Toward a Just Transition?

A Framework for Analyzing Nickel-Driven Social-Ecological Violence

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ABSTRACT

The global demand for nickel is surging, driven by the electric vehicle (EV) and energy storage sectors' push for decarbonization. This paper introduces a social-ecological violence framework to analyse the interconnected forms of violence within the nickel supply chain that are fuelled by surging demand from these sectors. Moving beyond direct human harm, it reveals how nickel extraction, processing, and trade generate overlapping violence against both communities and ecosystems. Examining case studies in nickel-rich countries and employing an eco-centric lens alongside interdisciplinary insights, the paper highlights the social and environmental impacts of the nickel supply chain, such as land dispossession, labour exploitation, pollution, and biodiversity loss, as systemic social-ecological violence. This framework offers a holistic understanding of the nickel supply chain's true costs, revealing feedback loops and power dynamics with the potential to improve extractive industry governance and foster social-ecological reflexivity. Ultimately, it contributes to a critical understanding of sustainability challenges in the energy transition and provides a basis for more sustainable and equitable resource governance towards social-ecological peace, defined by the absence of social-ecological violence and the presence of social-ecological justice and ecological integrity.

INTRODUCTION

The escalating climate crisis, driven by greenhouse gas emissions, necessitates an urgent global transition to a sustainable energy system. This paradigm shift entails a fundamental move from fossil fuel dependency to the widespread adoption of renewable energy technologies (Hassan et al., 2024; Cronin et al., 2018). Integral to this effort is the implementation of battery systems used in electric vehicles (EVs) and advanced energy storage systems (Hayes & McCullough, 2018). EVs are crucial for decarbonising transportation (Zimmer & Themann, 2020). At the same time, energy storage systems ensure grid stability and reliability when relying on intermittent renewable sources such as solar, wind, and tidal power (Hassan et al., 2024)..

Nickel is a pivotal mineral in the global transition to a sustainable energy system, integral to the operational efficacy and scalability of key green technologies. It is a critical component in the manufacturing of high-performance lithium-ion battery cathodes, notably the nickel-manganese-cobalt (NMC) and nickel-cobalt-aluminum (NCA) chemistries used in contemporary electric vehicles and large-scale energy storage applications (Hayes & McCullough, 2018. Nickel's incorporation enhances energy density, which directly extends the range of EVs and augments storage capacity, while also contributing to improved electrochemical stability and operational longevity (Nguyen et al., 2021. Consequently, the intensifying global demand for decarbonization via electrification has precipitated an unprecedented surge in demand for high-grade nickel, positioning it as an indispensable resource in realizing a sustainable energy future.

However, the escalating reliance on nickel to facilitate the green transition is attended by significant complexities and potential adverse consequences (Valencia et al., 2025). Although aimed at sustainability, the transition to a decarbonized global economy risks perpetuating extractive practices that impose a substantial socio-ecological burden, threatening the integrity of ecosystems and the well-being of dependent communities (Luckeneder et al., 2021).From an environmental perspective, nickel mining operations can precipitate extensive deforestation (Iwatsuki et al., 2018), soil degradation (Prematuri et al., 2020), biodiversity loss (Luckeneder et al., 2021), and aquatic contamination (Gissi et al., 2016). Socially, the establishment and expansion of mining activities may result in community displacement (Gamu & Soendergaard, 2024), engender land-use conflicts (Hyldmo et al., 2025), generate adverse public health outcomes attributable to pollution (Levická & Orliková, 2024), and perpetuate precarious labor conditions (Camba, 2021).

This emergent disjuncture between the commendable objectives of the green transition and the potentially harmful methods of sourcing raw material call for an urgent and critical inquiry. As global efforts intensify to mitigate climate change and construct a more sustainable society through technologies based on mineral inputs such as nickel (Zhang et al., 2023), it becomes crucial to questionwhether the pursuit of this seeminglygreen future may inadvertently contribute to, or indeed exacerbate, socio-ecological violence within the resource-rich regions supplying these critical mineral inputs. Such an inquiry challenges the often-reductionist narrative of the green transition as entirely beneficial, necessitating a more profound examination of the distributional impacts and ethical considerations inherent in the global supply chains for critical minerals.

Addressing this multifaceted dilemma is essential to ensure that the transition towards a sustainable development is also just and inclusive. Accordingly, this article aims to develop and propose a comprehensive analytical framework designed to explain and evaluate phenomena that may be conceptualized as 'social-ecological violence,' specifically within the complex nexus of the nickel supply chain. Through the conceptualization and operationalization of social-ecological violence, this research aims to providea nuanced analytical lens. This lens is intended to facilitate the systematic identification, rigorous

analysis, and ultimately, the mitigation of interconnected anthropogenic and environmental harms associated with nickel extraction, processing, and distribution, thereby contributing to the formulation of more equitable and authentically sustainable green transition pathways.

