The Extractive Industries and Society 20 (2024) 101552

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Original article

Drivers and barriers of voluntary sustainability initiatives in mining raw materials for batteries

Bernardo Mendonca Severiano *, Stephen A. Northey, Damien Giurco

University of Technology Sydney, Institute for Sustainable Futures, Bldg 10, 235 Jones St, Ultimo, NSW 2007, Australia

ARTICLE INFO

Keywords:
Voluntary sustainability initiatives
Battery minerals
Mining
IRMA
Corporate social responsibility

ABSTRACT

The increasing adoption of electric vehicles (EV) is growing demand for battery raw materials including lithium, cobalt, nickel, and manganese. The potential for Voluntary Sustainability Initiatives (VSI) to mitigate the social and environmental impacts of mine development and operation is now in focus as resource supply scales rapidly. This study examines and synthesizes the drivers and barriers that influence extractive companies to voluntarily adopt sustainability initiatives, including certification and reporting, to mitigate social and environmental impacts. The methodology involved a thematic analysis of articles, initially identified through a systematic keyword search and further expanded with a snowball search technique. Thematic insights were classified and mapped against actors operating within the lithium-ion battery value-chain. The research found that drivers for adopting voluntary sustainability initiatives include maintaining market access, and addressing the increased need for frameworks to facilitate communication between companies and local communities. Barriers encompass short-term greenwashing undermining VSI legitimacy, and the lack of comprehensiveness of such initiatives regarding risk identification and risk mitigation for responsibly sourced commodities.

1. Introduction

A key strategy for reducing greenhouse gas (GHG) emissions is the electrification of the transportation sector to enable the use of low-carbon energy sources (Habib et al., 2020). Several countries and manufacturers are implementing policies to phase-out internal combustion vehicles (IEA, 2020). The shift towards renewable energy generation and clean energy storage is increasing the demand for minerals used in lithium-ion batteries (LIBs), creating supply concerns (Dominish et al., 2019), especially since these raw materials are often concentrated in resource-rich geographies in the Global South (Riofrancos, 2023). These concerns are particularly focused on lithium-ion cathode materials due to their high relative cost (20 % of a LIB), often composed of lithium (Li), nickel (Ni), manganese (Mn), and cobalt (Co) in varying quantities, depending on battery chemistry (Habib et al., 2020; Murdock et al., 2021; Nitta et al., 2015).

Overall, the mining sector is under pressure from investors, regulators, and civil society to engage in supply-chain reporting (Franken and Schütte, 2022). The European Union (EU) has established regulation concerning batteries and waste batteries that, among other elements, requires carbon footprint declarations for electric vehicle (EV) batteries, and supply chain due diligence procedures (European Union (EU), 2023). Moreover, consumer-facing companies such as EV manufacturers play a significant role in gauging customer sentiment, willingness-to-pay and perceived value towards products and their respective environmental and social impacts within their supply chain (Amnesty International, 2017). Companies working directly with the extraction of battery minerals are being exposed to increased pressure to play a role in mitigating the negative impacts of mineral extraction and processing (Franken and Schütte, 2022). An established way to enact more sustainable practices related to raw material extraction, production, and processing phases is through the adoption of Voluntary Sustainability Initiatives (VSIs), inclusive of standards and certification schemes (Franken et al., 2020). Significant advancements have been made in developing standards and certifications tailored to battery minerals. Industry organizations and multi-stakeholder platforms have increasingly focused on materials used specifically in batteries such as the *Battery Passport*, (Global Battery Alliance, 2024), The *Nickel Mark* (The Nickel Institute, 2024), and the *Guidance on determining the product carbon footprint of lithium products* (International Lithium Association, 2024). Furthermore, the Responsible Minerals Initiative (RMI) has dedicated focus to cobalt since 2017, with a range of tools and resources

* Corresponding author.
E-mail addresses: Bernardo.MendoncaSeveriano@student.uts.edu.au, Bernardo.MendoncaSeveriano@uts.edu.au (B. Mendonca Severiano).

https://doi.org/10.1016/j.exis.2024.101552
Received 12 February 2024; Received in revised form 24 September 2024; Accepted 26 September 2024
Available online 7 October 2024

made available, such as the *Responsible Minerals Assurance Process* (RMAP) providing independent third-party assessments, and *Conformant Cobalt Refiners* assessment reports (Responsible Minerals Initiative, 2024).

This study aims to inform discussions on the adoption of VSIs by providing a systematic understanding of the implementation of sustainable practices across the minerals and metals sector, focusing on lithium, nickel, manganese, and cobalt. Tröster and Hiete (2018) highlight the complexity of assessing VSI legitimacy, noting that it varies by industry, commodity, and geography. We will explore the specific drivers and barriers to the adoption of voluntary practices in mining operations, influenced by supply-chain factors intrinsic to battery supply-chains, under the lens of the current green energy transition. We also elicit drivers and barriers ubiquitous to the mining sector, that in turn, also influence battery minerals. Our research advances the understanding of how voluntary initiatives can legitimize sustainable sourcing efforts amidst contested debates about corporate social responsibility (CSR) in mining operations. However, this study also critically examines how the potential for short-term greenwashing erodes VSI credibility, which can undermine genuine sustainability efforts in raw material mining. Finally, we explore the role that VSIs might play in helping battery and EV manufacturers mitigate supply risks, and the challenges associated with provenance tracing.

This research employs a thematic analysis, drawing on literature from Corporate Social Responsibility (CSR), Environmental, Social, and Governance (ESG) management, Environmental Stewardship, and overall mining literature. Our objective is to answer the question: *"What factors drive or hinder the adoption of voluntary sustainability initiatives in mining operations extracting lithium, nickel, manganese, and cobalt for lithium-ion batteries?"*. The paper is structured as follows: Section 2 introduces the research context and background, Section 3 details the methodological framework, Section 4 presents key findings, Section 5 discusses the identified drivers and barriers, and Section 6 concludes with final remarks and future research directions.

2. Background to voluntary sustainability initiatives

Since the 1990s, the mining sector has increasingly adopted self-regulation and transnational governance frameworks to address the complex social, environmental, and economic challenges it faces. Initiatives such as the establishment of the International Council on Metals and the Environment (ICME), under the auspices of the Mining Association of Canada (MAC) marked the beginning of formal self-regulatory efforts for the sector with a code of conduct for environmental management (Bomsel et al., 1996). Over time, these efforts have expanded to include comprehensive self-regulatory mechanisms at both national industry and firm levels, aimed at improving social and environmental performance indicators due to external control and scrutiny, with some self-regulatory efforts involving very specific actions that serve to reduce externalities for a specific industry (Peck and Sinding, 2003). These non-state market-driven systems have proliferated to address problems that span global areas and have a far-from-trivial potential for impact (e.g. fisheries depletion, forest deterioration, environmental impacts from mining) (Bernstein and Cashore, 2007). These systems are not legitimized by default, but can achieve "*the acceptance of shared rule by a community as appropriate and justified*"[a] (Bernstein, 2004, p. 142). Non-state market-driven governance shifts authority away from traditional state regulation toward market-based instruments such as certifications, adopted voluntarily. These instruments, driven by market demand and buyer preference, create incentives for firms to adopt sustainable practices, thereby establishing authority and legitimacy through market dynamics rather than state influence. The legitimacy and adoption of these governance systems occurs across the supply chain, as economic actors at each point of exchange choose to abide by the rules inherent in this system, reinforcing its authority throughout the production process (Cashore, 2002).

Voluntary initiatives at a mine-site level were first documented in 1992, with the Whitehorse Mining Initiative (WMI), led by a group of Canadian companies and representatives from civil society, under the leadership of the Mining Association of Canada (MAC). The WMI efforts were oriented towards promoting a common vision among stakeholders with respect to the future of the industry. The main areas addressed involved finance/taxation, environment, land-access, and workforce (UN departament of economic and social affairs, 1999). Regarded as a successful endeavor in demonstrating the potential of multistakeholder collaboration (Potts et al., 2018, p. 11), WMI inspired other global initiatives like the Extractive Industries Transparency Initiative (EITI) in 2002, which leveraged government and other actors in mineral supply-chains to guide demand, capacity, and commitments among producing countries. Other initiatives such as the Towards Sustainable Mining (TSM) from 2004, also under the leadership of MAC, have focused on mine-level commitments, designed to meet the rising demand for responsible, industrial-scale mining, operating as a generic multi-commodity initiative.

In the years after the WMI, the landscape of voluntary initiatives grew in scope, approach, and focus. A comparative study done by the German Federal Institute for Geosciences and Natural Resources (BGR) mapped more than 50 Sustainability Standards Systems (or schemes) that are applicable to the mineral sector (Kickler and Franken, 2017). These vary significantly regarding the number of sub-issues addressed, extent of requirements, and specificity. Global schemes aimed towards large-scale mining like the International Council on Mining and Metals (ICMM) Sustainable Development Framework (ICMM, 2023), the Initiative for Responsible Mining Assurance (IRMA) (IRMA, 2018), the Global Reporting Initiative (GRI) Reporting Principles and Standards (GRI, 2023), and the International Finance Corporation (IFC) Environmental and Social Performance Standards (IFC, 2012), cater to various mineral commodities across several geographies. Additionally, there are commodity-specific schemes for copper (Copper Mark), gold (Cyanide Code and the World Gold Council Industry Standards), aluminium (Aluminium Stewardship Initiative), and others. Lastly, the governance structure of such standards systems also varies significantly, with some being industry led (e.g. ICMM), others being industry-led with structured stakeholder engagement (e.g. TSM), and some being non-industry initiated, but industry inclusive (e.g. IRMA) (Erdmann and Franken, 2022). Moreover, the involvement of civil society and impacted stakeholders in the development process of these schemes can increase legitimacy, even with a longer ramp-up period. Nonetheless, despite decades of development, the long-term impact and uptake of these initiatives remains uncertain and often varies by commodity and geography. However, the focus on short-term impacts without acknowledging longer-term changes might serve immediate corporate interests to discredit established reporting requirements (Franken and Schütte, 2022). Specific to the mining industry, the adoption of voluntary standards is described as a key indicator of early mover status (Dashwood, 2012) providing firms with cooperative relations with government regulators and greater flexibility in the enforcement of existing environmental regulations (Potoski and Prakash, 2005), which might act against VSI legitimacy. Some authors consider VSIs to be the "second best option", being useless in front of total conformity with national and international laws, regulations, and standards (Franken et al., 2012). Moreover, community relations and development, under the umbrella of CSR, can be deployed to de-escalate crises, becoming purely transactional approaches to community relations and mining (Kemp and Owen, 2013). Assessing the legitimacy of VSIs is complex, being defined by their ability to solve a problem, behavioral effectiveness, market diffusion, and constitutive effectiveness, which are industry-, commodity-, and geography-specific (Tröster and Hiete, 2018). The EV industry,

[a] The original quote from 2005 is "the acceptance and justification of shared rule by a community", updated on Bernstein's work from 2007.

and the lithium-ion battery manufacturers by proxy, face a significant challenge when keeping a secure, responsible, and sustainable stream of minerals. Raw materials such as lithium, nickel, manganese, and cobalt are extracted from mines located in diverse regions - Often in countries like Australia, Chile, Indonesia, and the Democratic Republic of the Congo. As the goods move mainly from the Global South to the Global North, transnational governance plays a critical role across these layers. The multi-layered and multi-tiered aspect of this value chain is showcased by Fig. 2.1.

