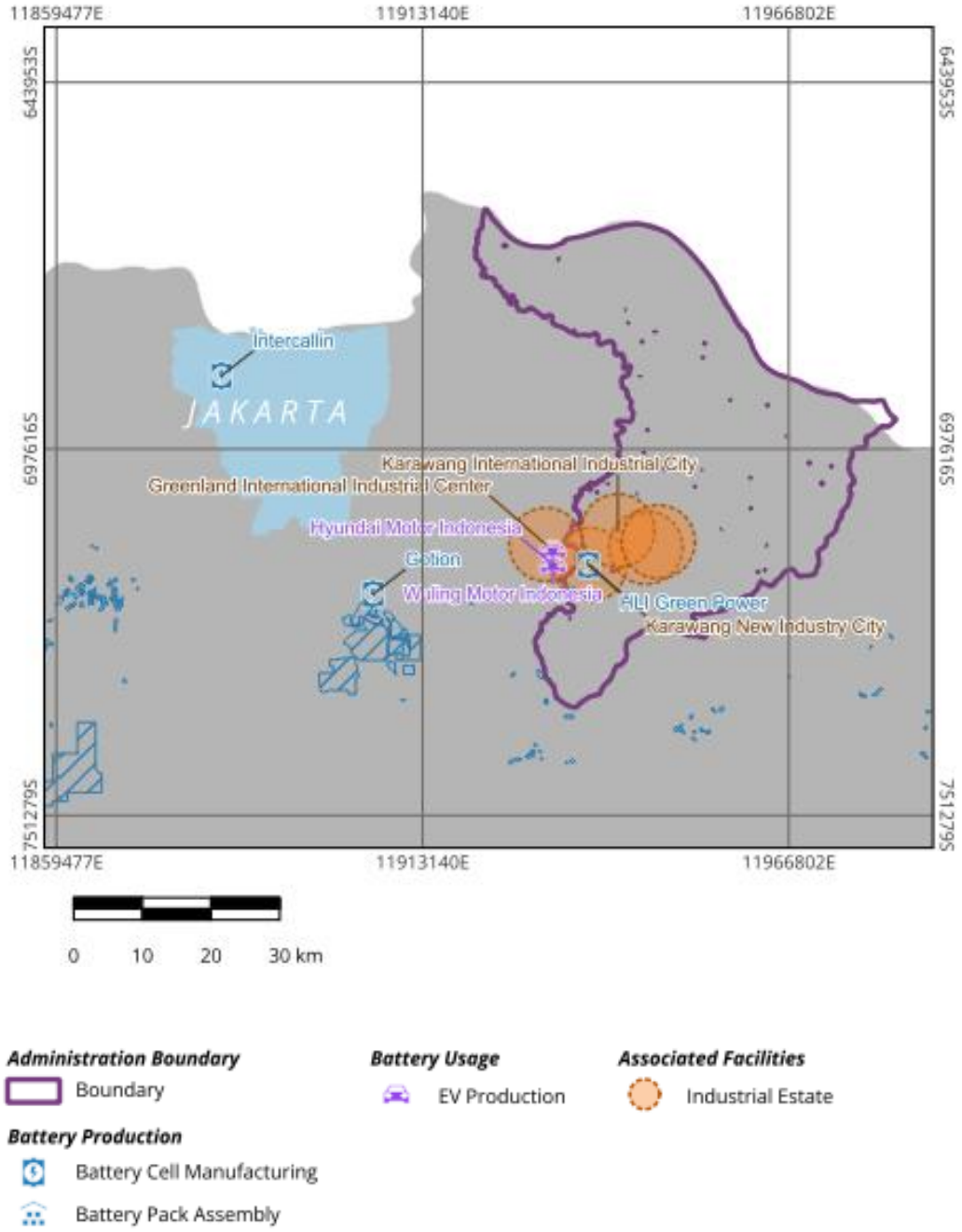

Sources: BRWA (2025)

## B.3 Karawang

Karawang is a regency located in the province of West Java, Indonesia. Below is an overview of the region's location, environment, and demographics.

### B.3.1 Location and Climate

Karawang has an area of 1,913.71 km², accounting for 5.40% of the total area of West Java Province (see Figure B.32 Locality of Karawang, West Java

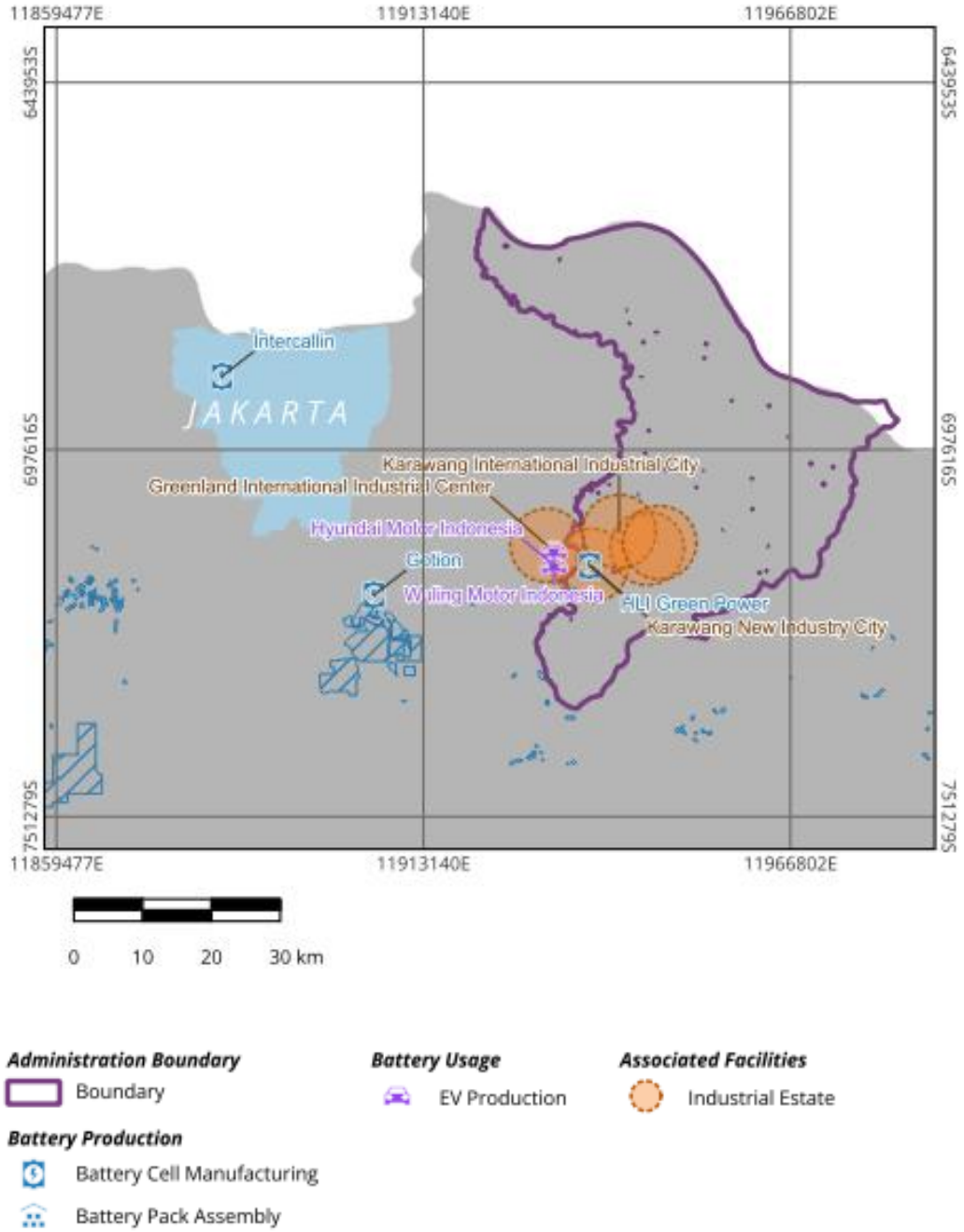



*Sources: Own elaboration, with maps from KSP (2024)44, MEMR (2025) 15*

*Figure B.33*). This area is divided into several districts, with the two most prominent being Cibuaya and Cikampek. Cibuaya covers approximately 118.22 km², and Cikampek spans 117.62 km². These two districts represent the largest territorial divisions within Karawang. The smallest district in terms of area is East Karawang, with only 30.37 km². Karawang

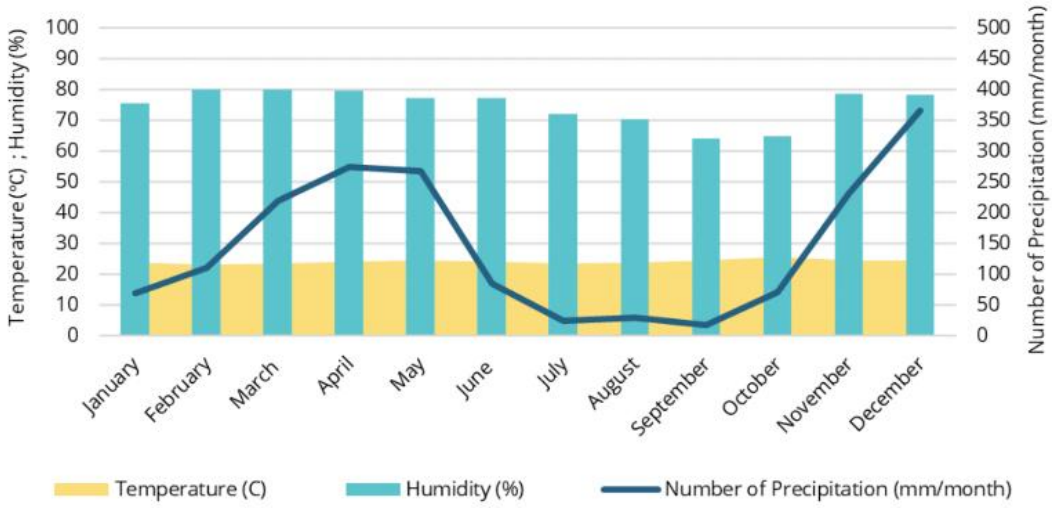
has a tropical climate with an average annual temperature of around 24 °C, high humidity (75%), and moderate rainfall (148 mm per month).

**Figure B.32 Locality of Karawang, West Java**




*Sources: Own elaboration, with maps from KSP (2024)[44], MEMR (2025) [15]*

**Figure B.33 Climate Data in Karawang, 2024**




*Sources: BPS Karawang (2024)*[231]

Karawang Regency is bordered to the north by the Java Sea, to the east by Subang Regency, to the southeast by Purwakarta Regency, to the south by Bogor and Cianjur Regencies, and the west by Bekasi Regency. These regency features fertile land that is widely used for agriculture, supported by favourable climatic conditions, with annual rainfall ranging from 1,100 to 3,200 mm, an average air temperature of 27°C, sunlight exposure at 66%, and relative humidity of 80%[231].

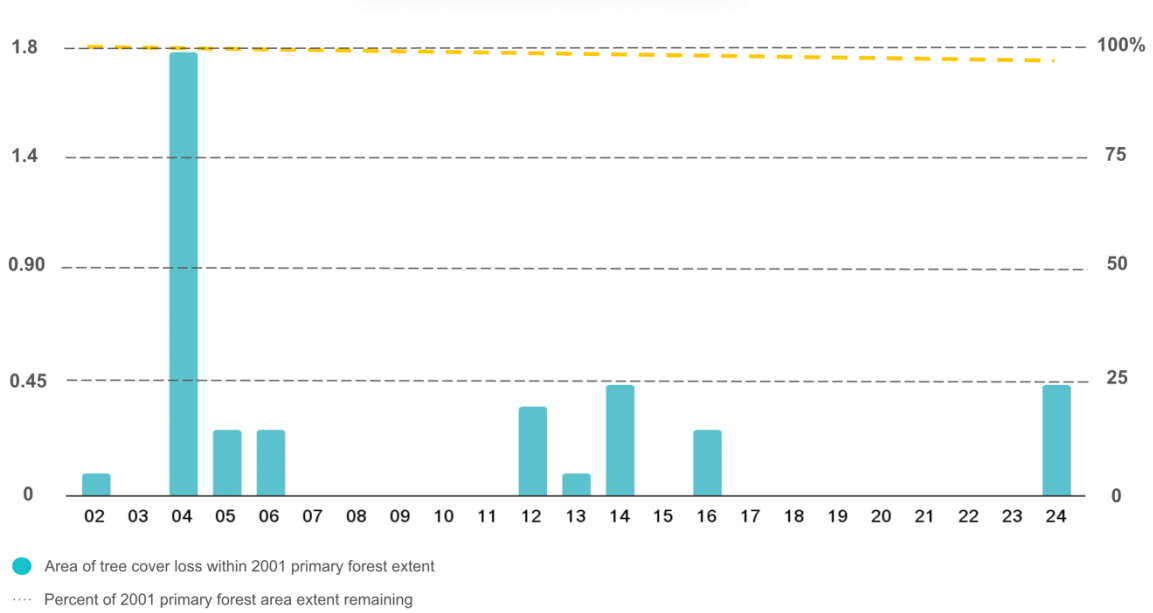
## B.3.2 Landscape

### Land Conversion

Based on Global Forest Watch data, Karawang lost approximately 4 Ha of humid primary forest, accounting for only 0.22% of the total tree cover loss between 2002 and 2024. The extent of humid primary forest decreased by 0.94%, indicating relatively low pressure on primary forest ecosystems. Karawang also recorded a loss of 2,090 Ha of tree cover, equivalent to 8.4% of the tree cover area in 2000, which is estimated to have generated 1.13 million tons of $CO_2e$ emissions.

[231] Badan Pusat Statistik Kabupaten Karawang. (2024). *Kabupaten Karawang dalam angka 2024*. Link

**Figure B.34 Primary Forest Loss In Karawang, 2025**

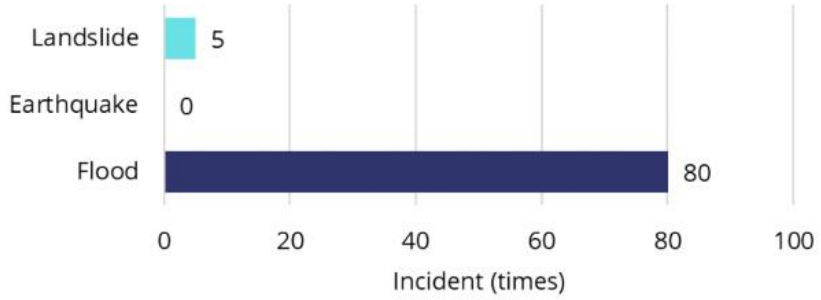



*Sources: Global Forest Watch (2025)*[232]

## Natural Disasters

Regarding natural disasters, there is no recent data except for 2021. Floods were reported to be the most prevalent threat in Karawang. In 2021, a total of 80 flood incidents were reported. Landslides were the second most common hazard, with five incidents, while no earthquakes were reported.

**Figure B.35 Natural Disasters in Karawang, 2021**




*Source: BPS Karawang (2024)*[231]

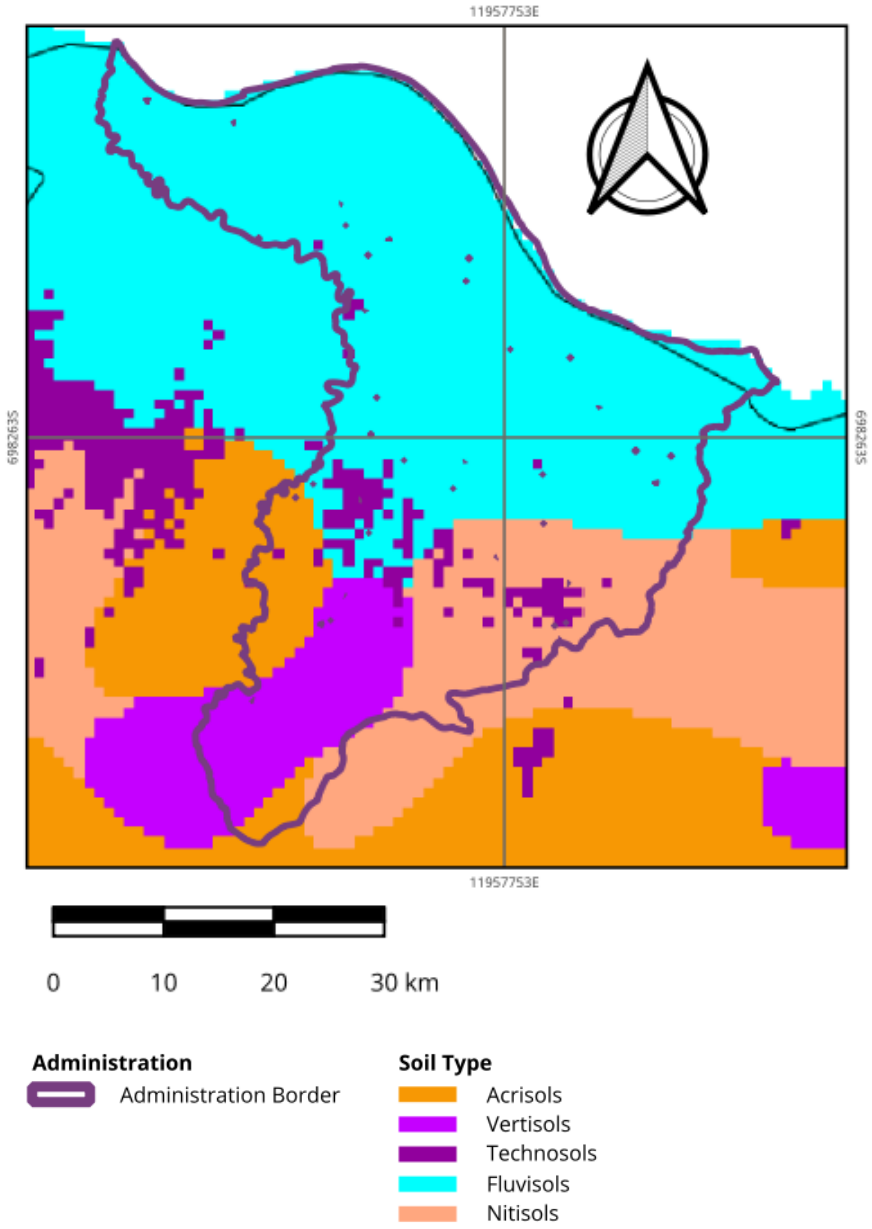
## B.3.3 Soil

According to the Harmonized World Soil Database classification system[231], Karawang is generally dominated by fluvisols. Fluvisols make up the northern area of Karawang. This soil type is generally soft, young soils formed from recent alluvial deposits. It is usually used for crops and flood control, which fits the overall land usage of north Karawang[233].

[232] Global Forest Watch (2025). *Karawang*. Link
[233] ISRIC. (2025). *Fluvisols (FL)*. Link

The southern area of Karawang is characterized by more stable soil types, which may be why it is where industrial complexes are typically located. Vertisols, in particular, are often associated with lime, which contributes to some of the elevated structures in the region.

**Figure B.36 Soil Map in Karawang**



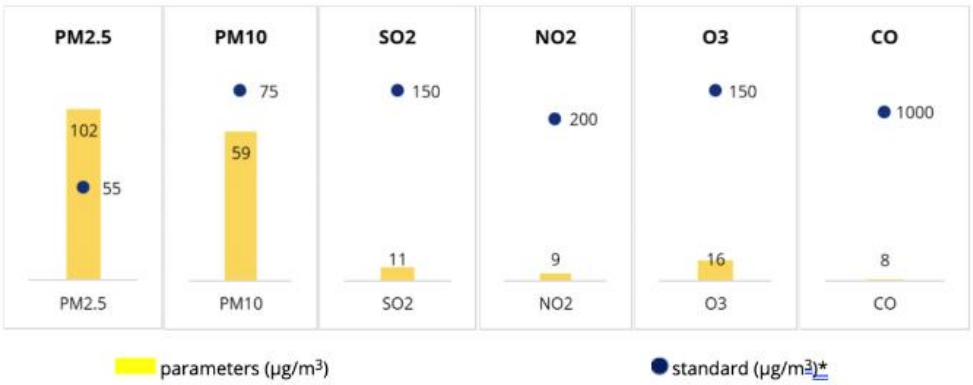

*Source: FAO (2023)*[45]

## B.3.4 Air

Publicly available data indicates that Karawang has relatively clean air, despite $PM_{2.5}$ content reaching elevated levels (102 ug/$m^3$)[234]. This is synonymous with Karawang, which is a robust industrial hub.

[234] Accuweather. (2024, November 16). *Karawang, West Java.* Link

**Figure B.37 Ambient Air Quality in Karawang, 2024**




*Source: Accuweather (2024)*[234]

## B.3.5 Water

### Surface Water

The most prominent water body in the Karawang area is the Citarum River. It is the longest river in West Java and the third longest on the island of Java. It flows from the Wayang Windu area in the Bandung region and empties into the Jakarta Bay[235]. While the Citarum River's water is widely used for agricultural irrigation, fisheries, a raw water source, industrial activities, and hydropower plants that provide electricity to the islands of Java and Bali, it is also heavily polluted by domestic and fecal coliform[236]. MoE data shows that the point of the river that passes through Karawang demonstrates acidic pH elevated level. This is an indicator of organic matter pollution, often associated with agriculture and domestic wastewater[237].

[235] Fulazzaky, Mohamad Ali. (2010). Water quality evaluation system to assess the status and the suitability of the Citarum river water to different uses. Environmental Monitoring and Assessment. 168. 669-684. 10.1007/s10661-009-1142-z.
[236] BBC Indonesia. (2023, March). Lima Tahun Citarum Harum: Sungai Penting yang Masih Jadi 'Kakus Raksasa' Karena Limbah Tinja. Link
[237] Abdullahi, A. B., Siregar, A. B., Pakiding, W., Mayyuddin. (2021). The Analysis of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) Contents in the Water of around Laying Chicken Farm. *The 3rd International Conference of Animal Science and Technology,* (788). doi:10.1088/1755-1315/788/1/012155. Link

**Figure B.38 Surface Water Quality of Citarum River, 2025**

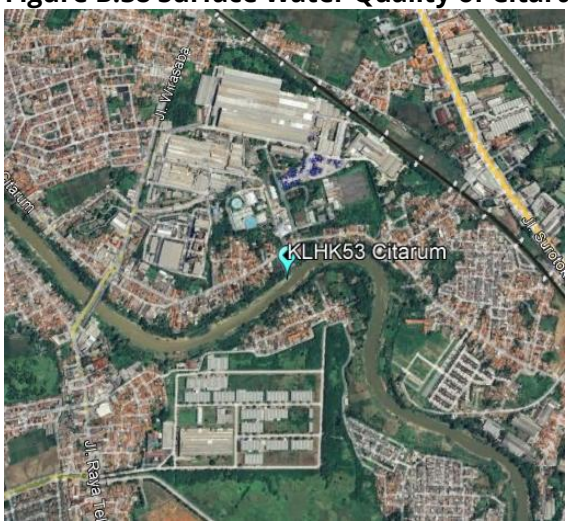



Photo source: Google Earth, 2025

| River | $NH_3$ | BOD | COD | DO | pH | TDS | TSS |
|---|---|---|---|---|---|---|---|
| **Citarum** | Standard | Standard | Standard | Standard | Noncompliant | Standard | Standard |

*Government Regulation No. 22/2021 – class 2 river (BOD = 3 mg/L ; COD = 25 mg/L ; pH = 6-9 ; TSS = 50 mg/L)

*Source: MoE (2025)*

## B.3.6 Biodiversity

In terms of conservation areas, there are almost no conservation areas in Karawang. A minor portion of the forest moratorium zones is also identified; however, its location is relatively far from the industrial areas.

**Figure B.39 Map of Conservation Areas in Karawang**

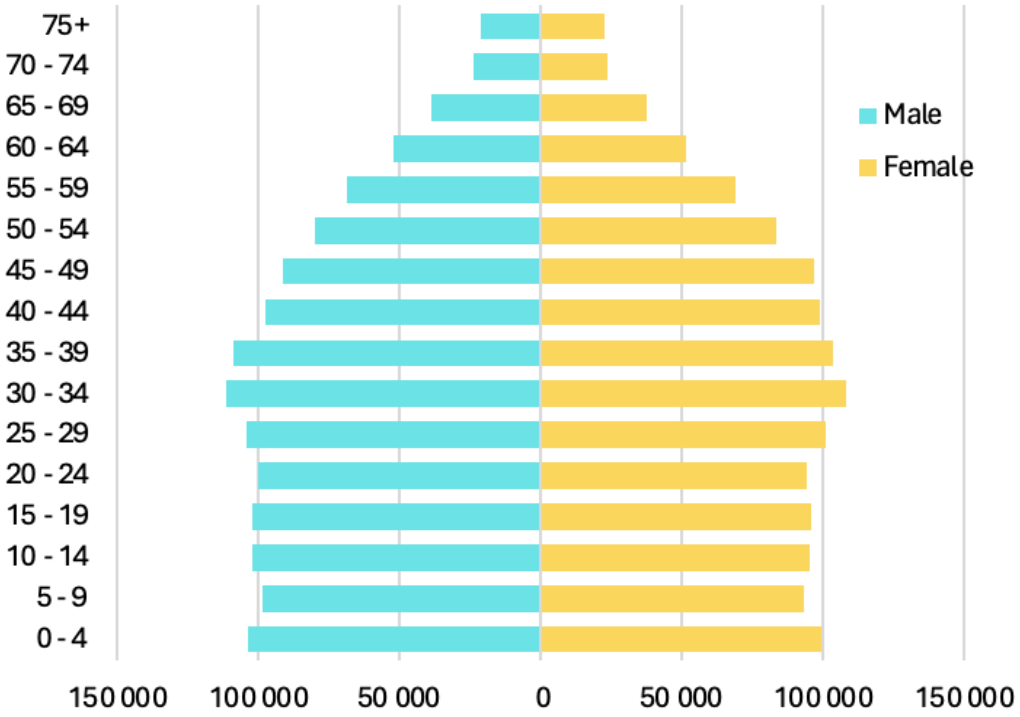

*Source: WDPA (2025)*[46]

## B.3.7 People

### Population

As of 2024, Karawang has a population of 2,554,384 people. The male population is 1,302,947, while the female population is 1,278,298. The population growth rate is 1.12%, with a sex ratio of 102 males per 100 females, indicating a slight imbalance in favor of males. The population density is 1,334.78 people per km². The district with the largest population is Klari, with 212,000 people, or 8.3% of the total population. The district with the smallest population is Tegalwaru, with 41,000 residents[238].

**Figure B.40 Population Pyramid by Age Group and Sex in Karawang, 2025**




*Source: BPS Karawang (2025)*[231]

### Community Health

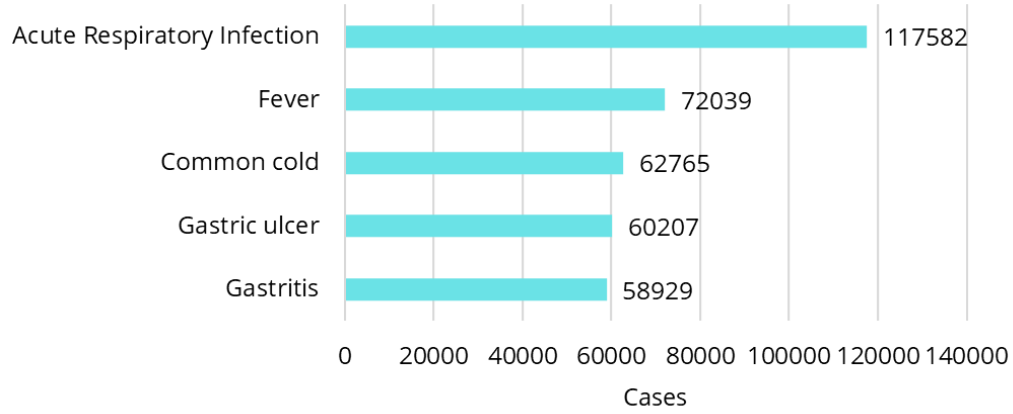
**Figure B.41** below shows key aspects of public health in Karawang. Acute respiratory infection is reported as the top disease, affecting 4.7% of the population[231]. This is followed by fever and the common cold. There is also an imbalance in the number of health facilities and medical personnel, indicating inadequate access to medical care. This needs to be improved, particularly with the high number of accute respiratory sufferes in Karawang. In similar case, study in Malaysia revealed that the rapid growth of industry has exposed more workers to occupational respiratory hazards, which has led to a rise in the prevalence of work-related respiratory diseases among them[239].