Previous research has identified various manifestations of violence within nickel supply chains. These include community conflicts stemming from inadequate consultation (Gamu & Soendergaard, 2024) and adverse environmental impacts (Luckeneder et al., 2021), intimidation (Gamu & Soendergaard, 2024) and forced displacement as responses to protests (Gamu & Soendergaard, 2024), unsafe and exploitative working conditions (Stevis & Felli, 2015) with the potential for forced and child labor (Schwartz et al., 2021), security and armed conflict in vulnerable regions (Church & Crawford, 2020), and structural violence arising from power imbalances that enable exploitation (Ash, 2024). Moreover, several studies have examined the environmental impacts of nickel mining, highlighting issues such as extensive deforestation (Iwatsuki et al., 2018), soil degradation (Prematuri et al., 2020), biodiversity loss (Luckeneder et al., 2021; Zuada et.al., 2024), and aquatic contamination (Gissi et al., 2016; Makati et.al., 2024). While these studies offer crucial insights, current research often lacks a comprehensive analytical framework on social-ecological violence. The research gap this article addresses is the development of social-ecological violence framework on an integrated nickel supply chain. This framework will be capable of mapping and connecting diverse dimensions of violence, from physical to structural forms, and specifically identifying potential risk points throughout the entire value chain, spanning from the extraction phase to the final product.

A deep understanding of socio-ecological violence is essential to the urgent pursuit of socio-ecological peace. This ideal condition is marked by the disappearance of violence against both humans and nature, as well as the emergence of positive qualities in their relationship (see Yanuardi et al., 2022). Given the persistent challenges of eliminating violence within the extractive industry, this socio-ecological violence framework emphasizes the importance of identifying and examining violence in broad meaning including various types and dimensions of such violence. With this understanding, efforts to reduce the negative impacts of critical mineral extraction for decarbonization can be designed more effectively. Furthermore, this identification forms the basis for developing actions that strengthen harmony between humans and nature. It is important to note that this framework does not aim to disregard the benefits of nickel, such as the potential for increased regional economic growth and its role in providing crucial minerals for the energy transition that supports decarbonization efforts in the transportation sector.

This article proceeds by laying a foundational understanding of "Social-Ecological Violence" in the next section, illustrating the interconnectedness of social and ecological systems and broadening the definition of violence beyond purely physical acts. It then focuses on the nickel supply chain as a concrete example, highlighting its potential for social-ecological violence and identifying the key players and power dynamics within it. Building upon this, the article proposes a specific framework for understanding social-ecological violence in the nickel supply chain, suggesting an analytical lens through which to examine the issue. Finally, the article concludes with a summary of its research implications and offers further research recommendations, likely aimed at addressing or mitigating the identified forms of violence.

METHODS

This article's approach to developing the framework began with a critical literature review. Rather than merely summarizing existing works, the review involved an in-depth analysis that evaluated, critiqued, and synthesized scholarly contributions to identify their strengths, limitations, and overall relevance to the field (Carnwell & Daly, 2001). This critical

engagement was essential for identifying key conceptual pillars and uncovering research gaps, which in turn informed the formulation of the specific research lens.

The authors then conducted a thorough analysis of numerous articles on violence and the nickel supply chain. These diverse perspectives were systematically categorized into core themes, which served as the foundational components of the framework. Through a process of careful synthesis, these thematic insights were integrated into a cohesive analytical framework. This framework aims to offer a more holistic and nuanced understanding of violence within global critical mineral supply chains and is adaptable to a range of research questions and contexts.

RESULT AND DISCUSSIONS

Defining Social-Ecological Violence

Social-ecological violence is a concept adopted from definitions of violence used as part of the social-ecological peace concept (Yanuardi, Bluemling, et al., 2022). Social-ecological violence describes harm inflicted upon both human societies and ecosystems through direct actions and structural inequalities, often culturally legitimized. This form of violence obstructs the ability of humans to meet their basic needs while simultaneously causing a decline in ecosystem health, with consequences that unfold across both time and space (Yanuardi, Bluemling, et al., 2022). This concept provides a critical lens through which to comprehend the complex interplay between social inequalities and environmental degradation (see (Yanuardi, Bluemling, et al., 2022). It is designed to understand violence beyond direct physical and mental harm, encompassing structural and cultural violence. This idea also includes violence against both humans and nature, recognizing consequences not only for the current generation and those located at the site of the violence but also across generations and locations (see (Yanuardi, Bluemling, et al., 2022). Hence, in this sense, a situation without physical violence, such as eviction or even war, does not necessarily mean the absence of violence. This is because such situations could involve structural violence legitimized by cultural norms that potentially marginalize a community or genders while simultaneously degrading the quality of human life and ecosystem health, thus potentially causing detrimental situations across generations and spaces.

Social-ecological violence broadens Johan Galtung's understanding of violence by incorporating an eco-centric perspective, interweaving the dimension of nature alongside time and space (Yanuardi, Bluemling, et al., 2022). Galtung originally explained that violence against humans, in its various forms, impedes the fulfillment of fundamental human needs, such as survival (e.g., lack of clean water leading to death or disease), well-being (e.g., inadequate healthcare causing chronic suffering), freedom (e.g., political oppression denying basic rights), and identity (e.g., cultural suppression eroding a sense of belonging) (Galtung & Fischer, 2013). These obstructions to human potential manifest as direct violence (e.g., physical assault, war), structural violence (e.g., systemic inequalities in access to education or resources), and cultural violence (e.g., discriminatory ideologies that justify harm) (Galtung & Fischer, 2013).