The material complexity in batteries and the fact that the extraction phase accounts for only about 0.5 % of a lithium-ion battery's value-added, contrasts sharply with industries like coffee, where 20 % of the value is added during extraction (Wills et al., 2018). Additionally, the complexity is compounded in the EV sector by the vast number of suppliers involved. For example, Panasonic, a leading EV battery manufacturer, works with over 10,000 suppliers globally (Panasonic, 2021). The complexity of battery supply chains can hinder the recognition of issues with deep suppliers. Junior mining companies, in particular, are more vulnerable to supply chain volatility and have less influence on sourcing practices due to their dependency on suppliers (Kalaitzi et al., 2019).

Whilst national adoption of standards have been implemented in some jurisdictions, the impacts of mining for battery minerals often extend beyond national borders, with demand concentrated in more affluent nations, and supply concentrated in less developed regions (Agusdinata et al., 2022). On that note, voluntary certification schemes can complement national standards when Original Equipment Manufacturers (OEMs) engage with tiered suppliers, being a way to reduce uncertainty and legitimize a claim within a multi-tiered supply chain that involves producing nations from the Global South (Sauer, 2021). Well established OEMs of a multi-tiered supply chain work towards translating their reputational risk to minimum required standards by their suppliers (Potts et al., 2018). This is done to mitigate the reputational risk they might be exposed to due to association with the social and environmental impacts of their suppliers. Also, multi-tiered supply chain initiatives fundamentally rely on the effective communication of information, from raw material sourcing to product end-use with emerging technologies and process innovations, like material fingerprinting and decentralized ledger technologies (using distributed databases, such as blockchain, to securely record and verify transactions), enhancing this communication, particularly in supply chain traceability (Vasilyev et al., 2022). However, the structural relations of power and modes of governance that voluntary initiatives belong have been criticized for potentially undermining national regulations, particularly in the Global South. Critics argue that certification schemes may serve corporate interests while neglecting deeper social or environmental reforms through *regulatory capture,* where industrial interests are overly represented (Blackman, 2008).

It becomes evident that the landscape of self-regulatory frameworks within the mining sector is complex and evolving. The adoption of such VSIs might be driven by a combination of market pressures, environmental concerns, and stakeholder engagement, although there's no consensus on the main adoption drivers. Despite their proliferation, their effectiveness is still unconfirmed. With an expectation of increased demand for battery minerals in the near future, the emphasis on analysing the landscape of VSI adoption is important and timely.

3. Methods

A thematic analysis was conducted to identify drivers and barriers to VSI adoption in mining operations part of battery minerals supply chains. We performed detailed keyword search in the literature, utilizing well-established terminologies related to voluntary sustainability in the mining sector. The selected articles were complemented by a snowball search, given the method's effectiveness in uncovering primary studies (Wohlin et al., 2022). By design, we've not included *grey literature* in the main corpus of the analysis and have kept the focus on peer-reviewed academic literature. The information within these articles was then systematically categorized into themes specifically focused on the various drivers and barriers influencing VSI adoption. The scope of this

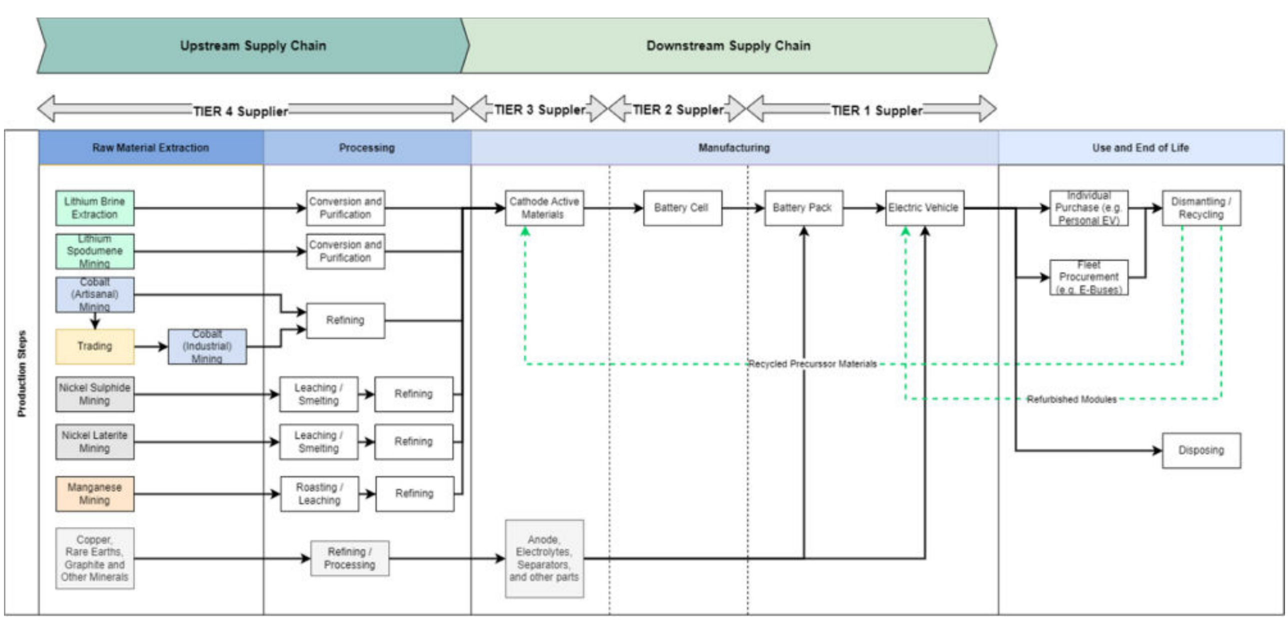

Fig. 2.1. Steps involved in the lithium-ion batteries' supply-chain, with particular emphasis on minerals used in cathode active materials.[b]

[b] The figure maps the EV's lithium-ion batteries' supply-chain, with particular emphasis on battery minerals. Definitions of upstream and downstream steps were taken from (Erdmann & Franken, 2022) and definitions of tiers within supply chain were based on (Petavratzi & Gunn, 2023). The basic structure of the cobalt supply chain for battery manufacturing was taken from (Deberdt & Le Billon, 2022), the lithium overarching processing steps were taken from (Khakmardan et al., 2023), nickel primary production routes were taken from (Schmidt et al., 2016), and manganese supply chain steps from (Snow, 2018).

Table 3.1
List of themes explored in the initial document selection. Each row represents a combination of key terms. Y = Yes; N = No. ESG = Environmental, social, and governance. CSR = Corporate social responsibility. ES = Environmental stewardship.

Voluntary initiatives	Broader sustainability terminology (ESG/CSR/ES)	Supply-chain	Lithium-ion batteries	Lithium / Nickel / Cobalt / Manganese	Battery minerals	Energy transition minerals	Results
Y	N	Y	Y	N	N	N	0
Y	N	Y	N	Y	N	N	0
Y	N	Y	N	N	Y	N	0
Y	N	Y	N	N	N	Y	0
Y	N	N	Y	N	N	N	0
Y	N	N	N	Y	N	N	0
Y	N	N	N	N	Y	N	0
Y	N	N	N	N	N	Y	0
N	Y	Y	Y	N	N	N	11
N	Y	Y	N	Y	N	N	16
N	Y	Y	N	N	Y	N	0
N	Y	Y	N	N	N	Y	0
N	Y	N	Y	N	N	N	40
N	Y	N	N	Y	N	N	82
N	Y	N	N	N	Y	N	1
N	Y	N	N	N	N	Y	0

was focused on the production of lithium, nickel, manganese and cobalt due to their critical role in manufacturing cathode active materials (Habib et al., 2020; Helbig et al., 2018).

3.1. Data sources and collection process

Previous bibliometric reviews suggest that the literature has not yet coalesced into a cohesive discourse or direction (Agusdinata et al., 2022). Initial keyword searches were guided by common terminology identified in relevant reports such as: *'Voluntary Sustainability Initiatives'* (Potts et al., 2018; Rutovitz et al., 2020), *'Voluntary Sustainability Standards'* (Franken et al., 2020), *'Sustainability Schemes'* (Kickler and Franken, 2017), and *'Sustainability Standard Systems'* (Erdmann and Franken, 2022). To analyze the battery minerals supply-chain, we've combined this with themes such as 'lithium-ion battery', 'battery minerals', 'energy transition minerals', and the commodity names (e.g. lithium). A total of 16 queries were used, which the combinations are described on Table 3.1. and under the tab 2_QUERIES in the supplementary material. Queries were conducted on the 23rd of November 2023.

The first 8 queries (all focused on VSIs) yielded no results. This finding is significant since it suggests a notable gap in the academic literature regarding the integration of VSIs in the context of mineral extraction for lithium-ion batteries. It seems that there's a lack of focused and integrative studies that combine such themes. Therefore, this research highlights a critical area of future exploration. After an initial screening of the literature, extra keywords were added to the query to broaden the scope of the research by incorporating alternative, yet related, terminologies. Keywords such as *'Corporate Social Responsibility'* (and '*CSR*'), *'Environmental, Social, and Governance'* (and *'ESG'*), and *'Environmental stewardship'* were included. These yielding significantly more results, as detailed on Table 3.2.

3.2. Data analysis framework

This purposive sampling initially yielded 150 results. After the removal of duplicates, 111 articles had their abstracts analyzed for thematic alignment, of which 69 were excluded for not aligning thematically with mining or mineral supply-chains (e.g. *"Application of three-phase Current Source Converter in Power Battery Testing System for Electric Vehicles"* or *"X-Ray Diffraction of Thin Polycrystalline Lithium-Fluoride Films with Silver Nanoparticles on Amorphous Substrates"*), leaving 42 relevant documents. Further analysis and a snowball search expanded this to include 125 additional articles, reports, and company statements. Of these, 30 were relevant, bringing the total count to 72 documents for analysis. Company-specific reports and grey literature is outside the scope of this work, and it's been suggested as complementary as part of an expanded future study.

A thematic analysis was then performed, being a widely-used methodology that involves both deductive and inductive approaches, outlined as a set of theme-building procedures (Braun and Clarke, 2006), stimulating knowledge building with a constant comparative method (Guest et al., 2012). The process follows a systematic guideline which involves *(i) Purposive Sampling; (ii) Initial Coding; (iii) Intermediate Coding;* and *(iv) Advanced Coding* (Chun Tie et al., 2019), as described in Table 3.3.

After the coding process, the codes were clustered into sub-categories of **drivers** and **barriers,** with all the results being presented in Section 4 and discussed in Section 5. Drivers have been defined as '*things that motivate people to want to take action*'; and barriers as '*things that prevent people from taking action*' (Khan, 2019). Within the context of this study:

I. **Drivers**: Internal or external forces that are responsible for the uptake of Voluntary Sustainability Initiatives at a mining operation involved in the extraction of lithium, nickel, manganese, or cobalt.
II. **Barriers:** Internal or external forces that demotivate companies or prevent them from engaging with Voluntary Sustainability Initiatives at a mining operation involved in the extraction of lithium, nickel, manganese, or cobalt.

The references are provided in the *supporting information.* A descriptive overview of the data collection methods and analytical framework used in this research can be found in Fig. 3.1.

4. Results

We initially analyzed the coverage of selected battery minerals against their thematic and commodity-focused filters. This analysis provided an initial overlap between the themes and the selected minerals, as shown in Fig. 4.1(A). A detailed paper-by-paper breakdown is available in the supplementary material under the tab '2_REFERENCES'. Additionally, we mapped individual mentions of battery minerals against their combined themes, as showcased in Fig. 4.1(B). In terms of spatial and research focus, a significant portion of published research originates from authors affiliated in Australia, followed by the United States and Canada. Most publications concentrated on the producing countries of lithium, nickel, and cobalt, as presented in Fig. 4.2.

When compiling a list of drivers and barriers from the surveyed literature, we focused on identifying those cited both with and without the inclusion of "supply-chain" as a keyword, as detailed in Table 3.2. A mapping of the drivers common to both sets of literature - those found using the "supply-chain" keywords and those found without - is

Table 3.2
Queries encompassing broader sustainability terminology, whilst still narrowed to minerals used in cathode active materials (lithium, nickel, manganese, and cobalt).