[238] Government of Karawang Regency. (n.d.). *General overview of Karawang Regency.* Link
[239] Asraff, M. S., Azzani, M., Anuar, M., Noor, A. F. A., hair, A. F. A., Bakhia, A. S., Hassan, M. S., Yasin, S. M. 2025. Prevalence of occupational respiratory disease and its determinants among workers in major industrial sectors in Malaysia in 2023. *Scientific reports.* 15: 25807. Link

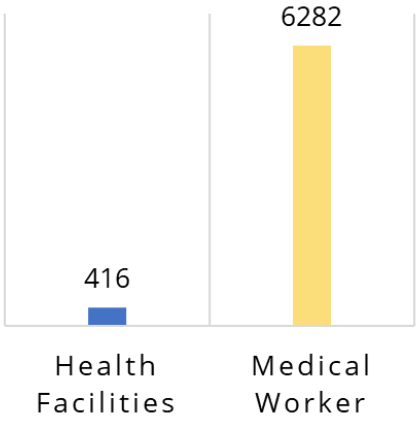
Regarding sanitation, about 90% of sanitation facilities are privately owned. This is an indicator that the majority of people living in Karawang have access to sanitation[240].

**Figure B.41 Public Health Figures in Karawang: (a) Top 5 Diseases, (b) Health Facilities, and (c) Sanitation Facilities**

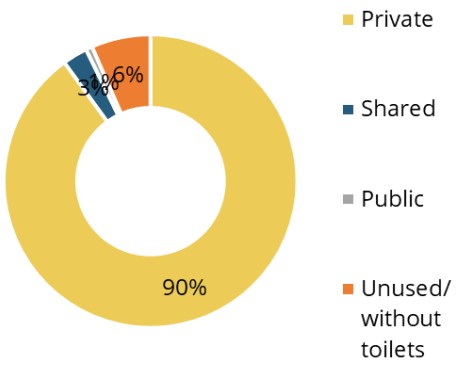
**(a) Top Diseases**




**(b) Health Facilites**




**© Sanitation Facilites**




*Source: BPS Karawang (2025)[240]*

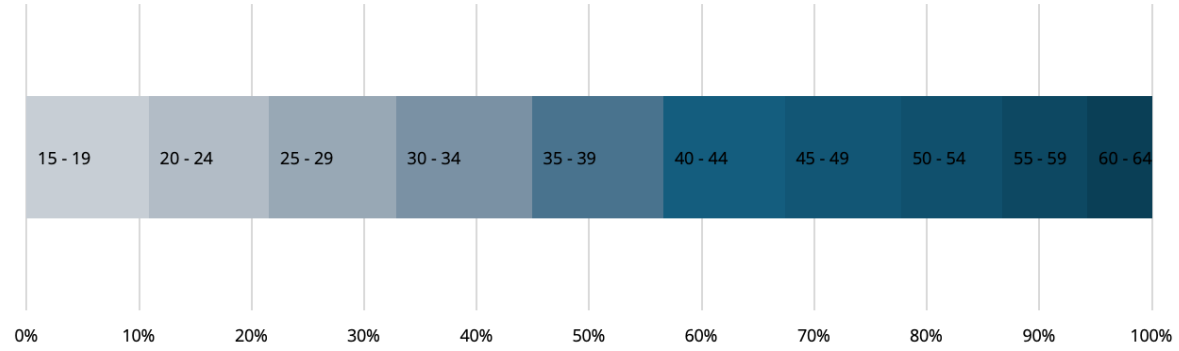
## B.3.8 Livelihood

### Productive Age Group

In general, Karawang sees a large number of people from the younger and productive age group. As shown in **Figure B.42,** the 30-34 age range is the largest group in the region[231], indicating high employment opportunities. The 30-34 age group illustrates the highest percentage (12%). This 12% proportion is also found in the 25-29 age bracket and the 35-39 age bracket. This represents the high number of migrants or fresh graduates seeking opportunities in the region's growing industries.

[240] Badan Pusat Statistik Provinsi Jawa Barat. (2025). Persentase Rumah Tangga Menurut Penggunaan Fasilitas Tempat Buang Air Besar dan Kabupaten/Kota (Persen) 2018-2024. Link

**Figure B.42 Working-Age (15–64) Population in Karawang (%), 2025**

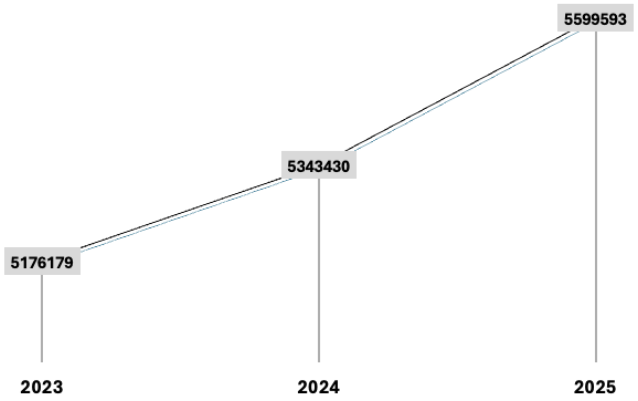



*Source: BPS Karawang (2025)*[231]

## Minimum Regional Wage

The minimum regional salary in Karawang is Rp 5,599,593[241]. Further details on wage developments can be seen in **Figure B.42**

**Figure B.43 Trends in Minimum Regional Wage in Karawang, 2023–2025**



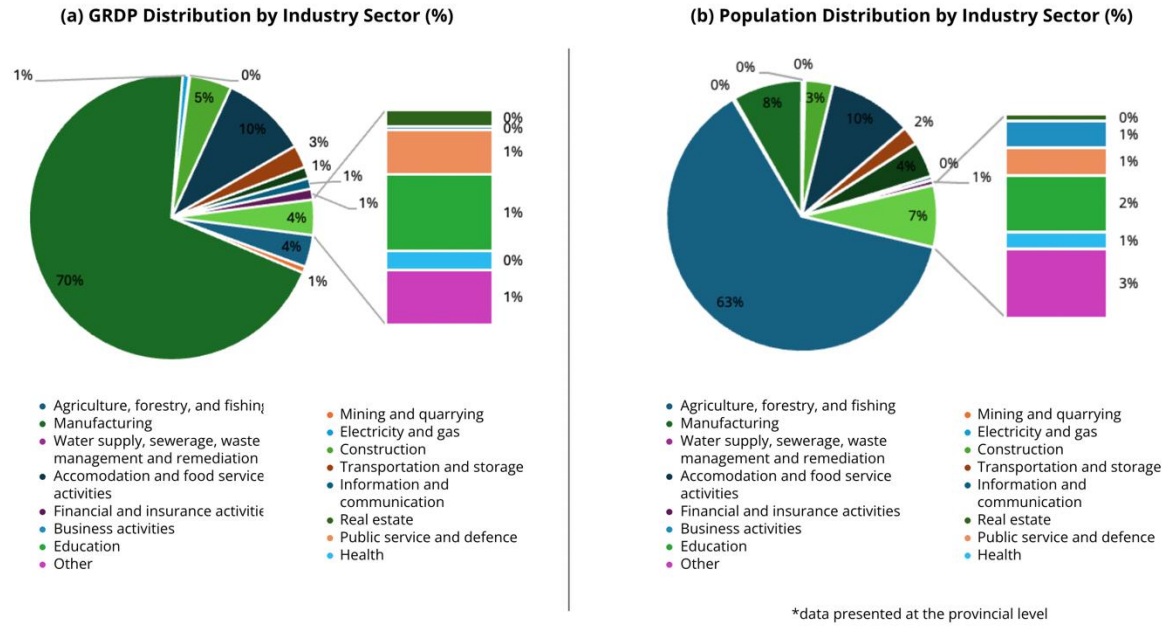

*Source: Money Kompas (2025)*[241]

## GRDP

The economic growth of Karawang Regency has experienced a decline over the past three years, reaching 4.20% in 2024, compared to above 5% in the previous three years. The Gross Regional Domestic Product (GRDP) at current prices is IDR 309.842 billion. The largest contributors to the GRDP are the manufacturing sector (69.91%), followed by wholesale and retail trade (9.81%), and construction (4.77%) (Figure B.44). The presence of the Karawang Industrial Zone has significantly contributed to the region's economy, with over 50% of regional income depending on the manufacturing sector. At the provincial level, the primary livelihood in West Java is dominated by agriculture, forestry, and fishing, accounting for 63%[242]. This is followed by wholesale and retail trade, including automotive repair (10%), and the manufacturing sector (8%).

[241] Money Kompas. (2025). UMK Karawang 2025, Tertinggi Kedua Se-Jawa Barat. Link
[242] Badan Pusat Statistik Provinsi Jawa Barat. (2024). *Provinsi Jawa Barat dalam Angka*. Central Bureau of Statistic of West Java Province. Link

**Figure B.44 GRDP and Population Distribution by Industry Sector (%) in Karawang, 2024**




*Sources: BPS Karawang (2025)*[231]*, Pemprov Jawa Barat (2024)*

## Industrialization and Driving Forces

### *Competitive land and infrastructure costs*

The cost of manufacturing infrastructure in Karawang is significantly lower compared to Jakarta (within 50 km distance) and the nearby industrial city of Bekasi (within 35 km distance)[243]. This cost advantage is one of the key reasons the area has been developed into an industrial hub. Karawang also offers lower population density and greater spatial flexibility, which is particularly important for industries that require large-scale facilities, such as automotive assembly plants. The industrial zones in Karawang have been developed with well-planned infrastructure that connects industries and links them directly to the automotive market.[244]

### *Labor availability*

As an industrial city with a highly strategic geographic location near Jakarta, Karawang Regency has a large and readily available labor force. This is driven by the presence of numerous industrial zones and foreign direct investments (FDI) in the region, which have created a significant number of job opportunities. In 2024, the regency recorded a Labor Force Participation Rate (LFPR) of 63.67%.[245] This situation benefits companies, as the high proportion of the working-age population and abundant human resources make it easier for global companies to recruit labor.

As an extension of the Greater Jakarta business hub, Karawang continues to attract job seekers from across Indonesia. The relatively high regional minimum wage further strengthens the labor ecosystem by drawing workers with diverse backgrounds and skill sets. This dynamic is also supported by local government policies—Karawang's regent

[243] Environmental Justice Atlas. (n.d.). *Karawang Airport and Cilamaya Seaport on North Coast of Java, Indonesia.* Link
[244] PwC Indonesia. (2016, March). *Pembangkit Terintegrasi: Manfaat Ekonomi Captive Power di Kawasan Industri di Indonesia*. Link
[245] Badan Pusat Statistik Kabupaten Karawang. (2025). *Kabupaten Karawang dalam angka 2025*. Link

has actively encouraged companies to submit their labor needs to the Karawang Manpower and Transmigration Office for proper listing and public dissemination of job openings.[246]

The manufacturing industry, which is the most significant contributor to Karawang's GDP[247], requires a wide range of workers, often with low initial skill levels. This has created strong interest among job seekers. Many companies offer internal training and skill development programs, making job entry requirements more accessible for the general population. The combination of a large available workforce, corporate training programs, and support from national initiatives positions Karawang as a highly competitive area in terms of labor readiness, supporting efficient recruitment and sustainable business operations.

***Industrial clustering***

Economic agglomeration in Karawang is firmly established, with various companies from different industries investing in multiple industrial zones across the region. There are approximately 13 industrial estates in total, with the largest ones being Karawang International Industrial City (KIIC), Karawang New Industry City (KNIC), Suryacipta City of Industry, and Sinar Primera Industrial Karawang Eco-City (SPIKE). The industrial sector is dominated by the automotive/motor sector, followed by daily products/chemicals/textiles and electronics/machinery.[248] [249]

In the battery supply chain, KIIC, KNIC, and Suryacipta have become industrial zones with relatively complete supply chain networks. There are companies such as PT HLI Green Power (Korea), Hyundai (Korea), and KIA Corporation (Korea) in KNIC. Meanwhile, Suryacipta hosts BYD Company (China) and TVS Motor Company (India). In KIIC, there are Toyota (Japan) and Daihatsu (Japan). These supply chain companies operate in close proximity, allowing for tight interactions between automotive manufacturing and electric vehicle (EV) battery production. Moreover, these companies utilize electricity from the same green energy provider, supporting the creation of a vertically integrated supply chain that allows them to achieve a larger production scale.

## B.3.9 Workers

**Workplace Accidents**

The only available data is at the provincial level. Based on available data, West Java recorded a total of 79,768 workplace accident cases, distributed across several segments (**Table B.10**). The majority occurred among wage earners, with 74,207 cases.

[246] Antara News, *"Many Factories in Karawang Do Not Inform Job Vacancies to the Manpower and Transmigration Office," May 10, 2025.* Link

[247] Governor of West Java. *Decree No. 561.7/Kep.798-Kesra/2024 on the Minimum Wage for Regencies/Municipalities in West Java Province for the Year 2025*. Issued on December 17, 2024. Link

[248] KF Map. "Karawang New Industry City. Link

[249] Karawang International Industrial City (KIIC), *Tenant Information.* Link

**Table B.10 Workplace Accidents in West Java, 2024**

| Province | Segment | | | Total |
|---|---|---|---|---|
| | Wage Recipients | Non-Wage Recipients | Construction Services | |
| West Java | 74,207 | 5000 | 561 | 79,768 |

*Source: BPJS Ketengakerjaan*[250]

## B.3.10 Vulnerable Groups

### Women and Children's Violence

Among vulnerable groups in Karawang, children and women are the most affected by violence. During 2024, a total of 147 cases involving these groups were recorded. **Table B.11** an overview of the number of victims and the types of violence experienced.

**Table B.11 Number of Women and Children's Violence in Karawang, 2024**

| Category | Type of Violence | Number |
|---|---|---|
| Girls | Sexual Violence | 35 |
| | Physical Violence | 3 |
| | Neglect | 3 |
| | Human Trafficking | 1 |
| | Others | 16 |
| | Total | 58 |
| Adult Women | Total | 53 |
| Boys | Total | 30 |
| Adult Men | Total | 6 |
| **Overall Total** | | **147** |

*Source: Merdeka (2025)*[251]

### Disability Groups

Based on BPS 2022 data, from the total population of Karawang, it is estimated and recorded that there are 291 people with disabilities (**Table B.12**).

**Table B.12 Number of People with Disability in Karawang, 2022**

| Regency/city | Number |
|---|---|
| Karawang | 291 |

*Source: BPS West Java (2022)*[252]

### Indigenous People

No indigenous lands in Karawang are listed in BWRA[253].

[250] BPJS Ketenagakerjaan. Link
[251] Merdeka (2025). Link
[252] BPS West Java (2022). Link
[253] BWRA. (2025). *Peta Wilayah Adat.* Link

## B.4 Raw Data

**Table B.13 Morowali atmospheric data, 2024**

| Month | Temperature (°C) | Humidity (%) | Number of Precipitation (mm/month) |
|---|---|---|---|
| January | 27.10 | 84.70 | 56.90 |
| February | 27.00 | 86.40 | 198.80 |
| March | 27.40 | 84.20 | 117.20 |
| April | 27.70 | 84.50 | 189.10 |
| May | 27.80 | 84.60 | 200.20 |
| June | 27.70 | 83.40 | 276.90 |
| July | 28.00 | 79.10 | 93.60 |
| August | 28.50 | 73.40 | 209.60 |
| September | 28.50 | 70.70 | 108.80 |
| October | 28.10 | 78.40 | 226.70 |
| November | 28.30 | 81.60 | 123.70 |
| December | 28.00 | 83.60 | 355.70 |

Source: BPS Morowali (2024)[171]

**Table B.14 Natural disasters in Morowali, 2024**

| Subdistrict | Flood | Earthquake | Landslide |
|---|---|---|---|
| Menui Kepulauan | | | |
| Bungku Selatan | | | |
| Bahodopi | 1 | | |
| Bungku Pesisir | 2 | 1 | 2 |
| Bungku Tengah | 8 | 2 | |
| Bungku Timur | 1 | | |
| Bungku Barat | 3 | | |
| Bumi Raya | | | |
| Witaponda | 3 | 1 | |
| **Total** | **18** | **4** | **2** |

Source: BPS Morowali (2024)[171]

**Table B.15 Ambient air quality in Keurea District**, 2024

| Parameters | Value (µg/m³) | Standard (µg/m³) |
|---|---|---|
| $PM_{2.5}$ | 17 | 55 |
| $PM_{10}$ | 8 | 75 |
| $SO_2$ | 0 | 150 |
| $NO_2$ | 1 | 200 |
| $O_3$ | 11 | 150 |
| CO | 1 | 1,000 |

Source: Accuweather (2024)

**Table B.16 Surface water quality in Ungkaya River, 2025**

| Parameters | Value | Standard |
|---|---|---|
| $NH_3$ | 1 | 0 ≤ PI ≤ 1.0 comply/standard<br>1.0 ≤ PI ≤ 5.0 lightly polluted<br>5.0 ≤ PI ≤ 10.0 moderately pollute<br>PI ≥ 10.0 heavily polluted |
| BOD | 2.67 | |
| COD | 0.98 | |
| DO | 0.02 | |
| $NO_3^-$ | 0.02 | |
| pH | 0.95 | |
| TDS | 0.08 | |
| TSS | 1.03 | |

PI = Pollution Index
Source: PPKL MenLHK (2025) with quality standard from the Minister of Environment and Forestry Regulation No. 27/2021, Appendix I - Water Quality Index

**Table B.17 Marine water quality of Jetty Siumbatu,** 2024

| Parameters | Value Station 1 (mg/L) | Value Station 2 (mg/L) | Standard (mg/L)* |
|---|---|---|---|
| pH | 8.19 | 8.18 | 6.5 – 8.5 |
| TSS | 38 | 26 | 80 |
| $Cr^{6+}$ | <0.001 | <0.001 | - |

*Government Regulation No. 22/2021
Source: Siharis et al. (2024)

**Table B.18 Sediment quality** near IMIP, 2024

| Parameters | Standard* | Port Area | Residential Area | Mangrove Ecosystem |
|---|---|---|---|---|
| **Ni (µg/g)** | 300 | 778.84 | 1,110.00 | 1,563.56 |
| **Fe (µg/g)** | 40,000 | 17,493.83 | 22,466.89 | 28,779.76 |

*IADC/CEDA 1997 – standard (max) for Ni = 300 µg/g ; standard (max) for Fe = 40,000 µg/g
Source: Lestari et al. (2024)

**Table B.19 Population by age group and sex in Morowali**, 2024

| Age Group | Male | Female | Total |
|---|---|---|---|
| **0 - 4** | 10,243 | 9,486 | 19,729 |
| **5 - 9** | 9,554 | 9,034 | 18,588 |
| **10 - 14** | 8,497 | 7,928 | 16,425 |
| **15 - 19** | 7,372 | 6,506 | 13,878 |
| **20 - 24** | 12,000 | 9,056 | 21,056 |
| **25 - 29** | 13,776 | 10,479 | 24,255 |
| **30 - 34** | 10,357 | 8,534 | 18,891 |
| **35 - 39** | 8,540 | 7,218 | 15,758 |
| **40 - 44** | 7,025 | 6,183 | 13,208 |
| **45 - 49** | 5,389 | 4,944 | 10,333 |
| **50 - 54** | 4,356 | 3,967 | 8,323 |
| **55 - 59** | 3,324 | 3,095 | 6,419 |
| **60 - 64** | 2,362 | 2,197 | 4,559 |
| **65 - 69** | 1,591 | 1,581 | 3,172 |

| Age Group | Male | Female | Total |
|---|---|---|---|
| **70 - 74** | 1,125 | 1,028 | 2,153 |
| **75+** | 1,079 | 1,142 | 2,221 |
| **Total** | **10,6590** | **92,378** | **19,8968** |

*Source: BPS Morowali (2024)*[171]

**Table B.20 Top diseases in Morowali**, 2024

| Diseases | Cases |
|---|---|
| Hypertension | 15,697 |
| Gastritis | 7,255 |
| Diabetes Mellitus | 6,082 |
| Pharyngitis | 3,447 |
| Influenza | 2,940 |

*Source: BPS Morowali (2024)*[171]

**Table B.21 Health facilities in Morowali**, 2024

| Subdistrict | Hospital | Polyclinic | Public Health Center | Subsidiary of Public Health Center | Pharmacy |
|---|---|---|---|---|---|
| Menui Kepulauan | | | 1 | 7 | |
| Bungku Selatan | 2 | | 1 | 4 | |
| Bahodopi | | 1 | 3 | 2 | 8 |
| Bungku Pesisir | | | 1 | 3 | |
| Bungku Tengah | 1 | 5 | 1 | 1 | 9 |
| Bungku Timur | | | 1 | 1 | 1 |
| Bungku Barat | | | 1 | 3 | |
| Bumi Raya | | | 1 | 2 | 4 |
| Witaponda | | 2 | 1 | 3 | 3 |
| **Total** | **3** | **8** | **11** | **26** | **25** |

*Source: BPS Morowali (2024)*[171]

**Table B.22 Medical Workers in Morowali**, 2024

| Subdistrict | Doctor | Dentist | Nurse | Midwife | Pharmacist | Environmental Health Worker | Nutritionist | Laboratory Technician |
|---|---|---|---|---|---|---|---|---|
| Menui Kepulauan | 1 | 1 | 15 | 35 | 2 | 2 | 3 | 1 |
| Bungku Selatan | 1 | 1 | 16 | 53 | 2 | 1 | 1 | 1 |
| Bahodopi | 3 | 1 | 35 | 59 | 6 | | | 2 |
| Bungku Pesisir | 1 | | 22 | 33 | 3 | | 5 | 4 |
| Bungku Tengah | 4 | 1 | 19 | 50 | 7 | | 4 | 3 |
| Bungku Timur | 2 | 1 | 25 | 35 | 7 | | 1 | 1 |
| Bungku Barat | 3 | | 18 | 40 | 3 | | | 2 |
| Bumi Raya | 3 | 1 | 19 | 39 | 5 | | 3 | 3 |
| Witaponda | 3 | 1 | 25 | 28 | 6 | 1 | 1 | 3 |
| **Total** | **21** | **7** | **194** | **372** | **41** | **4** | **18** | **20** |

*Source: BPS Morowali (2024)*[171]

**Table B.23 Sanitation facilities in Morowali**, 2024

| Category | Percentage (%) |
|---|---|
| Private | 85.89 |
| Shared | 5.40 |
| Public | 2.77 |
| Unused | 0.12 |
| Without toilets | 5.82 |

*Source: BPS Morowali (2024)*

**Table B.24 GRDP in Morowali**, 2024

| Code | Sector | Percentage (%) |
|---|---|---|
| A | Agriculture, forestry, and fishing | 1.55% |
| B | Mining and quarrying | 16.80% |
| C | Manufacturing | 73.60% |
| D | Electricity and gas | 0.00% |
| E | Waster supply, sewerage, waste management and remediation | 0.00% |
| F | Construction | 5.23% |
| G | Wholesale and retail trade ; repair of vehicle | 1.39% |
| H | Transportation and storage | 0.44% |
| I | Accomodation and food service activities | 0.03% |
| J | Information and communication | 0.21% |
| K | Financial and insurance activities | 0.15% |
| L | Real estate | 0.18% |

| Code | Sector | Percentage (%) |
|---|---|---|
| M, N | Business activities | 0.00% |
| O | Pubic service and defence | 0.18% |
| P | Education | 0.09% |
| Q | Health and social | 0.07% |
| R, S, T, U | Others | 0.08% |

*Source: BPS Morowali (2024)*[171]

**Table B.25 Population distribution by industry sector** in Central Sulawesi, 2024

| Code | Sector | Total | Percentage (%) |
|---|---|---|---|
| A | Agriculture, forestry, and fishing | 627,840 | 40.58 |
| B | Mining and quarrying | 32,632 | 2.11 |
| C | Manufacturing | 134,905 | 8.72 |
| D | Electricity and gas | 5,382 | 0.35 |
| E | Water supply, sewerage, waste management and remediation | 2,257 | 0.15 |
| F | Construction | 81,465 | 5.27 |
| G | Wholesale and retail trade ; repair of vehicle | 228,242 | 14.75 |
| H | Transportation and storage | 42,778 | 2.76 |
| I | Accomodation and food service activities | 82,674 | 5.34 |
| J | Information and communication | 5,884 | 0.38 |
| K | Financial and insurance activities | 11,332 | 0.73 |
| L | Real estate | 338 | 0.02 |
| M, N | Business activities | 13,036 | 0.84 |
| O | Public service and defence | 119,285 | 7.71 |
| P | Education | 81,256 | 5.25 |
| Q | Health and social | 29,314 | 1.89 |
| R, S, T, U | Others | 48,549 | 3.14 |

*Source: BPS Morowali (2024)*[171]

**Table B.26 Central Halmahera atmospheric data, 2025**

| Month | Temperature (°C) | Number of Precipitation (mm/month) |
|---|---|---|
| January | 27 | 5538 |
| February | 27.2 | 3491 |
| March | 27.2 | 4729.7 |
| April | 27.4 | 5662.7 |
| May | 27.3 | 5441.7 |
| June | 26.5 | 5682.2 |
| July | 26 | 5941.4 |
| August | 26.2 | 3509.4 |
| September | 26.5 | 3868.1 |
| October | 27.2 | 3763.9 |

| Month | Temperature (°C) | Number of Precipitation (mm/month) |
|---|---|---|
| November | 27.5 | 4030.5 |
| December | 27.2 | 5414.1 |

Source: BPS Central Halmahera (2025)

**Table B.27 Natural disaster in** Central Halmahera, 2025

| Subdistrict | Flood | Earthquake | Landslide |
|---|---|---|---|
| Weda | 1 | | 1 |
| Weda Selatan | 4 | 3 | |
| Weda Utara | 3 | | |
| Weda Tengah | 4 | | |
| Weda Timur | 3 | | 2 |
| Puau Gebe | | | |
| Patani | 3 | | 2 |
| Patani Utara | | | |
| Patani Barat | | | |
| Patani Timur | | | |
| **Total** | **18** | **3** | **5** |

Source: BPS Central Halmahera (2024)

**Table B.28 Ambient air quality in** Lelilef Sawai District, 2024

| Parameters | Value (µg/m³) | Standard (µg/m³) |
|---|---|---|
| $PM_{2.5}$ | 11 | 55 |
| $PM_{10}$ | 6 | 75 |
| $SO_2$ | 0 | 150 |
| $NO_2$ | 0 | 200 |
| $O_3$ | 11 | 150 |
| CO | 1 | 1,000 |

Source: Accuweather (2024)

**Table B.29 Surface water quality in selected river**s in Central Halmahera, 2023

| River | pH | TDS (mg/L) | $Cr^{6+}$ (mg/L) |
|---|---|---|---|
| Kobe | 8.39 | 108 | 0.010 |
| Ake Doma | 8.57 | 288 | 0.003 |
| Wosea | 9.14 | 235 | 0.017 |
| Wosea | 9.16 | 171 | 0.016 |
| Woyelo | 8.42 | 114 | 0.007 |
| Danah Sagea Waterfal | 9.14 | 173 | 0.004 |
| Yonelo | 8.44 | 9,175 | <0.05 |
| Yonelo | 8.69 | 9,625 | <0.05 |
| Goa Boki Maruru | 8.26 | 1,486 | 0.002 |

Quality Standard based on Government Regulation No. 22/2021 – class 2 river (pH = 6-9 ; TDS = 1000 mg/L ; Cr6+ = 0.05 mg/L)
Source: AEER (2023)