Expanding on this, social-ecological violence, with its eco-centric dimension, considers that violence can also be inflicted upon nature itself. This viewpoint recognizes humans as interconnected components within a larger ecosystem. Violence against nature, therefore, occurs when the health of an ecosystem deteriorates to an irreparable state. Ecosystem health (Rapport & Maffi, 2011; Yanuardi, Bluemling, et al., 2022) is characterized by organization (biotic structure, biodiversity, interactions), vitality (functional capacity), and resilience (ability to recover). Consequently, violence against nature takes place when harm to ecosystems diminishes their capacity to withstand disturbances and provide essential services. For example, extensive deforestation (harm) reduces a forest's ability to regulate

water cycles and support biodiversity (diminished capacity), leading to soil erosion and species extinction (impaired essential services). Similarly, significant pollution of a river (harm) can destroy aquatic life and render the water unusable for drinking or irrigation (diminished capacity and impaired essential services). These instances illustrate how actions that degrade the organization, vitality, and resilience of ecosystems constitute violence against nature within the social-ecological violence framework.

The impacts of social-ecological violence extend beyond immediate incidents or specific locations, radiating outwards across time, leaving multi-generational legacies of harm, and across space, from localized environmental degradation to global crises like climate change. Temporally, this violence manifests as both rapid, acute events with immediate repercussions and as "slow violence," (Nixon, 2011) to describe often environmentally rooted harm that unfolds gradually, with delayed and cross-generational consequences. Spatially, harm can be concentrated, as seen in mining regions, yet its effects can also cascade across regions, impacting distant communities and ecosystems on local and global scales. Crucially, violence against nature often unfolds across vast and protracted timescales and geographical expanses, characterized by its gradual and frequently invisible attritional nature, where the destructive impacts of actions like toxic drift, deforestation, bioaccumulation of pollutants, or the long-term consequences of climate change are dispersed across time and space. Because its effects are not immediate or spectacular, slow violence is often not perceived as violence at all, yet it erodes the ecological foundations necessary for life and disproportionately impacts vulnerable and marginalized communities who may lack the resources to mitigate or escape its creeping devastation. Recognizing these temporal and spatial dimensions, particularly the cross-generational and local-to-global reach, is vital for a thorough understanding of social-ecological violence, allowing us to move beyond immediate and localized impacts to comprehend its far-reaching and enduring consequences, as well as the challenges in attributing responsibility and mobilizing immediate action despite the profound and lasting harm inflicted by its temporal and spatial dispersal.

Based on the preceding discussion of social-ecological violence, it can be developed specific definitions for social-ecological direct violence, structural violence, and cultural violence as follows:

1. **Social-ecological direct violence** occurs when specific actors commit violent acts that directly threaten both human physical and mental well-being and the health of nature. Consequently, this diminishes human capacity to meet basic needs—survival, well-being, freedom, and identity—and deteriorates ecosystem health.
2. **Socio-ecological cultural violence** encompasses aspects of a culture that legitimize and normalize both direct and structural forms of social-ecological violence. Operating in the symbolic realm through elements like religion, ideology, language, art, science, and other cultural expressions, it makes inequality, oppression, and environmental degradation appear natural or acceptable. By legitimizing social-ecological direct and structural violence against humans, it inhibits the fulfillment of their basic needs (such as survival, well-being, freedom, and identity). Simultaneously, socio-ecological cultural violence that targets nature legitimizes actions that inhibit and degrade ecosystem health from local to global levels.
3. **Social-ecological structural violence** refers to the systematic ways in which social structures or institutions harm and disadvantage humans—preventing them from meeting basic needs like survival, well-being, identity, and freedom, and thus hindering their full potential—while simultaneously harming nature and the integrity of healthy ecosystems.
4. **Temporal and Spatial Dimensions:** Understanding social-ecological violence requires tracking the timeline and geographical spread of such violence. This involves recognizing

both immediate impacts and, crucially, delayed consequences that may manifest far from the original site of violence and long after the initial act. This dimension is particularly relevant to the concept of "slow violence."

The Nickel Supply Chain: A Site of Potential Social-Ecological Violence

1. The Intertwined Socio-Ecological Challenges of the Nickel Supply Chain

The nickel supply chain constitutes a complex network encompassing various stages, commencing with the exploration and mining of nickel ore at source locations, followed by processing and refining to yield refined nickel products (such as nickel matte, ferronickel, nickel pig iron, and nickel chemical compounds), transportation, component manufacturing (e.g., electric vehicle batteries, stainless steel), and ultimately, the distribution of finished goods to consumers (Nakajima et al., 2014). Each stage within this chain involves a diverse array of stakeholders, including mining corporations, processing enterprises, logistics companies, component manufacturers, governmental bodies, local communities, and civil society organizations (Malik, 2024). The globalization of the nickel industry further complicates this supply chain, with nickel ore frequently being mined in one nation, processed in another, and utilized in products manufactured and consumed across various global regions (Nakajima et al., 2014).