Themes	Web of science query	Results
Lithium-ion batteries; Broader sustainability terminology; Supply-chain	TS=("lithium ion" OR "lithium-ion" OR "electric vehicle*") **AND** TS=("supply chain*" OR "value chain*") **AND** TS=("Corporate Social Responsibility" OR "CSR" OR "Environmental, Social, and Governance" OR "ESG" OR "Environmental stewardship")	11
Lithium-ion batteries; Broader sustainability terminology;	TS=("lithium ion" OR "lithium-ion" OR "electric vehicle*") **AND** TS=("Corporate Social Responsibility" OR "CSR" OR "Environmental, Social, and Governance" OR "ESG" OR "Environmental stewardship")	40
Battery minerals (specific); Broader sustainability terminology; Supply-chain;	TS=("lithium" OR "Nickel" OR "Manganese" OR "Cobalt") **AND** TS=("supply chain*" OR "value chain*") **AND** TS=("Corporate Social Responsibility" OR "CSR" OR "Environmental, Social, and Governance" OR "ESG" OR "Environmental stewardship")	16
Battery minerals (specific); Broader sustainability terminology;	TS=("lithium" OR "Nickel" OR "Manganese" OR "Cobalt") **AND** TS=("Corporate Social Responsibility" OR "CSR" OR "Environmental, Social, and Governance" OR "ESG" OR "Environmental stewardship")	82
Battery minerals (generic); Broader sustainability terminology;	TS=("battery mineral*") **AND** TS=("Corporate Social Responsibility" OR "CSR" OR "Environmental, Social, and Governance" OR "ESG" OR "Environmental stewardship")	1

Table 3.3
Research design steps of a thematic analysis. Adapted from (Chun Tie et al., 2019).

Thematic analysis step	Description
Purposive sampling	Purposive sampling is the first step and directs the collection and/or generation of data. The researcher purposively selects data sources that can be supportive of answering the research questions. Moreover, this data collection process from secondary literature can be supplemented by a snowball search.
Initial coding	This is a procedure for developing categories of information. The purpose of this step is to start the process of fracturing the data collected with purposive sampling, and to incidentally find similarities and patterns in the data.
Intermediate coding	Intermediate coding is a procedure for interconnecting the categories. At this research stage, core categories become more evident and some relationships between categories are refined.
Advanced coding	Advanced Coding is a procedure for connecting the categories. During this last step, theoretical integration is pursued. Concepts were integrated in pursuit of a substantive theory.

represented in Fig. 4.3 (for drivers) and Fig. 4.4 (for barriers). For both images, the leftmost grouping combines the themes found in the literature surveyed under the 'supply-chain' filter, and on the rightmost grouping, the themes found in the literature surveyed without the 'supply-chain' filter. In the middle, we can see the themes that are common to both categories. A detailed breakdown of which sources the drivers and barriers were found originally, and how many works include such drivers and barriers can be found in the supplementary material. Tables 4.1 and 4.2 provide further descriptions and references for these drivers and barriers, organized by the number of sources that discuss them. These factors are often geography-specific, as well as mineral-specific, supporting an analytical framework on the success of VSIs such as the one proposed by (Tröster and Hiete, 2018). For example, the concentration of cobalt supply in the Democratic Republic of Congo has led auto manufacturers to implement responsible sourcing initiatives (Malone et al., 2023) in response to client and investor concerns (Deberdt and Billon, 2021). To expand on these insights, we also analyzed drivers and barriers without the supply-chain filter, focusing on mining operations not explicitly associated with the extraction of lithium, nickel, cobalt or manganese. The most frequently cited factors, not already covered in Tables 4.1 and 4.2, are presented in Tables 4.3 and 4.4.

5. Discussion

5.1. Drivers

5.1.1. Insights on company-community communication: social license, conflicts, and voluntary sustainability

The findings presented at Table 4.1 underscore the critical need for comprehensive frameworks on company-community communication, especially in regions where lithium, nickel, and cobalt projects are situated, which often present high ESG risks (Lèbre et al., 2020). The social aspect of this risk assessment is evidenced by the frequent social conflicts in such regions, including lithium mining in the lithium triangle (Liu and Agusdinata, 2020), nickel mining in Indonesia (Hudayana et al., 2020) and New Caledonia (Lassila, 2016), and cobalt mining in both the United States (Malone et al., 2023) and the Democratic Republic of the Congo (DRC) (Savinova et al., 2023).

During the pre-permitting stage, when company-community conflicts are at their highest due to the proximate and imminent social and environmental impacts, such as pollution, resource competition, and lack of consent, concerns over health and safety and the influence of external agents is particularly evident (Franks et al., 2014). Mine-site developments being delayed, interrupted, and shut down due to public opposition are ubiquitous (Moffat and Zhang, 2014), with most of the company-community conflicts being observed during exploration, feasibility, and construction (Franks et al., 2014). Past instances of conflict, have resulted in mining operations being delayed, interrupted, or shut down (Jenkins, 2004). With recent examples being the Jadar Lithium mine project in Serbia, having its exploration licenses revoked by the government due to strong protests (Wired, 2022), effectively limiting further exploration of the combined indicated and inferred resource of 143.5Mt at 1.80 % Li20 (~2.58 Mt Li2O) (Rio Tinto, 2022), which could be relevant for future supply. Authors have discussed that the implementation of sustainability certification schemes, taking the form of VSIs, may be an effective mean of improving the company-community relationship regarding environmental impact mitigation and preventing opposition to mine-site development (Tröster and Hiete, 2018). This poses an interesting reflection on the Jadar lithium mine project, since Rio Tinto is a member of ICMM, with public commitments to CSR (ICMM, 2024), it's unclear from the literature review if the adoption of VSIs are enough to avoid community opposition to a project, and more importantly, if this should even be the driving element behind VSI adoption.

Analyses of implementation of voluntary practices related to new

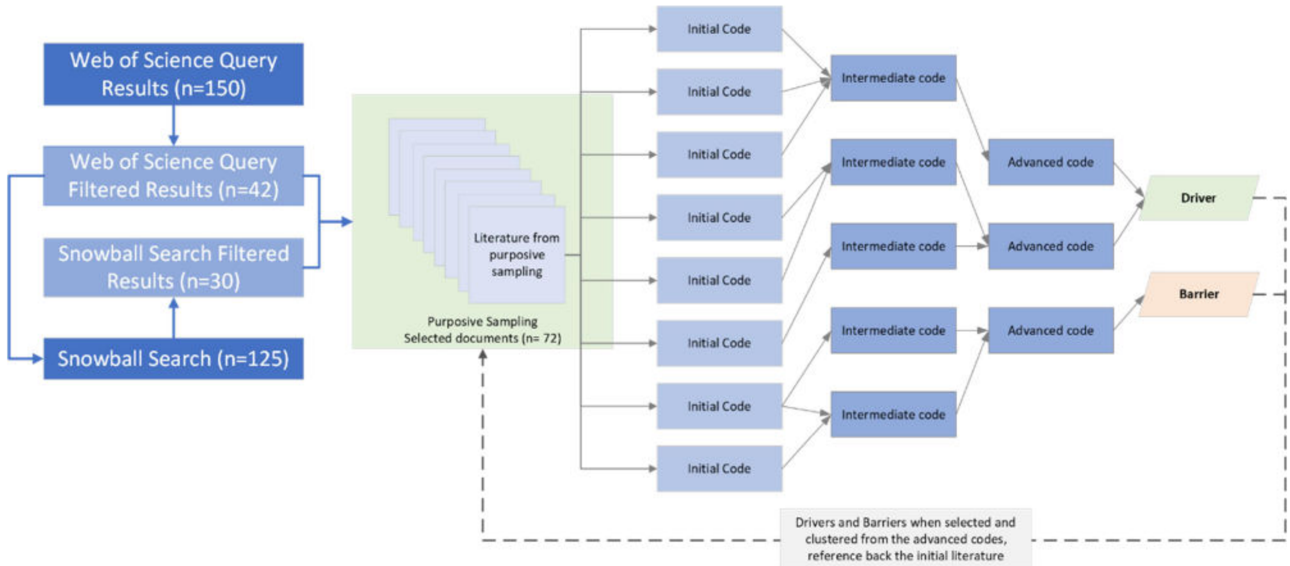

Fig. 3.1. Descriptive methodological overview and coding process leading to the identification of drivers and barriers and how information is referenced.

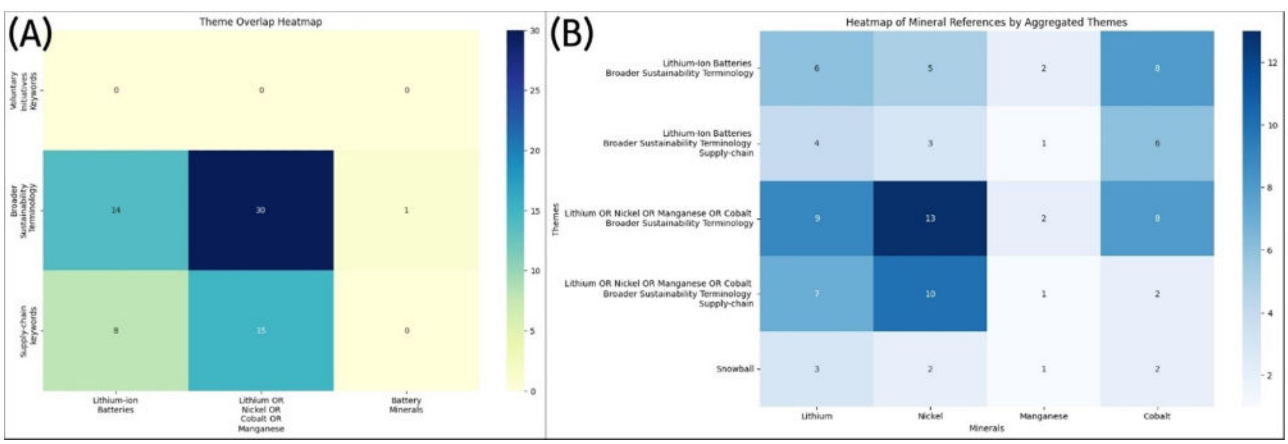

Fig. 4.1. (A) Thematic overlap between research themes and battery minerals; (B) Distribution of mentions to individual battery minerals across combination of research themes.

nickel projects in Southeast Sulawesi, Indonesia have linked CSR practices with an effective licence to operate (Hudayana et al., 2020). Correlations between CSR implementation and community resilience were drawn (Zainuddin Rela et al., 2020), which is corroborated by previous studies that established that CSR projects contribute to economic welfare, income, employment, and asset financing (Sarmila et al., 2015). Agusdinata et al. (2023) has concluded that the nickel mining in Sulawesi contributes positively to the achievement of some SDGs, while acknowledging a need to mitigate impacts related to effects on farmland and displaced farmers.

Current perspectives view CSR primarily as a risk management tool for companies (Agusdinata et al., 2023). For example, to expedite regulatory approval due to the absence of conflict, practices such as organizing public forums, funding community events, and donating to local charities have been noted in proposed nickel mines in the United States. Additionally, risk-management strategies such as public tours of undeveloped land are used to engage local community members. The under-developed land showcased during tours doesn't express the future impacts and can be a method of suppressing opposition (Kojola and McMillan Lequieu, 2020). Therefore, it's crucial to understand the line between the adoption of VSIs from an *increased need for frameworks on company-community communication* (a mapped driver from this work), and *short-term greenwashing undermining genuine sustainability efforts in mining* (a barrier to the legitimacy of VSIs, affecting their adoption), further explored under the *barriers* discussion section.