**Table B.30 Marine water quality in selected estuaries in Central Halmahera**, 2023

| Location | pH | $Cr^{6+}$ (mg/L) |
|---|---|---|
| Batepo, Gemaf Village | 8.62 | 0.005 |
| Lolaro, Gemaf Village | 8.28 | 0 |
| Estuary Ake Sake River | 8.39 | 0.001 |
| Estuary wastewater disposal | 8.60 | 0.024 |
| Estuary wastewater disposal | 8.60 | 0.009 |
| Port Area | 8.71 | 0.001 |
| Tanjung Ulie | 8.64 | 0.003 |
| Estuary Wosea River | 8.69 | 0 |
| Estuary Ake Doma River | 8.62 | 0.015 |

Quality Standard based on Government Regulation No. 22/2021 – marine water quality for aquatic biota (pH = 7.0-8.5 ; $Cr^{6+}$ = 0.005 mg/L)
Source: AEER (2023)

**Table B.31 Population by age group and sex in** Central Halmahera, 2025

| Age Group | Male | Female | Total |
|---|---|---|---|
| 0 - 4 | 3,170 | 2,823 | 5,993 |
| 5 - 9 | 4,032 | 3,821 | 7,853 |
| 10 - 14 | 3,776 | 3,457 | 7,233 |
| 15 - 19 | 4,972 | 2,639 | 7,611 |
| 20 - 24 | 16,288 | 4,856 | 21,144 |
| 25 - 29 | 13,065 | 5,462 | 18,527 |
| 30 - 34 | 7,205 | 3,847 | 11,052 |
| 35 - 39 | 4,618 | 2,932 | 7,550 |
| 40 - 44 | 3,138 | 2,511 | 5,649 |
| 45 - 49 | 2,172 | 1,992 | 4,164 |
| 50 - 54 | 1,510 | 1,411 | 2,921 |
| 55 - 59 | 1,164 | 1,119 | 2,283 |

| Age Group | Male | Female | Total |
|---|---|---|---|
| 60 - 64 | 919 | 791 | 1,710 |
| 65 - 69 | 658 | 553 | 1,211 |
| 70 - 74 | 450 | 406 | 856 |
| 75+ | 363 | 380 | 743 |
| **Total** | **67,500** | **39,000** | **106,500** |

Source: BPS Central Halmahera (2024)

**Table B.32 Top diseases in** Central Halmahera, 2024

| Diseases | Cases |
|---|---|
| Acute Respiratory Infection | 6,945 |
| Common Cold | 3,955 |
| Myalgia | 3,477 |
| Dyspepsia | 2,928 |
| Hypertension | 1,996 |

Source: BPS Central Halmahera (2024)

**Table B.33 Health facilities in** Central Halmahera, 2024

| Subdistrict | Hospital | Polyclinic | Public Health Center | Subsidiary of Public Health Center | Pharmacy |
|---|---|---|---|---|---|
| Weda | 1 | | 1 | 2 | 2 |
| Weda Selatan | | | 1 | 6 | |
| Weda Utara | | | 1 | 5 | |
| Weda Tengah | | | 2 | 6 | |
| Weda Timur | | | | 2 | |
| Pulau Gebe | | 1 | 1 | 6 | |
| Patani | | | 1 | 2 | |
| Patani Utara | | | 1 | 2 | 1 |
| Patani Barat | | | 1 | 3 | |
| Patani Timur | | | 1 | 5 | |
| **Total** | **1** | **1** | **10** | **39** | **3** |

Source: BPS Central Halmahera (2024)

**Table B.34 Medical Workers in Central Halmahera**, 2024

| Subdistrict | Doctor | Nurse | Midwife | Pharmacist | Public Health Worker | Environmental Health Worker | Nutritionist | Laboratory Technician |
|---|---|---|---|---|---|---|---|---|
| Weda | 22 | 121 | 92 | 25 | 54 | 4 | 31 | 1 |
| Weda Selatan | 4 | 17 | 18 | 4 | 6 | 3 | 2 | |
| Weda Utara | 3 | 12 | 10 | 2 | 2 | 1 | 2 | |
| Weda Tengah | 5 | 24 | 26 | 4 | 2 | 3 | 2 | |
| Weda Timur | 3 | 11 | 16 | 3 | 5 | 2 | 4 | |
| Pulau Gebe | 3 | 26 | 14 | 3 | 6 | 2 | 3 | |
| Patani | 2 | 14 | 8 | 1 | 10 | 1 | 2 | |
| Patani Utara | 4 | 24 | 35 | 5 | 22 | 3 | 2 | |
| Patani Barat | 3 | 17 | 24 | 2 | 5 | 1 | 5 | |
| Patani Timur | 2 | 14 | 18 | 1 | 10 | 1 | 3 | |
| **Total** | **51** | **280** | **261** | **50** | **122** | **21** | **56** | **1** |

Source: BPS Central Halmahera (2024)

**Table B.35 Sanitation facilities in** Central Halmahera, 2024

| Category | Percentage (%) |
|---|---|
| Private | 85.71 |
| Shared | 6.82 |
| Public | 5.86 |
| Without toilets | 1.61 |

Source: BPS Central Halmahera (2024)

**Table B.36 GRDP in** Central Halmahera, 2024

| Code | Sector | Percentage (%) |
|---|---|---|
| A | Agriculture, forestry, and fishing | 2.07% |
| B | Mining and quarrying | 30.25% |
| C | Manufacturing | 60.14% |
| D | Electricity and gas | 0.01% |
| E | Water supply, sewerage, waste management and remediation | 0.00% |
| F | Construction | 1.84% |
| G | Wholesale and retail trade ; repair of vehicle | 2.54% |
| H | Transportation and storage | 0.30% |
| I | Accomodation and food service activities | 0.03% |
| J | Information and communication | 0.22% |
| K | Financial and insurance activities | 0.30% |

| Code | Sector | Percentage (%) |
|---|---|---|
| L | Real estate | 0.00% |
| M, N | Business activities | 0.00% |
| O | Pubic service and defence | 1.89% |
| P | Education | 0.21% |
| Q | Health and social | 0.16% |
| R, S, T, U | Others | 0.04% |

Source: BPS Central Halmahera (2024)

**Table B.37 Population distribution by industry sector** at North Maluku, 2024

| Sector | Percentage (%) |
|---|---|
| Agriculture | 25.62 |
| Processing industries | 24.66 |
| Trade | 12.09 |
| Administration and public services | 9.41 |
| Education | 6.37 |
| Transportation, information & communication | 4.71 |
| Construction | 4.18 |
| Accomodation and food service activities | 3.39 |
| Health | 2.61 |
| Mining and quarrying | 2.42 |
| Others | 2.27 |
| Financial, real estate & company services | 1.48 |
| Electricity and gas | 0.79 |
| Agriculture | 25.62 |

Source: Pemprov Maluku Utara (2024)

**Table B.38 Karawang atmospheric data**, 2024

| Month | Temperature (°C) | Humidity (%) | Number of Precipitation (mm/month) |
|---|---|---|---|
| January | 24.00 | 75.70 | 69.80 |
| February | 23.10 | 80.00 | 111.10 |
| March | 23.60 | 80.00 | 219.90 |
| April | 24.10 | 79.70 | 275.50 |
| May | 24.60 | 77.30 | 268.50 |
| June | 24.10 | 77.50 | 85.20 |
| July | 23.70 | 72.30 | 24.00 |
| August | 23.80 | 70.50 | 30.20 |
| September | 24.70 | 64.20 | 18.20 |
| October | 25.50 | 65.10 | 70.80 |
| November | 24.60 | 78.60 | 231.00 |
| December | 24.60 | 78.30 | 366.50 |

Source: BPS Karawang (2024)

**Table B.39 Natural disaster**s in Karawang, 2024

| Subdistrict | Flood | Earthquake | Landslide |
|---|---|---|---|
| Pangkalan | 3 | | |
| Tegalwaru | 2 | | |
| Ciampel | | | 1 |
| Telukjambe Timur | 8 | | 1 |
| Telukjambe Barat | 8 | | 1 |
| Klari | | | |
| Cikampek | 4 | | |
| Purwasari | 1 | | |
| Tirtamulya | 3 | | |
| Jatisari | 1 | | 2 |
| Banyusari | 2 | | |
| Kotabaru | 1 | | |
| Cilamaya Wetan | 10 | | |
| Cilamaya Kulon | 3 | | |
| Lemahabang | 1 | | |
| Telagasari | | | |
| Majalaya | | | |
| Karawang Timur | 1 | | |
| Karawang Barat | 2 | | |
| Rawamerta | 1 | | |
| Tempuran | 1 | | |
| Kutawaluya | 4 | | |
| Rengasdengklok | 6 | | |
| Jayakerta | | | |
| Pedes | 2 | | |
| Cilebar | 9 | | |
| Cibuaya | 4 | | |
| Tirtajaya | 2 | | |
| Batujaya | 1 | | |
| Pakisjaya | | | |
| **Total** | **80** | **0** | **5** |

Source: BPS Karawang (2024)

**Table B.40 Ambient air quality in** Karawang, 2024

| Parameters | Value (µg/m³) | Standard (µg/m³) |
|---|---|---|
| $PM_{2.5}$ | 102 | 55 |
| $PM_{10}$ | 59 | 75 |
| $SO_2$ | 11 | 150 |
| $NO_2$ | 9 | 200 |
| $O_3$ | 16 | 150 |
| CO | 8 | 1,000 |

Source: Accuweather (2024)

**Table B.41 Surface water quality in Citarum River in Karawang, 2025**

| Parameters | Value | Standard |
|---|---|---|
| $NH_3$ | - | 0 ≤ PI ≤ 1.0 comply/standard<br>1.0 ≤ PI ≤ 5.0 lightly polluted<br>5.0 ≤ PI ≤ 10.0 moderately polluted<br>PI ≥ 10.0 heavily polluted |
| BOD | - | |
| COD | - | |
| DO | - | |
| $NO_3^-$ | 0.6 | |
| pH | 2.69 | |
| TDS | - | |
| TSS | - | |

PI = Pollution Index
Source: PPKL MenLHK (2025) with quality standard from Ministrial Regulation of The Minister of Environment and Forestry No. 27/2021, Appendix I - Water Quality Index

**Table B.42 Population by age group and sex in** Karawang, 2024

| Age Group | Male | Female | Total |
|---|---|---|---|
| 0 - 4 | 103,663 | 99,504 | 203,167 |
| 5 - 9 | 98,277 | 93,520 | 191,797 |
| 10 - 14 | 101,965 | 95,456 | 197,421 |
| 15 - 19 | 101,992 | 95,748 | 197,740 |
| 20 - 24 | 99,766 | 94,502 | 194,268 |
| 25 - 29 | 104,312 | 101,205 | 205,517 |
| 30 - 34 | 111,213 | 108,328 | 219,541 |
| 35 - 39 | 108,721 | 103,628 | 212,349 |
| 40 - 44 | 97,389 | 98,849 | 196,238 |
| 45 - 49 | 91,336 | 96,777 | 188,113 |
| 50 - 54 | 79,877 | 83,706 | 163,583 |
| 55 - 59 | 68,616 | 69,061 | 137,677 |
| 60 - 64 | 52,086 | 51,815 | 103,901 |
| 65 - 69 | 38,571 | 37,661 | 76,232 |
| 70 - 74 | 23,921 | 23,647 | 47,568 |
| 75+ | 21,242 | 22,891 | 44,133 |
| **Total** | **1,302,947** | **1,276,298** | **2,579,245** |

Source: BPS Karawang (2024)

**Table B.43 Top** diseases in Karawang, 2024

| Diseases | Cases |
|---|---|
| Acute Respiratory Infection | 117,582 |
| Fever | 72,039 |
| Common Cold | 62,765 |
| Gastric ulcer | 60,207 |
| Gastritis | 58,929 |

Source: BPS Karawang (2024)

**Table B.44 Health facilities in** Karawang, 2024

| Subdistrict | Hospital | Maternity Hospital | Polyclinic | Public Health Center | Subsidiary of Public Health Center | Pharmacy |
|---|---|---|---|---|---|---|
| Pangkalan | | | 5 | 1 | 2 | 3 |
| Tegalwaru | | | 1 | 1 | 1 | 1 |
| Ciampel | | | 3 | 1 | 2 | 2 |
| Telukjambe Timur | 4 | | 9 | 2 | 1 | 9 |
| Telukjambe Barat | | | 4 | 1 | 1 | 3 |
| Klari | 2 | | 10 | 3 | 3 | 9 |
| Cikampek | 3 | 1 | 8 | 1 | | 7 |
| Purwasari | | | 7 | 1 | 2 | 3 |
| Tirtamulya | | | 5 | 1 | 2 | 5 |
| Jatisari | 3 | | 5 | 2 | 2 | 4 |
| Banyusari | | | 2 | 2 | 1 | 4 |
| Kotabaru | 1 | | 8 | 3 | 1 | 8 |
| Cilamaya Wetan | | | 8 | 2 | 2 | 8 |
| Cilamaya Kulon | | | 7 | 2 | 3 | 4 |
| Lemahabang | 1 | | 7 | 1 | 2 | 4 |
| Telagasari | | | 3 | 1 | 3 | 5 |
| Majalaya | | | 4 | 1 | 3 | 4 |
| Karawang Timur | 2 | | 7 | 2 | 2 | 7 |
| Karawang Barat | 3 | | 7 | 6 | 2 | 6 |
| Rawamerta | | | 4 | 2 | 4 | 3 |
| Tempuran | | | 4 | 2 | 3 | 5 |
| Kutawaluya | | | 6 | 2 | 2 | |
| Rengasdengklok | 1 | | 7 | 2 | 1 | 5 |
| Jayakerta | | | 5 | 2 | 1 | 1 |
| Pedes | | | 8 | 2 | 2 | 4 |
| Cilebar | | | 7 | 1 | 1 | 2 |
| Cibuaya | | | 3 | 1 | 2 | 2 |
| Tirtajaya | | | 3 | 1 | 3 | 4 |
| Batujaya | | | 2 | 1 | 2 | 3 |

| Subdistrict | Hospital | Maternity Hospital | Polyclinic | Public Health Center | Subsidiary of Public Health Center | Pharmacy |
|---|---|---|---|---|---|---|
| Pakisjaya | | | 1 | 1 | 1 | 2 |
| **Total** | **20** | **1** | **160** | **51** | **57** | **127** |

Source: BPS Karawang (2024)

**Table B.45 Medical workers in Karawang**, 2024

| Subdistrict | Medical Worker | Nursing Worker | Midwifery Workers | Pharmautical Worker | Pharmautical Technician | Environmental Health Worker | Nutritioist | Physical Therapist | Medical Technicians | Public Health Worker |
|---|---|---|---|---|---|---|---|---|---|---|
| Pangkalan | 4 | 16 | 18 | | 1 | 1 | | 1 | 1 | |
| Tegalwaru | 4 | 10 | 28 | | 1 | 1 | 1 | 1 | 1 | |
| Ciampel | 3 | 8 | 20 | | 2 | 1 | 1 | 1 | | 1 |
| Telukjambe Timur | 110 | 801 | 194 | 43 | 89 | 9 | 35 | 15 | 60 | 6 |
| Telukjambe Barat | 5 | 8 | 28 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Klari | 37 | 319 | 136 | 8 | 24 | 2 | 6 | 10 | 14 | 2 |
| Cikampek | 47 | 227 | 113 | 13 | 17 | 2 | 7 | 17 | 19 | 2 |
| Purwasari | 3 | 9 | 17 | 1 | | 1 | 1 | | | |
| Tirtamulya | 2 | 10 | 18 | | | 1 | 2 | 1 | 1 | 1 |
| Jatisari | 38 | 310 | 75 | 10 | 27 | 3 | 6 | 10 | 22 | 7 |
| Banyusari | 7 | 19 | 34 | | | 1 | 1 | | 1 | 2 |
| Kotabaru | 32 | 148 | 55 | 5 | 15 | 3 | 7 | 2 | 9 | |
| Cilamaya Wetan | 6 | 16 | 41 | | 1 | 2 | 1 | 1 | 2 | 2 |
| Cilamaya Kulon | 6 | 19 | 41 | | 1 | | 1 | 1 | 1 | |
| Lemahabang | 6 | 48 | 36 | 1 | 5 | 2 | 2 | 1 | 1 | |
| Telagasari | 5 | 10 | 32 | | 1 | 1 | 1 | 1 | 1 | 1 |
| Majalaya | 3 | 5 | 12 | 1 | | 1 | 1 | 1 | 1 | 1 |
| Karawang Timur | 68 | 346 | 89 | 32 | 40 | 5 | 10 | 12 | 38 | 1 |
| Karawang Barat | 84 | 598 | 133 | 24 | 63 | 6 | 15 | 20 | 57 | 7 |
| Rawamerta | 7 | 14 | 32 | 1 | 1 | 2 | 1 | | 1 | 1 |
| Tempuran | 6 | 20 | 30 | 1 | | | | 3 | | 2 |
| Kutawaluya | 9 | 22 | 35 | | 1 | 1 | | 1 | 2 | 1 |
| Rengasdengklok | 20 | 100 | 73 | 4 | 16 | 3 | 5 | 9 | 2 | 3 |
| Jayakerta | 6 | 26 | 28 | 1 | 2 | 1 | 1 | 2 | 2 | 4 |
| Pedes | 7 | 26 | 41 | | | 1 | 1 | | 1 | 1 |
| Cilebar | 2 | 14 | 24 | | | | | 1 | 1 | |
| Cibuaya | 5 | 16 | 24 | | | 1 | | | | |
| Tirtajaya | 2 | 22 | 36 | | 1 | | | 1 | 1 | 1 |

| Subdistrict | Medical Worker | Nursing Worker | Midwifery Workers | Pharmautical Worker | Pharmautical Technician | Environmental Health Worker | Nutritioist | Physical Therapist | Medical Technicians | Public Health Worker |
|---|---|---|---|---|---|---|---|---|---|---|
| Batujaya | 2 | 22 | 34 | 1 | | | 1 | | 1 | |
| Pakisjaya | 2 | 16 | 22 | | | 1 | 1 | 1 | | |
| **Total** | **538** | **3,225** | **1,499** | **147** | **309** | **53** | **109** | **114** | **241** | **47** |

Source: BPS Karawang (2024)

**Table B.46 Sanitation facilities in** Karawang, 2024

| Category | Percentage (%) |
|---|---|
| Private | 89.87 |
| Shared | 2.74 |
| Public | 0.71 |
| Without toilets | 6.52 |

Source: BPS Karawang (2024)

**Table B.47 GRDP in** Karawang, 2024

| Code | Sector | Percentage (%) |
|---|---|---|
| A | Agriculture, forestry, and fishing | 3.62% |
| B | Mining and quarrying | 0.72% |
| C | Manufacturing | 69.91% |
| D | Electricity and gas | 0.73% |
| E | Water supply, sewerage, waste management and remediation | 0.10% |
| F | Construction | 4.77% |
| G | Wholesale and retail trade ; repair of vehicle | 9.81% |
| H | Transportation and storage | 2.58% |
| I | Accomodation and food service activities | 1.32% |
| J | Information and communication | 1.21% |
| K | Financial and insurance activities | 1.23% |
| L | Real estate | 0.31% |
| M, N | Business activities | 0.06% |
| O | Pubic service and defence | 0.83% |
| P | Education | 1.43% |
| Q | Health and social | 0.35% |
| R, S, T, U | Others | 1.02% |

Source: BPS Karawang (2024)

**Table B.48 Population distribution by industry sector** in West Java, 2024

| Sector | Total | Percentage (%) |
|---|---|---|
| Agriculture, forestry, and fishing | 33603172 | 62.81 |
| Mining and quarrying | 121346 | 0.23 |
| Manufacturing | 4439057 | 8.30 |
| Electricity and gas | 69190 | 0.13 |
| Water supply, sewerage, waste management and remediation | 132613 | 0.25 |
| Construction | 1785412 | 3.34 |
| Wholesale and retail trade ; repair of vehicle | 5359329 | 10.02 |
| Transportation and storage | 1187049 | 2.22 |
| Accomodation and food service activities | 2276859 | 4.26 |
| Information and communication | 250391 | 0.47 |
| Financial and insurance activities | 323583 | 0.60 |
| Real estate | 139256 | 0.26 |
| Business activities | 511159 | 0.96 |
| Public service and defence | 539896 | 1.01 |
| Education | 1092869 | 2.04 |
| Human health and social work activities | 333422 | 0.62 |
| Others | 1338995 | 2.50 |

Source: Pemprov Jawa Barat (2024)

# Annex C: Environmental and Social Impact Assessment

**Table D.1 Environmental Impact Assessment: Battery Production**

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Mining** | | | | | | | |
| Pre-construction | Construction of mining facilities (i.e., haul road, office) | Land conversion | Landscape | Negligible (1) | Known to occur (4) | **Low** | Exploration activities can cause land conversion at a limited scale, particularly to build road access and facilities. |
| Pre-construction | Construction of mining facilities (i.e., haul road, office) | Degraded air quality | Air | Negligible (1) | Known to occur (4) | **Low** | Exploration activities can cause degraded air quality at a limited scale. This is usually due to exploration equipment that causes fumes. However, the scale of this activity is typically limited. In addition, exploration activities take place far from human settlement which renders these impacts as negligible. |
| Pre-construction | Construction of mining facilities (i.e., haul road, office) | Noise disruption | Air | Negligible (1) | Known to occur (4) | **Low** | Exploration activities can cause noise disruption at a limited scale. This is usually due to exploration equipment. However, the scale of this activity is typically limited. In addition, exploration activities take place far from human settlement which renders these impacts as negligible. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Massive land conversion | Landscape | Severe (5) | Common occurrence (5) | **High** | Large-scale clearing and grading are required to build mine pits, access roads, stockpile areas, and other facilities. According to data by Nusantara Atlas[86], there are currently 8,867,895 Ha of mining concession area in Indonesia. Deforestation in concessions amounted to 32,376 Ha in 2023 alone, and the forest area in concessions remained at 2,816,032 Ha in 2024. Forest loss in both areas amounted to 1% and 2% of total forest areas, respectively. Although the impact on land cover is comparatively medium against the total forest area in both regions, land conversion leads to the loss of vegetation, natural habitats, loss of carbon storage, and other impacts. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of mining facilities (i.e., haul road, office) | Significant change of landscape and morphology | Landscape | Severe (5) | Common occurrence (5) | **High** | Mining and construction often result in significant changes to the landscape and its morphology. Land clearing and excavation cause permanent changes to natural contours. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Degraded soil quality | Soil | Medium (3) | Common occurrence (5) | **Substantial** | Construction activities can negatively impact soil quality through land clearing, excavation, and the use of heavy machinery. These actions may lead to soil compaction, erosion, and loss of topsoil, reducing soil fertility and its ability to support vegetation. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Increased probability of soil erosion and landslide | Soil | Severe (5) | Likely (3) | **High** | Vegetation removal, slope cutting, and ground disturbance during construction can destabilize the land, especially in hilly or high-rainfall areas. Without proper control measures, these activities increase the risk of soil erosion and landslides. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Degraded air quality | Air | Minor (2) | Known to occur (4) | **Moderate** | Construction activities generate dust through land clearing, excavation, and the movement of heavy machinery. Emissions from construction equipment and vehicles also contribute to air pollution. That said, the impact of such activities is generally localized within mining concessions that are often away from nearby communities. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Noise disruption | Air | Minor (2) | Known to occur (4) | **Moderate** | Noise is generated during construction from the operation of heavy machinery such as excavators and bulldozers. Additionally, the constant movement of trucks and other vehicles carrying materials contributes to a continuous background noise throughout the site. That said, the impact of such activities is generally localized within mining concessions that are often away from nearby communities. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Disrupted surface water quality & quantity | Water | Major (4) | Common occurrence (5) | **High** | Land clearing for construction will cause increased surface water runoffs. Surface water runoffs usually carry total suspended solids (TSS) from eroded soil particles, causing sedimentation in nearby water bodies. Additionally, vegetation removal can reduce the land's ability to retain water. |
| Construction | Construction of mining facilities | Disrupted groundwater quality & quantity | Water | Major (4) | Common occurrence (5) | **High** | Land clearing can impact groundwater quality by disrupting the groundwater reservoir and altering its chemistry. The removal of vegetation and alteration of land surfaces limit water absorption, |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | (i.e., haul road, office) | | | | | | resulting in reduced groundwater recharge in the long term. Altered groundwater chemistry usually results from the weathering or leaching of exposed soil chemistry from land clearing[254]. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Terrestrial biodiversity degradation | Biodiversity | Major (4) | Common occurrence (5) | **High** | Land clearing for construction will harm terrestrial biodiversity. Massive tree loss can lead to the degradation of natural habitats (e.g., habitat encroachment and fragmentation), which in turn impacts terrestrial diversity. Additionally, the disruption of natural ecosystems can lead to the proliferation of invasive species, which can outcompete native species and alter native diversity[255]. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Aquatic biodiversity degradation | Biodiversity | Major (4) | Common occurrence (5) | **High** | Increased sedimentation and altered surface water chemistry can harm aquatic biodiversity. This condition will render the aquatic ecosystem unsuitable for several freshwater species, thereby reducing the number of species that can survive in water. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Decline in ecosystem services | Biodiversity | Major (4) | Common occurrence (5 ) | **High** | Disrupted natural ecosystems will lead to the decline of ecosystem services. Altered landscapes, vegetation loss, and poor water quality reduce the ecosystem's natural functions such as food provision, water retention and filtration, and eventually the loss of livelihoods[213] |
| Construction | Construction of mining facilities (i.e., haul road, office) | Solid waste generation | Waste generation | Minor (2) | Common occurrence (5) | **Moderate** | Mining typically generates a significant amount of solid waste from excavation. The land area and volume of soil are usually identified and mitigated in the mine plan. During the construction phase, excavated soil is typically stored for later backfilling. That said, the temporary storage for soil dumping requires proper management as it is prone to oxidation and rainfall, which can lead to surface water degradation. AEER[213] reported such an occurrence in Halmahera. |

[254] Abanyie, S.K. *et al*. (2023). (Link)
[255] Kompas. Com. https://www.kompas.id/artikel/flora-dan-fauna-pulau-wawonii-terancam-tambang-nikel

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of mining facilities (i.e., haul road, office) | Wastewater generation | Waste generation | Major (4) | Common occurrence (5) | **High** | Construction of mining facilities typically generates wastewater from construction activities (i.e., land clearing) and base camp facilities. As it occurs still in the construction phase, the mitigation measures are usually not yet in place, resulting in wastewater being more prone to being released to open waters. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Increased CO2 emissions | Carbon emissions | Severe (5) | Common occurrence (5) | **High** | Land clearing linked to mining can increase CO2 emissions. For this parameter, an analysis is essential in Morowali and Halmahera, where mining is expected to be most prominent in response to the battery industry. Using 2023 forest loss data from Global Forest Watch[209] the forest loss in Morowali and Central Halmahera contributes to an estimate of 786.9 t CO2/Ha and 866.7 t CO2/Ha, respectively. This indicates that these forests serve as a significant carbon storage in pre-mining conditions, and their loss has a substantial impact on increased CO2 emissions. |
| Operation | Mining operation | Massive land conversion | Landscape | Severe (5) | Common occurrence (5) | **High** | Just as in construction, operational mining will result in further land clearing and grading for the duration of the Life of Mine, leading to the loss of vegetation, topsoil, and natural habitats. According to data by Nusantara Atlas[86] , there are currently 8,867,895 Ha of mining concession area in Indonesia. Deforestation in concessions amounted to 32,376 Ha in 2023 alone, and the forest area in concessions remained at 2,816,032 Ha in 2024. Forest loss in both areas amounted to 1% and 2% of total forest areas, respectively. Although the impact on land cover is comparatively medium against the total forest area in both regions, land conversion leads to the loss of vegetation, natural habitats, loss of carbon storage, and other impacts. |
| Operation | Mining operation | Significant change of landscape and morphology | Landscape | Severe (5) | Common occurrence (5) | **High** | Mining operations can cause significant changes to the landscape due to large-scale excavation, stockpiling, and waste disposal activities. Open-pit mining, commonly used in nickel extraction, removes vast areas of vegetation and topsoil, altering the natural contours and landforms. Over time, this transformation can lead to permanent changes in visual impacts and challenges for land rehabilitation if not managed properly. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Operation | Mining operation | Decreased soil quality | Soil | Major (4) | Common occurrence (5) | **High** | Mining activities can negatively impact soil quality through land clearing, excavation, and heavy machinery use. These actions may remove topsoil in a wider area, making it unable to support vegetation. |
| Operation | Mining operation | Increased probability of soil erosion and landslide | Soil | Severe (5) | Not expected to occur (2) | **Substantial** | Mining operations, particularly in steep and high-rainfall areas, increase the risk of soil erosion and landslides due to the removal of vegetation, loss of topsoil, and ground disturbance caused by heavy machinery. Instances where this has caused casualties have been reported in certain mining companies[256]. |
| Operation | Mining operation | Degraded air quality | Air | Minor (2) | Known to occur (4) | **Moderate** | Mining activities have reportedly contributed to air pollution through the generation of dust from mining operations and the use of heavy machinery[257]. However, the impact of such activities is generally localized within mining concessions that are often away from nearby communities. |
| Operation | Mining operation | Noise disruption | Air | Minor (2) | Known to occur (4) | **Moderate** | Noise is generated during the operation phase from heavy machinery such as excavators and bulldozers. Scheduled regular blasting also contributes to noise pollution. That said, the impact of such activities is generally localized within mining concessions, which are often located away from nearby communities. |
| Operation | Mining operation | Disrupted surface water quality & quantity | Water | Major (4) | Not expected to occur (2) | **Moderate** | Mining operation will disrupt the surface water. Mining wastewater typically contains total suspended solids (TSS) and oxidized heavy metals, such as Cr6+, which contribute to acid mine drainage[213]. Good mining practices typically identify these measures at the planning stage and implement mitigation measures (i.e., sedimentation ponds) before wastewater is released into open waters. The facility visit to a |