Nickel mining, as the initial phase of the supply chain, often represents a primary source of socio-ecological impacts. This process can lead to deforestation, biodiversity loss, soil erosion, and the contamination of water and air due to dust and mining waste (Hyldmo et al., 2025; Yuli, 2024). Local communities in the vicinity of mining areas frequently face displacement(Hudayana et al., 2020; Upadhyaya, 2024), the loss of traditional livelihoods such as agriculture and fishing (Barends, 2025), and health consequences stemming from pollution (Amnesty International, 2025). For instance, in Indonesia, a major global nickel producer, the expansion of nickel mining in Central Sulawesi and North Maluku has instigated agrarian conflicts with indigenous communities, significant tropical rainforest destruction, and concerns regarding the management of tailings waste with the potential for environmental contamination (Climate Right International, 2024).

The nickel processing and refining stage also entails distinct socio-ecological risks. Nickel smelting, for example, demands substantial energy input and can generate greenhouse gas emissions and other air pollutants, such as sulfur dioxide and particulate matter (Amnesty International, 2025). The utilization of hazardous chemicals in the refining process also carries the potential for water and soil contamination if not managed appropriately (Ravi et al., 2024). In Canada, for instance, the historical legacy of nickel mining in Sudbury includes environmental damage in the form of acidic soil and damaged vegetation resulting from decades of sulfur dioxide emissions (Hutchinson & Whitby, 1974). Although current environmental regulations are more stringent, challenges in remediation and the management of long-term impacts persist (Newman et al., 2023).

Furthermore, the governance and regulatory aspects within the nickel supply chain play a crucial role in mitigating potential socio-ecological violence. Weak law enforcement (Hudayana et al., 2020), a lack of transparency in permitting and mining operations (Indonesia Business Post, 2023), and corrupt practices can exacerbate negative impacts to ecosytem health (Luckeneder et al., 2021)and create injustices for local communities and future generation (Hyldmo et al., 2025). In several African nations, such as Madagascar, nickel mining practices, including those undertaken by foreign companies, have occasionally been criticized for a lack of consultation with local communities and potentially inadequate environmental impact assessments (Hercelin & Dörry, 2024). This underscores the importance of accountability mechanisms and community participation in decision-making processes related to mining projects.

Finally, the continuously increasing global demand for nickel, primarily driven by the energy transition towards electric vehicles, has the potential to intensify socio-ecological pressures in major nickel-producing countries. Competition for nickel resources may lead to an acceleration of mining expansion without adequate oversight (Sebrell & Ivanov, 2023), disregarding the rights of local communities and environmental standards (Climate Right International, 2024). The case in the Philippines, another significant nickel producer, illustrates how irresponsible mining practices can cause widespread environmental degradation and social conflicts (Amnesty International, 2025). Therefore, constructing a framework for addressing socio-ecological violence within the nickel supply chain necessitates a profound understanding of the complex interactions between economic dynamics, mining practices, environmental governance, and social impacts at various levels and geographical contexts.

2. Key Actors and Power Dynamics: Identifying the roles and influence of mining companies, governments, international investors, and local communities

To truly understand the social-ecological violence embedded within the nickel supply chain, we must first identify the key actors and dissect the intricate power dynamics that shape their interactions (Yanuardi, Bluemling, et al., 2022). Dominating the landscape are the mining companies, wielding significant economic power through their control over extraction and processing . Their influence often extends to shaping local economies and infrastructure, and their decisions regarding mining practices directly impact the environment and local communities (Ravi et al., 2024). Governments at multiple levels – local, regional, and national – play a crucial role in regulation, policy enforcement, and granting permits (Hyldmo et al., 2025). However, their capacity and willingness to effectively oversee mining operations can vary greatly, sometimes leading to regulatory gaps or even instances of collusion (Amnesty International, 2024).

Fueling the industry are international investors, whose financial backing drives expansion and innovation within the nickel sector. Their investment decisions, often guided by global market demands and sustainability considerations (or lack thereof), can exert considerable pressure on mining companies and governments alike (Deshpande, 2011; Malik, 2024). Counterbalancing these powerful economic and political forces are non-governmental organizations (NGOs), acting as watchdogs and advocates for environmental protection and community rights (Amnesty International, 2024; Yanuardi et al., 2021). They play a vital role in monitoring mining activities, raising awareness about social and ecological impacts, and holding powerful actors accountable.

Finally, at the heart of the supply chain are local communities, who bear the direct consequences of mining activities on their land, livelihoods, and social fabric(Handelsman, 2002). Their power often lies in their collective voice, their ability to organize and resist, and the moral weight of their experiences (Amnesty International, 2024). Understanding how these actors interact, the power imbalances that exist between them, and the strategies they employ is fundamental to analyzing the complex web of social-ecological violence that can permeate the nickel supply chain, from extraction to end use.