5.1.2. *Navigating supply-chain pressures and VSIs*

The drivers for VSI adoption span further than just its mining footprint. The second most frequently found driver in the literature we covered is the need to manage *supply-chain disruption risk*. Supply risk is often assessed through potential for supply reduction, increased demand, product concentration, and political risk, with all minerals described within this study (Li, Ni, Mn, and Co) presenting a high risk of supply disruption (Helbig et al., 2018). These risks are exacerbated by the geographical concentration of battery minerals, aligning regions with high ESG risks to critical points in the global supply chain (Agusdinata et al., 2022; van den Brink et al., 2020) (described under driver "*Geographical Concentration of Battery Minerals*"). Long-term supply strategies to address supply risk through cross-sector collaboration have been emphasized (Petavratzi and Gunn, 2023), with VSIs potentially playing a role in signalling risk management and mitigation through transparent adaptive management.

When looking at the driver "*Downstream pressure to mitigate reputational risk*", some authors claim that the automotive industry

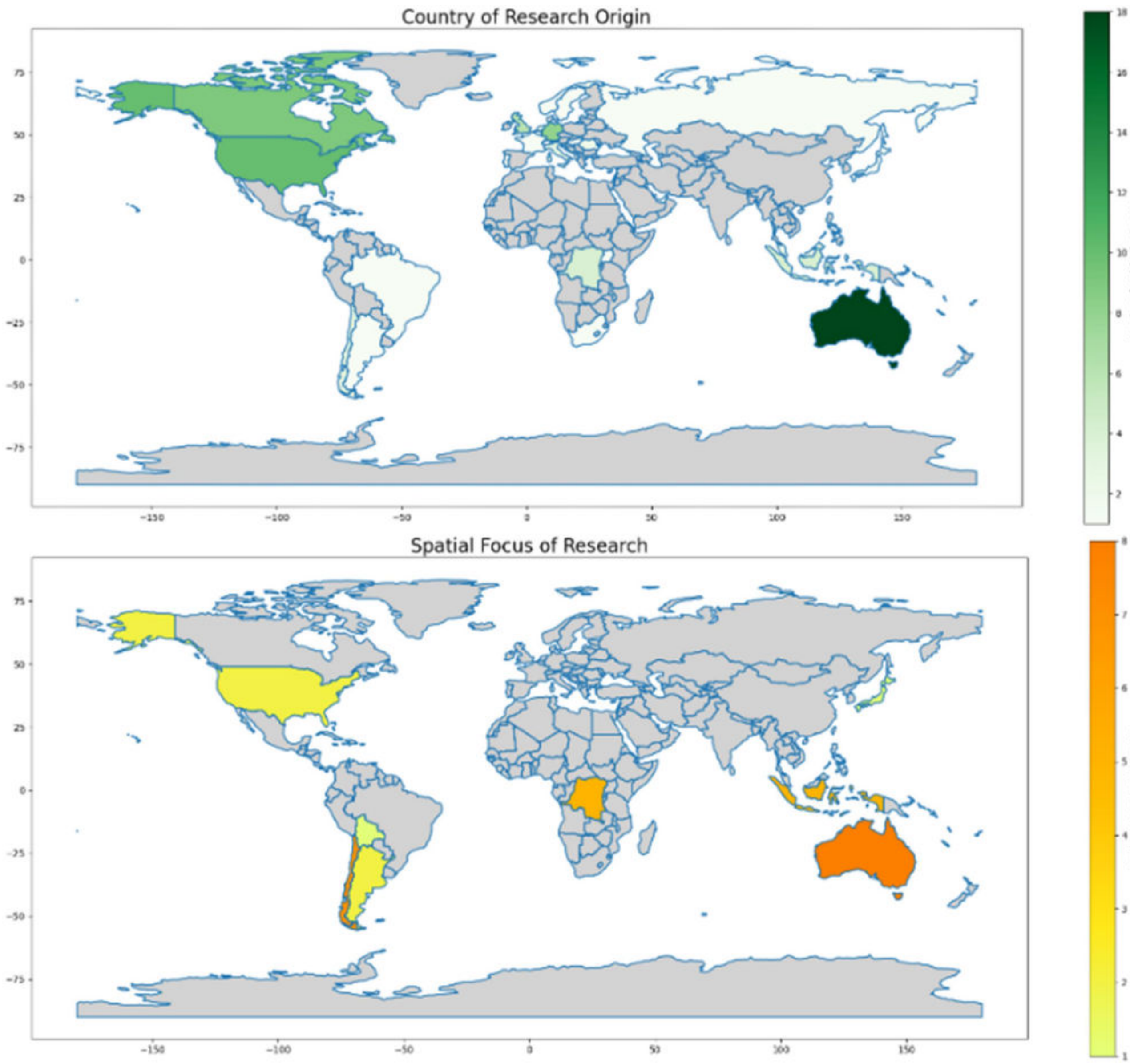

Fig. 4.2.. Geographic distribution of author affiliations (above), and spatial focus of analysis (below).

procurement sectors are showing greater interest in responsible sourcing practices for raw materials (Rutovitz et al., 2020). Due to the potential for opposition and social impact associated with mining operations, mining companies are especially vulnerable to reputational risks (Innis and Kunz, 2020), making certification and compliance with standards an attractive potential de-risking strategy. From the literature review several key drivers relate to environmental performance monitoring, namely: (i) *Improved guidelines on life cycle assessment*, (ii) *increased need to manage biodiversity impacts*, and (iii) *operating in complex water management contexts*. The importance of monitoring environmental performance and life cycle indicators at the source of raw material extraction might be driven by legislation such as directives on corporate sustainability due diligence (European Union (EU), 2023) and battery passports (Berger et al., 2023). Article 77 of the most recent EU battery regulation requires that, by 2027, operators provide a record of all stages of the battery life cycle. Such regulation might be associated with *harder accountability*¸ as mentioned by (Johnson and Khosravani, 2024), which although wasn't part of the analyzed literature, adds a significant amount to the discussion. An important point raised is that, although the EU's battery regulation is mandatory, the transnational nature of the battery supply chain might require voluntary environmental management at the mining operation level to clarify any ambiguities or address the potential overemphasis on European interests.

Lastly, the incorporation of mining stakeholders in initiatives related to the responsible recycling of metals, such as the Roundtable on the Responsible Recycling of Metals (RRRM, 2023) will likely lead to increased requirements on visibility and transparency across the supply chain. These all speak to an increased prominent role of transnational corporations in mineral extraction. Extending on the importance of improved monitoring efforts, an author discussed the need to incorporate life cycle assessments to capture the full costs of mineral extraction (Agusdinata et al., 2022). Another author mentions that emerging frameworks should consider that the legislation in the 'demand country' should consider impacts from mining from the 'supplying countries' (Kosai et al., 2022). Some authors discuss that for EV consumers, information about local impacts of minerals extractions should be factored into the life cycle cost of EVs ownership (Mitropoulos et al., 2017) which is consistent with a growing body of literature looking at *telecoupling, global value chains, global production networks,* and other associated concepts.

Fig. 4.3. Sankey diagram of drivers that were commonly found both in literature queried with supply-chain keywords and literature queried without such keywords. The leftmost grouping (blue) combines the drivers found in the literature surveyed under the 'supply-chain' filter, and on the rightmost grouping (orange), the drivers found in the literature surveyed without the 'supply-chain' filter. In the middle, all the drivers that are shared amongst these two groups.

5.1.3. Insights on investor impact on adoption of VSIs

Institutional investors are increasingly conscious of the environmental performance of mining companies leading to higher environmental performance expectations (Dyck et al., 2019), with some investors using screening techniques or impact investing to incentivize adherence to certifications and standards (Barber et al., 2021). It's important to call attention to the observation that while these actions can improve the returns of specific portfolios, their overall impact on the system may be limited. Moreover, institutional investors have recently started to pay attention to responsible tailings management (Innis and Kunz, 2020) that can be covered by standards such as the *Global Industry Standard on Tailings Management* (International Council on Mining and Metals, 2020), the *Tailings Management Protocol* encompassed by the *Towards Sustainable Mining* standard (Towards Sustainable Mining, 2022), and the *Community Health and Safety* section of the *Initiative for Responsible Mining Assurance* (IRMA, 2018). Similarly to environmentally-oriented investment funds, socially responsible investment (SRI) is also growing rapidly and has been associated with *social signalling* (Bialkowski and Starks, 2016), which may influence institutional investors' future investment decisions. The number of institutional investors publicly committed to non-governmental, market-oriented responsibility initiatives is significant, with more than 5319 signatories owning assets equivalent to U$121 trillion as of 2022 under the UN Principles for Responsible Investment (UN PRI, 2022), requiring disclosure of information on ESG integration and engagement efforts by signatories. Lastly, increased cooperation among non-governmental organizations (NGOs), governments, and companies has led to the adoption of standards as a comprehensive framework for communication in a shared language (Barry et al., 2012), with NGOs also acting as third-party certifiers and verifiers, which might provide NGOs with extended sources for funding.

5.2. Barriers

5.2.1. VSI legitimacy, greenwashing, and feasibility

Petavratzi and Gunn (2023) highlight a significant gap between the increased pace to develop new mining projects and the adoption of better ESG practices. Downstream entities in the EV sector, encompassing design, development, component manufacturing, and production, typically operate with a lead time not exceeding 10 years for new projects. In contrast, upstream participants, responsible for extraction and processing, can face a lead time surpassing 20 years, however this is dependent on the economics of a project, with some operations having a quick turn-around when there are clear and stable price signals. The implementation of VSIs during the feasibility stage can extend the exploration phase, consequently delaying the inauguration of new mining operations. Also, it's been noted that is in the investors' interest to minimize the mine construction time to ensure not only rapid payback of the investment made, but also to minimize the risk of the conclusions of previous studies becoming outdated and thus invalid. It remains