[256] Kompas TV. (2024). *Syahrun, Satpam Perusahaan Tambang Nikel yang Tewas Tertimpa Longsor*. Link
[257] Walhi Sulsel. (2023). *WALHI Sulsel Beberkan 3 Dampak Sosial-Lingkungan Tambang Nikel PT Vale Indonesia di Desa Asuli, Luwu Timur*. Link

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | mining company in Morowali shows that wastewater parameters were properly managed before wastewater entered open waters[18]. |
| Operation | Mining operation | Disrupted groundwater quality & quantity | Water | Major (4) | Common occurrence (5) | **High** | Mining operations can impact groundwater quality by disrupting the groundwater reservoir and altering its chemistry. The removal of vegetation and alteration of land surfaces limit water absorption, resulting in reduced groundwater recharge in the long term. Altered groundwater chemistry usually results from the weathering or leaching of soil chemistry exposed by land clearing[254]. |
| Operation | Mining operation | Terrestrial biodiversity degradation | Biodiversity | Major (4) | Common occurrence (5) | **High** | Mining operations will harm terrestrial biodiversity. Massive tree loss can lead to the degradation of natural habitats (e.g., habitat encroachment and fragmentation), which in turn impacts terrestrial diversity. Additionally, the disruption of natural ecosystems can lead to the proliferation of invasive species, which can outcompete native species and alternative diversity[255]. |
| Operation | Mining operation | Aquatic biodiversity degradation | Biodiversity | Major (4) | Not expected to occur (2) | **Moderate** | Increased sedimentation and altered surface water chemistry can harm aquatic biodiversity. This condition will render the aquatic ecosystem unsuitable for several freshwater species, potentially reducing the number of species that can survive in water as well as the presence of novel species[255]. That said, the likelihood of this is relatively low, as the facility visit to a mining company in Morowali shows that wastewater parameters were properly managed before wastewater entered open waters (see Annex A). |
| Operation | Mining operation | Decline in ecosystem services | Biodiversity | Major (4) | Common occurrence (5) | **High** | Disrupted natural ecosystems will lead to the decline of ecosystem services. Altered landscapes, vegetation loss, and poor water quality reduce the ecosystem's natural functions such as water retention and filtration, carbon storage, and erosion control[255]. |
| Operation | Mining operation | Solid waste generation | Waste generation | Major (4) | Known to occur (4) | **Substantial** | Mining typically generates a significant amount of solid waste from excavation. The land area and volume of soil are usually identified and mitigated in the mine plan. During the operation phase, excavated soil is typically stored or backfilled once mining operations are complete. That said, the temporary storage for soil dumping requires proper |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | management as it is prone to oxidation and rainfall, which can lead to surface water degradation. AEER[213] reported such an occurrence in Halmahera. |
| Operation | Mining operation | Wastewater generation | Waste generation | Major (4) | Not expected to occur (2) | **Moderate** | Wastewater is a common occurrence in many surface mining operations. Mining wastewater typically contains total suspended solids (TSS) and oxidized heavy metals, such as Cr6+, which contribute to acid mine drainage[213.] Good mining practices normally identify these measures at the planning stage and implement mitigation measures (i.e., sedimentation ponds) before wastewater is released into open waters. The facility visit to a mining company in Morowali shows that wastewater parameters were properly managed before wastewater entered open waters (see Annex A). |
| Operation | Mining operation | Hazardous waste generation | Waste generation | Negligible (1) | Common occurrence (5) | **Low** | Mining activities generate hazardous waste through several operational processes. The use of heavy equipment involves the consumption of fuels, oils, and lubricants, which generate used oil, oily rags, and other waste products. Meanwhile, maintenance workshops produce chemical containers, solvents, and bulbs. These impacts typically occur in workshop areas, where mitigation measures such as oil traps and temporary hazardous waste storage. |
| Operation | Mining operation | Increased power consumption | Energy | Minor (2) | Common occurrence (5) | **Moderate** | The amount of power consumed for mining activities alone is comparatively small compared to other phases of the supply chain. The Nickel Institute[258] quantified the primary energy demand (PED) as 23.08 MJ/kg of Class 1 nickel. Some companies, like PTVI, have an ore separation and preparation plant near their mining area before the ore is shipped to refining. The Nickel Institute quantified the PED of these activities as 13.18 and 1.73 MJ/kg, respectively. If these activities |

[258] The Nickel Institute. (n.d.) *Life Cycle Data.* Link

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | are integrated with the mining activities, the total PED would be approximately 37.99 MJ/kg. |
| Operation | Mining operation | Increased CO2 emissions | Carbon emissions | Severe (5) | Common occurrence (5) | **High** | Land clearing linked to mining can increase CO2 emissions. For this parameter, an analysis at Morowali and Halmahera is essential, where mining is expected to be most prominent in response to the battery industry. Using 2023 forest loss data from Global Forest Watch[209], the forest loss in Morowali and Halmahera contributes to an estimate of 786.9 t CO2/Ha and 866.7 t CO2/Ha, respectively. This shows that these forests are a large carbon storage in pre-mining conditions, and their loss greatly impacts increased CO2 emissions. |
| Post-operation | Facility decommisioning | Solid waste generation | Waste generation | Negligible (1) | Common occurrence (5) | **Low** | Facility decommissioning and dismantlement can generate significant amounts of solid waste, including scrap metal, concrete debris, and used construction components. The general practice is that mining companies usually involve third parties in proper waste handling, minimizing potential solid waste. |
| Post-operation | Mine reclamation | Land conversion | Landscape | Major (4) | Likely (3) | **Substantial** | Post-mining land reclamation and rehabilitation are standard practices enforced by the government. Proper planning, often involving government entities such as the MEMR, can lead to positive impacts. Although the reclaimed land may not be able to return to baseline conditions, reclaimed areas can be transformed into productive land uses, such as agriculture, forestry, or conservation zones, thereby supporting biodiversity and promoting ecosystem restoration[259]. |
| Post-operation | Mine reclamation | Significant change of landscape and morphology | Landscape | Major (4) | Likely (3) | **Substantial** | Mine reclamation can positively impact morphology by stabilizing slopes and reshaping the land to blend with the natural environment[259]. This process reduces the visual impact of mining |

[259] Feng, Z. *et al.*. (2023). "Integrated Mining and Reclamation Practices Enhance Sustainable Land Use: A Case Study in Huainan Coalfield, China". *Land*. 2023, 12(11), 1994 Link

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | activities, restoring the aesthetic value of the landscape and promoting environmental integration. |
| Post-operation | Mine reclamation | Soil quality improvement | Soil | Major (4) | Likely (3) | **Substantial** | Soil quality can be improved when doing reclamation. This can be done by replenishing topsoil, replanting native vegetation, and enhancing soil structure. Revegetation can improve deprived soil nutrients during the mining operation[259]. |
| Post-operation | Mine reclamation | Decreased probability of soil erosion and landslide | Soil | Major (4) | Likely (3) | **Substantial** | Proper mine reclamation can reduce soil erosion and the risk of landslides by stabilizing slopes and reintroducing vegetation[259]. These actions help restore soil structure, prevent further erosion, and promote long-term land stability. |
| Post-operation | Mine reclamation | Air quality improvement | Air | Major (4) | Known to occur (4) | **Substantial** | Mine reclamation helps improve air quality by reducing dust generation through vegetation restoration and soil stabilization. Reintroducing plant cover can trap dust particles and promote healthier air by mitigating the impact of previous mining activities. |
| Post-operation | Mine reclamation | Surface water improvement | Water | Major (4) | Likely (3) | **Substantial** | Mine reclamation can improve surface water quality and retention by stabilizing slopes and reducing sediment runoff into nearby water bodies. Reintroducing vegetation and restoring natural drainage patterns help prevent erosion, maintain water clarity, and indirectly promote healthier aquatic ecosystems[259]. |
| Post-operation | Mine reclamation | Groundwater improvement | Water | Major (4) | Likely (3) | **Substantial** | Mine reclamation improves groundwater quality by restoring vegetation and enhancing soil filtration. These actions help reduce pollutants' infiltration and promote natural purification processes, leading to cleaner and safer groundwater over time[259]. Additionally, increased rainwater catchment from restoration enhances groundwater replenishment. This supports long-term water availability for ecosystems and local communities. |
| Post-operation | Mine reclamation | Terrestrial biodiversity improvement | Biodiversity | Major (4) | Likely (3) | **Substantial** | Mine reclamation supports terrestrial biodiversity by restoring habitats and reintroducing native plant species. One study estimated that consistent management of revegetated forests for about 10 years |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | can promote the return of the native tree stand, which is essential for wildlife and species diversity[260]. |
| Post-operation | Mine reclamation | Aquatic biodiversity improvement | Biodiversity | Major (4) | Likely (3) | **Substantial** | The improvement of surface water runoffs from the mine reclamation can help improve aquatic ecosystems. |
| Post-operation | Mine reclamation | Ecosystem services | Biodiversity | Medium (3) | Likely (3) | **Moderate** | The improvement of terrestrial and aquatic ecosystems can improve ecosystem services. |
| **Refining** | | | | | | | |
| Construction | Construction of smelter | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Construction activities generate dust through land clearing, excavation, and the movement of heavy machinery. Emissions from construction equipment and vehicles also contribute to air pollution.<br><br>Based on the trajectory in Morowali or Central Halmahera, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of IWIP or IMIP), causing less disturbance to the surrounding environment and local communities. |
| Construction | Construction of smelter | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Noise is generated during construction from the operation of heavy machinery such as excavators and bulldozers.<br><br>Based on the trajectory in Morowali or Central Halmahera, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated |

[260] Yuningsih, L. *et al.* (2021). "Diversity, structure and composition of vegetation in post-coal mining reclamation area in Sumatra, Indonesia". *Biodiversitas*, 2021, Vol. 22, No. 8 Link

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | (i.e., tenants of IWIP or IMIP), causing less disturbance to the surrounding environment and local communities. |
| Operation | Smelter operation | Degraded air quality | Air | Severe (5) | Common occurrence (5) | **High** | Smelter operations can significantly disrupt air quality. An air emission modelling of planned and developed nickel smelters[72] projected significant increases of NO2, SO2, and PM2.5 within the perimeter of nickel smelters spread across Sulawesi and Halmahera by 2027. These pollutants contribute to air pollution, posing risks to human health and the environment. In addition, the dispersion of these pollutants is projected to be widespread, regardless of whether the smelters are located within an industrial estate or not. |
| Operation | Smelter operation | Noise disruption | Air | Minor (2) | Likely (3) | **Moderate** | Smelting processes can generate significant noise due to various types of equipment, including crushers, furnaces, and conveyors. However, the noise disruption tends to be isolated within the smelting facility, where the receptors are mainly workers who are generally equipped with personal protective equipment (PPE).<br><br>The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of IWIP or IMIP), causing less disturbance to the surrounding environment and local communities. |
| Operation | Smelter operation | Disrupted surface water quality & quantity | Water | Major (4) | Known to occur (4) | **High** | Smelters generate discharged cooling water during the processing of raw materials. Discharged cooling water can be avoided by recirculating water for processing or with the help of heat exchangers. This is an important issue highlighted by the Morowali Local Environmental Agency. They reported that cooling water discharge caused increased seawater temperature, which negatively impacted aquatic ecosystems (see Annex A) |
| Operation | Smelter operation | Aquatic biodiversity degradation | Biodiversity | Major (4) | Known to occur (4) | **High** | Smelter wastewater discharged to rivers can negatively impact aquatic biodiversity. Discharged cooling water has reportedly caused poor fish yields in aquatic ecosystems due to the heightened water temperature (see Annex A) |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Operation | Smelter operation | Marine biodiversity degradation | Biodiversity | Major (4) | Known to occur (4) | **High** | Smelter wastewater discharged to rivers can negatively impact marine biodiversity. Discharged cooling water has reportedly caused poor fish yield in marine ecosystems due to the heightened water temperature[63]. |
| Operation | Smelter operation | Decline in ecosystem services | Biodiversity | Major (4) | Known to occur (4) | **High** | Smelter wastewater discharged to rivers can negatively impact the ecosystem's capacity to provide food. Discharged cooling water has reportedly led to poor fish yields in marine ecosystems due to the increased water temperature[63] |
| Operation | Smelter operation | Wastewater generation | Waste generation | Major (4) | Known to occur (4) | **High** | Smelters generate discharged cooling water during the processing of raw materials. Discharged cooling water can be avoided by recirculating water for processing or with the help of heat exchangers. However, the fact remains that grievances have been reported related to discharged cooling water in aquatic ecosystems[63] |
| Operation | Smelter operation | Hazardous waste generation | Waste generation | Major (4) | Not expected to occur (2) | **Moderate** | The most significant waste from smelters is processing residue, including slag and tailings. Slags are by-products of pyrometallurgy, whereas tailings are by-products of hydrometallurgy[17]. Both types of waste require confirmation of their toxicity, which must be approved by the government. Field verification confirmed that the industrial estate manages this waste. Thus, the company is only responsible for the proper handling and transportation of waste to the dumping site managed by the industrial estate. |
| Operation | Smelter operation | Increased power consumption | Energy | Severe (5) | Common occurrence (5) | **High** | The amount of power consumed for refining activities is the largest of all battery supply chain activities. The Nickel Institute[258] quantified the primary energy demand (PED) as 84.03 MJ/kg of Class 1 nickel. Some companies, like PT HNC, have an ore separation and preparation plant located near the refining plant to prepare the feedstock. The Nickel Institute quantified the PED of these activities as 13.18 and 1.73 MJ/kg, respectively. If these activities are integrated into the refining, the total PED would be approximately 98.94 MJ/kg. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Operation | Smelter operation | Increased CO2 emissions | Carbon emissions | Major (4) | Known to occur (4) | **Substantial** | Conventional smelting activities are inherently carbon-heavy, particularly if they are powered by CFPPs. A study by IEEFA[261] on three coal-powered nickel companies in Indonesia—Antam, MBMA, and TBP—found that the average carbon intensity per Ni is 65.0 t CO2/Ni. This calculation includes emissions from mine hauling, smelting, and their power sources, predominantly coal. The amount of 65.0 t CO2/Ni falls into the higher spectrum of the industry standards, which range between 20 and 80 t CO2/Ni[262]. However, one company—Vale—exhibits lower carbon intensity at 28.7 t CO2/Ni, showing that it is possible for smelting to be less carbonized, provided that companies install alternative energy. |
| **CAM/anode manufacturing** | | | | | | | |
| Construction | Construction of facility | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Construction of facilities can lead to decreased air quality due to dust from movement of heavy machinery. Besides, emissions from construction equipment and vehicles also contribute to air pollution, such as carbon monoxide.<br><br>Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Construction | Construction of facility | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Noise is generated during construction from the operation of heavy machinery such as excavators and cranes. Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial |

[261] IEEFA. (2024). *Indonesia's Nickel Companies: The Need for Renewable Energy Amid Increasing Production*. Link
[262] CommDev. (n.d.) *Net Zero Roadmap to 2050 : For Copper & Nickel Mining Value Chains.* Link

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Operation | Manufacturing facility operation | Degraded air quality | Air | Negligible (1) | Common occurrence (5) | **Low** | Manufacturing facility operations can significantly reduce air quality by releasing emissions such as metal-containing dust (from either nickel, cobalt, lithium, or graphite; based on the facility's product). Air pollutants are generally produced during processes such as dosing and mixing, slitting, separating, laser welding, coating, drying, and degassing[263]. While the pollutants pose a risk to human health, a study in Germany found that these pollutants are still well below air quality standards.<br><br>The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. However, facilities located outside industrial estates are more likely to disrupt the surrounding area. This was implied in a discussion with Karawang's worker union, where they reported an ongoing facility built outside industrial estates and can generate impacts not buffered by estate boundaries[21]. |
| Operation | Manufacturing facility operation | Noise disruption | Air | Minor (2) | Likely (3) | **Moderate** | Manufacturing processes can generate significant noise due to various types of equipment in the production facility. However, the noise disruption tends to be isolated within the facility, where the receptors are mainly workers who are generally equipped with personal protective equipment (PPE). |

[263] Degen, F. *et al.* (2025). https://www.nature.com/articles/s43247-025-02376-0

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. However, facilities located outside industrial estates are more likely to disrupt the surrounding area. This was implied in a discussion with Karawang's worker union, where they reported an ongoing facility built outside industrial estates and can generate impacts not buffered by estate boundaries (see Annex A). |
| Operation | Manufacturing facility operation | Degraded soil quality | Soil | Severe (5) | Likely (3) | **High** | Manufacturing facility operations can degrade soil quality through air emissions that deposit into the soil. A study in Germany has shown that heavy metals contained in air pollutants from a battery factory can accumulate in the soil, where the heavy metal content exceeds legal standards[263]. This exceedance is identified at up to a radius of 6 km from the battery factory. |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | Negligible (1) | Likely (3) | **Low** | Manufacturing facility operations can degrade surface water quality by releasing wastewater containing battery materials (nickel, cobalt, lithium, or graphite, depending on the factory product). Effluent discharge from factory sites can carry pollutants into nearby rivers, lakes, or streams, leading to contamination. That said, wastewater from CAM/anode manufacturing is relatively small in volume[263]. |
| Operation | Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Severe (5) | Likely (3) | **High** | Groundwater may be disrupted due to the high accumulation of heavy metals in the soil that penetrates the aquifer. |
| Operation | Manufacturing facility operation | Aquatic biodiversity degradation | Biodiversity | Negligible (1) | Not expected to occur (2) | **Low** | Although wastewater is generated from the production facility, due to its relatively small volume, aquatic biodiversity impacts are not expected to occur. |
| Operation | Manufacturing facility operation | Wastewater generation | Waste generation | Negligible (1) | Common occurrence (5) | **Low** | Manufacturing facility operations release wastewater containing battery materials (from either nickel, cobalt, lithium, or graphite; based on the facility's product). Effluent discharge from factory sites can carry pollutants into nearby rivers, lakes, or streams, leading to |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | contamination. That said, wastewater from battery cell manufacturing is relatively small in volume[263]. |
| Operation | Manufacturing facility operation | Hazardous waste generation | Waste generation | Major (4) | Known to occur (4) | **Substantial** | Manufacturing facility operation generates hazardous waste from materials, such as spent solvents, heavy metals, and contaminated materials[264]. Battery waste by regulation is classified as electronic waste, signaling the potential for material recovery and/or recycling. However, the current regulatory framework has not encouraged this by businesses. Without proper management, the amount of hazardous waste would very likely grow with increased battery production, signifying this may be a significant problem in the future. |
| Operation | Manufacturing facility operation | Increased power consumption | Energy | Minor (2) | Common occurrence (5) | **Moderate** | The amount of power consumed for CAM and anode manufacturing is comparatively less compared to other supply chain activities. A study on lithium-ion battery packs[265] found that the energy consumption for CAM and anode manufacturing is approximately 7.6 kWh/cell or 22.91 kWh/kg battery pack. It is worth noting that the drying process takes up most of the energy consumption, which is about 6.22 kWh/cell or 19.29 kWh/kg in this study. |
| Operation | Manufacturing facility operation | Increased CO2 emissions | Carbon emissions | Major (4) | Known to occur (4) | **Substantial** | Active material production significantly contributes to GHG emissions within a battery's life cycle. Using China's current electricity mix model, it is estimated that the CAM/anode manufacturing stage can amount to about 40% of a battery's life-cycle GHG emissions, which equals 28 kg CO2e/kWh for LFP batteries and 35 kg CO2e/kWh for NCM batteries[266]. This stage requires high-temperature processing, i.e., using boilers and electricity to precipitate and dry materials. A stable power source is typically required for this stage, which heavily |

[264] Xiaodong, S. *et al.* (2024). "Environmental Impact Analysis of Waste Lithium-Ion Battery Cathode Recycling". *Journal of Ecological Engineering* 2024, 25(7), 352–358 Link
[265] Yuan, C. *et al.* (2017). "Manufacturing energy analysis of lithium ion battery pack for electric vehicles". *CIRP Annals* 2017, 66(1), 53-56 Link
[266] Xu, C. *et al.* (2022). "Future greenhouse gas emissions of automotive lithium-ion battery cell production". *Resources, Conservation, and Recycling* 2022, 187, 106606 Link.

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | determines the output GHG emissions. Higher RE share, as done in the EU, can minimize active-material production emissions. However, as fossil fuels are still the primary power source in Indonesia, this can also indirectly contribute to higher GHG emissions. |
| **Battery cell manufacturing** | | | | | | | |
| Construction | Construction of facility | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Construction of facilities can lead to decreased air quality due to dust from the movement of heavy machinery. Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Construction | Construction of facility | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Noise is generated during construction from the operation of heavy machinery such as excavators and cranes. Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Operation | Manufacturing facility operation | Degraded air quality | Air | Negligible (1) | Common occurrence (5) | **Low** | Manufacturing facility operations can significantly reduce air quality by releasing emissions such as metal-containing dust (from either NMC, LFP, or graphite; based on the facility's product). Air pollutants are generally produced during processes such as dosing and mixing, slitting, separating, laser welding, coating, drying, and degassing[263]. While the pollutants pose a risk to human health, a study in Germany found that these pollutants are still well below air quality standards.<br><br>The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. However, facilities located |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | outside industrial estates are more likely to disrupt the surrounding area. This was implied in a discussion with Karawang's worker union, where they reported an ongoing facility built outside industrial estates and can generate impacts not buffered by estate boundaries (see Annex A). |
| Operation | Manufacturing facility operation | Noise disruption | Air | Minor (2) | Likely (3) | **Moderate** | Manufacturing processes can generate significant noise due to various types of equipment in the production facility. However, the noise disruption tends to be isolated within the facility, where the receptors are mainly workers who are generally equipped with personal protective equipment (PPE).<br><br>The impact of such activities varies depending on the location of the facility. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. However, facilities located outside industrial estates are more likely to disrupt the surrounding area. This was implied in a discussion with Karawang's worker union, where they reported an ongoing facility built outside industrial estates and can generate impacts not buffered by estate boundaries (see Annex A). |
| Operation | Manufacturing facility operation | Decreased soil quality | Soil | Severe (5) | Likely (3) | **High** | Manufacturing facility operations can degrade soil quality through air emissions that deposit into the soil. A study in Germany has shown that heavy metals contained in air pollutants from a battery factory can accumulate in the soil, where the heavy metal content exceeds legal standards[263]. This exceedance is identified at up to a radius of 6 km from the battery factory. |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | Negligible (1) | Likely (3) | **Low** | Manufacturing facility operations can degrade surface water quality by releasing wastewater containing battery materials (NMC, LFP, or graphite). Effluent discharge from factory sites can carry pollutants into nearby rivers, lakes, or streams, leading to contamination. That said, wastewater from battery cell manufacturing is relatively small in volume[263]. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Operation | Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Severe (5) | Likely (3) | **High** | Groundwater may be disrupted due to the high accumulation of heavy metals in the soil that penetrates the aquifer. |
| Operation | Facility operation | Wastewater generation | Waste generation | Negligible (1) | Common occurrence (5) | **Low** | Manufacturing facility operations release wastewater containing battery materials (NMC, LFP, or graphite). Effluent discharge from factory sites can carry pollutants into nearby rivers, lakes, or streams, leading to contamination. That said, wastewater from battery cell manufacturing is relatively small in volume[263]. |
| Operation | Facility operation | Hazardous waste generation | Waste generation | Major (4) | Likely (3) | **Substantial** | Manufacturing facility operations generate hazardous waste from materials, including spent solvents, heavy metals, and contaminated materials[264]. Battery waste by regulation is classified as electronic waste, signaling the potential for material recovery and/or recycling. However, the current regulatory framework has not encouraged this by businesses. Without proper management, the amount of hazardous waste would very likely grow with increased battery production, signifying this may be a significant problem in the future. |
| Operation | Facility operation | Increased power consumption | Energy | Minor (2) | Common occurrence (5) | **Moderate** | The amount of power consumed for CAM and anode manufacturing is comparatively less compared to other supply chain activities. A study on lithium-ion battery packs[265] found that the energy consumption for this stage is approximately 5.68 kWh/cell or 27.23 kWh/kg battery pack. It is worth noting that the drying process accounts for the majority of energy consumption, which is approximately 3.9 kWh/cell or 21.78 kWh/kg in this study. |
| Operation | Facility operation | Increased CO2 emissions | Carbon emissions | Major (4) | Known to occur (4) | **Substantial** | Battery cell production is the third contributor to GHG emissions within a battery's life cycle. Using China's current electricity mix model, it is estimated that this stage can amount to 35-40% of a battery's life-cycle GHG emissions, which equals 24-28 kg CO2e/kWh for LFP batteries and 30-35 kg CO2e/kWh for NCM batteries[266]. This stage is typically electrified, with non-electricity emissions from the electrode-drying process. Switching electricity sources to less-carbon resources can lower production emissions significantly, as demonstrated in EU. |
| **Battery pack assembly** | | | | | | | |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of facility | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Construction of facilities can lead to decreased air quality due to dust from the movement of heavy machinery. Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Construction | Construction of facility | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Noise is generated during construction from the operation of heavy machinery such as excavators and cranes. Based on the trajectory in Karawang, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding environment and local communities. |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | Negligible (1) | Very unlikely to occur (1) | **Low** | Manufacturing facility operations can degrade surface water quality by releasing wastewater containing battery materials (NMC, LFP, or graphite). Effluent discharge from factory sites can carry pollutants into nearby rivers, lakes, or streams, leading to contamination[263]. That said, battery pack assembly is a less water-intensive phase out of the rest of the battery production stage, which signals minimum wastewater. |
| Operation | Manufacturing facility operation | Wastewater generation | Waste generation | Negligible (1) | Very unlikely to occur (1) | **Low** | Manufacturing facility operations can release wastewater containing battery materials (NMC, LFP, or graphite). However, the amount is very minimal compared to other phases of the battery production stage. |
| Operation | Manufacturing facility operation | Hazardous waste generation | Waste generation | Major (4) | Likely (3) | **Substantial** | Manufacturing facility operation generates hazardous waste from materials, such as material scraps, defective packs, and other traces |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | of hazardous materials[267]. No good batteries are reportedly shipped overseas for recycling or handled by third-party authorized hazardous waste handlers[21].<br><br>Indonesia's current battery recycling capacity is still nascent. Thus, shipping overseas is an option for some producers to exhibit responsible resource efficiency. Without proper management, the amount of hazardous waste is likely to increase with increased battery production, indicating that this may become a significant problem in the future. |
| Operation | Facility operation | Increased power consumption | Energy | Negligible (1) | Common occurrence (5) | **Low** | The amount of power consumed for battery pack assembly is the least among all supply chain activities. A study on lithium-ion battery packs[265] found that the energy consumption for this stage is approximately 0.03 kWh/kg battery pack. |
| Operation | Facility operation | Increased CO2 emissions | Carbon emissions | Negligible (1) | Known to occur (4) | **Low** | Battery pack assembly is the least contributor to GHG emissions within a battery's life cycle. Based on the electricity models of several countries, battery pack assembly is less than 20% of a battery's life-cycle GHG emissions[268]. Although this process is generally less electricity-intensive, higher RE share can significantly reduce GHG emissions at this stage. |

[267] Yu, L. *et al.* (2024). "Unlocking the value of recycling scrap from Li-ion battery manufacturing: Challenges and outlook". *Journal of Power Sources* 2024, 593, 233955 Link.
[268] Llamas-Orozco, J.A. *et al.* (2023). "Estimating the environmental impacts of global lithium-ion battery supply chain: A temporal, geographical, and technological perspective". *PNAS Nexus* 2023, 2(11), 361 Link.