A Framework for Understanding Social-Ecological Violence in the Nickel Supply Chain

A comprehensive framework for understanding social-ecological violence in the nickel supply chain could manifests in interconnected ways, directly and indirectly harming both human basic needs (survival, well-being, freedom, and identity) and ecosystem health. It could be understood through three primary types of social ecological violence and its temporal and spatial dimensions as elaborated in Section II above.

This framework provides a research lens to comprehensively analyze the multifaceted forms of social-ecological violence embedded within the nickel supply chain. It is structured around four key dimensions: Direct Violence, Cultural Violence, Structural Violence, and the Temporal and Spatial Dimensions of Violence (see Table 1).

Table 1. Analytical Framework of Social-Ecological Violence

I. Analyzing Direct Social-Ecological Violence	
This dimension focuses on identifying and analyzing tangible instances where the nickel supply chain directly harms both human communities and ecosystems. It examines impacts across various stages, including mining, processing, manufacturing, and waste disposal.	
Basic Human Needs	o Documenting cases of physical injuries and health issues (e.g., respiratory and waterborne diseases) directly linked to nickel operations. o Analyzing instances of displacement and loss of livelihoods resulting from nickel extraction and related activities. o Investigating impacts on cultural identity and the disruption of traditional ways of life. o Identifying cases of psychological distress within affected communities. o Examining instances of suppressed freedom of expression related to concerns about the nickel industry.
Ecosystem Health	o Assessing the extent of deforestation and habitat destruction caused by nickel mining and infrastructure development. o Analyzing water and soil contamination resulting from mining and processing activities. o Evaluating biodiversity loss in areas impacted by the nickel supply chain. o Measuring air pollution levels associated with industrial processes. o Investigating the disruption of ecological processes, including the contribution to greenhouse gas emissions.
II. Investigating Socio-Ecological Cultural Violence	
This dimension explores the normalized and often invisible ways in which cultural norms, ideologies, and discourses justify and perpetuate the negative impacts of the nickel supply chain.	
Dominant Narratives and Ideologies	o Analyzing how environmental degradation and social inequalities are framed and justified in the context of economic development agendas. o Examining how narratives of technological progress are used to downplay or legitimize negative consequences. o Investigating how the "green" agenda (e.g., the role of nickel in electric vehicles) is used to obscure social and ecological harms.
Cultural Practices and Beliefs	o Exploring whether existing cultural norms or power dynamics marginalize specific communities affected by the nickel industry. o Analyzing if cultural beliefs or values devalue nature in ways that make environmental destruction more acceptable.
Media and Discourse	o Analyzing how media outlets represent the nickel industry, its benefits, and its impacts. o Examining public discourse surrounding nickel extraction and processing, identifying dominant frames and silences.
Scientific and Technical Discourses	o Investigating how scientific and technical framings might inadvertently obscure or legitimize social and ecological harms associated with the nickel supply chain.

III. Examining Social-Ecological Structural Violence		
This dimension focuses on the systemic and institutional factors embedded within the nickel supply chain that create and perpetuate inequalities and environmental degradation.		
Policy and Regulatory Frameworks	o	Analyzing how environmental regulations (or lack thereof) contribute to environmental degradation.
	o	Examining how land tenure systems may disadvantage local communities and facilitate resource extraction.
	o	Investigating the role of labor laws in protecting or failing to protect workers in the nickel industry.
	o	Analyzing how broader economic policies incentivize or fail to address the negative externalities of the nickel supply chain.
Power Dynamics and Governance	o	Identifying the key actors and power structures involved in decision-making processes related to nickel extraction and processing.
	o	Analyzing the extent to which marginalized communities and environmental concerns are represented (or not) in these processes.
Economic Structures and Market Forces	o	Investigating how global market demands for nickel influence extraction practices and environmental standards.
	o	Analyzing the economic incentives within the supply chain that may prioritize profit over social and ecological well-being.
Corporate Practices and Accountability	o	Examining the environmental and social responsibility practices of companies operating within the nickel supply chain.
	o	Analyzing mechanisms for holding these companies accountable for negative social and ecological impacts.

IV. Mapping the Temporal and Spatial Dimensions of Social-Ecological Violence		
This dimension focuses on understanding how the impacts of the nickel supply chain unfold over time and across geographical locations.		
Identifying Immediate Impacts	o	Documenting the direct and localized consequences of nickel extraction and processing on specific communities and ecosystems at the point of impact.
Analyzing Delayed and Distant Impacts (Slow Violence)	o	Investigating long-term health consequences that may emerge years after exposure to pollutants or environmental changes.
	o	Analyzing cumulative environmental degradation resulting from ongoing nickel operations.
	o	Examining the transboundary effects of pollution (e.g., water and air) and resource depletion that extend beyond immediate operational areas.
Tracing the Geographical Spread of Impacts	o	Understanding how actions in one location (e.g., mining sites) can have cascading effects on other regions (e.g., downstream communities, global climate through emissions).

Source: Processed by the author, 2025

This analytical framework provides a comprehensive structure for investigating the complex and interconnected forms of social-ecological violence within the nickel supply chain. By examining the three primary types of social-ecological violence and their expressions across time and space, researchers can gain a deeper understanding of the root causes, manifestations, and long-term consequences of this violence, ultimately contributing to more just and sustainable practices.