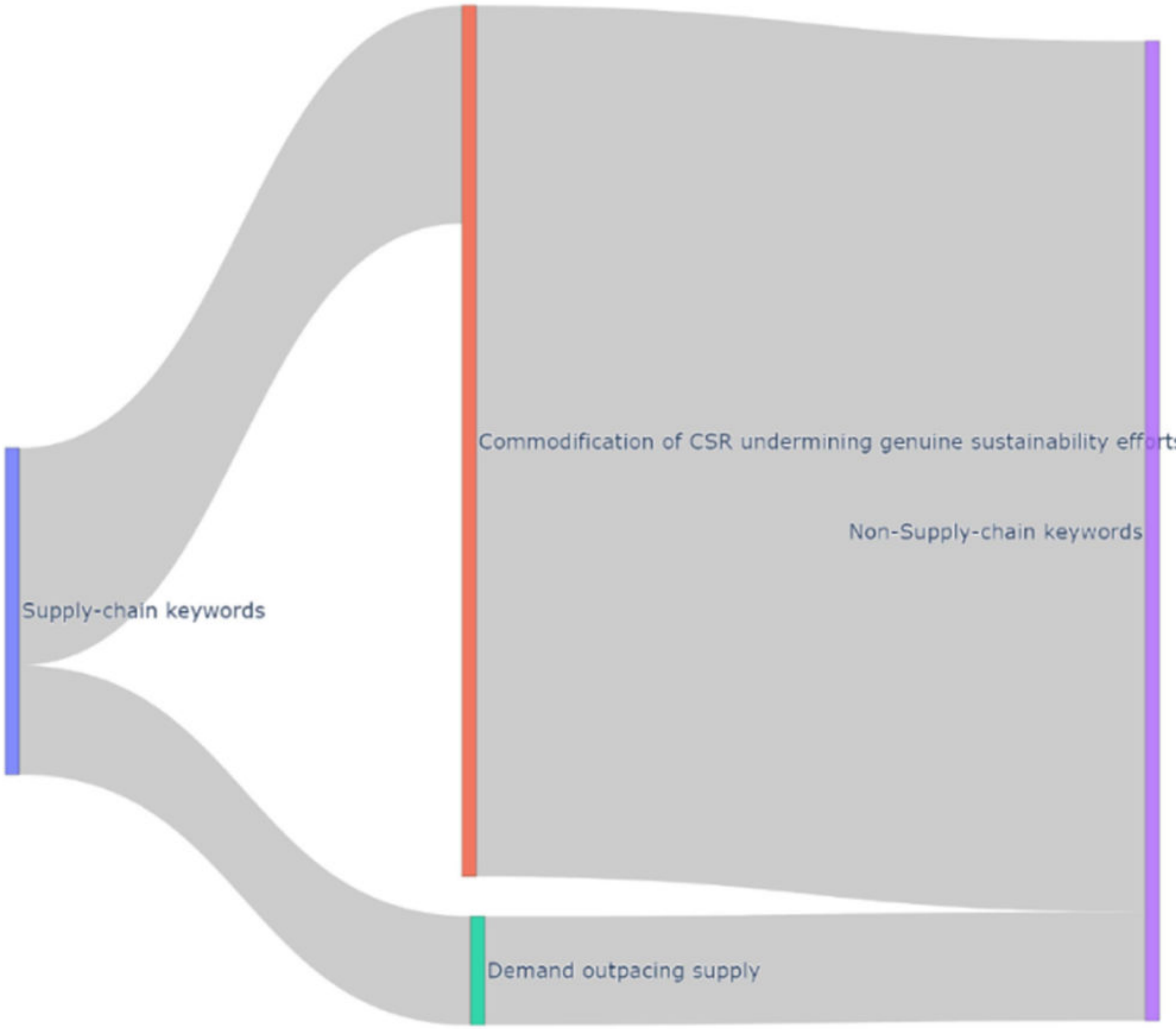

Fig. 4.4. Sankey diagram of barriers that were commonly found both in literature queried with supply-chain keywords and literature queried without such keywords. The leftmost grouping (blue) combines the barriers found in the literature surveyed under the 'supply-chain' filter, and on the rightmost grouping (purple), the barriers found in the literature surveyed without the 'supply-chain' filter. In the middle, all the barriers that are shared amongst these two groups.

uncertain whether improved CSR practices during feasibility analysis and community engagement can offset delays caused by community opposition and the time needed to implement VSIs.

Moreover, CSR practices have been criticized as ways to circumnavigate popular discontent. With an example of corporate dissonance is the Weda Bay Nickel (WBN) Mine Project on Halmahera Island, Indonesia. Palpacuer and Roussey (2023) described the repression and defeat of several countermovements, also corroborated by the Environmental Justice Atlas (EJ atlas, 2023), whilst Eramet describes it as a *'success story'* (Eramet, 2023). Hudayana et al. (2020) concludes that communal conflicts can be resolved through cooperation between companies and communities through an established mechanism for compensation. Such financial compensation might be sufficient to eliminate public opposition, but no studies have shown direct correlation with long-lasting sustainability goals.

Hence, we argue that the *social-licence-to-mitigate-risk* narrative merits criticism. While quantifying risks as an externality is a foundational part of business, and authors have made significant progress in developing this discussion (Franks et al., 2014), significant concerns remain on the short term approach to risk mitigation in the form of greenwashing, and how this de-legitimizes sincere efforts. Predominantly, there's is the tendency from businesses to perceive local communities simply as barriers to overcome, rather than recognizing them as stakeholders with legitimate concerns and local knowledge. There's also an apprehension that companies might exploit VSIs to pre-emptively suppress emerging local movements that could surface a range of environmental and social issues (Lassila, 2016; Malone et al., 2023; Palpacuer and Roussey, 2023). This has led to open-ended questions around the long-lasting effects of voluntary sustainability practices when involving local communities during a new project development. Third-party observance of local conflicts, such as the ones done across the globe by EJ atlas (2023), in Indonesia by Jatam (2023), and in South America by *Olca, Conflictos Mineros,* and OPSAL (Conflictos Mineros, 2023; Olca, 2023; OPSAL, 2023) are crucial to decentralized research, and should often be incorporated into the risk analysis, and the transparency of local opposition should not be obfuscated.

It's also worth mentioning that the cost of implementing VSIs and adhering to certified standards can make products uncompetitive in price-sensitive markets, deterring decision-makers from adopting and maintaining VSIs due to the lack of financial incentives (Barry et al., 2012; Ndhlukula and du Plessis, 2007). This challenge is particularly acute for junior mining companies, where the relative costs of

Table 4.1
Drivers influencing the voluntary adoption of ESG, CSR, and environmental stewardship practices in lithium, nickel, manganese, or cobalt mining operations. These have been compiled as representative of the overlap between drivers extracted from the literature queried with supply-chain keywords and without such keywords. N = Count of total of sources that included the driver.

Driver	Description	Specific Mentions	Selected references	*N*
Increased need for frameworks on company-community communication	Lithium, nickel, and cobalt projects are often located in high-ESG risk areas. These regions face significant challenges due to inadequate social participation and heightened geopolitical risks (Jowitt et al., 2020). Social conflicts have been reported in various locations, such as lithium mining in the Lithium Triangle (Liu and Agusdinata, 2020), nickel mining in Indonesia (Hudayana et al., 2020) and New Caledonia (Lassila, 2016), and cobalt mining in both the United States (Malone et al., 2023) and the Democratic Republic of the Congo (DRC) (Savinova et al., 2023). These conflicts are frequently attributed to insufficient engagement with local communities and stakeholders.	• Lithium • Nickel • Cobalt	(Agusdinata et al., 2022; Malone et al., 2023; Petavratzi and Gunn, 2023; Ralph and Hancock, 2018; Savinova et al., 2023; Zainuddin Rela et al., 2020)	21
Supply chain disruption risk management	In the context of battery minerals, being part of multi-tiered supply-chains, risk of disruption is prominent. Sustainability standards and certifications might act to reduce uncertainty and legitimize claims by mining companies to battery and EV manufacturers.	• Lithium • Nickel • Cobalt • Manganese	(Agusdinata et al., 2022; Deberdt and Le Billon, 2022; Malone et al., 2023; Mugurusi and Ahishakiye, 2022; Murdock et al., 2021; Petavratzi and Gunn, 2023; Savinova et al., 2023; Vivoda and Matthews, 2023)	13
Improved guidelines on life cycle assessment	With lifecycle assessment being chose as the methodology for the EU Battery Regulation (European Union (EU), 2023), data-intensive impact assessment will have to be put in place in mining operations.	• Lithium • Nickel • Cobalt	(Agusdinata et al., 2022; Mugurusi and Ahishakiye, 2022; Petavratzi and Gunn, 2023)	10
Increased legitimacy of non-state market-driven initiatives specific to battery components	Given the prominent role of transnational corporations in mineral extraction, the potential and limitations of state governance become apparent, especially due to the geographical concentration of battery minerals in the Global South. Initiatives like the Cobalt Working Group by the Responsible Minerals Initiative, and the Global Battery Alliance demonstrate the need for raising the profile on mining challenges.	• Lithium • Nickel • Cobalt • Manganese	(Agusdinata et al., 2022; Deberdt and Le Billon, 2022; Lèbre et al., 2020; Petavratzi and Gunn, 2023)	9
Downstream pressure to mitigate reputational risk	Downstream companies that are concerned with reputational damage by association might drive VSI adoption. Battery and EV manufacturers are increasing their due-diligence process and supply-chain transparency to avoid reputational risk associated with low environmental-performers. (Barry et al., 2012; CATL, 2021; Newbold, 2006; Potts et al., 2018)	• Cobalt	(Deberdt and Billon, 2021)	7
Geographical concentration of battery minerals	The geographical concentration of battery minerals, with raw material supply centred in the Global South, and manufacturing and EV demand in the Global North, raises sustainability and supply chain stability concerns.	• Lithium • Nickel • Cobalt • Manganese	(Agusdinata et al., 2022; Deberdt and Le Billon, 2022; Murdock et al., 2021; Vivoda and Matthews, 2023)	7
Investment attraction	Mining activities are increasingly seen as high risk by insurers, therefore VSIs taking the form of certifications may give rise to benefits such as lower insurance premiums. Moreover, many institutional investors consider ESG investments to provide risk insurance and market differentiation. Moreover, Institutional investors that take into consideration environmental and social (E&S) risk measures provided by third parties are already pushing companies towards an improvement on E&S metrics. Through exclusion, selection, and shareholder proposals, this might drive certification adoption and standards compliance.	• Lithium • Nickel • Cobalt • Manganese	(Petavratzi and Gunn, 2023; Savinova et al., 2023)	7
Consumer awareness and mobilization	There is some evidence that consumers of low-carbon technologies are increasingly aware that such technologies use a multitude of minerals that could cause environmental degradation and regions of mineral extraction (International Resource Panel, 2020).	• Lithium • Nickel • Cobalt	(Agusdinata et al., 2022; Deberdt and Le Billon, 2022; Ralph and Hancock, 2018)	4
Increased need to manage biodiversity impacts	The expansion of mining activities necessitates comprehensive mining plans that assess and mitigate impacts on nearby ecosystems, including long-term effects and rehabilitation strategies. Due to the proximity of mining operations to critical biodiversity preservation areas, there is an increasing need to address potential ecological disruptions.	• Lithium • Nickel • Cobalt • Manganese	(Lèbre et al., 2020; Murdock et al., 2021)	2
State-to-state commercial agreements	The potential for state-to-state commercial arrangements to replace open-markets in the case of military and energy applications might lead to requirements related to due-diligence backed by standards compliance and certifications.	• Lithium • Nickel • Cobalt • Manganese	(Petavratzi and Gunn, 2023; Vivoda and Matthews, 2023)	2

Table 4.2
Barriers influencing the voluntary adoption of ESG, CSR, and environmental stewardship practices in lithium, nickel, manganese, or cobalt mining operations. These have been compiled as representative of the overlap between barriers extracted from the literature queried with supply-chain keywords and without such keywords. N = Count of total of sources that included the barrier.

Barrier	Description	Specific mentions	References	*N*
Short-term greenwashing undermining VSI legitimacy	Short-term greenwashing can manifest when firms adopt CSR policies primarily to meet stakeholder expectations, secure investment, or maintain their social license to operate, rather than to address significant social or environmental issues (Palpacuer and Roussey, 2023). For example, CSR practices in nickel mining in Indonesia and cobalt mining in the DRC often fail to address deep-rooted issues like land ownership.	• Nickel • Cobalt	(Deberdt, 2022; Deberdt and Le Billon, 2022; Malone et al., 2023; Palpacuer and Roussey, 2023; Zainuddin Rela et al., 2020)	15
Demand outpacing supply	In an economy where demand for a product or service outpaces supply, known as a sellers' market, companies may prioritize maximizing output over adopting voluntary sustainability initiatives. The urgency to supply high-demand critical minerals can limit the willingness of companies to engage in sustainability efforts.	• Lithium • Nickel • Cobalt	(Agusdinata et al., 2023; Vivoda and Matthews, 2023)	2

Table 4.3
Drivers influencing the adoption of ESG, CSR, and environmental stewardship at overall mining operations that can influence mining for battery minerals. These contain the drivers most frequently mentioned ($N \geq 4$) and not included in Table 4.1. N = Count of total of sources that included the driver.