**Table D.2 Social Impact Assessment: Battery Production**

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Mining** | | | | | | | |
| Pre-construction | Land acquisition | Livelihood | Surrounding community | Severe (5) | Not expected to occur (2) | **Substantial** | The nickel boom has driven further displacement of community-owned lands and their landowners (Nancy 2022). BPS data shows that the proportion of the Morowali workforce working in agriculture shifted from 46.5% in 2015 to 36.0% in 2020, whereas manufacturing grew from 5.9% in 2015 to 18.2% in 2020. This shows that land conversion indeed negatively impacts agriculture as a livelihood. However, it does not ultimately lead to decreased job opportunities, as other opportunities emerge in the wake of industrialization, e.g., working in industries. |
| Pre-construction | Land acquisition | Human rights | Surrounding community | Medium (3) | Common occurrence (5) | **Substantial** | During land acquisition processes, reports have surfaced of land grabbing, frequently involving little or no compensation or pricing perceived as unfair. These practices have often heightened tensions and led to an increased police and military presence in villages near mining sites.<br>However, experiences are not uniform across all Indigenous Peoples (IPs). Field observations in Morowali, particularly through stakeholder engagement with community leaders, revealed positive practices in Kolono village. The head of the local indigenous institution emphasized that the approaches implemented there could serve as a benchmark for surrounding communities.<br><br>In Kolono, company representatives have adopted structured, transparent, and inclusive engagement methods. They prioritize open dialogue, demonstrate respect for local customs and traditions, and actively incorporate the well-being and needs of the community into decision-making. This contrast underscores the importance of consistent standards for equitable land acquisition and community relations[18]. |
| Pre-construction | Land acquisition | IP and Cultural heritage | Vulnerable people | Severe (5) | Known to occur (4) | **High** | Land acquisition in mining has long been associated with the displacement of Indigenous Peoples (IP) and the loss of cultural lands. A study in Halmahera found that IP groups experience degraded environments, reduced quality of life, and long-term economic hardship beyond the pre- |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | construction phase (Nancy 2022). The study also highlights that FPIC (Free, Prior, and Informed Consent) is rarely implemented, leaving IP groups vulnerable and unable to adapt to industrialization. BPS data (July 17, 2023) indicates that the poverty rate in Central Sulawesi, a major nickel-producing area, increased slightly from 12.30% to 12.41%.<br><br>According to AMAN, during exploration activities Vale committed multiple violations against Indigenous rights. The Karonsi'e Indigenous community lost access to traditional land and livelihoods, including fruit tree groves. Only a few Indigenous members now work as temporary contract laborers.<br><br>Almost 10% of nickel concessions in Indonesia are linked to the country's highest deforestation rates. Mining companies have been accused of illegally clearing forests and failing to implement FPIC with local communities. Indigenous Peoples have the right to participate in decision-making processes that affect their rights. |
| Pre-construction | Land acquisition | GEDSI | Vulnerable people | Medium (3) | Common occurrence (5) | **Substantial** | A study by the World Agroforestry Centre found that women are under-recognized as landholders, with most land certificates registered under male names. As a result, women have limited influence in decision-making and earn lower incomes than men. |
| Pre-construction | Exploration | Community lifestyle | Surrounding community | Minor (2) | Common occurrence (5) | **Moderate** | Exploration activities can create short-term jobs, particularly for local contractors and support workers. Opportunities include positions such as surveyors, equipment operators, and base camp staff. These activities stimulate local economies by engaging local businesses in logistics and operations. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Livelihood | Surrounding community | Major (4) | Known to occur (4) | **Substantial** | Many communities near nickel mining operations reported that FPIC was not obtained. Bajau seafarers, for example, have suffered economic and health losses from contaminated freshwater and seawater, without adequate compensation. |
| Construction | Construction of mining facilities | Community health | Surrounding community | Minor (2) | Likely (3) | **Moderate** | Mining activities impact community health through air pollution and dust from heavy equipment. This exposure contributes to respiratory and skin |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | (i.e., haul road, office) | | | | | | conditions. While some concessions are remote, others are close enough to communities to cause concern. |
| Construction | Construction of mining facilities (i.e., haul road, office) | Community lifestyle | Surrounding community | Minor (2) | Likely (3) | **Moderate** | Mining increases safety risks for workers and communities. Heavy vehicle traffic, unsafe zones, and accident risks can cause injuries and raise public concern without adequate safety measures. |
| Operation | Mining operation | Community health | Surrounding community | Severe (5) | Common occurrence (5) | **High** | Deforestation and habitat destruction from mining and smelting contaminate water sources and increase flooding, disrupting local ways of life. Communities report rising cases of respiratory and skin illness linked to mining dust and air pollution. From 2018 onward, the Bahodopi community health center recorded over 7,000 cases of upper respiratory infections. |
| Operation | Mining operation | Livelihood | Surrounding community | Severe (5) | Common occurrence (5) | **High** | Water pollution has devastated fishing livelihoods. In Tapunggaeya (North Konawe, Southeast Sulawesi), fishermen lost income, forcing young villagers to migrate to mining jobs locally or in other regions. |
| Operation | Mining operation | Community lifestyle | Surrounding community | Medium (3) | Likely (3) | **Moderate** | Increased militarization has been reported near mining concessions. In Sorowako (Sulawesi), the Karonsi'e Dongi community faced intimidation from police, mining companies, and armed security guards. In 2003, police and Inco security threatened to burn their homes; in 2009, they were forcibly relocated. Some community members accepted compensation under pressure. |
| Operation | Mining operation | Human rights | Surrounding community | Severe (5) | Common occurrence (5) | **High** | Nickel mining and smelting operations threaten community land rights, access to clean water, traditional practices, and health. Reports submitted to Indonesia's National Human Rights Commission allege land grabbing, coercion, and OHS violations. Companies were accused of appointing foreign workers as safety supervisors in violation of labor laws. |
| Operation | Mining operation | OHS | Workers | Severe (5) | Known to occur (4) | **High** | The Prosperous Indonesian Workers Union reports poor working conditions, including lack of safety measures, long hours, unfair contracts, and low wages. Those unable to secure mining jobs remain in agriculture, fisheries, or service sectors. Mining operations pose OHS risks including exposure to dust, noise, vibrations, hazardous substances, heavy machinery, and |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | confined spaces. Without proper safeguards, accidents, injuries, and chronic health issues are common. |
| Operation | Mining operation | GEDSI | Vulnerable people | Medium (3) | Likely (3) | **Moderate** | The workload of women in villages has increased as land and resources sustaining livelihoods are lost. Some women have become "contract wives" — marrying migrant workers temporarily, only to be abandoned once contracts end. Others, often newcomers, entered sex work. Reports also highlight rising violence against women in mining regions. |
| Post-operation | Mine reclamation | Labor compliance | Workers | Medium (3) | Known to occur (4) | **Moderate** | Indonesia has no mines that have yet reached closure. By 2050, nearly one million coal mining jobs (990,200) are expected to be lost due to closures, representing 37% of the workforce. Global comparisons highlight major risks: Shanxi (China) may lose 241,900 jobs; Coal India could see 73,800 direct workers displaced. |
| **Refining** | | | | | | | |
| Construction | Construction of smelter | Community health | Surrounding community | Major (4) | Common occurrence (5) | **High** | Sulawesi highlands farmers have reported that their source of water could be at risk,when more of the forest is cleared for refining production facility. Eventhough, there is a commitment from the Merdeka Battery Materials company that is in charge of SCM Nickel and Cobalt Mine, Existing and Future Metal Processing Facilities, the Industrial Park (IKIP) and other Infrastructure Assets, and other Future Battery Processing Facilities, to provide ongoing community investment and empowerment programs in local communities where they operate (through local government is yet to reach local people). |
| Construction | Construction of smelter | Human rights | Surrounding community | Major (4) | Known to occur (4) | **Substantial** | Construction of new development within IWIP, led by Eramet, BASF, POSCO, are related to land grabbing, water and soil pollution weaken the rights of indigenous communities, |
| Operation | Smelter operation | Community health | Surrounding community | Severe (5) | Likely (3) | **High** | Smelter operations contribute to respiratory and skin-related illnesses in nearby communities. Air pollution and dust from factories increase risks for workers and residents living close to smelting sites. In December 2024, the Central Sulawesi Health Department recorded 80,713 cases of acute respiratory infection, with 66,000 cases in Bahodopi Subdistrict, home to PT IMIP. The Head of Morowali Health Department stated that industrial growth has driven a sharp rise in respiratory and environmental diseases (Tempo, |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | 2025).<br><br>Smelter operations may also threaten environmental compliance. Third-party contractors often fail to fully implement environmental measures outlined in SOPs, ESIAs, or regulatory requirements. Tirta Media (2024) reported that PT Ceria Nugraha Indotama (CNI) did not meet water treatment requirements, contaminating fishponds in Wolo District, Kolaka Regency, Southeast Sulawesi, and rendering them unproductive.<br><br>Tailings storage facility (TSF) operations pose risks to community health. Hazardous substances such as heavy metals and toxic chemicals can migrate into surface water, groundwater, or become airborne as dust. Long-term exposure increases risks of respiratory illness, skin diseases, and other serious health conditions. |
| Operation | Smelter operation | Livelihood | Surrounding community | Major (4) | Common occurrence (5) | **High** | Fishermen near Indonesia Weda Bay Industrial Park (IWIP), which began construction in 2018 and operations in 2020, report significant declines in skipjack tuna and grouper catches. This represents a major threat to family nutrition and income. Farmers of cocoa, sago, and nutmeg have also experienced land excavation and blocked access without permission. Compensation offers from IWIP representatives covered only 20% of affected land. Reports indicate companies, together with Indonesian police and military, have engaged in land grabbing, coercion, and intimidation of Indigenous Peoples and local communities. CRI reported an increase in police and military presence near IWIP, including Mobile Brigade units and a permanent army outpost. |
| Operation | Smelter operation | Community lifestyle | Surrounding community | Medium (3) | Not expected to occur (2) | **Moderate** | Smelter operation can pose risks to community safety through the potential release of toxic gases, accidental chemical spills, and fire or explosion hazards from high-temperature processes. Transportation of hazardous materials to and from the site also increases the risk of accidents. Without strict safety measures, these risks can affect nearby residents. |
| Operation | Smelter operation | OHS | Workers | Severe (5) | Common occurrence (5) | **High** | Smelter operations also pose community safety risks. Potential hazards include toxic gas releases, accidental chemical spills, and fire or explosions |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | from high-temperature processes. Transport of hazardous materials to and from smelters further raises accident risks. Without strong safety protocols, nearby residents remain vulnerable. Worker safety is a major concern. Smelters involve risks from heavy machinery, chemicals, and accidents. Betahita (2023) reported two worker deaths in a PT Gunbuster Nickel Industry (GNI) smelter fire. Trend Asia data show nine workplace accidents at GNI, with six fatalities. On December 24, 2023, an explosion at an IMIP smelting furnace killed 13 workers instantly and injured 39 others. |
| Operation | Smelter operation | Labor compliance | Surrounding community | Medium (3) | Likely (3) | **Moderate** | Since IMIP began operations in 2015, thousands of respiratory disease cases among workers have been reported, with similar issues at IWIP. Conditions are linked to coal pollution, ore dust, and sulfur odors from processing chemicals. According to the AMAR Law Firm & Public Interest Law Office, workers believe accident and fatality numbers in Morowali are far higher than official reports, as no government database exists. |
| Operation | Tailing storage facilities (TSF) operation | Livelihood | Surrounding community | Medium (3) | Likely (3) | **Moderate** | Planned deep-sea tailings disposal (DSTD) remains highly controversial. If implemented, it could release over 30 million tonnes of tailings annually into the sea, polluting marine ecosystems and harming biodiversity. Studies show migratory fish avoid DSTD areas, altering migration routes and undermining fishing, aquaculture, and marine tourism. In regions where DSTD is banned, dams are used for tailings management. However, leaks from factories, pipelines, or dams can still contaminate communities, water sources, marine life, and human health. |
| Operation | Manufacturing facility operation | Community health | Surrounding community | Medium (3) | Likely (3) | **Moderate** | Increase respiratory and skin-related illnesses sufferers. Manufacturing facility can affect community health through increased air pollution and dust due to factory activities. This condition will cause health issues, including respiratory and skin-related illnesses to workers and local inhabitants closed to factory area. |
| Operation | Manufacturing facility operation | Community lifestyle | Surrounding community | Minor (2) | Not expected to occur (2) | **Low** | Manufacturing facility can pose risks to community safety through the potential release of accidental chemical spills, material powder, and fire or explosion hazards from flammable substances. Transportation of hazardous |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | materials to and from the site also increases the risk of accidents. Without strict safety measures, these risks can affect nearby residents. |
| **CAM/anode manufacturing** | | | | | | | |
| Construction | Construction of facility | Community health | Surrounding community | Minor (2) | Not expected to occur (2) | **Low** | Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding communities. However, battery cell plants built in other countries have faced concerns and local opposition to the factory. i.e.Hungary have faced local protest against construction of Chinese lithium-ion battery plant[269]. |
| Operation | Manufacturing facility operation | OHS | Workers | Medium (3) | Not expected to occur (2) | **Moderate** | Exposure to chemicals and inadequate PPE use contribute to increased risk in occupational health. |
| **Battery cell manufacturing** | | | | | | | |
| Construction | Construction of facility | Community health | Surrounding community | Minor (2) | Not expected to occur (2) | **Low** | Facilities located in industrial estates are generally isolated (i.e., tenants of KNIC), causing less disturbance to the surrounding communities. |
| Operation | Manufacturing facility operation | OHS | Workers | Medium (3) | Not expected to occur (2) | **Moderate** | Exposure to chemicals and inadequate PPE use contribute to increased risk in occupational health |

[269] Business and Human Rights, 2024. Hungary: Locals oppose construction of Chinese lithium-ion battery plant over air pollution & fear of becoming 'battery wasteland. Available at: https://www.business-humanrights.org/en/latest-news/hungary-locals-protest-against-construction-of-chinese-lithium-ion-battery-plant-over-air-pollution-fear-of-battery-wasteland/

## Table C.3 Environmental Impact Assessment: Battery Usage

| Activity Phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|
| | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **EV Usage** | | | | | | |
| Battery usage in EV lifetime | Decreased CO2 emissions | Carbon emissions | Minor (2) | Likely (3) | **Moderate** | Based on calculations made using lifecycle GHG emissions[270], nationwide EV usage using 2030 and 2034 EV projection targets (943.764 4W units by 2030 and 2,883,764 by 2034) can minimize CO2 emissions related to passenger vehicles. Against 2022 EV adoption rates, the projected 2030 emissions account for a 5% decrease using the Baseline scenario and 11% decrease using the NZE scenario. Using the 2034 projection, the Baseline scenario could reduce 6% of carbon emissions, whereas the NZE scenario could reduce by 13% (see **Table C.4**). |
| **BESS Usage** | | | | | | |
| Battery usage in the BESS lifetime | Decreased CO2 emissions | Carbon emissions | Severe (5) | Likely (3) | **Moderate** | Calculating the contribution of BESS applications alone to Indonesia's carbon emissions is a complex process that takes into consideration many variables. To simplify the process, we refer to the 2025-2034 RUPTL. It is unclear which technology BESS and BESS applications will replace, so we quantify the impact by comparing the Business As Usual (BAU) scenario with the RE Base and ARED scenarios (see **Table 3.8** and **Table 3.9**). The RE Base and ARED scenarios are projected to reduce carbon emissions by 145 and 152 million t CO2 emissions by 2030. This is about 29% and 30%, respectively, of the BAU scenario projection. |

[270] ICCT. (2024). *Charging Indonesia's vehicle transition: Infrastructure needs for electric passenger cars in 2030*. Link

## Table C.4 Environmental Impact Assessment: Calculation of GHG Emissions in EV Battery Usage

| Type | Total vehicles in 2022 (units)[271] | Actual and Target EV deployment | | | | Life-cycle GHG Emissions (g CO2e/km) | | | | | | GHG Emissions by 10,000 Vehicles (t CO2e/km)[272] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2022 Condition (units)[273] | Proportion (%) | Projection (units)[25] | Proportion (%)[274] | Average ICEV and HEV Models Sold in 2023[275] | Average of Projected ICEV and HEV Models Sold in 2030[276] | Average BEV Models Sold in 2023, Baseline[277] | Average of Projected BEV Models Sold in 2030, Baseline | Average BEV Models Sold in 2023, NZE[278] | Average of Projected BEV Models Sold in 2030, NZE | Calculated Emissions with Current EV Deployment Rate | Projected Emissions in 2030 Conditions, Baseline | Projected Emissions in 2030 Conditions, NZE |
| **4W (2030)** | **17,168,862** | **33,555** | 0.20% | **943,764** | 5.50% | 359 | 352 | 173 | 155 | 149 | 111 | **877,942.10** | **835,186.62 (5% reduction from 2022)** | **829,265.75 (6% reduction from 2022)** |
| **4W (2034)** | | | | **2,883,764** | 16.80% | | | | | | | | **780,693.98 (10% reduction from 2022)** | **762,602.16 (13% reduction from 2022)** |

[271] Badan Pusat Statistik. (2023). *Jumlah Kendaraan Bermotor Menurut Provinsi dan Jenis Kendaraan (unit), 2023.* Link
[272] Expected life expectancy of all vehicle types are 18 years, or a lifetime mileage of 244,800 km, as noted in ICCT study.
[273] MoT. (2022). *Data Penerbitan Sertifikat Registrasi Uji Tipe (SRUT)*. Link
[274] Proportion done against total vehicles in 2022 .
[275] Calculation by ICCT[270]: Normalized GHG emissions for selected models sold in 2023, includes vehicle manufacture, battery manufacture, maintennace, fuel production, fuel consumption, and electricity consumption
[276] Calculation by ICCT[270]: Normalized GHG emissions for selected models sold in 2030, includes vehicle manufacture, battery manufacture, maintennace, fuel production, fuel consumption, and electricity consumption
[277] Baseline electricity mix based on 2017 RUEN; 23% RE share by 2025 and 31% RE share by 2050 (ICCT 2024[270])
[278] Net-zero 2060 electricity mix is based on the Long-Term Strategy for Low Carbon and Climate Resilience 2050; 89% RE share by 2050 (ICCT 2024[270])

## Table C.5 Social Impact Assessment: Battery Usage

| Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|
| | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **EV Usage** | | | | | | |
| Battery usage in EV lifetime | Community health | Community health | Minor (2) | Not expected to occur (2) | **Low** | Poor battery collection and recycling systems can lead to illegal battery dumping, which may cause environmental hazards, such as lead contamination in water. This can result in localized impacts where illegal workshops operate, for example, in large cities in Indonesia, if battery collection and recycling systems are not fully established by 2030 (per BEV development targets in MoI Regulation 38/2023 Appendix I). |
| **BESS Usage** | | | | | | |
| BESS Usage | Community lifestyle | Community safety | Minor (2) | Not expected to occur (2) | **Low** | Battery Energy Storage Systems (BESS) can support Indonesia in integrating more renewable energy, expanding energy access, and creating new employment opportunities. However, their deployment is also associated with risks comparable to those faced by other industrial facilities. Since BESS projects are more likely to be developed within industrial estates, these risks should be assessed and managed within the context of such estates.<br>A UNOPS project regarding BESS is being implemented in 2025 in Indonesia. |

## Table C.6 Environmental Impact Assessment: Battery End-of-life

| Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|
| | Environmental/ social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Battery Waste** | | | | | | |
| Battery waste | Increased hazardous waste | Waste generation | Medium (3) | Likely (3) | **Moderate** | Inadequate battery collection and recycling facilities at the end of the EV lifecycle can lead to increased battery waste, which is generally considered hazardous by Indonesian standards. In China, EVs are reportedly abandoned in many cities, creating a serious waste problem[279], leading to illegal battery removals[280]. This can occur in large cities in Indonesia if battery collection and recycling systems are not yet established by 2030 (per BEV development targets in MoI Regulation 38/2023 Appendix I). |
| **Battery Material Recycling** | | | | | | |
| Construction of facility | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Construction of facilities can lead to decreased air quality due to dust from the movement of heavy machinery. Based on the trajectory in the snapshot regions, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of IMIP), causing less disturbance to the surrounding environment and local communities. |
| Construction of facility | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Noise is generated during construction from the operation of heavy machinery such as excavators and cranes. Based on the trajectory in the snapshot regions, newer facilities are more likely to be built in industrial estates, which can contain these impacts and isolate them from the surrounding areas. Facilities located in industrial estates are generally isolated (i.e., tenants of IMIP), causing less disturbance to the surrounding environment and local communities. |
| Manufacturing facility operation | Degraded air quality | Air | Minor (2) | Not expected to occur (2) | **Low** | Recycling facility operations can significantly reduce air quality by releasing emissions such as metal-containing dust (from either nickel, cobalt, or lithium; based on the facility's product), organic, and inorganic gases. Air pollutants are generally produced during processes such as dismantling, crushing and screening, calcination and pyrolysis, acid |

[279] Bloomberg. (2023). *China's Abandoned, Obsolete Electric Cars Are Piling Up in Cities* Link
[280] Dialogue Earth. (2023).*How can China address its EV battery-recycling challenge?* Link

| Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|
| | Environmental/ social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | leaching, extraction, and product drying[264]. No air dispersion studies are publicly available for battery recycling, but a study on a battery factory in Germany found that these pollutants are still well below air quality standards[263]. In addition, facilities are generally located within industrial complexes, further isolating facilities from the local communities. |
| Manufacturing facility operation | Noise disruption | Air | Minor (2) | Not expected to occur (2) | **Low** | Recycling processes can generate significant noise due to various types of equipment in the facility. However, the noise disruption tends to be isolated within the facility, where the receptors are mainly workers who are generally equipped with personal protective equipment (PPE). As facilities usually occur within guarded compounds, the impact on local communities is less likely. |
| Manufacturing facility operation | Decreased soil quality | Soil | Severe (5) | Likely (3) | **High** | Recycling facility operations can degrade soil quality through air emissions that deposit into the soil. Although such a study has not been done for battery recycling plants, a study on a battery factory in Germany has shown that heavy metals contained in air pollutants from a battery factory can accumulate in the soil, where the heavy metal content exceeds legal standards[263]. This exceedance is identified at up to a radius of 6 km from the battery factory. |
| Manufacturing facility operation | Disrupted surface water quality & quantity | Water | Negligible (1) | Likely (3) | **Low** | Recycling facility operations can degrade surface water quality by releasing wastewater. Effluent discharge from recycling plants typically contains organic content and wastewater from acid-leaching[264]. That said, wastewater from battery recycling is reportedly small in volume. |
| Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Severe (5) | Likely (3) | **High** | Groundwater may be disrupted due to the high accumulation of heavy metals in the soil that penetrates the aquifer. |
| Manufacturing facility operation | Aquatic biodiversity degradation | Biodiversity | Negligible (1) | Not expected to occur (2) | **Low** | Although wastewater is generated from the production facility, due to its relatively small volume, aquatic biodiversity impacts are not expected to occur. |
| Facility operation | Solid waste generation | Waste generation | Major (4) | Known to occur (4) | **Substantial** | The dismantling process in recycling plants generates solid waste. Typical waste would include plastic connectors, circuit boards, wiring, powders, and casings[264]. Although the current battery recycling rate in Indonesia remains far below its maximum capacity, this could pose a significant problem in the future. Recycling schemes are encouraged to minimize solid waste generation. |

| Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|
| | Environmental/ social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Facility operation | Wastewater generation | Waste generation | Negligible (1) | Common occurrence (5) | **Low** | Recycling facility operations release effluent discharge containing organic content and wastewater from acid-leaching[264]. That said, wastewater from battery recycling is reportedly small in volume. |
| Facility operation | Hazardous waste generation | Waste generation | Major (4) | Common occurrence (5) | **High** | The amount of hazardous waste from the operation of the recycling plant may come from two sources: from the recycling process and from the potential black mass imports. Manufacturing facility operations generate hazardous waste from materials, including spent solvents, heavy metals, and contaminated materials[264]. Battery waste by regulation is classified as electronic waste, signaling the potential for material recovery and/or recycling. However, the current regulatory framework has not encouraged this among businesses. Without proper management, the amount of hazardous waste would very likely grow with increased battery production, signifying this may be a significant problem in the future. In addition, recycling plants encourage black mass imports to serve as feedstock. This would cause increased stockpiling of black mass in the recycling plant. Black mass is considered hazardous in several countries[281]. Proper measures should be taken to contain hazardous substances within controlled storage. |
| Facility operation | Increased power consumption | Energy | Minor (2) | Common occurrence (5) | **Moderate** | The energy consumption for the battery material recycling process highly depends on the method. Based on calculated energy consumption in an UAE case study[282], where they identified two methods—pyrometallurgy and hydrometallurgy. The results show that the pyrometallurgy process consumes about 4.59 MJ/kg or 1.275 kWh/kg of processed feedstock, whereas the hydrometallurgy process consumes 23.37MJ/kg or 6.491 kWh/kf of processed feedstock. |
| Facility operation | Increased CO2 emissions | Carbon emissions | Minor (2) | Known to occur (4) | **Moderate** | The amount of carbon emissions produced in battery recycling is comparatively lower than in battery production activities. According to a case study in the UAE, the identified carbon emissions for the different recycling methods—pyrometallurgy and hydrometallurgy—are 1,224.12 and 1,730.79 g/kg, respectively[282]. |

[281] BD Law. (2025). *China and Europe Diverge on Classification of Black Mass from Recycling of Lithium-Ion Batteries* Link

[282] Almahri, R. *et al.*. (2025). "Evaluating economic and environmental viability of recycling lithium-ion battery for electric vehicles in the middle east: a case study in the UAE". *Humanities and Social Sciences Communications* 2025, 12(508) Link

## Table C.7 Social Impact Assessment: Battery End-of-life

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Battery waste** | | | | | | | |
| Waste | Battery waste | Community health | Surrounding community | Medium (3) | Likely (3) | **Moderate** | As components are potentially dangerous, inadequate battery collection can lead to increased health issues in community that participate in the illegal battery removals.<br>According to the FDG with PT Hyundai Energy Indonesia, Hyundai currently exports battery waste to Korea, incurring additional export costs. This situation not only creates financial losses but also poses a barrier to the development of the domestic electric vehicle (EV) industry. This also leads to challenges in waste storage time. Hyundai cited that the storage of no-good batteries, which are classified as hazardous, is a noncompliance in terms of policy. This is due to the discrepancy between low stored waste and the cost needed for recycling. This issue has been monitored and approved by the Local Environmental Agency. |
| **Battery material recycling** | | | | | | | |
| Operation | Recycling facility operation | Community lifestyle | Surrounding community | Minor (2) | Not expected to occur (2) | **Low** | Recycling facility operation can pose risks to community safety through the potential release of accidental chemical spills, flammable reagents, or reactive reagents. Transportation of hazardous materials to and from the factory also increases the risk of accidents. Without strict safety measures, these risks can affect nearby residents. |
| Operation | Manufacturing facility operation | OHS | Workers | Medium (3) | Not expected to occur (2) | **Moderate** | One of the major environmental risks of battery manufacturing is the handling of batteries that become waste and the large quantity of defective batteries generated during production. In the early stages of a new factory, the rate of defective batteries can be as high as 40 percent, and these are typically stored and processed near their point of origin, |