CONCLUSION

In conclusion, this article has presented an analytical framework designed to unravel the intricate web of social-ecological violence embedded within the nickel supply chain. By adopting the expanded concept of violence that integrates Johan Galtung's definition of violence with the concept of ecosystem health, as well as incorporating the time dimension and spatial dimension (Yanuardi, Bluemling, et al., 2022), this framework moves beyond traditional analyses that often treat these dimensions in isolation by examining the nickel supply chain to better understand the adverse impacts of the escalating nickel extraction driven by the energy transition. Its significance lies in providing a more comprehensive lens through which to understand the multifaceted impacts of the global demand for nickel.

The analytical framework presented here offers a valuable tool for researchers seeking to deepen their understanding of resource-driven conflicts and environmental injustices. Furthermore, it can inform policymakers in the development of more robust environmental and social safeguards within the mining sector. By providing a structured approach to analysing the interconnectedness of social and ecological harms, it can also empower civil society organizations in their advocacy efforts and encourage industry actors to adopt more responsible sourcing practices.

While this framework offers a significant step towards a more integrated analysis, it is important to acknowledge certain limitations. Future research could further explore the role of specific cultural contexts, the complexities of informal economies within the supply chain, and the long-term cumulative impacts of social-ecological violence. Further empirical testing and application of this framework across diverse geographical contexts and scales of analysis will be crucial for its continued refinement and strengthening.

As such, by providing a robust and interconnected lens for understanding the social and ecological dimensions of violence in the nickel supply chain, this analytical framework not only contributes to a more critical and nuanced understanding of the sustainability challenges inherent in the global energy transition but also ensures that the resulting research can be employed to foster social-ecological reflexivity (Pickering, 2019; Yanuardi, Vijge, et al., 2022) in recognizing social-environmental impacts, and in rethinking and appropriately responding to the institutional performance of climate actions and extractive industry governance (Yanuardi, Vijge, et al., 2022). By revealing feedback loops and power dynamics, this framework has the potential to improve governance quality within extractive industry sectors (Yanuardi, Bluemling, et al., 2022). This deeper understanding is crucial for identifying pathways towards social-ecological peace, defined by the absence of both social and ecological violence and the presence of social-ecological justice and ecological integrity (Yanuardi, Bluemling, et al., 2022), thereby underscoring the urgent need for more just and equitable resource governance (Yanuardi, 2024) and proactive social-ecological peacebuilding efforts—in the broader meaning of peace (Yanuardi, Bluemling, et al., 2022).

REFERENCES

Amnesty International. (2024). *What Do We Get In Return?* https://www.amnesty.org/en/wp-content/uploads/2025/01/ASA3586072024ENGLISH.pdf

Amnesty International. (2025, January 9). *Philippines: Nickel mining projects approved despite inadequate consultation and serious risks to communities' health and environment.* Amnesty International. https://www.amnesty.org/en/latest/news/2025/01/philippines-nickel-mining-projects-approved-despite-inadequate-consultation-and-serious-risks-to-communities-health-and-environment/

Ash, J. (2024). Social impacts of critical mineral exploration on Indigenous peoples' lands: A case study from Solomon Islands. *The Extractive Industries and Society*, *17*, 101439. https://doi.org/10.1016/J.EXIS.2024.101439

Barends, J. (2025, March 11). *Nickel miners dig up Indonesia's Gebe Island despite Indigenous and legal opposition.* Mongabay. https://news.mongabay.com/2025/03/nickel-miners-dig-up-indonesias-gebe-island-despite-indigenous-and-legal-opposition/

Camba, A. (2021). The unintended consequences of national regulations: Large-scale-small-scale relations in Philippine and Indonesian nickel mining. *Resources Policy*, *74*, 102213. https://doi.org/10.1016/J.RESOURPOL.2021.102213

Carnwell, R., & Daly, W. (2001). Strategies for the construction of a critical review of the literature. *Nurse Education in Practice*, *1*(2), 57–63. https://doi.org/10.1054/NEPR.2001.0008

Church, C., & Crawford, A. (2020). Minerals and the metals for the energy transition: Exploring the conflict implications for mineral-rich, fragile states. *Lecture Notes in Energy*, *73*, 279–304. https://doi.org/10.1007/978-3-030-39066-2_12

Climate Right International. (2024). *Indonesia: Huge Nickel Project Driving Climate, Rights, Environmental Harms.* https://cri.org/indonesia-huge-nickel-project-driving-climate-rights-environmental-harms/

Cronin, J., Anandarajah, G., & Dessens, O. (2018). Climate change impacts on the energy system: a review of trends and gaps. *Climatic Change*, *151*(2), 79–93. https://doi.org/10.1007/S10584-018-2265-4

Deshpande, A. (2011, January 27). Equator Principles: Do they make business sense? *Eco-Business.* https://www.eco-business.com/opinion/equator-principles-do-they-make-business-sense-abh/

Galtung, J., & Fischer, D. (2013). *Johan Galtung. 5.* https://doi.org/10.1007/978-3-642-32481-9