Driver	Description	Selected references	*N*
Operating in complex water management contexts	The imperative to manage water resources effectively is driven by the significant environmental and socio-economic impacts observed in mining regions. In areas like Bahodopi in Indonesia (Hudayana et al., 2020) and the Salar de Atacama (Heredia et al., 2020), mining activities have led to water contamination and scarcity, respectively. The majority of lithium resources and future projects are located in areas facing medium to very high water risks (Lèbre et al., 2020), emphasizing the urgency of adopting sustainable water management strategies.	(Heredia et al., 2020; Hudayana et al., 2020; Lèbre et al., 2020)	6
Onshoring of mineral extraction - Closer to consumption markets	The strategic shift to localize mineral extraction near consumption markets, notably in the U.S. through the Mineral Security Partnership (MSP), is acting to secure a steady source of critical minerals. This trend is driven by the desire to reduce dependency on foreign sources. With stricter regulatory environments and higher societal expectations, companies might be motivated to adhere to VSIs to maintain their social license to operate.	(Agusdinata et al., 2022; Malone et al., 2023; Petavratzi and Gunn, 2023; Vivoda and Matthews, 2023)	5
Public campaigns by civil society and NGO calling attention to negative sustainable practices	Publications such as the one by Amnesty International (2017) can highlight significant sustainability gaps in the mining of battery minerals, leading to increased scrutiny.	(Deberdt and Billon, 2021; Deberdt and Le Billon, 2022)	4

certification are higher, and compliance demands extensive personnel and technical training (Deberdt and Billon, 2021), potentially excluding them from markets with strict import requirements (Tröster and Hiete, 2018). Therefore, the narrative in relation to cost-effectiveness of VSIs remains to be seen. Studies have linked increased adoption of social and environmental standards to improved water and/or energy usage (Dummett, 2006), minimization of operational disruptions (Franks et al., 2014), and improved employee retention (Lodhia and Hess, 2014). However, these might be counterbalanced by costs incurred from more thorough life cycle assessments (Agusdinata et al., 2022), detailed feasibility studies (Petavratzi and Gunn, 2023), and technological implementation (e.g. uptake of renewable energy) (Jowitt et al., 2020).

Ways in which these financial challenges have been overcome have been documented in Chile, which the government provided a support programme called Associated Development Programmes (PROPO) that partially funded the costs for VSI adoption. In 2002, Minera Escondida took a more active role in the project, with the provision of extra expenses not initially included, which lead to a to successful ISO 14001 certification for participating small and medium enterprises (Ghorbani and Kuan, 2017; Newbold, 2006). Moreover, authors have discussed that VSI interoperability has the potential to reduce costs and can amplify the outcomes achieved by individual certifications (Barry et al., 2012; Mori Junior et al., 2016; Potts et al., 2018), with notable work being done in evaluating and mapping VSIs commonalities (Langdon et al., 2021). This evolving landscape highlights the necessity for participatory research in integrating VSIs into business models, weighing their potential financial benefits against the accompanying costs, and exploring innovative strategies to mitigate financial challenges.

5.2.2. *Tracing provenance at key points*

Tracing the provenance of materials within the lithium-ion battery supply chain is a technically challenging task due to the presence of multiple, overlapping supply chains and several chemical and physical transformations, as made clear by the breadth of works that mention this barrier (*"Tracing provenance at key points"* on Table 4.4.). Downstream procurement sectors might face a lack of visibility into what has been certified and to what extent. Additionally, a persistent focus on immediate suppliers or *focal companies* exacerbates this challenge (Young et al., 2019), with the interface between manufactures and higher-tier suppliers being a common theme in the literature.

Typically, manufacturers engage primarily with their direct suppliers, concentrating on ensuring these suppliers adhere to environmental and social standards (Mugurusi and Ahishakiye, 2022). Adding to these challenges, smelters often serve as critical choke points within the supply chain (Deberdt and Le Billon, 2022; Vasilyev et al., 2022), potentially disrupting the continuity of the material's chain-of-custody, thereby diminishing the effectiveness of certifications initiated at the mining stage. Moreover, there's a significant concentration of refining operations, with China refining 73 % of cobalt, 59 % of lithium, and 68 % of nickel (Vivoda and Matthews, 2023). The European Union has implemented a regulatory approach that mandates due diligence for companies wishing to trade within its borders, specifically targeting sourcing from a list of responsible smelters and refiners (European Commission, 2021). The China Chamber of Commerce of Metals,

Table 4.4
Barriers hindering the adoption of ESG, CSR, and environmental stewardship at overall mining operations that can influence mining for battery minerals. These contain the barriers most frequently mentioned ($N \geq 2$) and not included in Table 4.2. N = Count of total of sources that included the barrier.

Barriers	Description	Selected references	*N*
Tracing provenance at key points	Smelters control information crucial to traceability which can undermine mine-site efforts when adopting VSIs, since both certified and non-certified commodities might be processed simultaneously, which due to the nature of the physical and chemical processes might make traceability more difficult.	(Förster and Mischo, 2022; Murdock et al., 2021; Petavratzi and Gunn, 2023)	4
VSIs interoperability and scope	There's an increasing number of VSIs in the market that might be suitable to the several industries operating in this supply-chain. It's unclear how much these VSIs overlap, to what extent they are interoperable and compatible. Moreover, it's still unclear to what extent this interoperability increases environmental and social impact mitigation.	(Franken et al., 2012; ; Potts et al., 2018; Rutovitz et al., 2020)	3
Limited regulatory capacity	Regulatory institutions face significant limitations in their personnel and technical capacity to promote the standard adoption and issue certifications. There's also a lack of governmental incentives and technical support during the implementation phase of standards.	(Franks et al., 2013)	2
Misalignment of regulatory initiatives	Local and international regulatory initiatives might be misaligned, leading to potential redundancy of efforts. Moreover, the majority of certification schemes analysed so far are not designed to interact with other governance systems. Furthermore, competing initiatives might deter the adoption of VSIs in face of other national policies.	(Franken et al., 2012;)	2

Minerals & Chemicals Importers and Exporters also published voluntary Gguidelines for Social Responsibility in Outbound Mining Investments (Ralph and Hancock, 2018), and the United States is invested with the Minerals Security Partnership, a multilateral collaboration aimed at securing critical minerals on the part of the United States (US Department of State, 2023). In addition, the introduction of the battery passport by the European Union requires that, by 2027, battery operators provide a full lifecycle record, including carbon footprints from raw material acquisition to pre-processing stages, reinforcing transparency and sustainability through market mechanisms (European Union (EU), 2023). The battery passport reflects growing expectations for supply chain transparency, and when combined with more robust lifecycle monitoring mechanisms, it may help address the challenges posed by smelters and refiners as bottlenecks in the chain of custody. Whether this increased traceability will enhance the credibility of non-state market-driven systems remains to be seen, as it pushes for stronger alignment between market incentives and sustainable sourcing.

Parallel to these regulatory approaches, blockchain technology has garnered attention in various studies as a promising solution (Deberdt and Le Billon, 2022; Mugurusi and Ahishakiye, 2022; van den Brink et al., 2019; Vasilyev et al., 2022). Its success in other industries and potential to preserve the integrity of ground-level information make it a noteworthy consideration (Deberdt and Billon, 2021). However, the effectiveness of blockchain as a decentralized ledger is contingent on the quality and availability of the data it records. Hence, its utility is maximized when implemented at the source, though it remains limited by the accuracy of the input data, a challenge that has been well-documented at the ground level (Deberdt and Le Billon, 2022), not to mention the challenges surrounding the discussion and definition regarding who has accessibility and visibility to the data, as it moves along the supply-chain.

6. Concluding remarks

As the widespread uptake of EVs continues, the demand for energy transition minerals – including lithium, nickel, manganese, and cobalt – is intensifying. These resources are mainly concentrated in resource-rich regions of the Global South, where mining operations have to grapple with significant ESG challenges (Lèbre et al., 2020). Simultaneously, nations from the Global North, which consume these resources in their final form, enforce stronger ESG requirements (e.g. battery passport). This situation foregrounds the complex dynamic of how OEM buyers navigate supply disruption risk and geography-specific ESG challenges while meeting trade requirements. This dynamic highlights the importance of sustainable and responsible mining practices, as governments and corporations seek to reconcile the demand with ethical and environmental imperatives, whilst securing mineral supply. VSIs emerge as potential instruments to bridge this gap, arguing they can promote more sustainable and responsible mining practices – currently concentrated in the Global South – to align with the ESG demands – currently driven by consumption of the Global North. However, the legitimacy of VSIs is often questioned due to instances of greenwashing.

This research contributes to the emerging body of literature on voluntary sustainability initiatives applicable to battery minerals by surfacing a range of drivers and barriers relevant to VSI adoption and market diffusion. By highlighting how specific factors prevalent in the Global South—such as regulatory environments, ESG risks, and market pressures—influence the adoption of VSIs, our findings lay the groundwork for a more comprehensive understanding of the system dynamics at play. This, in turn, enriches discussions on the critical linkage between resource production in the Global South and consumption in the Global North. The geographical concentration of battery raw materials, along with the risk of missing energy transition deadlines due to supply disruptions of battery raw materials, has raised interest in the legitimacy of voluntary initiatives adopted at mining operations. The legitimacy of these initiatives, however, remains a contested issue in the literature, as exemplified by the opposing drivers related to the legitimacy of non-state market driven systems sought by initiatives such as the Global Battery Alliance and the Nickel Mark, contrasted with short-term greenwashing in mining operations observed in Indonesia, Australia, New Caledonia, and United States.

The potential drivers to voluntary sustainability initiatives are varied and multifaceted, but many include the adoption of some level of CSR to mitigate risks associated with their extraction process, mainly driven from a corporate risk-mitigation perspective. It's important to surface that voluntary practices to achieve and maintain social license to operate are promoted by global and national industry peak bodies and business advisers (Mayes, 2015). Furthermore, sustainability standards and certifications in mining operations are increasingly relevant due to downstream reputational pressure from EV and battery manufacturers, serving to reduce uncertainty and substantiate sustainability claims. Few studies have comprehensively assessed the balance between the costs of certification and the potential reduction in direct and indirect costs. Moreover, no comprehensive study has focused on premiums related to VSI adoption, indicating a potential future research avenue. Lastly, the complexity of tracing provenance in a supply chain characterized by physical and chemical transformations and international trade has been a recurring challenge. In this context, the potential application of blockchain technology as a solution to this challenge has been highlighted in several articles.

For future research, we suggest focusing on (*i*) an expansion of this analysis to include industry and non-technical reporting; and (*ii*) conducting stakeholder interviews to verify or challenge the results informed by contemporary industry practices. Our study focuses primarily on the factors that promote the adoption of these practices, however, the enduring effectiveness of adopting VSIs requires more in-depth investigation, particularly in the context of their long-term impacts on the mining governance landscape, local populations' quality of life, and developmental trajectories in the Global South.

CRediT authorship contribution statement

Bernardo Mendonca Severiano: Writing – original draft, Visualization, Data curation. **Stephen A. Northey:** Writing – review & editing, Supervision. **Damien Giurco:** Writing – review & editing, Supervision.

Declaration of competing interest

No conflict of interest.

Acknowledgments

This article was prepared as part of the Australian Future Battery Industries Cooperative Research Centre (FBI CRC) project 'Battery Materials for a Circular Economy: Advancing Certification and Improving Life-Cycle Impacts for Market Advantage'. The authors gratefully acknowledge the support of the FBI CRC and participant organisations.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.exis.2024.101552.

References

Agusdinata, D.B., Eakin, H., Liu, W., 2022. Critical minerals for electric vehicles: a telecoupling review. Environ. Res. Lett. 17 (1), 013005. https://doi.org/10.1088/1748-9326/ac4763.

Agusdinata, D.B., Liu, W., Sulistyo, S., LeBillon, P., Wegner, J.a., 2023. Evaluating sustainability impacts of critical mineral extractions: integration of life cycle sustainability assessment and SDGs frameworks. J. Ind. Ecol. 27 (3), 746–759. https://doi.org/10.1111/jiec.13317.