## Table C.8 Environmental Impact Assessment: Associated Facilities

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Industrial Estate** | | | | | | | |
| Construction | Construction of estate lots and infrastructure | Massive land conversion | Landscape | Medium (3) | Common occurrence (5) | **Substantial** | Large-scale clearing and grading are necessary for building industrial estates and their supporting facilities, resulting in the loss of vegetation, topsoil, and natural habitats. |
| Construction | Construction of estate lots and infrastructure | Significant change of landscape and morphology | Landscape | Severe (5) | Common occurrence (5) | **High** | Construction of the industrial estate requires extensive land grading and leveling, which will significantly change the landscape and morphology. This will alter natural contours, disrupt drainage, and, if not properly managed, may lead to erosion and long-term degradation. |
| Construction | Construction of estate lots and infrastructure | Decreased soil quality | Soil | Medium (3) | Common occurrence (5) | **Substantial** | Construction activities can negatively impact soil quality through land clearing, excavation, and the use of heavy machinery. These actions may lead to soil compaction, erosion, and loss of topsoil, reducing soil fertility and its ability to support vegetation. |
| Construction | Construction of estate lots and infrastructure | Increased probability of soil erosion and landslide | Soil | Severe (5) | Likely (3) | **High** | Vegetation removal, slope cutting, and ground disturbance during construction can destabilize the land, especially in hilly or high-rainfall areas. Without proper control measures, these activities increase the risk of soil erosion and landslides. |
| Construction | Construction of estate lots and infrastructure | Degraded air quality | Air | Minor (2) | Known to occur (4) | **Moderate** | Construction activities generate dust through land clearing, excavation, and the movement of heavy machinery. Emissions from construction equipment and vehicles also contribute to air pollution. That said, the impact of such activities is generally localized within mining concessions that are often away from nearby communities. |
| Construction | Construction of estate lots and infrastructure | Noise disruption | Air | Minor (2) | Known to occur (4) | **Moderate** | Noise is generated during construction from the operation of heavy machinery such as excavators and bulldozers. Additionally, the constant movement of trucks and other vehicles carrying materials contributes to a continuous background noise throughout the site. That said, the impact of such activities is generally localized within industrial concessions that are often away from nearby communities. |

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of estate lots and infrastructure | Disrupted surface water quality & quantity | Water | Major (4) | Common occurrence (5) | High | Land clearing for construction will cause increased surface water runoffs. Surface water runoffs usually carry total suspended solids (TSS) from eroded soil particles, causing sedimentation in nearby water bodies. Additionally, vegetation removal can reduce the land's ability to retain water. |
| Construction | Construction of estate lots and infrastructure | Disrupted groundwater quality & quantity | Water | Major (4) | Common occurrence (5) | High | Land clearing can impact groundwater quality by disrupting the groundwater reservoir and altering its chemistry. The removal of vegetation and alteration of land surfaces limit water absorption, resulting in reduced groundwater recharge in the long term. Altered groundwater chemistry usually results from the weathering or leaching of exposed soil chemistry from land clearing[254]. |
| Construction | Construction of estate lots and infrastructure | Terrestrial biodiversity degradation | Biodiversity | Major (4) | Common occurrence (5) | High | Land clearing for construction will harm terrestrial biodiversity. Massive tree loss can lead to the degradation of natural habitats (e.g., habitat encroachment and fragmentation), which in turn impacts terrestrial diversity. Additionally, the disruption of natural ecosystems can lead to the proliferation of invasive species, which can outcompete native species and alter native diversity[255]. |
| Construction | Construction of estate lots and infrastructure | Aquatic biodiversity degradation | Biodiversity | Major (4) | Common occurrence (5) | High | Increased sedimentation and altered surface water chemistry can harm aquatic biodiversity. This condition will render the aquatic ecosystem unsuitable for several freshwater species, thereby reducing the number of species that can survive in water. |
| Construction | Construction of estate lots and infrastructure | Decline in ecosystem services | Biodiversity | Major (4) | Common occurrence (5) | High | Disrupted natural ecosystems will lead to the decline of ecosystem services. Altered landscapes, vegetation loss, and poor water quality reduce the ecosystem's natural functions such as food provision, water retention and filtration, and, eventually, the loss of livelihoods[213]. |
| Construction | Construction of estate lots and infrastructure | Wastewater generation | Waste generation | Major (4) | Common occurrence (5) | High | Land clearing typically generates wastewater from construction activities (i.e., land clearing) and base camp facilities. As it occurs still in the construction phase, the mitigation measures are usually not yet in place, resulting in wastewater being more prone to be released to open waters. |

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of estate lots and infrastructure | Increased CO2 emissions | Carbon emissions | Severe (5) | Common occurrence (5) | **High** | Land clearing linked to industrial expansion can increase CO2 emissions. For this parameter, analysis is conducted at all snapshot regions where industrial expansion is likely to occur in response to the battery industry. Using 2023 forest loss data from Global Forest Watch[209] the forest loss in Morowali, Halmahera, and Karawang contributes to an estimate of 786.9, 866.7, 255.0, and 227.0 t CO2/Ha, respectively. This shows that these forests are a large carbon storage in pre-industry conditions, and their loss greatly impacts increased CO2 emissions. |
| Operation | Industrial estate operation | Significant change of landscape and morphology | Landscape | Severe (5) | Not expected to occur (2) | **Substantial** | Tenant operations, especially related to refining, can create significant landscape changes due to the development of waste dams. Mineral processing, particularly via HPAL, produces waste from the acid-leaching process[258]. Waste dams are usually developed in such a way that they alter the landscape and morphology of the area. |
| Operation | Industrial estate operation | Decreased soil quality | Soil | Major (4) | Very unlikely to occur (1) | **Low** | Following the development of the waste dam and dumping site, stored waste is treated by being confined in dams with semi-permeable or impermeable linings to minimize leakage to the soil and groundwater. If the lining system is damaged, pollutants from the dumping site can infiltrate the soil and contaminate groundwater through seepage[283]. That said, such cases (related to waste dams, not waste dumping) have not been reported or identified in Indonesia, which is a demonstration of good design and maintenance. |
| Operation | Industrial estate operation | Increased probability of soil erosion and landslide | Soil | Severe (5) | Not expected to occur (2) | **Substantial** | As mentioned above, waste dams are typically developed in a manner that alters the landscape and morphology. This inadvertently increases the landslide risk of the area. In Indonesia, |

[283] Cheng, Y. *et al.* (2024). "Seepage and Deformation Analysis of Tailing Dam regarding the Upper Reservoir of Tiantai Pumped Storage Station". *Journal of Physics: Conference Series* 2024, 7736, 012021 Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | tailing dams are typically consulted with the National Dam Committee to ensure proper measures are taken and accidents are avoided. However, dam accidents are a global concern, and such an accident has been reported in IMIP[284]. The fact remains that a landslide risk remains in the developing of a waste dam. |
| Operation | Industrial estate operation | Degraded air quality | Air | Major (4) | Common occurrence (5) | **High** | Tenant operations can significantly disrupt air quality. An air emission modelling of planned and developed nickel smelters, most of which are located within industrial estates, projected significant increases of NO2, SO2, and PM2.5 within the perimeter of the smelters spread across Sulawesi and Halmahera by 2027[72]. These pollutants contribute to air pollution, posing risks to human health and the environment. In addition, the dispersion of these pollutants is projected to be widespread, regardless of whether the smelters are located within an industrial estate or not. |
| Operation | Industrial estate operation | Disrupted surface water quality & quantity | Water | Major (4) | Known to occur (4) | **High** | Tenant operational wastewaters are usually treated in a centralized wastewater treatment facility provided by the industrial estate, ensuring proper disposal and minimum pollution to open water bodies. That said, the presence of industrial estates such as IWIP in Central Halmahera does not guarantee compliant wastewater standards, causing disruption to open water bodies[213]. This signifies that industrial estate practices must be improved. |
| Operation | Industrial estate operation | Disrupted marine water quality | Water | Major (4) | Known to occur (4) | **High** | Tenant operational wastewaters are usually treated in a centralized wastewater treatment facility provided by the industrial estate, ensuring proper disposal and minimum pollution to open water bodies. That said, the presence of industrial estates in Morowali and Central Halmahera (i.e., IMIP, IWIP) do not guarantee compliant wastewater standards, disrupting to open water bodies, including |

[284] YTM. (2025). *11,5 Juta Ton Limbah Tailing IMIP Ancam Sungai Bahodopi* Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | coastal and marine ecosystems, as reported in Halmahera[213]. This signifies that industrial estate practices must be improved. |
| Operation | Industrial estate operation | Aquatic biodiversity degradation | Biodiversity | Major (4) | Known to occur (4) | **High** | Noncompliant wastewater discharged to rivers can negatively impact aquatic biodiversity. |
| Operation | Industrial estate operation | Marine biodiversity degradation | Biodiversity | Major (4) | Known to occur (4) | **High** | Noncompliant wastewater discharged to the ocean can negatively impact marine biodiversity. Poor fish yield in marine ecosystems is reported due near industrial areas[213]. |
| Operation | Industrial estate operation | Decline in ecosystem services | Biodiversity | Major (4) | Known to occur (4) | **High** | Disrupted biodiversity and ecosystems can lead to poor fish yields[213] |
| Operation | Industrial estate operation | Wastewater generation | Waste generation | Major (4) | Known to occur (4) | **High** | Tenant operational wastewaters are usually treated in a centralized wastewater treatment facility provided by the industrial estate, ensuring proper disposal and minimum pollution to open water bodies. That said, the presence of industrial estates in Morowali and Central Halmahera (i.e., IMIP, IWIP) do not guarantee compliant wastewater standards, as reported in Halmahera[213]. This indicates that industrial estate practices need to be improved. |
| Operation | Industrial estate operation | Hazardous waste generation | Waste generation | Severe (5) | Not expected to occur (2) | **Substantial** | The most prominent hazardous waste from industrial estates, particularly in Morowali and Central Halmahera, is slag produced from the refining process. Slag is classified as nonhazardous by legislation, yet requires an additional technical recommendation from the MoE to confirm its nontoxicity. It is treated by being confined in dams with semi-permeable or impermeable linings to minimize leakage. In Indonesia, such dams are typically consulted with the National Dam Committee to ensure proper measures are taken and accidents are avoided. However, dam accidents are a global concern, and such an accident has been reported in IMIP[284]. A dam accident can result in significant water pollution and disruption of aquatic ecosystems. In IMIP, nickel slags from different smelters are collected within one centralized area. The magitude of a combined slag dump in an industrial estate, compared to one slag |

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | dump from one smelter, may pose a significantly larger risk should accidents occur. |
| **Special port** | | | | | | | |
| Construction | Construction of special terminal (e.g. dredging) | Massive land conversion | Landscape | Minor (2) | Common occurrence (5) | **Moderate** | Massive land conversion during the construction of a special terminal involves clearing coastal areas, reclaiming land, and altering natural shorelines. This process can lead to habitat loss, disruption of coastal ecosystems, and changes in sedimentation patterns. As a result, the natural resilience of the coastal environment is reduced. |
| Construction | Construction of special terminal (e.g. dredging) | Significant change of landscape and morphology | Landscape | Minor (2) | Common occurrence (5) | **Moderate** | The construction of a special terminal can cause significant changes in landscape and morphology through large-scale excavation, land reclamation, and shoreline modification. These activities alter natural land contours, slopes, and visual characteristics of the area. Dredging, in particular, can cause coastal abrasion and decrease coastal stability[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Decreased soil quality | Soil | Minor (2) | Common occurrence (5) | **Moderate** | Construction of a special terminal can significantly impact the soil within the project area due to excavation, compaction, and the introduction of construction materials and machinery. These activities may reduce soil permeability and fertility which can inhibit vegetation growth[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Increased probability of coastal abrasion | Soil | Minor (2) | Common occurrence (5) | **Moderate** | Soil erosion and landslide risks during special port construction may increase due to alterations to the coastline. Exposed soils near the coast can become more susceptible to rain and tidal forces, resulting in increased coastal abrasion risk[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Noise disruption | Air | Minor (2) | Common occurrence (5) | **Moderate** | Continuous operation of heavy machinery and dredging activities can generate noise disruptions. This potentially cause disturbance to coastal residents and wildlife. |

[285] Iwasaki, K. *et al.* (2022). "Port construction alters dune topography and coastal forest growth: A study on forest decline due to coastal erosion". *Ecological Engineering* 2022, 180, 106640 Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of special terminal (e.g. dredging) | Disrupted marine water quality | Water | Medium (3) | Common occurrence (5) | **Substantial** | Dredging and coastal earthworks can disrupt marine water quality through surface water run-offs and sedimentation[286]. |
| Construction | Construction of special terminal (e.g. dredging) | Terrestrial biodiversity degradation | Biodiversity | Minor (2) | Common occurrence (5) | **Moderate** | Land clearing for construction will harm terrestrial biodiversity. Massive tree loss can lead to the degradation of natural habitats (e.g., habitat encroachment and fragmentation), which in turn impacts terrestrial diversity. Degraded soil can also impact terrestrial biodiversity[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Marine biodiversity degradation | Biodiversity | Medium (3) | Common occurrence (5) | **Substantial** | Construction activities can disrupt marine ecosystems. Dredging activities impact bottom biota (i.e., corals), disrupt marine water chemistry, and cause the displacement of marine species. In addition, rubbles, concrete surfaces, and other structures can introduce invasive marine species[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Decline in ecosystem services | Biodiversity | Medium (3) | Common occurrence (5) | **Substantial** | Construction activities can disrupt vital ecosystem services, including coastal protection, water purification, carbon sequestration, and fisheries productivity. Disruption to these natural functions can impact both environmental resilience and the livelihoods that depend on coastal and marine resources. |
| Construction | Construction of special terminal (e.g. dredging) | Solid waste generation | Waste generation | Medium (3) | Common occurrence (5) | **Substantial** | Construction activities generate a large amount of dredged materials as the main solid waste. This can impact the surrounding ecosystems as dredged materials may contain contaminated materials and cause an unsightly view for the local community[285]. |
| Construction | Construction of special terminal (e.g. dredging) | Wastewater generation | Waste generation | Major (4) | Known to occur (4) | **Moderate** | Wastewater generated from construction activities typically include sedimentation and surface water run-offs which can disrupt marine water[285]. |

[286] UNESCAP. (1992). *Assessment of the Environmental Ipact of Port Development.* Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Operation | Construction of special terminal (e.g. dredging) | Disrupted marine water quality | Water | Medium (3) | Common occurrence (5) | **Substantial** | Port establishments generally disrupt marine ecosystems. This is achieved through a combination of disrupted marine water chemistry, coastal hydrology, and bottom contamination[285]. One established port may not be able to cause substantial impacts. However, increased demand in the battery supply chain may drive the development of several ports within the same area. This can render the coastal areas of Morowali or Central Halmahera no longer eligible for fisheries, further impacting community livelihoods. |
| Operation | Special terminal operation (not including hauling) | Marine biodiversity degradation | Biodiversity | Medium (3) | Common occurrence (5) | **Substantial** | Port establishments generally disrupt marine ecosystems. This is achieved through a combination of disrupted marine water chemistry, coastal hydrology, and bottom contamination[285]. Diminished bottom biota may lead to reduced fishery resources and an increase in invasive species. One established port may not be able to cause substantial impacts. However, increased demand in the battery supply chain may drive the development of several ports within the same area. This can render the coastal areas of Morowali or Central Halmahera no longer eligible for fisheries, further impacting community livelihoods. |
| Operation | Special terminal operation (not including hauling) | Decline in ecosystem services | Biodiversity | Medium (3) | Common occurrence (5) | **Substantial** | Poor marine biodiversity may lead to reduced fishery resources, which provide a valuable ecosystem service for the local communities[285]. |
| Operation | Construction of special terminal (e.g. dredging) | Increased energy consumption | Energy | Medium (3) | Likely (3) | **Moderate** | The amount of energy consumed for the operation of a container terminal largely depends on the port design. This includes variables such as the layout efficiency, area size, equipment, and other factors. A calculation of two different port models[287], where the energy consumption for both ports is approximately 11 and 7.5 GWh/year. |

[287] Budiyanto, M.A. *et al.* (2021). "Evaluation of CO2 emissions and energy use with different container terminal layouts". *Scientific Reports* 2021, 11, 5476 Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | While there are no true standard for how many carbon emissions should a logistics port produce, many port operators are heading towards carbon neutrality through many efforts. |
| Operation | Construction of special terminal (e.g. dredging) | Increased CO2 emissions | Carbon emissions | Medium (3) | Likely (3) | **Moderate** | Based on a study conducted at an unidentified Indonesian container terminal[288], the amount of carbon emissions produced during the operation of a logistics port is approximately 15.6 kg CO2e/TEU (twenty-foot equivalent unit, a unit of cargo measurement). This falls within the typical range of carbon emissions produced by logistics ports worldwide (9.3-26.5 kg CO2e/TEU). |
| **Transport and logistics** | | | | | | | |
| Construction & operation | Hauling of goods | Degraded air quality | Air | Minor (2) | Common occurrence (5) | **Moderate** | Transport vehicles, including trucks, ships, and loaders, emit exhaust gases such as nitrogen oxides (NO), sulphur oxides (SO), carbon monoxide (CO), and particulate matter (PM). These pollutants degrade ambient air quality, especially along major transport routes and port loading areas. The extent of impact may occur within a certain perimeter from the main transport routes. |
| Construction & operation | Hauling of goods | Noise disruption | Air | Minor (2) | Common occurrence (5) | **Moderate** | Heavy vehicle movement, cargo loading/unloading, and port operations generate high noise levels. This continuous noise can disturb local residents and wildlife, especially in densely populated or ecologically sensitive areas. |
| Construction & operation | Hauling of goods | Disrupted marine water quality | Water | Minor (2) | Common occurrence (5) | **Moderate** | Logistics shipping may impact marine water through waste discharged from ships, such as oil spills, discharge of ballast water, and wastewater discharges. |
| Construction & operation | Hauling of goods | Marine biodiversity degradation | Biodiversity | Minor (2) | Common occurrence (5) | **Moderate** | Logistics shipping can cause marine biodiversity disruption through the vessel operation, such as the noise from navigation tools. Noise from vessels is known to cause behavioral disturbances in marine |

[288] Budiyanto, M.A. *et al.* (2024). "Modest Method for Estimating CO2 Emissions from Container Handling Equipment at Ports". *Sustainability* 2024, 16(23), 10293 Link

| Activity phase | Activity phase | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | wildlife, such as whales and seals[289], particularly during migration months. |
| Construction & operation | Hauling of goods | Decline in ecosystem services | Biodiversity | Minor (2) | Common occurrence (5) | **Moderate** | Disruption towards marine water quality may impact fish yield, which is a source of livelihood for coastal communities. |
| Construction & operation | Hauling of goods | Increased CO2 emissions | Energy | Minor (2) | Common occurrence (5) | **Moderate** | IEA[290] reports that the energy intensity for international shipping is about 70 MJ/tnm per 2023. This represents a marked reduction from the 2000 numbers, which were around 100 MJ/tonne at the time. The ongoing trend of decarbonizing the transportation sector can further minimize energy consumption at this phase. |
| Construction & operation | Hauling of goods | Increased CO2 emissions | Carbon emissions | Negligible (1) | Common occurrence (5) | **Low** | Transport and logistics contribute the least to battery production. McKinsey[291] estimated that this stage can amount to 5% of a battery's life-cycle GHG emissions, which is about 5 kg CO2e/kWh for nickel-containing batteries and 4 kg CO2e/kWh for "nickel-free" batteries. The ongoing trend of decarbonizing the transportation sector can further minimize emissions at this phase. |

[289] Badino, A. *et al.* 2012. "Noise Emitted from Ships: Impact Inside and Outside the Vessels". *Procedia – Social and Behavioral Sciences* 2012, 48, 868-879 Link
[290] IEA. (2025).*International shipping energy intensity and its components, 2000-2023*. Link
[291] McKinsey. (2023).*The race to decarbonize electric-vehicle batteries*. Link

## Table C.9 Social Impact Assessment: Associated Facilities

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| **Industrial estate** | | | | | | | |
| Pre-construction | Land acquisition | IP and cultural heritage | Vulnerable people | Severe (5) | Known to occur (4) | **High** | Indigenous Peoples have reported that the State and representatives of nickel mining or smelting companies did not disclose the purpose of land acquisition or provide any project details. Despite Indigenous Peoples having the right to participate in decision-making, the State did not consult them to obtain Free, Prior, and Informed Consent (FPIC) before approving projects affecting their land, territories, or resources.<br><br>Local residents reported that their land was taken, deforested, or excavated without consent. This includes individuals holding land certificates and indigenous groups claiming customary land. In some cases, landowners were only compensated for a portion of their land. |
| Pre-construction | Land acquisition | Livelihood | Surrounding community | Severe (5) | Likely (3) | **High** | Local residents were not consulted regarding land possession for the Konawe Industrial Park project, which focuses on hydrometallurgical nickel processing for battery production using high-pressure acid leach (HPAL) technology. Communities no longer have access to lands that support their livelihoods, including ancestral burial sites.<br><br>Communities are required to make space for potential nickel processing projects when private companies with national and international capital receive approval from the Ministry of Environment and Forestry to convert production forests into industrial zones. |
| Pre-construction | Land acquisition | Human rights | Surrounding community | Severe (5) | Likely (3) | **High** | For the Konawe Industrial Park under construction, local communities have been intimidated by corrupt police officers and criminalized for cultivating their lands, posing human rights risks. The affected area covers 3,500 ha. In the Sulawesi Highlands, the Mopute people maintained small homes and farms on traditional lands where ancestors are buried. In 2022, Merdeka Battery Materials (MBMA) acquired the land and controls the nearby Sulawesi Cahaya Mineral (SCM) mine. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | Private companies offered compensation, which the communities rejected. Reports were filed with the National Commission on Human Rights. Local residents were not consulted regarding construction plans, violating FPIC rights. Many indigenous tribes do not hold government-recognized land certificates. In some cases, village leaders have made deals with companies without villagers' consent.<br><br>Near IWIP, community members who refused to sell or contested land prices faced intimidation, threats, and retaliation from company representatives, police, and military personnel. |
| Construction | Construction of estate lots and infrastructure | Community lifestyle | Surrounding community | Medium (3) | Known to occur (4) | **Substantial** | For the Morowali Industrial Park (IMIP), Bahodopi district had 7,517 residents and 1,738 households in 2017; these numbers have doubled due to incoming workers. Migrants mainly come from southern Sulawesi, including Torajan and Bugis ethnic groups. IMIP prioritized locals in recruitment, which caused competition among newcomers. Economic activity increased, including restaurants, rental housing, machine shops, and fuel retailers.<br><br>IMIP construction has caused conflicts between migrant communities and locals, as well as between local residents and companies. Pollution and wastewater runoff have reduced water quality, decreased fish populations, and forced fishers to travel further out to sea. |
| Construction | Construction of estate lots and infrastructure | Livelihood | Surrounding community | Major (4) | Known to occur (4) | **Substantial** | Community members have also reported that fish ponds were destroyed due to land clearing operations related to industrial construction. |
| Operation | Industrial estate operation | Labor compliance | Workers | Major (4) | Known to occur (4) | **Substantial** | Workers paid Rp 3.5–7 million to secure construction jobs, creating employment instability. Overtime was restricted as retaliation for union membership. After the 2023 IMIP accident, compensation for Indonesian workers was lower than for Chinese workers. Personal protective equipment (PPE) was reported as poor quality, limited, and |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | not replaced when damaged. IMIP representatives claim compliance with labor regulations, accident reporting, and PPE provisions. |
| Operation | Industrial estate operation | Human Rights | Workers | Major (4) | Known to occur (4) | **Substantial** | China Labor Watch reported Chinese migrant workers in IMIP have passports confiscated and restricted movement, a serious human rights concern. Workers face low wages, unsafe conditions, and job instability. In February 2025, a worker died from a workplace accident. Conflicting reports exist between IMIP management and Workers Union Confederation (SPIM-KPBI). Between 2015 and mid-2024, 114 incidents caused 101 deaths and 240 injuries, with reports of accident concealment and penalization. |
| Operation | Industrial estate operation | OHS | Workers | Major (4) | Known to occur (4) | **Substantial** | Workers have reported to lack labor protections and face job instability, low wages and workplace safety hazards. In past February 2025, a worker in the Morowali Industrial Park died after a heavy object crushed his head. PT IMIP Media Relations Representative has issued an official statement which information differs from the statement from the Workers Union Confederation of Indonesian Workers Unions (SPIM-KPBI). Two dozens of workers at ninve companies in the IMIP complex allege widespread lax safety practices, inadequate protective equipment, and poor communication between Indonesian and Chinese workers, resulting in unsafe working conditions and frequent accidents. Between 2015, and the first half of 2024, 114 incidents in Indonesia have resulted in 101 deaths and 240 injuries accordint to data compiled by non-profit group Trend Asia. There has been reported that within IMIP there is a practice to hide accidents as they are penalised through pay cuts or warning letters. Additionally the practice of reporting accidents using social media is seen as unfaithful. |
| Operation | Industrial estate operation | Community lifestyle | Surrounding community | Medium (3) | Known to occur (4) | **Moderate** | Despite the employment opportunities created by the park, most local residents remain engaged in agriculture because they lack the skills required for industrial work. IMIP representatives informed the community of a power purchase agreement allowing PLN to buy excess electricity (5 MW) from IMIP's power plant and distribute it to 12 villages in Bahodopi via transmission lines built by IMIP. Villages reported that |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | promised subsidies for electricity rates have not been implemented. Protests were organized over the lack of subsidy implementation and delays in the disbursement of the company's 2016 Corporate Social Responsibility (CSR) fund of Rp 5 billion, which was intended for public infrastructure such as roads and facilities rather than direct community distribution. As industrial parks within Special Economic Zones are classified as National Strategic Projects (NSP), police presence has increased, and additional military deployment is planned.<br><br>Industrial estate activities can pose significant risks to community safety, including potential release of toxic gases, accidental chemical spills, and fire or explosion hazards from high-temperature processes. Transportation of hazardous materials to and from the site also increases accident risks. Without strict safety measures, these hazards can affect nearby residents. |
| Operation | Industrial estate operation | Livelihood | Surrounding community | Medium (3) | Known to occur (4) | **Substantial** | The Indonesia Morowali Industrial Park (IMIP) is the country's largest nickel-based industrial area, located in Morowali Regency, Central Sulawesi, and served by coal-fired power plants with over 2 GW capacity. Populations have reported increasing cases of industrial-related diseases, though exact figures are not available.<br><br>Some industrial parks implement CSR strategies. For example, Weda Bay Industrial Park (IWIP) provides infrastructure support to more than 25 schools and Islamic boarding schools, literacy training programs in Central Halmahera, scholarships for students from vocational to postgraduate levels, and laboratory equipment for the Faculty of Medicine and Faculty of Engineering at Khairun University, Ternate. IWIP also provided 10 gas cylinders to community health centers, built six pavilions at Weda Regional Hospital, supplied three ambulances, and constructed an inpatient community health center. Company representatives report providing financial assistance and infrastructure development to the Central Halmahera district government to improve |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| | | | | | | | clean water services. Additional CSR initiatives include support for the elderly, distribution of sacrificial animals in four regencies and cities in North Maluku, five three-wheeled motorcycles for waste collection, road and drainage repairs in surrounding villages, and a Water Intake and Treatment Plant supplying 15,000 cubic meters of clean water per day. IWIP has received awards from the Ministry of Investment for contributions to micro, small, and medium enterprises (MSMEs). |
| Operation | Industrial estate operation | GEDSI | Vulnerable people | Medium (3) | Likely (3) | **Moderate** | Workers have reported that women are not allowed to take menstrual leave, as mandated under national law. Pregnant women have been assigned night shifts despite legal protections designed to safeguard maternal and child health. While women manage approximately 64% of micro, small, and medium enterprises, many face limited access to collateral, financial literacy challenges, and exclusion from formal banking. |
| Operation | Industrial estate operation | Community health | Surrounding community | Medium (3) | Likely (3) | **Moderate** | At IWIP, public health studies directly linking industrial activity to community health issues are limited. However, reported health impacts are consistent with expected outcomes from exposure to industrial and coal-fired power plant pollution, including increased respiratory and skin-related illnesses among workers and nearby residents.<br><br>Merdeka and CATL signed an MoU for collaboration on the battery metals supply chain in Indonesia, involving future investments in clean energy assets. Merdeka has committed to a 29% reduction in greenhouse gas emission intensity by 2030 and achieving net-zero emissions. However, respiratory illnesses are a common complaint among communities surrounding IMIP, which relies on coal power. Residents in Lelilef Sawai Village reported being prohibited from fishing in Tanjung Uli, Karkar, and Cacu, and restricted from collecting firewood. Additionally, nickel ore storage reclamation by PT IWIP in the Karkar area has disrupted local fishing activities. |
| **Special port** | | | | | | | |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction | Construction of special terminal (e.g. dredging) | Livelihood | Surrounding community | Medium (3) | Likely (3) | **Moderate** | The Makassar New Port (MNP) project is being developed on coastal areas that have been used and managed by local communities for generations, including women who depend on shellfish and fish for their livelihoods. Since coastal reclamation began for the construction of the CPI and MNP, shellfish production has declined sharply. Fishermen report that shellfish are now increasingly rare, and 1,105 fishing families were displaced due to the reclamation project. Many young people have changed professions, taking work as construction laborers, street vendors at Losari Beach, parking attendants, or even scavengers. |
| Construction | Construction of special terminal (e.g. dredging) | GEDSI | Vulnerable people | Medium (3) | Likely (3) | **Moderate** | Despite women being central to coastal resource management, the State made no effort to accommodate their interests. According to data from Women's Solidarity (Solidaritas Perempuan) in 2018, 1,105 fishing households faced threats of eviction due to the mega-project. On average, the wives of these fisherfolk were responsible for shellfish gathering, highlighting the disproportionate impact on women's livelihoods. |
| Construction | Construction of special terminal (e.g. dredging) | OHS | Workers | Medium (3) | Not expected to occur (2) | **Moderate** | The construction of the special terminal also poses significant risks to human safety, particularly for workers, due to the use of heavy machinery, chemical substances, and potential accidents. Without proper safety measures and clear communication, these risks could result in injuries and broader public concern. |
| **Transport and logistics** | | | | | | | |
| Construction & operation | Hauling of goods | Community health | Surrounding community | Medium (3) | Likely (3) | **Moderate** | There has been an increase in respiratory and skin-related illnesses. Airborne pollutants and dust generated from transport activities can cause respiratory problems, particularly for communities living near roads, ports, or logistics hubs. Prolonged exposure to vehicle emissions may increase the risk of asthma, bronchitis, and cardiovascular diseases. |

| Activity phase | | Source of risk | | Assessment | | | Analysis |
|---|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | Impact | Likelihood | Significance of impact | |
| Construction & operation | Hauling of goods | Community lifestyle | Surrounding community | Medium (3) | Not expected to occur (2) | **Moderate** | The increased movement of large trucks and heavy equipment also raises the risk of traffic accidents, especially in areas with mixed traffic, including pedestrians and motorcycles.<br><br>According to Detik (2025), 4W electric vehicles (EVs) are considered particularly hazardous because their batteries store large amounts of energy—up to 100 kilowatt-hours. Currently, no effective extinguishing method exists for EV fires. Therefore, EVs should be parked in monitored, safe areas near ship exits or ramp doors to facilitate evacuation in case of fire, protecting people nearby.<br><br>Some industrial parks provide transportation facilities, though they are limited and not available for all departments. This limited access contributes to the high number of traffic accidents along roads near industrial park areas during working hours. |