Gamu, J. K., & Soendergaard, N. (2024). Governance capture and socio-environmental conflict: a critical political economy of the global mining industry's prior consultation regime. *Review of International Political Economy*, *31*(3), 880–904. https://doi.org/10.1080/09692290.2023.2265976

Gissi, F., Stauber, J. L., Binet, M. T., Golding, L. A., Adams, M. S., Schlekat, C. E., Garman, E. R., & Jolley, D. F. (2016). A review of nickel toxicity to marine and estuarine tropical biota with particular reference to the South East Asian and Melanesian region. *Environmental Pollution*, *218*, 1308–1323. https://doi.org/10.1016/J.ENVPOL.2016.08.089

Handelsman, S. D. (2002). *Human Rights in the Minerals Industry.*

Hassan, Q., Algburi, S., Sameen, A. Z., Al-Musawi, T. J., Al-Jiboory, A. K., Salman, H. M., Ali, B. M., & Jaszczur, M. (2024). A comprehensive review of international renewable energy growth. *Energy and Built Environment.* https://doi.org/10.1016/J.ENBENV.2023.12.002

Hayes, S. M., & McCullough, E. A. (2018). Critical minerals: A review of elemental trends in comprehensive criticality studies. *Resources Policy*, *59*, 192–199. https://doi.org/10.1016/J.RESOURPOL.2018.06.015

Hercelin, N., & Dörry, S. (2024). Valuation conflicts in Madagascar's mining reform: A pragmatic inquiry into surplus distribution from strategic transition minerals. *Environment and Planning F*. https://doi.org/10.1177/26349825241241319

Hudayana, B., Suharko, & Widyanta, A. B. (2020). Communal violence as a strategy for negotiation: Community responses to nickel mining industry in Central Sulawesi, Indonesia. *The Extractive Industries and Society*, *7*(4), 1547–1556. https://doi.org/10.1016/J.EXIS.2020.08.012

Hutchinson, T. C., & Whitby, L. M. (1974). Heavy-metal Pollution in the Sudbury Mining and Smelting Region of Canada, I. Soil and Vegetation Contamination by Nickel, Copper, and Other Metals. *Environmental Conservation*, *1*(2), 123–132. https://doi.org/10.1017/S0376892900004240

Hyldmo, H. da S., Wardhani, I. S., Kurniawan, N. I., Cahayati, D. D., Rye, S. A., & Vela-Almeida, D. (2025). Urgent transition, urgent extraction? Global decarbonization, national governance, and local impacts in the Indonesian nickel industry. *Environmental Research Letters*, *20*(5), 054003. https://doi.org/10.1088/1748-9326/ADC31C

Indonesia Business Post. (2023, May 22). *Report reveals human rights violations and environmental abuses in nickel supply chains in the Philippines and Indonesia.* https://indonesiabusinesspost.com/829/Politics/report-reveals-human-rights-violations-and-environmental-abuses-in-nickel-supply-chains-in-the-philippines-and-indonesia

Iwatsuki, Y., Nakajima, K., Yamano, H., Otsuki, A., & Murakami, S. (2018). Variation and changes in land-use intensities behind nickel mining: Coupling operational and satellite data. *Resources, Conservation and Recycling*, *134*, 361–366. https://doi.org/10.1016/J.RESCONREC.2018.02.028

Levická, J., & Orliková, M. (2024). The Toxic Legacy of Nickel Production and Its Impact on Environmental Health: A Case Study. *International Journal of Environmental Research and Public Health 2024, Vol. 21, Page 1641*, *21*(12), 1641. https://doi.org/10.3390/IJERPH21121641

Luckeneder, S., Giljum, S., Schaffartzik, A., Maus, V., & Tost, M. (2021). Surge in global metal mining threatens vulnerable ecosystems. *Global Environmental Change*, *69*, 102303. https://doi.org/10.1016/J.GLOENVCHA.2021.102303

Makati, K., Rahman, A., Danial, D. (2024) Industri Ekstraktif dan Dampak Terhadap Warga Lingkar Tambang. *Auriga Nusantara*. https://wallacea.id/id/riset/4/industri-ekstraktif-dan-dampak-terhadap-warga-lingkar-tambang

Malik, R. H. (2024). *Stakeholder views on the uptake of sustainable and responsible nickel mining and processing supply chains for electric vehicles in Indonesia* [Massachusetts Institute of Technology]. https://dspace.mit.edu/handle/1721.1/156950

Nakajima, K., Otsuka, Y., Iwatsuki, Y., Nansai, K., Yamano, H., Matsubae, K., Murakami, S., & Nagasaka, T. (2014). Global supply chain analysis of nickel: importance andpossibility of controlling the resource logistics. *Metallurgical Research & Technology*, *111*(6), 339–346. https://doi.org/10.1051/METAL/2014036

Newman, J. E., Levasseur, P. A., Beckett, P., & Watmough, S. A. (2023). The impact of severe pollution from smelter emissions on carbon and metal accumulation in peatlands in Ontario, Canada. *Environmental Pollution*, *320*, 121102. https://doi.org/10.1016/J.ENVPOL.2023.121102