Amnesty International. (2017). *Democratic Republic of the Congo: time to recharge: corporate action and inaction to tackle abuses in the cobalt supply chain*. https://www.amnesty.org/en/documents/afr62/7395/2017/en/.

E.J. atlas. (2023). Retrieved 29/11/2023 from https://ejatlas.org/.

Barber, B.M., Morse, A., Yasuda, A., 2021. Impact investing. J. Financ. Econ. 139 (1), 162–185. https://doi.org/10.1016/j.jfineco.2020.07.008.

Barry, W., Cashore, B., Clay, J., Fernandez, M., Lebel, L., Lyon, T., Mallet, P., Matus, K., Melchett, P., Vandenbergh, M., Kees Vis, J., & Whelan, T. (2012). *Toward sustainability: the roles and limitations of certification*. https://www.resolve.ngo/docs/toward-sustainability-report-summary-and-appendicesv2.pdf.

Berger, K., Baumgartner, R.J., Weinzerl, M., Bachler, J., Preston, K., Schöggl, J.-P., 2023. Data requirements and availabilities for a digital battery passport – a value chain actor perspective. Cleaner Production Lett. 4, 100032. https://doi.org/10.1016/j.clpl.2023.100032.

Bernstein, S., 2004. Legitimacy in global environmental governance environment. J. Int. Law and Int. Relations 1 (1–2), 139–166. https://heinonline.org/HOL/P?h=hein.journals/jilwirl1&i=141.

Bernstein, S., Cashore, B., 2007. Can non-state global governance be legitimate? An analytical framework. Regul. Gov. 1 (4), 347–371. https://doi.org/10.1111/j.1748-5991.2007.00021.x.

Bialkowski, J., & Starks, L.T. (2016). SRI Funds: Investor Demand, Exogenous Shocks and ESG Profiles. University of Canterbury. Department of Economics and Finance. http://hdl.handle.net/10092/12492.

Blackman, A., 2008. Can voluntary environmental regulation work in developing countries? Lessons from Case Studies Policy Stud. J. 36 (1), 119–141. https://doi.org/10.1111/j.1541-0072.2007.00256.x.

Bomsel, O., Börkey, P., Glachant, M., Lévêque, F., 1996. Is there room for environmental self-regulation in the mining sector? Resour. Policy. 22 (1), 79–86. https://doi.org/10.1016/S0301-4207(96)00030-X.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3 (2), 77–101. https://doi.org/10.1191/1478088706qp063oa.

Cashore, B., 2002. Legitimacy and the privatization of environmental governance: how non-state market-driven (NSMD) governance systems gain rule-making authority. Governance 15 (4), 503–529. https://doi.org/10.1111/1468-0491.00199.

CATL. (2021). *2021 Environmental, social and governance (ESG) report*. https://www.catl.com/en/uploads/1/file/public/202204/20220428220129_xn1h4ae31b.pdf.

Chun Tie, Y., Birks, M., Francis, K., 2019. Grounded theory research: a design framework for novice researchers. SAGe Open. Med. 7. https://doi.org/10.1177/2050312118822927, 2050312118822927.

Conflictos Mineros. (2023). Retrieved 29/11/2023 from https://mapa.conflictosmineros.net/ocmal_db-v2/.

Dashwood, H.S., 2012. The Rise of Global Corporate Social Responsibility : Mining and the Spread of Global Norms. Cambridge University Press. http://ebookcentral.proquest.com/lib/uts/detail.action?docID=989175.

Deberdt, R., 2022. Land access rights in minerals' responsible sourcing. The case of cobalt in the Democratic Republic of the Congo. Resour. Policy. 75, 102534. https://doi.org/10.1016/j.resourpol.2021.102534.

Deberdt, R., Billon, P.L., 2021. Conflict minerals and battery materials supply chains: a mapping review of responsible sourcing initiatives. Extr. Ind. Soc. 8 (4), 100935. https://doi.org/10.1016/j.exis.2021.100935.

Deberdt, R., Le Billon, P., 2022. The green transition in context—cobalt responsible sourcing for battery manufacturing. Soc. Nat. Resour. 35 (7), 784–803. https://doi.org/10.1080/08941920.2022.2049410.

Dominish, E., Teske, S., & Florin, N. (2019). *Responsible minerals sourcing for renewable energy*. https://www.uts.edu.au/sites/default/files/2019-04/ISFEarthworks_Responsible%20minerals%20sourcing%20for%20renewable%20energy_Report.pdf.

Dummett, K., 2006. Drivers for corporate environmental responsibility (CER). Environ. Dev. Sustain. 8 (3), 375–389. https://doi.org/10.1007/s10668-005-7900-3.

Dyck, A., Lins, K.V., Roth, L., Wagner, H.F., 2019. Do institutional investors drive corporate social responsibility? International evidence. J. Financ. Econ. 131 (3), 693–714. https://doi.org/10.1016/j.jfineco.2018.08.013.

Eramet. (2023). *The success story of Weda Bay Nickel*. Retrieved 29/11/2023 from https://www.eramet.com/en/group/the-success-story-of-weda-bay-nickel/.

Erdmann, M., & Franken, G. (2022). *Sustainability standard systems for mineral resources a comparative overview* (2022). https://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Downloads/studie_sustainability_standard_systems_2022.pdf?_blob=publicationFile&v=7.

European Commission. (2021). *Conflict minerals regulation: the regulation explained*. Retrieved 29/11/2023 from https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation/regulation-explained_en.

European Union (EU), 2023. 2023/1542 Of The European Parliament and of the council of 12 july 2023 concerning batteries and waste batteries, amending directive 2008/98/EC and regulation (EU) 2019/1020 and repealing directive 2006/66/EC. Off. J. Eur. Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542#:~:text=This%20Regulation%20imposes%20battery%20due,into%20which%20batteries%20are%20incorporated.

Förster, L., Mischo, H., 2022. Excursus into the certification of mineral raw materials – development and implementation of a sustainability standard. Int. J. Min. Reclam. Environ. 36 (9), 642–650. https://doi.org/10.1080/17480930.2022.2133428.

Franken, G., Schütte, P., 2022. Current trends in addressing environmental and social risks in mining and mineral supply chains by regulatory and voluntary approaches. Miner. Econ. 35 (3), 653–671. https://doi.org/10.1007/s13563-022-00309-3.

Franken, G., TOtherey, L., & Kickler, K. (2020). Chapter 11 - voluntary sustainability initiatives: an approach to make mining more responsible? In A. Bleicher & A. Pehlken (Eds.), *The Material Basis of Energy Transitions* (pp. 169–186). Academic Press. https://doi.org/10.1016/B978-0-12-819534-5.00011-8.

Franken, G., Vasters, J., Dorner, U., Melcher, F., Sitnikova, M., Goldmann, S., 2012. Certified trading chains in mineral production: a way to improve responsibility in mining. In: Sinding-Larsen, R., Wellmer, F.W. (Eds.), Non-Renewable Resource Issues: Geoscientific and Societal Challenges. Springer, Netherlands, pp. 213–227. https://doi.org/10.1007/978-90-481-8679-2_11.

Franks, D.M., Brereton, D., Moran, C.J., 2013. The cumulative dimensions of impact in resource regions. Resour. Policy. 38 (4), 640–647. https://doi.org/10.1016/j.resourpol.2013.07.002.

Franks, D.M., Davis, R., Bebbington, A.J., Ali, S.H., Kemp, D., Scurrah, M., 2014. Conflict translates environmental and social risk into business costs. Proc. Natl. Acad. Sci. - PNAS 111 (21), 7576–7581. https://doi.org/10.1073/pnas.1405135111 (From the Cover).

Ghorbani, Y., Kuan, S.H., 2017. A review of sustainable development in the Chilean mining sector: past, present and future. Int. J. Min. Reclam. Environ. 31 (2), 137–165. https://doi.org/10.1080/17480930.2015.1128799.

Global Battery Alliance. (2024). *GBA battery passport*. Retrieved 11/05/2024 from https://www.globalbattery.org/battery-passport/.

GRI. (2023). *GRI standards*. Retrieved 15/11 from https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language/#:~:text=The%20GRI%20Standards%20represent%20global,negative%20contributions%20to%20sustainable%20development.

Guest, G., MacQueen, K.M., Namey, E.E., 2012. Applied Thematic Analysis. SAGE Publications.

Habib, K., Hansdóttir, S.T., Habib, H., 2020. Critical metals for electromobility: global demand scenarios for passenger vehicles, 2015–2050. Resour. Conserv. Recycl. 154, 104603. https://doi.org/10.1016/j.resconrec.2019.104603.

Helbig, C., Bradshaw, A.M., Wietschel, L., Thorenz, A., Tuma, A., 2018. Supply risks associated with lithium-ion battery materials. J. Clean. Prod. 172, 274–286. https://doi.org/10.1016/j.jclepro.2017.10.122.

Heredia, F., Martinez, A.L., Surraco Urtubey, V., 2020. The importance of lithium for achieving a low-carbon future: overview of the lithium extraction in the 'Lithium Triangle. J. Energy & Nat. Resources L. 38 (3), 213–236. https://doi.org/10.1080/02646811.2020.1784565.

Hudayana, B., Suharko, Widyanta, A.B, 2020. Communal violence as a strategy for negotiation: community responses to nickel mining industry in Central Sulawesi, Indonesia. Extr. Ind. Soc. 7 (4), 1547–1556. https://doi.org/10.1016/j.exis.2020.08.012.

ICMM. (2023). *ICMM's mining principles*. Retrieved 15/11 from https://www.icmm.com/en-gb/our-principles.

ICMM. (2024). *ICMM members*. Retrieved 21/02/2024 from https://www.icmm.com/en-gb/our-story/our-members.

IEA. (2020). *Global EV outlook 2020*. https://iea.blob.core.windows.net/assets/af46e012-18c2-44d6-becd-bad21fa844fd/Global_EV_Outlook_2020.pdf.

IFC. (2012). *IFC's performance standards on environmental and social sustainability*. Retrieved 15/11 from https://www.ifc.org/en/insights-reports/2012/ifc-performance-standards.

Innis, S., & Kunz, N.C. (2020). The role of institutional mining investors in driving responsible tailings management. Extr. Ind. Soc., 7(4), 1377–1384. https://doi.org/10.1016/j.exis.2020.10.014.

International Council on Mining & Metals. (2020). *Global industry standard on tailings management*. https://globaltailingsreview.org/wp-content/uploads/2020/08/global-industry-standard_EN.pdf.

International Lithium Association. (2024). *Guidance on determining the product carbon footprint of lithium products*. Retrieved 11/05/2024 from https://lithium.org/guidance/.

International Resource Panel. (2020). *Mineral resource governance in the 21st Century: gearing extractive industries towards sustainable development*. www.resourcepanel.org/reports/mineral-resource-governance-21st-century.

IRMA. (2018). *IRMA standard for responsible mining IRMA-STD-001* https://responsiblemining.net/wp-content/uploads/2018/07/IRMA_STANDARD_v.1.0_FINAL_2018-1.pdf.

Jatam. (2023). Retrieved 29/11/2023 from https://www.jatam.org/en/.

Jenkins, H., 2004. Corporate social responsibility and the mining industry: conflicts and constructs. Corp. Soc. Responsib. Environ. Manage. 11 (1), 23–34. https://doi.org/10.1002/csr.50.

Johnson, C.A., Khosravani, J., 2024. Greening the global battery chain? Critical reflections on the EU's 2023 battery regulations. Extr. Ind. Soc. 18, 101467. https://doi.org/10.1016/j.exis.2024.101467.