# Annex D: Environmental and Social Mitigation Matrix

**Table D.1 Environmental Mitigation Matrix: Battery Production**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| **Mining** | | | | | | |
| Construction | Construction of mining facilities (i.e., haul road, office) | Massive land conversion | Landscape | Adherence to ATRBPN Reg 13/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Collaborate and coordinate with the National Land Agency, local governmental agencies, and other relevant stakeholders on mitigation strategies, i.e., reduce potential illegal deforestation due to increased forest access. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Significant change of landscape and morphology | Landscape | Adherence to ATRBPN Reg 13/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. After land conversion, the company must ensure land stabilization is enforced through proper design and mechanisms. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities | Degraded soil quality | Soil | USDA Soil Quality | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies. | • Ministry of Environment<br>• Ministry of Forestry |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | (i.e., haul road, office) | | | Assessment Guidelines[292] | • Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Minimizing the work area and regulating the usage of heavy machinery to minimize soil compaction. Topsoil should be reused during land rehabilitation to preserve its organic content. | • Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Increased probability of soil erosion and landslide | Soil | Soil stability and subsequent water quality | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Preparing slope management, erosion control, and hydrological planning. This stage can combine with land rehabilitation by revegetating native species in the terrace. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Disrupted surface water quality & quantity | Water | Adherence to Gov Reg 22/2021<br><br>IRMA Water Quality Criteria[293] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency |

[292] USDA. (2001).*Guidelines for Soil Quality Assessment in Conservation Planning* Link
[293] IRMA. (2018). *IRMA Water Quality Criteria by End-Use Tables* Link

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | | • Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Disrupted groundwater quality & quantity | Water | Adherence to Minister of Health (MoH) Reg 2/2023 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Ensure enough forest stand is retained in the surrounding area of the cleared land to ensure water retention is preserved.<br>• Continuously conduct groundwater quantity monitoring, i.e., water level tapes. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Land Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Terrestrial biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Limited land clearing only in the designated project area based on biological survey, including avoiding sensitive habitats and maintaining buffer zones around key ecological features, such as riparian zones and wildlife corridors. | • Ministry of Environment<br>• Regional Environmental Agency<br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Construction | Construction of mining facilities | Aquatic biodiversity degradation | Biodiversity | Critical habitat identification | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies. | • Ministry of Environment<br>• Regional Environmental Agency |

[294]Many MDBs approve the critical habitat assessment and management procedures developed by the IUCN.
IUCN. n.d. "The Red List Process". Link

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | (i.e., haul road, office) | | | and management as approved by the IUCN[294] | • Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • The company must ensure land clearing is conducted within the approved boundary.<br>• Minimize land disturbance, preserving critical vegetation cover, and maintaining natural drainage patterns along with a sedimentation pond to control sediment runoff.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency<br><br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Solid waste generation | Waste generation | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Construction | Construction of mining facilities (i.e., haul road, office) | Wastewater generation | Waste generation | Adherence to Gov Reg 22/2021<br><br>IRMA Water Quality Criteria[293]<br><br>International Standards provided by Multilateral | • At this stage, sediment traps usually are not yet in place. To minimize surface water runoffs, sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | Development Banks (MDBs) | | |
| Construction | Construction of mining facilities (i.e., haul road, office) | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Proper study before activities, which includes potential carbon sequestration in the project area and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Limited land clearing only in the designated project area based on biological survey, including avoiding potential carbon sequestration sports.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Massive land conversion | Landscape | Adherence to MEMR Reg 26/2018 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Collaborate and coordinate with the National Land Agency, local governmental agencies, and other relevant stakeholders on mitigation strategies, i.e., reduce potential illegal deforestation due to increased forest access. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency<br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Operation | Mining operation | Significant change of landscape and morphology | Landscape | Adherence to MEMR Reg 26/2018 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • After land conversion, the company must ensure land stabilization is enforced through proper design and mechanisms. | • Regional Land Agency<br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Operation | Mining operation | Degraded soil quality | Soil | USDA Soil Quality Assessment Guidelines[292] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Minimizing the work area and regulating the usage of heavy machinery to minimize soil compaction. Topsoil should be reused during land rehabilitation to preserve its organic content. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Increased probability of soil erosion and landslide | Soil | Soil stability and subsequent water quality | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Preparing slope management, erosion control, and hydrological planning. This stage can combine with land rehabilitation by revegetating native species in the terrace. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Decreased air quality | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Mining operation | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Operation | Mining operation | Disrupted surface water quality & quantity | Water | Adherence to Gov Reg 22/2021<br><br>IRMA Water Quality Criteria[293]<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Maintaining drainage systems and sedimentation ponds, together with other wastewater treatment. Discharged wastewater should be treated to ensure that it follows national and international standards before entering open water bodies.<br>• Conduct revegetation and rehabilitation as per the mine plan to minimize further surface water run-offs. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Disrupted groundwater quality & quantity | Water | Adherence to MoH Reg 2/2023 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Ensure enough forest stand is retained in the surrounding area of the cleared land to ensure water retention is preserved.<br>• Continuously conduct groundwater quantity monitoring, i.e., water level tapes. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Terrestrial biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Limited land clearing only in the designated project area based on biological survey, including avoiding sensitive habitats and maintaining | • Ministry of Environment<br>• Regional Environmental Agency<br><br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | buffer zones around key ecological features, such as riparian zones and wildlife corridors. | |
| Operation | Mining operation | Aquatic biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Maintaining drainage systems and sedimentation ponds, together with other wastewater treatment. Discharged wastewater should be treated to ensure that it follows national and international standards before entering open water bodies.<br>• Conduct revegetation and rehabilitation as per the mine plan to minimize further surface water run-offs. | • Ministry of Environment<br>• Regional Environmental Agency<br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Operation | Mining operation | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • The company must ensure land clearing is conducted within the approved boundary.<br>• Minimize land disturbance, preserving critical vegetation cover, and maintaining natural drainage patterns along with a sedimentation pond to control sediment runoff.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency<br>If the concession is inside the forest estate:<br>• Ministry of Forestry<br>• Regional Forestry Agency |
| Operation | Mining operation | Solid waste generation | Waste generation | Adherence to Law 18/2008 | • Conduct mining based on the approved mine plan.<br>• Minimize overburden and topsoil through careful planning and controlled operations, with proper segregation, storage, and regular removal to approved disposal sites. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Wastewater generation | Waste generation | Adherence to Gov Reg 22/2021 | • Maintaining drainage systems and sedimentation ponds, together with other wastewater treatment. Discharged wastewater should be | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | IRMA Water Quality Criteria[293]<br><br>International Standards provided by Multilateral Development Banks (MDBs) | treated to ensure that it follows national and international standards before entering open water bodies.<br>• Conduct revegetation and rehabilitation as per the mine plan to minimize further surface water run-offs. | |
| Operation | Mining operation | Hazardous waste generation | Waste generation | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Mining operation | Increased power consumption | Energy | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Mining operation | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Monitor carbon emissions regularly and explore opportunities for carbon sequestration to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |
| Post-operation | Facility decommisioning | Solid waste generation | Waste generation | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Post-operation | Mine reclamation | Land conversion | Landscape | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (*Rencana Penutupan Tambang*) that adheres to government regulations on reclamation and rehabilitation standards. Opt to aim for a productive post-mine, such as agriculture, forestry, or conservation areas. While | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | complete restoration to original conditions may not be feasible, these efforts support biodiversity recovery and ecosystem restoration[295]. | • Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Significant change of landscape and morphology | Landscape | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Stabilize altered slopes and landforms following the approved Mine Closure Plan. Opt to blend them with the natural environment[295]. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Soil quality improvement | Soil | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Restore stored topsoil as well as plant endemic and fast-growing species to optimize soil fertility. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Decreased probability of soil erosion and landslide | Soil | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency |

[295] Feng, Z. *et al.* (2023). https://www.mdpi.com/2073-445X/12/11/1994

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Conducting proper reclamation and revegetation, together with land management for erosion control. | • Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Air quality improvement | Air | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Restore stored topsoil as well as plant endemic and fast-growing species to optimize revegetation, which contributes to minimizing dust and serves as buffer zones. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Surface water improvement | Water | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Stabilize altered slopes and landforms following the approved Mine Closure Plan to minimize surface water runoffs.<br>• Restore stored topsoil as well as plant endemic and fast-growing species to optimize revegetation which contirbutes to minimizing surface water runoffs. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Groundwater improvement | Water | Adherence to MEMR Reg 26/2018 | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Stabilize altered slopes and landforms following the approved Mine Closure Plan to minimize surface water runoffs. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Restore stored topsoil as well as plant endemic and fast-growing species to optimize revegetation, which contributes to groundwater retention. | • Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Terrestrial biodiversity improvement | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Restore ecosystems using a critical habitat-based approach to target significant species of note as well as key ecosystem functions. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Aquatic biodiversity improvement | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Restore stored topsoil as well as plant endemic and fast-growing species to optimize revegetation which contirbutes to minimizing surface water runoffs.<br>• Restore ecosystems using a critical habitat-based approach to target significant species of note as well as key ecosystem functions. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |
| Post-operation | Mine reclamation | Ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Conduct mining based on the approved mine plan.<br>• Prepare a government-approved Mine Closure Plan (Rencana Penutupan Tambang) that adheres to government regulations on reclamation and rehabilitation standards. The document should include stabilization of altered landforms.<br>• Restore ecosystems using a critical habitat-based approach, to target significant species of note as well as key ecosystem functions. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Mineral Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Energy and Mineral Resources Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| **Refining** | | | | | | |
| Construction | Construction of smelter | Degraded air quality | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Construction | Construction of smelter | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Smelter operation | Degraded air quality | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Conduct a government-approved technical study to incorporate technological approaches to meet emission standards.<br>• Continuous watering in haul roads and transportation roads to minimize dust. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Smelter operation | Noise disruption | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Smelter operation | Disrupted surface water quality & quantity | Water | Adherence to Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Smelter operation | Disrupted ground water quality & quantity | Water | Adherence to MoH Reg 2/2023 | • Preventing contamination of groundwater by implementing proper wastewater management practices, including containment and treatment of process and cooling water.<br>• Minimizing groundwater extraction to maintain groundwater levels and protect surrounding ecosystems. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Operation | Smelter operation | Aquatic biodiversity degradation | Biodiversity | Adherence to Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Smelter operation | Marine biodiversity degradation | Biodiversity | Adherence to Gov Reg 22/2021<br><br>Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |
| Operation | Smelter operation | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |
| Operation | Smelter operation | Wastewater generation | Waste generation | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | Development Banks (MDBs) | | |
| Operation | Smelter operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Conduct a government-approved technical study on the proper handling and storage of hazardous waste.<br>• Hazardous waste shall be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | |
| Operation | Smelter operation | Increased power consumption | Energy | | • Considering the heavy reliance of refining on coal via captive power plants, companies should start to consider optimizing energy efficiency across preparation processes and integrating renewable energy sources. | • Ministry of Environment<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency<br>• Regional Energy and Mineral Resources Agency |
| Operation | Smelter operation | Increased CO2 emissions | Carbon emissions | | • Considering the heavy reliance of refining on coal via captive power plants, companies should start to consider optimizing energy efficiency across preparation processes and integrating renewable energy sources.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |
| **CAM/anode manufacturing** | | | | | | |
| Construction | Construction of facility | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Operation | Manufacturing facility operation | Degraded air quality | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Conduct a government-approved technical study to incorporate technological approaches to meet emission standards.<br>• Air pollution abatement technology must be installed in air emission stacks to minimize pollutants[263]. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Degraded soil quality | Soil | USDA Soil Quality Assessment Guidelines[292] | • Minimize potential penetration of air pollutant particles on soil through proper technical study on emissions and use of air pollution abatement technology.<br>• Engaging in soil remediation activities where necessary to reduce contamination[296]. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Adherence to MoH Reg 2/2023 | • Minimize potential penetration of air pollutant particles on soil through proper technical study on emissions and use of air pollution abatement technology.<br>• Engaging in soil remediation activities where necessary to reduce contamination[296]. | • Ministry of Environment<br>• Regional Environmental Agency |

[296] Rasyid, R.A. *et al.* (2021). https://e-journals.unmul.ac.id/index.php/TK/article/view/5300/pdf_1

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Implementing strict controls on soil contamination to prevent wastewater and heavy metals from leaching into groundwater. | |
| Operation | Manufacturing facility operation | Aquatic biodiversity degradation | Biodiversity | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Wastewater generation | Waste generation | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Conduct a government-approved technical study on the proper handling and storage of hazardous waste.<br>• Hazardous waste shall be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Increased power consumption | Energy | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid. | • Ministry of Environment<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency<br>• Regional Energy and Mineral Resources Agency |
| Operation | Manufacturing facility operation | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |
| **Battery cell production** | | | | | | |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Construction | Construction of facility | Degraded air quality | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Construction | Construction of facility | Noise disruption | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Degraded air quality | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Conduct a government-approved technical study to incorporate technological approaches to meet emission standards.<br>• Air pollution abatement technology must be installed in air emission stacks to minimize pollutants (Degen et al. 2025). | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Decreased soil quality | Soil | USDA Soil Quality Assessment Guidelines[292] | • Minimize potential penetration of air pollutant particles on soil through proper technical study on emissions and use of air pollution abatement technology.<br>• Engaging in soil remediation activities where necessary to reduce contamination (Ar Rasyid et al., 2021). | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Adherence to MoH Reg 2/2023 | • Minimize potential penetration of air pollutant particles on soil through proper technical study on emissions and use of air pollution abatement technology.<br>• Engaging in soil remediation activities where necessary to reduce contamination[296]. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Implementing strict controls on soil contamination to prevent wastewater and heavy metals from leaching into groundwater. | |
| Operation | Manufacturing facility operation | Aquatic biodiversity degradation | Biodiversity | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Facility operation | Wastewater generation | Waste generation | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Facility operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Conduct a government-approved technical study on the proper handling and storage of hazardous waste.<br>• Hazardous waste shall be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Mining operation | Increased power consumption | Energy | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid. | • Ministry of Environment<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency<br>• Regional Energy and Mineral Resources Agency |
| Operation | Facility operation | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |
| **Battery Pack Assembly** | | | | | | |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Construction | Construction of facility | Degraded air quality | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Construction | Construction of facility | Noise disruption | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Wastewater generation | Waste generation | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Conduct a government-approved technical study on the proper handling and storage of hazardous waste.<br>• Hazardous waste shall be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Increased power consumption | Energy | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid. | • Ministry of Environment<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |

**Table D.2 Social Mitigation Matrix: Battery Production**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Mining** | | | | | | |
| Pre-construction | Land acquisition | Livelihood | Surrounding community | Number of FPIC implemented | • Improve communication with communities on industrial projects, including public meetings in local languages. Prioritize, disclosure project information and environmental and social risks associated, with potentially affected communities.<br>• Establish Free, Prior, and Informed Consent (FPIC) guidelines, with safeguards against bribery and provisions for communication in local languages. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Ministry of Agrarian Affairs and Spatial Planning (ATR/BPN)<br>• Regonal environmental agency<br>• Regional energy and mineral resources agency<br>• Regional land agency |
| Pre-construction | Land acquisition | Human rights | Surrounding community | - | • Implement just compensation schemes and involve communities in decision-making processes. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Pre-construction | Land acquisition | IP and Cultural heritage | Vulnerable people | Number of FPIC implemented | • Repairing social damage instruments (Just compensation schemes).<br>• Strenghtened the FPIC process, as well as sensitize the policy makers.<br>• A Sustainable Livelihood Framework can be implemented. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Ministry of Agrarian Affairs and Spatial Planning (ATR/BPN)<br>• Regonal environmental agency<br>• Regional energy and mineral resources agency<br>• Regional land agency |
| Pre-construction | Land acquisition | GEDSI | Vulnerable people | - | • Knowledge about gender and land-use systems may help to increase gender participation in land use management | • Ministry of Environment |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | | | | | | • Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Pre-construction | Exploration | Community lifestyle | Surrounding community | Number of programs aimed to MSME and vulnerable people | • Require companies to support local MSMEs through procurement, financial training, and micro-loans for women entrepreneurs. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Livelihood | Surrounding community | Number of FPIC implemented | • Improve communication with communities on industrial projects, including public meetings in local languages. Prioritize, disclosure project information and environmental and social risks associated, with potentially affected communities.<br>• Establish Free, Prior, and Informed Consent (FPIC) guidelines, with safeguards against bribery and provisions for communication in local languages.<br>• Implement just compensation schemes and involve communities in decision-making processes. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Ministry of Agrarian Affairs and Spatial Planning (ATR/BPN)<br>• Regonal environmental agency<br>• Regional energy and mineral resources agency<br>• Regional land agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Community health | Surrounding community | | • Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Construction | Construction of mining | OHS | Workers | | • Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment). | • Ministry of Environment |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | facilities (i.e., haul road, office) | | | | • Proper PPE use, workplace hygiene, and worker health education programs.<br>• Expand employee entry and exit routes to reduce congestion and accidents. | • Ministry of Energy and Mineral Resources<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional energy and mineral resources agency<br>• Regional manpower agency |
| Operation | Mining operation | Community health | Surrounding community | | • Involve the community in decision making processes, provide just compensations. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Operation | Mining operation | Livelihood | Surrounding community | | • Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Operation | Mining operation | Community lifestyle | Surrounding community | | • Implement third party audits to assure that nickel mining and industrial estates respect the rights of local and indigenous communities | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Operation | Mining operation | Human rights | Surrounding community | | • Implement third party audits to assure that nickel mining and industrial estates respect the rights of local and indigenous communities | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | | | | | Improve communication with communities on industrial projects, including public meetings in local languages.<br>• Prioritize, disclosure project information and environmental and social risks associated, with potentially affected communities. | • Regional environmental agency<br>• Regional energy and mineral resources agency |
| Operation | Mining operation | OHS | Workers | | • Increase the number of labor inspections in mining projects to also:<br>o Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>o Proper PPE use, workplace hygiene, and worker health education programs. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional energy and mineral resources agency<br>• Regional manpower agency |
| Operation | Mining operation | GEDSI | Vulnerable people | | • Gathering data about vulnerable groups, such as gender and children.<br>• Implement third party audits to assure that nickel mining and industrial estates respect the rights of local, women and indigenous communities. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Regional environmental agency<br>• Regional energy and mineral resources agency |
| Post-operation | Mine reclamation | Labor compliance | Workers | | • Adopt a just transition framework to support coal workers, with reskilling, social protection, and local economic diversification. | • Ministry of Environment<br>• Ministry of Energy and Mineral Resources<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional energy and mineral resources agency<br>• Regional manpower agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Refining** | | | | | | |
| Construction | Construction of smelter | Community health | Surrounding community | | • Implement just compensation schemes and involve communities in decision-making processes.<br>• Improve communication with communities on industrial projects, including public meetings in local languages.<br>• Prioritize, disclosure project information and environmental and social risks associated, with potentially affected communities.<br>• Require companies to support local MSMEs through procurement, financial training, and micro-loans for women entrepreneurs. | • Ministry of Environment<br>• Regional environmental agency |
| Construction | Construction of smelter | Human rights | Surrounding community | | • Government institutions should implement or strengthen mechanisms to recognize indigenous communities´s customary land and implement third party audits to assure that refining companies respect the rights of local and indigenous communities. A modification in regulation should be considered in order to ask companies to increase transparency about their minerals supply chain at each stage. | • Ministry of Environment<br>• Regional environmental agency |
| Operation | Smelter operation | Community health | Surrounding community | | • Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust. Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Regional environmental agency |
| Operation | Smelter operation | Livelihood | Surrounding community | | • Implement third party audits to assure that nickel mining and industrial estates respect the rights of local, women and indigenous communities. In this sense, robust resources and capacity to evaluate permit applications is needed.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Regional environmental agency |
| Operation | Smelter operation | Community lifestyle | Surrounding community | | • Increase the number of labor inspections in industrial parks. | • Ministry of Environment<br>• Regional environmental agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | | | | | • Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | |
| Operation | Smelter operation | OHS | Workers | | • Increase the number of labor inspections in industrial parks.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional manpower agency |
| Operation | Smelter operation | Labor compliance | Workers | | • Increase the number of labor inspections in industrial parks to also:<br>  ○ Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>  ○ Proper PPE use, workplace hygiene, and worker health education programs. | • Ministry of Environment<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional manpower agency |
| **CAM/anode manufacturing** | | | | | | |
| Operation | Manufacturing facility operation | Community health | Surrounding community | Reports from medical clinics | • Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Regional environmental agency |
| Operation | Manufacturing facility operation | Community lifestyle | Surrounding community | - | • Significance of impact is low. No mitigation strategy is proposed. | - |
| **Battery cell production** | | | | | | |
| Construction | Construction of facility | Community health | Surrounding community | | • Significance of impact is low. No mitigation strategy is proposed. | |
| Operation | Manufacturing facility operation | OHS | Workers | | • Increase the number of labor inspections in industrial parks and mining projects to also:<br>  ○ Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>  ○ Proper PPE use, workplace hygiene, and worker health education programs. | • Ministry of Environment<br>• Regional environmental agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Battery pack assembly** | | | | | | |
| Construction | Construction of facility | Community health | Surrounding community | | • Significance of impact is low. No mitigation strategy is proposed. | |
| Operation | Manufacturing facility operation | OHS | Workers | | • Strenghthen proper PPE use, workplace hygiene and health education programs is crucial to prevent health issues on workers | • Ministry of Environment<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional manpower agency |

**Table D.3 Environmental Mitigation Matrix: Battery Usage**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental risk | Sensitive receptor | Key performance indicator | Methodology | |
| **EV Usage** | | | | | | |
| Usage | Battery usage in EV lifetime | Decreased CO2 emissions | Carbon emissions | | The current EV production target and projection (see **Table 3.7**) indicates that EV adoption in 2030 may not contribute significantly to decarbonization in the transportation sector. EV production must be ramped up for decarbonization efforts to be effectively met. | |
| **BESS Usage** | | | | | | |
| Usage | Battery usage in BESS lifetime | Decreased CO2 emissions | Carbon emissions | | The 2025-2034 RUPTL indicates additional inclusion of BESS applications for renewable energy and grid stabilization up to 2034 (see **Table 3.8**). However, it is unclear if BESS applications serve as additions or replacements for existing technologies. Considering the advantages of BESS for renewable technology, future electricity business plans could further scale the proportion of BESS usage, notably in off-grid areas. | |

**Table D.4 Social Mitigation Matrix: Battery Usage**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **EV Usage** | | | | | | |
| Usage | Battery usage in EV lifetime | Community health | Community | | Significance of impact is low. No mitigation strategy is proposed. | |
| Usage | Battery usage in EV lifetime | Community lifestyle | Community | | Significance of impact is low. No mitigation strategy is proposed. | |
| **BESS Usage** | | | | | | |
| Usage | Battery usage in BESS lifetime | Livelihood | Community | | As the 2025-2034 RUPTL ties BESS applications to renewable energy (see **Table 3.8**), job displacement linked to energy transition is seen as a risk that needs to be mitigated. At a high-level view, job displacement is a genuine issue in energy transition. Addressing this early on is beneficial for policymakers as well as companies to develop corrective mitigation measures. This can be done through:<br>• Conducting feasibility studies on alternative energy scenarios that take into account implications for displaced workers, reskilling needs, and social protection.<br>• If needed, engage international partners to mobilize financial and technical support for a just energy transition.<br>• Promote multi-stakeholder collaboration among different government institutions and businesses.<br>The government can leverage the national net-zero emission goals to accelerate the energy transition in refining processes. | |