Nguyen, R. T., Eggert, R. G., Severson, M. H., & Anderson, C. G. (2021). Global Electrification of Vehicles and Intertwined Material Supply Chains of Cobalt, Copper and Nickel. *Resources, Conservation and Recycling*, *167*, 105198. https://doi.org/10.1016/J.RESCONREC.2020.105198

Nixon, R. (2011). *Slow Violence and the Environmentalism of the Poor*. https://doi.org/10.4159/HARVARD.9780674061194

Prematuri, R., Turjaman, M., Sato, T., & Tawaraya, K. (2020). The Impact of Nickel Mining on Soil Properties and Growth of Two Fast-Growing Tropical Trees Species. *International Journal of Forestry Research*, *2020*(1), 8837590. https://doi.org/10.1155/2020/8837590

Rapport, D. J., & Maffi, L. (2011). Eco-cultural health, global health, and sustainability. *Ecological Research*, *26*(6), 1039–1049. https://doi.org/10.1007/S11284-010-0703-5

Ravi, B., Bhuwalka, K., Moore, E. A., Diersen, I., Malik, R. H., Young, E., Billy, R. G., Stoner, R., Ceder, G., Müller, D. B., Roth, R., & Olivetti, E. A. (2024). Clean energy demand must secure sustainable nickel supply. *Joule*, *8*(11), 2960–2973. https://doi.org/10.1016/j.joule.2024.10.008

Schwartz, F. W., Lee, S., & Darrah, T. H. (2021). A Review of Health Issues Related to Child Labor and Violence Within Artisanal and Small-Scale Mining. *GeoHealth*, *5*(2), e2020GH000326. https://doi.org/10.1029/2020GH000326

Sebrell, N., & Ivanov, F. V. (2023). *Nickel: Supply Risks and ESG Issues*. https://insights.issgovernance.com/posts/nickel-supply-risks-and-esg-issues/

Stevis, D., & Felli, R. (2015). Global labour unions and just transition to a green economy. *International Environmental Agreements: Politics, Law and Economics*, *15*(1), 29–43. https://doi.org/10.1007/S10784-014-9266-1

Upadhyaya, A. (2024). Indonesia's Nickel Empire at the Expense of Human Rights. *VA Journal of International Affairs*, *Spring 2024*. https://vajournalia.org/opeds-1/2024/3/27/indonesias-nickel-empire-at-the-expense-of-human-rights

Valencia, F., Rabbani, M., Fahimi, A., & Vahidi, E. (2025). Assessing the environmental burden of nickel sulfate for batteries: A life cycle perspective. *Resources, Conservation and Recycling*, *215*, 108130. https://doi.org/10.1016/J.RESCONREC.2025.108130

Yanuardi, Y. (2024). *Governance for sustainability in the extractive industry sector: Addressing the Resource Curse through Global Standard-Setting - Experiences from Indonesia*. https://doi.org/10.33540/2212

Yanuardi, Y., Bluemling, B., & Biermann, F. (2022). Social-Ecological Peace – A framework to analyze the transition from violence to peace in post-conflict areas, applied to Aceh, Indonesia. *Journal of Political Ecology*, *29*(1), 247–265. https://doi.org/10.2458/JPE.4707

Yanuardi, Y., Vijge, M. J., & Biermann, F. (2021). Improving governance quality through global standard setting? Experiences from the Extractive Industries Transparency Initiative in Indonesia. *The Extractive Industries and Society*, *8*(3), 100905. https://doi.org/10.1016/J.EXIS.2021.100905

Yanuardi, Y., Vijge, M. J., & Biermann, F. (2022). Social-ecological reflexivity of extractive industry governance? The case of the Extractive Industries Transparency Initiative in Indonesia. *Environmental Policy and Governance*, *32*(5), 426–437. https://doi.org/10.1002/EET.1988

Yuli, Z. (2024, February 4). *Nickel Mining Operation Is 'Slowly Killing Us', Indonesian Farmers Say*. ProjectMultatuli. https://projectmultatuli.org/en/nickel-mining-operation-is-slowly-killing-us-indonesian-farmers-say/

Zhang, C., Yan, J., & You, F. (2023). Critical metal requirement for clean energy transition: A quantitative review on the case of transportation electrification. *Advances in Applied Energy*, *9*, 100116. https://doi.org/10.1016/J.ADAPEN.2022.100116

Zimmer, F., & Themann, D. (2020). The rise of e-mobility as a trade-off between social and ecological benefits and distributional injustice : How the socio-technical regime and externalisation prevent a profound transformation of the mobility sector. *Sustainable Development and Resource Productivity*, 42–54. https://doi.org/10.4324/9781003000365-5

Zuada, L.H., Putra, E., Lasimpo, G. (2024) Industrialisasi Nikel, Perubahan Tata Guna Lahan dan Eksistensi Keanekaragaman Hayati di Lanskap Ambunu. *Auriga Nusantara*. https://wallacea.id/id/riset/5/industrialisasi-nikel-perubahan-tata-guna-lahan-dan-eksistensi-keanekaragaman-hayati-di-lanskap-ambunu