**Table D.5 Environmental Mitigation Matrix: Battery End-of-Life**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| **Battery Waste** | | | | | | |
| Waste | Battery usage in EV lifetime | Increased hazardous waste | Waste generation | Amount of hazardous waste generated | • Government to prepare proper and regulated battery waste collection mechanisms aimed at end-users, i.e., EV users, power companies that employ BESS technology. | • Ministry of Environment<br>• Ministry of National Development Planning<br>• Regional Environmental Agency |
| **Battery Material Recycling** | | | | | | |
| Construction | Construction of facility | Noise disruption | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | |
| Operation | Manufacturing facility operation | Degraded air quality | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Conduct a government-approved technical study to incorporate technological approaches to meet emission standards.<br>• Air pollution abatement technology must be installed in air emission stacks to minimize pollutants[263]. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Noise disruption | Air | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Degraded soil quality | Soil | USDA Soil Quality Assessment Guidelines[292] | • Employing proper waste handling and containment measures to prevent soil contamination whether from air pollution or wastewater.<br>• Engaging in soil remediation activities where necessary to reduce contamination[296]. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Operation | Manufacturing facility operation | Disrupted surface water quality & quantity | Water | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Disrupted groundwater quality & quantity | Water | Adherance to MoH Reg 2/2023 | • Implementing strict controls on soil contamination to prevent wastewater and heavy metals from leaching into groundwater. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Aquatic biodiversity degradation | Biodiversity | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Solid waste generation | Waste generation | International Standards provided by Multilateral Development Banks (MDBs) | • Implementing waste minimization practices during dismantling to reduce solid waste generation and promoting the recycling and reuse of materials such as plastics, metals, and electronic components.<br>• Engage with authorized third parties to optimize waste recycling and reuse. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Wastewater generation | Waste generation | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Manufacturing facility operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Conduct a government-approved technical study on the proper handling and storage of hazardous waste.<br>• Hazardous waste shall be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Manufacturing facility operation | Increased power consumption | Energy | International Standards provided by Multilateral | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid. | • Ministry of Environment<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | Development Banks (MDBs) | | • Regional Energy and Mineral Resources Agency |
| Operation | Manufacturing facility operation | Increased $CO_2$ emissions | Carbon emissions | International Standards provided by Multilateral Development Banks (MDBs) | • Optimize energy efficiency and promote the use of renewable energy sources to reduce reliance on fossil fuels from the electricity grid.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | • Ministry of Environment<br>• Regional Environmental Agency |

**Table D.6 Social Mitigation Matrix: Battery End-of-Life**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Battery Waste** | | | | | | |
| Waste | Battery usage in EV lifetime | Surrounding community | Community health | | • Adopt national extended producer responsibility mechanism and a safe battery collection network. | • Ministry of National Development Planning |
| **Battery Material Recycling** | | | | | | |
| Operation | Recycling facility operation | Community lifestyle | Surrounding community | | • Significance of impact is low. No mitigation strategy is proposed. | |
| Operation | Manufacturing facility operation | OHS | Workers | | • Strenghthen proper PPE use, workplace hygiene and health education programs is crucial to prevent health issues on workers | • Ministry of Environment<br>• Minister of Manpower<br>• Regional environmental agency<br>• Regional manpower agency |

**Table D.7 Environmental Mitigation Matrix: Associated Facilities**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| **Industrial Estate** | | | | | | |
| Construction | Construction of estate lots and infrastructure | Massive land conversion | Landscape | Adherence to ATRBPN Reg 13/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Collaborate and coordinate with the National Land Agency, local governmental agencies, and other relevant stakeholders on mitigation strategies, i.e., reduce potential illegal deforestation due to increased forest access. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency |
| Construction | Construction of estate lots and infrastructure | Significant change of landscape and morphology | Landscape | Adherence to ATRBPN Reg 13/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Only clear lands in accordance with the site plan to minimize land degradation.<br>• After land conversion, the company must ensure land stabilization is enforced through proper design and mechanisms. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency |
| Construction | Construction of estate lots and infrastructure | Degraded soil quality | Soil | USDA Soil Quality Assessment Guidelines[292] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Minimizing the work area and regulating the usage of heavy machinery to minimize soil compaction.<br>• Only clear lands in accordance with the site plan to minimize land degradation. | |
| Construction | Construction of estate lots and infrastructure | Increased probability of soil erosion and landslide | Soil | Soil stability and subsequent water quality | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Preparing slope management, erosion control, and hydrological planning.<br>• Only clear lands in accordance with the site plan to minimize land degradation. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Degraded air quality | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Maintain schedule for hauling of goods to minimize air quality disruption in community areas.<br>• Continuous watering in haul roads and transportation roads to minimize dust. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of mining facilities (i.e., haul road, office) | Noise disruption | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral | • Allow buffer zones surrounding the hauling road.<br>• Maintain schedule for hauling of goods to minimize noise disruption in community areas. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | Development Banks (MDBs) | | |
| Construction | Construction of estate lots and infrastructure | Disrupted surface water quality & quantity | Water | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots and infrastructure | Disrupted groundwater quality & quantity | Water | Adherence to MoH Reg 2/2023 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Ensure enough forest stand is retained in the surrounding area of the cleared land to ensure water retention is preserved.<br>• Continuously conduct groundwater quantity monitoring, i.e., water level tapes. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots and infrastructure | Terrestrial biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Limited land clearing only in the designated project area based on biological survey, including avoiding sensitive habitats and maintaining buffer zones around key ecological features, such as riparian zones and wildlife corridors. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Construction | Construction of estate lots and infrastructure | Aquatic biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots and infrastructure | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • The company must ensure land clearing is conducted within the approved boundary.<br>• Minimize land disturbance, preserving critical vegetation cover, and maintaining natural drainage patterns along with a sedimentation pond to control sediment runoff.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots and infrastructure | Wastewater generation | Waste generation | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • At this stage, wastewater treatment plants (WWTP) are not yet in place. To minimize surface water runoffs, sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots and infrastructure | Increased CO2 emissions | Carbon emissions | International Standards provided by Multilateral | • Proper study before activities, which includes potential carbon sequestration in the project area and mitigation strategies. - Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | Development Banks (MDBs) | • Limited land clearing only in the designated project area based on biological survey, including avoiding potential carbon sequestration sports.<br>• Monitor carbon emissions regularly and explore opportunities for carbon sequestration, to reduce the carbon footprint. | |
| Operation | Industrial estate operation | Significant change of landscape and morphology | Landscape | Adherence to ATRBPN Reg 13/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary.<br>• Collaborate and coordinate with the National Land Agency, local governmental agencies, and other relevant stakeholders on mitigation strategies, i.e., reduce potential illegal deforestation due to increased forest access. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency |
| Operation | Industrial estate operation | Increased probability of soil erosion and landslide | Soil | ICOLD Tailings Dams Guidelines[297] | • Designing rigorous engineering design and construction standards for waste storage facilities in consultation with national authorities to minimize landslide and erosion risks.<br>• Secure proper permits required for the waste storage facilities. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Degraded air quality | Air | Adherence to Gov Reg 22/2021 | • Ensure that tenants adhere to government standards on air quality and emissions. | • Ministry of Environment<br>• Regional Environmental Agency |

[297] ICOLD. (2022). https://unece.org/sites/default/files/2023-04/S4-1Andy%20Small_ENG.pdf

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | IFC General EHS Guidelines[298] | | |
| Operation | Industrial estate operation | Noise disruption | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Ensure that tenants adhere to government standards on noise levels. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Disrupted surface water quality & quantity | Water | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Disrupted marine water quality | Water | Adherence to Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies. | • Ministry of Environment<br>• Regional Environmental Agency |

[298] EHS Guidelines: General Manufacturing

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | International Standards provided by Multilateral Development Banks (MDBs) | • Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | |
| Operation | Industrial estate operation | Aquatic biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Marine biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Wastewater generation | Waste generation | Adherence to Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | International Standards provided by Multilateral Development Banks (MDBs) | • Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | |
| Operation | Industrial estate operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021 | • Hazardous waste will be properly stored, labeled, and segregated in designated facilities following approved guidelines and standard procedures. Documentation of waste generation will be maintained, and licensed third-party contractors will be engaged for safe handling and disposal. All storage areas will be clearly marked to ensure safety and compliance. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Hazardous waste generation | Waste generation | Adherence to Gov Reg 22/2021 and MoEF Reg 6/2021<br><br>ICOLD Tailings Dams Guidelines[297] | • Designing rigorous engineering design and construction standards for waste storage facilities (ICOLD, 2022) in consultation with national authorities to minimize landslide and erosion risks.<br>• Secure proper permits required for the waste storage facilities.<br>• Ensure waste gathered from tenants are tested for toxicity before being dumped in the waste management facilities.<br>• Install impermeable lining to prevent penetration of toxic chemicals from the waste. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Energy and Minerals Resources<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Dinas Energi dan Sumber Daya Mineral |
| **Special port** | | | | | | |
| Construction | Construction of special terminal (e.g. dredging) | Massive land conversion | Landscape | Adherence to ATRBPN Reg 13/2021, MoMAF Reg 28/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas (i.e., mangroves, sea grass).<br>• After land conversion, the company must ensure land clearing is conducted within the approved boundary. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Marine Affairs and Fisheries<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Collaborate and coordinate with the National Land Agency, local governmental agencies, and other relevant stakeholders on mitigation strategies, i.e., reduce potential illegal deforestation due to increased forest access. | • Regional Marine Affairs and Fisheries Agency<br>• Regional Land Agency |
| Construction | Construction of special terminal (e.g. dredging) | Significant change of landscape and morphology | Landscape | Adherence to ATRBPN Reg 13/2021, MoMAF Reg 28/2021, Gov Reg 28/2025, and Gov Reg 22/2021 | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Only clear lands in accordance with the site plan to minimize land degradation.<br>• After land conversion, the company must ensure coastal stabilization is enforced through proper design and mechanisms. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Marine Affairs and Fisheries<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Marine Affairs and Fisheries Agency<br>• Regional Land Agency |
| Construction | Construction of special terminal (e.g. dredging) | Degraded soil quality | Soil | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Construction | Construction of special terminal (e.g. dredging) | Increased probability of coastal abrasion | Soil | OSPAR Guidelines for the Management of Dredged Materials at Sea[299] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. | • Ministry of Environment<br>• Ministry of Forestry<br>• Ministry of Marine Affairs and Fisheries<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency |

[299] OSPAR. (2014). https://www.ospar.org/documents?v=33037

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | | • Conduct coastal stabilization management and only clear lands in accordance with the site plan to minimize land degradation. | • Regional Environmental Agency<br>• Regional Forestry Agency<br>• Regional Marine Affairs and Fisheries Agency<br>• Regional Land Agency |
| Construction | Construction of special terminal (e.g. dredging) | Noise disruption | Air | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Maintain schedule for hauling of goods to minimize air quality disruption in community areas.<br>• Continuous watering in haul roads and transportation roads to minimize dust. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of special terminal (e.g. dredging) | Disrupted marine water quality | Water | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas.<br>• Implementing effective sediment control measures such as well-anchored and high silt curtains (Ogilive et al., 2012) to prevent sediment dispersion during dredging and coastal earthworks. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of special terminal (e.g. dredging) | Terrestrial biodiversity degradation | Biodiversity | Critical habitat identification and management | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Conduct proper permitting process, i.e., spatial plan permit. This is to ensure business activities adhere to spatial plan regulations and conservation areas. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | | | | as approved by the IUCN[294] | • Limited land clearing only in the designated project area based on biological survey, including avoiding sensitive habitats and maintaining buffer zones around key ecological features, such as mangrove and seagrass areas. | |
| Construction | Construction of special terminal (e.g. dredging) | Marine biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies.<br>• Maintaining and ensuring all discharged wastewater is properly treated to meet standards before entering water bodies. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |
| Construction | Construction of special terminal (e.g. dredging) | Decline in ecosystem services | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • The company must ensure land clearing is conducted within the approved boundary.<br>• Minimize land disturbance, preserving critical vegetation cover, and maintaining natural drainage patterns along with a sedimentation pond to control sediment runoff.<br>• Sediment control measures such as silt fences and sediment traps will be implemented to reduce runoff into aquatic habitats. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |
| Construction | Construction of special terminal (e.g. dredging) | Solid waste generation | Waste generation | OSPAR Guidelines for the Management of Dredged Materials at Sea[299] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies (i.e., Dredged Material Management Plan, or DMMP).<br>• Dredged materials must be characterized based on physical and chemical properties to determine their later usage (i.e., remediation if contaminated).<br>• Appropriate dredged materials can be reused for construction (i.e, materials), habitat restoration, or shoreline protection.<br>• If reuse is not possible, dredged materials are subject to containment and disposal. Disposal can be done via containment, dewatering, and placement. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Construction | Construction of special terminal (e.g. dredging) | Wastewater generation | Waste generation | OSPAR Guidelines for the Management of Dredged Materials at Sea[299] | • Proper study before activities, which includes project feasibility, detailed engineering design, identification of environmental impacts, and mitigation strategies (i.e., Dredged Material Management Plan, or DMMP).<br>• Dredged materials must be characterized based on physical and chemical properties to determine their later usage (i.e., remediation if contaminated).<br>• Appropriate dredged materials can be reused for construction (i.e, materials), habitat restoration, or shoreline protection.<br>• If reuse is not possible, dredged materials are subject to containment and disposal. Disposal can be done via containment, dewatering, and placement. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Construction of special terminal (e.g. dredging) | Disrupted marine water quality | Water | Adherence to Gov Reg 22/2021<br><br>International Standards provided by Multilateral Development Banks (MDBs) | • Promote and implement green shipping principles in special terminals. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Special terminal operation (not including hauling) | Marine biodiversity degradation | Biodiversity | Critical habitat identification and management as approved by the IUCN[294] | • Promote and implement green shipping principles in special terminals. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Special terminal operation | Decline in ecosystem services | Biodiversity | Critical habitat identification | • Promote and implement green shipping principles in special terminals. | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| | (not including hauling) | | | and management as approved by the IUCN[294] | | |
| Operation | Construction of special terminal (e.g. dredging) | Increased energy consumption | Energy | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Operation | Construction of special terminal (e.g. dredging) | Increased CO2 emissions | Carbon emissions | - | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| **Transport and Logistics** | | | | | | |
| Construction & operation | Hauling of goods | Degraded air quality | Air | | • No mitigation st-rategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Construction & operation | Hauling of goods | Noise disruption | Air | | • No mitigation strategy is proposed other than the general procedure already applied based on industrial standards. | - |
| Construction & operation | Hauling of goods | Disrupted marine water quality | Water | UNESCAP Green Shipping Corridors[99] | • Encouraging shipping routes to adhere to Green Shipping Corridors. This is to minimize disturbance to routes that intersect with areas of conservation or socioeconomic significance. | • Ministry of Transportation<br>• Regional Transportation Agency |
| Construction & operation | Hauling of goods | Marine biodiversity degradation | Biodiversity | UNESCAP Green Shipping Corridors[99] | • Encouraging shipping routes to adhere to Green Shipping Corridors. This is to minimize disturbance to routes that intersect with areas of conservation or socioeconomic significance. | • Ministry of Transportation<br>• Regional Transportation Agency |
| Construction & operation | Hauling of goods | Decline in ecosystem services | Biodiversity | UNESCAP Green Shipping Corridors[99] | • Encouraging shipping routes to adhere to Green Shipping Corridors. This is to minimize disturbance to routes that intersect with areas of conservation or socioeconomic significance. | • Ministry of Transportation<br>• Regional Transportation Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Environmental/social risk | Sensitive receptor | KPI/Standard | Methodology | |
| Construction & operation | Hauling of goods | Energy consumption | Energy | UNESCAP ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[100] | • Transport and logistics should adhere to the Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[100]. | • Ministry of Transportation<br>• Regional Transportation Agency |
| Construction & operation | Hauling of goods | Increased $CO_2$ emissions | Carbon emissions | UNESCAP ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[100] | • Transport and logistics should adhere to the Ten Guiding Principles for Sustainable Freight Transport in Asia and the Pacific[100]. | • Ministry of Transportation<br>• Regional Transportation Agency |

**Table E.8 Social Mitigation Matrix: Associated Facilities**

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Industrial Estate** | | | | | | |
| Pre-construction | Land acquisition | IP and cultural heritage | Vulnerable people | | • Improve mechanism of communication about industrial pollution efforts, as well as made publicly available or accesible information on air and water quality to local residents. | • Ministry of Environment<br>• Regional Environmental Agency |
| Pre-construction | Land acquisition | Livelihood | Surrounding community | Number of FPIC implemented | • Establish and strengthen Free, Prior, and Informed Consent (FPIC) guidelines, with safeguards against bribery and provisions for communication in local languages.<br>• Implement third party audits to assure that nickel mining and industrial estates respect the rights of local, women and indigenous communities. In this sense, robust resources and capacity to evaluate permit applications is needed. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency |
| Pre-construction | Land acquisition | Human rights | Surrounding community | Number of FPIC implemented | • As in other latitudes, the FPIC process should have specific guidelines and community transparency to avoid an specific community leader receive brivery or make unknown deals. To implement proper consultation with local communities and develop mechanisms of recognition for indigenous people that do not have land ownwership certificates recognised by the government. As well as robust resources and capacity to evaluate permit applications.<br>• Build a mechanism that connect the project information and associated environmental and social risks with potentially affected communities, in local languagues.<br>• Ratify ILO Convention 169 to sthrenghten the regulatory framework of recognition of indigenous communities and customary lands. | • Ministry of Environment<br>• Ministry of Agrarian Affairs and Spatial Planning/National Land Agency<br>• Regional Environmental Agency<br>• Regional Land Agency |
| Construction | Construction of estate lots and infrastructure | Community lifestyle | Surrounding community | | • Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of estate lots | Livelihood | Surrounding community | | • Implement third party audits to assure that nickel mining and industrial estates respect the rights of local, women and indigenous communities. | • Ministry of Environment |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | and infrastructure | | | | | • Regional Environmental Agency |
| Operation | Industrial estate operation | Labor compliance | Workers | | • Increasing the number of labor inspections in industrial parks and in their surroungind nickel mining projects. | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |
| Operation | Industrial estate operation | Human Rights | Workers | | • Implement third party audits to protect migrant workers of forced labor | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |
| Operation | Industrial estate operation | OHS | Workers | | • Mandate stricter human rights due diligence to identify harms caused by company operations and require mediation with affected communities. Require third-party audits to protect workers from forced labor (including immigrants' workers). | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |
| Operation | Industrial estate operation | Community health | Surrounding community | ICOLD Tailings Dams Guidelines[297] | • Prioritize best available techniques (backfilling and dry stacking) with third-party oversight, to eliminate the need for deep-sea tailings disposal. As well as establishing early warning systems for coastal communities located near waste storage facilities. In this sense, every waste management process must be closely monitored and checked for feasibility periodically by third parties, | • Ministry of Environment<br>• Regional Environmental Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| | | | | | prioritizing safety and the interest of local communities. An Emergency Response Plan should be prepared[300]. | |
| Operation | Industrial estate operation | Community lifestyle | Surrounding community | | • Regarding funds to be disbursed to surrounding community, it has been reported that IMIP pay taxes to Central Sulawesi, not to the Morowali administration, and other payments directly to central government. The law should encourage disbursed the benefits directly to the community.<br>• Encouraging companies within Industrial Parks to involve local communities as they vendors of food supplies, implementing capacity building, financial training and promote small loans to women to improve their entrepreneurships through local organizations. | • Ministry of Environment<br>• Regional Environmental Agency |
| Operation | Industrial estate operation | Livelihood | Surrounding community | Number of labor inspections | • Increase the number of labor inspections in industrial parks and mining projects to also:<br>o Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>o Proper PPE use, workplace hygiene, and worker health education programs.<br>o Ensure women's rights in the workplace, including maternity protections and gender-sensitive policies.<br>Promote sucess case studies | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |
| Operation | Industrial estate operation | GEDSI | Vulnerable people | Number of labor inspections | • Increase the number of labor inspections in industrial parks and mining projects to ensure women's rights in the workplace, including maternity protections and gender-sensitive policies. | • Ministry of Environment<br>• Regional Environmental Agency |

[300] IFC suggest the ERP should be prepared in accordance with the guidance of the APELL for Mining, Awareness and Preparedness for Emergencies at Local Level, Technical Report No. 41, UNEP 2001. The report provides a framework for preparation of an Emergency Response Plan involving the mine, emergency response agencies, local authorities and communities. Available at: APELL for mining: guidance for the mining industry in raising awareness and preparedness for emergencies at local level

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| Operation | Industrial estate operation | Community health | Surrounding community | Number of related medical reports from health clinics | • Improve mechanism of communication about industrial pollution efforts, as well as made publicly available or accesible information on air and water quality to local residents.<br>• The Government of Indonesia should require third party companies to implement due diligence processes to fully identify harms caused by companies operations and engage in mediation with impacted communities. It meas it is necessary that GoI conduct regular, transparent independent audits of mines and facilities to ensure that companies respect human rights and the environment. | • Ministry of Environment<br>• Regional Environmental Agency |
| **Special port** | | | | | | |
| Construction | Construction of special terminal (e.g. dredging) | Livelihood | Surrounding community | | • Require companies to support local MSMEs through procurement, financial training, and micro-loans for women entrepreneurs.<br>• Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Implement third party audits to assure that nickel mining and industrial estates respect the rights of local, women and indigenous communities.<br>• In this sense, robust resources and capacity to evaluate permit applications is needed. | • Ministry of Environment<br>• Ministry of Marine Affairs and Fisheries<br>• Regional Environmental Agency<br>• Regional Marine Affairs and Fisheries Agency |
| Construction | Construction of special terminal (e.g. dredging) | GEDSI | Vulnerable people | | • Gathering data about gender and land-use systems to increase gender-sensitive participation in land use management. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction | Construction of special terminal (e.g. dredging) | OHS | Workers | | • Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>• Proper PPE use, workplace hygiene, and worker health education programs. | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |

| Supply chain activity | Activity | Source of risk | | Mitigation approach | | Relevant stakeholders |
|---|---|---|---|---|---|---|
| | | Social risk | Sensitive receptor | Key performance indicator | Methodology | |
| **Transport and Logistics** | | | | | | |
| Construction & operation | Hauling of goods | Community health | Surrounding community | | • Mandate public disclosure of air and water quality data from industrial facilities to ensure transparency and build community trust.<br>• Establish independent monitoring units within companies to oversee compliance with environmental protection and human rights standards. | • Ministry of Environment<br>• Regional Environmental Agency |
| Construction & operation | Hauling of goods | OHS | Workers | Increase employee entry and exit routes to minimize congestion and accidentes | • Increase the number of labor inspections in work areas to also:<br>○ Strengthen enforcement of OHS regulations (safe chemical use, reduced overtime, proper maintenance of equipment).<br>○ Proper PPE use, workplace hygiene, and worker health education programs.<br>○ Expand employee entry and exit routes to reduce congestion and accidents; and,<br>○ Develop national standards for EV fire safety in ports and logistics hubs, including evacuation drills and specialized extinguishers. | • Ministry of Environment<br>• Ministry of Manpower<br>• Regional Environmental Agency<br>• Regional Manpower Agency |

# Annex E: Maternal and Child Welfare for Working Mothers

In 2024, the Government of Indonesia enacted Law No. 4 of 2024 on Maternal and Child Welfare during the First Thousand Days of Life. This law establishes a set of rights for working mothers, including the following:

| Topic | Maternal and Child Welfare considerations under Law 4/2024 | ILO standards |
|---|---|---|
| **Maternity leave** | At least 3 months of maternity leave after giving birth, with up to 3 additional months if there are special circumstance validate by medical practitioner.<br>Salary payment during maternity leave of:<br>• 100% of salary during the first three months.<br>• 100% of salary during the fourth month; and<br>75% of salary during the fifth and sixth months. | The Convention 183 sets at least 14 weeks as the international minimum standard for maternity leave. It also establishes a right to additional leave in case of illness, complications or risks of complication arising out of pregnancy.<br>Regarding cash benefits, Convention provides that the cash benefit shall be at a level that ensures that the woman can maintain herself and her child in proper conditions of health and with a suitable standard of living.<br>The amount of such benefit shall be not less than two-thirds of the woman's previous or insured earnings and be provided through social insurance or public funds or in a manner determined by national law and practice. |
| **Bereavement leave due to miscarriages** | • 1.5 months or any other period as recommend by a medical practitioner in the event of a miscarriage.<br>Working fathers are entitled to two days paternity leave in the event of a miscarriage. | Convention No. 183 mandates leave for illness or complications, subject to national laws. |
| **Paternity leave** | Working fathers are entitled to:<br>• Two days of paid paternity leave during delivery,<br>• Up to an additional three days after delivery or another period that may be agreed with employer. | The ILO's Recommendation No. 165 (Workers with Families Responsibilities, 1981) calls on member states to promote measures such as paternity leave to enable fathers to share child-rearing responsibilities. ILO promotes that paternity leave is an important tool to promote gender equality, reduce discrimination against working women. |
| **Employment protection** | Employers must provide adequate opportunities and facilities to breastfeed, express and/or store expressed breast milk during work hours | Convention No. 183 entitles women to one or more daily breaks or a reduction of hours of work for breastfeeding. Breaks or reduction of working hours shall be counted as working time and remunerated accordingly. The length and numbers of breaks are to be determined by national law or practice (Article 10). |

| Topic | Maternal and Child Welfare considerations under Law 4/2024 | ILO standards |
|---|---|---|
| **Sufficient time off in their children's best interest** | Employers must adjust the duties, work hours and/or workplace of working mothers as necessary | Convention encourages breaks and nursing protection, but detailed facility requirements are not included. |
| **Affordable daycare** | Law mandates that every working woman has the right to affordable daycare. | |

Implementing regulations for Law No. 4/2024 are expected within the next two years. If effectively enforced, the Law's provisions would surpass current ILO standards. Ensuring rigorous supervision of their application—particularly among companies operating within the battery value chain—would be instrumental in achieving a genuinely sustainable approach.

# Annex F: Just Transition measures adopted by different countries

Effective just transition programs also include early retirement schemes, pension protections, compensation mechanisms, and community-level investments. The following examples highlight measures adopted by different countries:

**Table 0.1 Just Transition measures adopted by different countries**

| Country | Brief description and measures |
|---|---|
| **Germany**[33] | Germany has committed to phasing out coal by 2038, reducing coal capacity from 30 GW in 2022 to 17 GW by 2030. In 2018, the sector employed about 32,800 workers, with most plants over 30 years old.<br>**Key measures implemented:**<br>• Training and internal recruitment<br>• Early retirement for workers **58+** (Coal Exit Law)<br>• Pension deficit coverage via adjustment fund<br>• Collective agreements with unions, businesses, and government<br>• Compensation to plant operators (via auctions)<br>• Consumer protection: mechanisms to avoid passing costs to electricity users<br>• Regional dialogue on open-cast mining adjustments and compensation |
| **Spain**[34] | Spain's transition strategy has centered on closing 26 uncompetitive coal mines (1,677 direct workers plus indirect jobs) and coal-fired thermal plants (2,300 workers). The approach has been largely reactive, responding to the industry's gradual decline.<br>**Key measures implemented:**<br>• Draft Climate Change Bill & Just Transition Strategy (incl. Just Transition Agreements)<br>• Early retirement for miners 48+<br>• Pension deficits covered by coal mining social security fund<br>• Severance pay (10,000 EUR + 35 days/year of service) for miners not eligible for fund contributions<br>• Local re-employment in environmental restoration<br>• Reskilling for green industries |
| **Australia**[35] | The closure of the Hazelwood power plant, Australia's most carbon-intensive facility, initiated by ENGIE, prompted a broad multi-sectoral dialogue on just transition.<br>**Key measures implemented:**<br>• Early retirement packages<br>• Retention of ~250 staff for decommissioning and rehabilitation<br>• National government support: retraining, job-seeking assistance, labour adjustment funds<br>• Regional Jobs and Investment Package (local jobs, regional diversification, skills development)<br>• Local infrastructure support<br>• Worker Transition Center and Community Infrastructure Fund<br>• Worker Transfer Scheme: older workers at nearby plants retire, enabling redeployment of younger workers |
| **Hungary**[36] | Hungary has pursued a gradual phase-out of coal, with a focus on redeveloping lignite mine and power plant sites into renewable energy and green industrial projects.<br>**Key measures implemented:**<br>• Project financed by plant owner with tax allowances<br>• Leveraging synergies between industries and existing assets<br>• Early retirement plans |

The above information underscores the need for Indonesia to adopt a comprehensive approach tailored to its national and sectoral context.

southeast-asia-energy-transition-partnership

The Southeast Asia Energy Transition Partnership is a programme of the United Nations Office for Project Services.

14th Floor, 208, Wireless Road, Bangkok, Thailand

etp@unops.org

AFD Agence Française de Développement
Federal Ministry for Economic Affairs and Climate Action
Department for Energy Security & Net Zero
Environment and Climate Change Canada
Environnement et Changement climatique Canada
Australian Government
Department of Climate Change, Energy, the Environment and Water
CIFF Children's Investment Fund Foundation
Sequoia Climate Foundation