Jowitt, S.M., Mudd, G.M., Thompson, J.F.H., 2020. Future availability of non-renewable metal resources and the influence of environmental, social, and governance conflicts on metal production. Commun. Earth. Environ. 1 (1), 13. https://doi.org/10.1038/s43247-020-0011-0.

Kalaitzi, D., Matopoulos, A., Clegg, B., 2019. Managing resource dependencies in electric vehicle supply chains: a multi-tier case study. Supply Chain Manag.: Int. J. 24 (2), 256–270. https://doi.org/10.1108/scm-03-2018-0116.

Kemp, D., Owen, J.R., 2013. Community relations and mining: core to business but not "core business. Resour. Policy. 38 (4), 523–531. https://doi.org/10.1016/j.resourpol.2013.08.003.

Khakmardan, S., Rolinck, M., Cerdas, F., Herrmann, C., Giurco, D., Crawford, R., Li, W., 2023. Comparative life cycle assessment of lithium mining, extraction, and refining technologies: a global perspective. Procedia CIRP. 116, 606–611. https://doi.org/10.1016/j.procir.2023.02.102.

Khan, I., 2019. Drivers, enablers, and barriers to prosumerism in Bangladesh: a sustainable solution to energy poverty? Energy Res. Soc. Sci. 55, 82–92. https://doi.org/10.1016/j.erss.2019.04.019.

Kickler, K., & Franken, G. (2017). *Sustainability schemes for mineral resources: a comparative overview (*2017*)*. https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/Downloads/Sustainability_Schemes_for_Mineral_Resources.pdf?__blob=publicationFile&v=6.

Kojola, E., McMillan Lequieu, A., 2020. Performing transparency, embracing regulations: corporate framing to mitigate environmental conflicts. Environ. Sociol. 6 (4), 364–374. https://doi.org/10.1080/23251042.2020.1790717.

Kosai, S., Hanqing, L., Zhang, Z., Matsubae, K., Yamasue, E., 2022. Multi-regional land disturbances induced by mineral use in a product-based approach: a case study of gasoline, hybrid, battery electric and fuel cell vehicle production in Japan. Resour. Conserv. Recycl. 178, 106093. https://doi.org/10.1016/j.resconrec.2021.106093.

Langdon, R., Berry, F., Northey, S., Giurco, D., Li, W., Farjana, S., & Cox, D. (2021). *Certification and sustainability assessment for battery materials: review of requirements and data commonalities.*.

Lassila, M., 2016. Outcomes of state territoriality and mining development for the Kanak in New Caledonia. Contemp. Pac. 28 (2), 384–409. https://doi.org/10.1353/cp.2016.0035.

Lèbre, É., Stringer, M., Svobodova, K., Owen, J.R., Kemp, D., Côte, C., Arratia-Solar, A., Valenta, R.K., 2020. The social and environmental complexities of extracting energy transition metals. Nat. Commun. 11 (1), 4823. https://doi.org/10.1038/s41467-020-18661-9.

Liu, W., Agusdinata, D.B., 2020. Interdependencies of lithium mining and communities sustainability in Salar de Atacama, Chile. J. Clean. Prod. 260, 120838. https://doi.org/10.1016/j.jclepro.2020.120838.

Lodhia, S., Hess, N., 2014. Sustainability accounting and reporting in the mining industry: current literature and directions for future research. J. Clean. Prod. 84, 43–50. https://doi.org/10.1016/j.jclepro.2014.08.094.

Malone, A., Smith, N.M., Holley, E.A., Htun, T., 2023. Prospects for American cobalt: reactions to mine proposals in Minnesota and Idaho. Energy Res. Soc. Sci. 105, 103284. https://doi.org/10.1016/j.erss.2023.103284.

Mayes, R., 2015. A social licence to operate: corporate social responsibility, local communities and the constitution of global production networks. Global networks (Oxford) S109–S128. https://doi.org/10.1111/glob.12090. *15*(s1).

Mitropoulos, L.K., Prevedouros, P.D., Kopelias, P., 2017. Total cost of ownership and externalities of conventional, hybrid and electric vehicle. Transp. Res. Proc. 24, 267–274. https://doi.org/10.1016/j.trpro.2017.05.117.

Moffat, K., Zhang, A., 2014. The paths to social licence to operate: an integrative model explaining community acceptance of mining. Resour. Policy. 39, 61–70. https://doi.org/10.1016/j.resourpol.2013.11.003.

Mori Junior, R., Franks, D.M., Ali, S.H., 2016. Sustainability certification schemes: evaluating their effectiveness and adaptability. Corp. Gov. 16 (3), 579–592. https://doi.org/10.1108/CG-03-2016-0066.

Mugurusi, G., & Ahishakiye, E. (2022). Blockchain technology needs for sustainable mineral supply chains: a framework for responsible sourcing of Cobalt. https://doi.org/10.1016/j.procs.2022.01.262.

Murdock, B.E., Toghill, K.E., Tapia-Ruiz, N., 2021. A perspective on the sustainability of cathode materials used in lithium-ion batteries. Adv. Energy Mater. 11 (39), 2102028. https://doi.org/10.1002/aenm.202102028.

Ndhlukula, K., & du Plessis, P. (2007). *Green labelling, eco-certification and fair trade: threats and opportunities for Namibia*. iisd.org/system/files/publications/rtea_namibia_eco_labels.pdf.

Newbold, J., 2006. Chile's environmental momentum: ISO 14001 and the large-scale mining industry – case studies from the state and private sector. J. Clean. Prod. 14 (3), 248–261. https://doi.org/10.1016/j.jclepro.2004.05.010.

Nitta, N., Wu, F., Lee, J.T., Yushin, G., 2015. Li-ion battery materials: present and future. Mater. Today 18 (5), 252–264. https://doi.org/10.1016/j.mattod.2014.10.040.

Olca. (2023). Retrieved 29/11/2023 from https://olca.cl/oca/index.php.

OPSAL. (2023). *Observatorio Plurinacional de Salares Andinos,*. Retrieved 22/05/2024 from https://salares.org/nosotros/.

Palpacuer, F., Roussey, C., 2023. Entangling global chains of wealth and value through CSR-ization: a critical Polanyian perspective on Weda Bay Nickel. Environ. Plan. A. https://doi.org/10.1177/0308518×231191946.

Panasonic. (2021). *Responsible supply chain: overview of supply chain*. https://holdings.panasonic/global/corporate/sustainability/pdf/sdb2021e-supply_chain.pdf.

Peck, P., Sinding, K., 2003. Environmental and social disclosure and data richness in the mining industry. Bus. Strategy. Environ. 12 (3), 131–146. https://doi.org/10.1002/bse.358.

Petavratzi, E., & Gunn, G. (2023). Decarbonising the automotive sector: a primary raw material perspective on targets and timescales. Miner. Econ., 36(4), 545–561. https://doi.org/10.1007/s13563-022-00334-2.

Potoski, M., Prakash, A., 2005. Covenants with weak swords: ISO 14001 and facilities' environmental performance. J. Policy Anal. Manag. 24, 745–769.

Potts, J., Wenban-Smith, M., TOtherey, L., & Lynch, M. (2018). *Standards and the extractive economy*. https://www.iisd.org/system/files/publications/igf-ssi-review-extractive-economy.pdf.

Ralph, N., Hancock, L., 2018. Exploring the role of alternative energy corporations in ethical supply chains and corporate peacebuilding. Global Governance 24 (1), 81–102. https://doi.org/10.1163/19426720-02401006.

Responsible Minerals Initiative. (2024). *Conformant Cobalt Refiners*. Retrieved 09/09/2024 from https://www.responsiblemineralsinitiative.org/minerals-due-diligence/cobalt/.

Rio Tinto. (2022). *Rio Tinto updates ore reserves and mineral resources at Jadar* https://www.riotinto.com/-/media/Content/Documents/Invest/Reserves-and-resources/2021/RT-Jadar-reserves-resources-2021.pdf?rev=e1220b9671424ad9b275dd6bdd2ed480.

Riofrancos, T., 2023. The security–sustainability nexus: lithium onshoring in the global north. Glob. Environ. Polit. 23 (1), 20–41. https://doi.org/10.1162/glep_a_00668.

RRRM. (2023). Roundtable on the responsible recycling of metals. https://www.rrmroundtable.org/.

Rutovitz, J., Dominish, E., Northey, S., Giurco, D., Li, W., & Farjana, S. (2020). *Certification and LCA of Australian battery materials – drivers and options* https://fbicrc.com.au/wp-content/uploads/2020/10/Certification-of-Au-Battery-Materials-WEB-INTERACTIVE-SEPT-2020.pdf.

Sarmila, M., Zaimah, R., Lyndon, N., Hussain, M.Y., Awang, A.H., 2015. Local community economic wellbeing through CSR project. Mediterr. J. Soc. Sci. 6 (4), 79.

Sauer, P.C., 2021. The complementing role of sustainability standards in managing international and multi-tiered mineral supply chains. Resour. Conserv. Recycl. 174, 105747. https://doi.org/10.1016/j.resconrec.2021.105747.

Savinova, E., Evans, C., Lèbre, É., Stringer, M., Azadi, M., Valenta, R.K., 2023. Will global cobalt supply meet demand? The geological, mineral processing, production and geographic risk profile of cobalt. Resour. Conserv. Recycl. 190, 106855. https://doi.org/10.1016/j.resconrec.2022.106855.

Schmidt, T., Buchert, M., Schebek, L., 2016. Investigation of the primary production routes of nickel and cobalt products used for Li-ion batteries. Resour. Conserv. Recycl. 112, 107–122. https://doi.org/10.1016/j.resconrec.2016.04.017.

Snow, J. (2018). *Manganese: is it the forgotten battery mineral?* https://www.moore-australia.com.au/MediaLibsAndFiles/media/australia.moorestephens.com/Images/Profile%20Photos%20(Contact%20boxes)%20110w%20x%20110h%20px/Western%20Australia/Manganese-Moore-Stephens-Report.pdf.

The Nickel Institute, 2024. The Nickel Mark. Retrieved 11/05/2024 from. https://nickelinstitute.org/en/policy/nickel-life-cycle-management/responsible-sourcing-and-esg-due-diligence/.

Towards Sustainable Mining. (2022). *Tailings Management Protocol*. https://mining.ca/wp-content/uploads/dlm_uploads/2022/08/TSM-Tailings-Management-Protocol-June-2022.pdf.

Tröster, R., Hiete, M., 2018. Success of voluntary sustainability certification schemes – a comprehensive review. J. Clean. Prod. 196, 1034–1043. https://doi.org/10.1016/j.jclepro.2018.05.240.

U.N. departament of economic and social affairs. (1999). *CSD-6 Follow-up: multi-stakeholder review of voluntary initiatives and agreements for industry*. https://www.un.org/esa/dsd/dsd_aofw_mg/mg_csd6_via_meet.shtml.

UN PRI. (2022). *Signatory update october to december 2022*. https://www.unpri.org/download?ac=18057.

US Department of State, 2023. Minerals Security Partnership. Retrieved 29/11/2023 from. https://www.state.gov/minerals-security-partnership/.

van den Brink, S., Kleijn, R., Sprecher, B., Tukker, A., 2020. Identifying supply risks by mapping the cobalt supply chain. Resour. Conserv. Recycl. 156, 104743. https://doi.org/10.1016/j.resconrec.2020.104743.

van den Brink, S., Kleijn, R., Tukker, A., Huisman, J., 2019. Approaches to responsible sourcing in mineral supply chains. Resour. Conserv. Recycl. 145, 389–398. https://doi.org/10.1016/j.resconrec.2019.02.040.

Vasilyev, P., Rankenburg, K., McInnes, B., Evans, N., Barker, K., Lange, R., Marrable, D., & Oskierski, H.C. (2022). *Development of a trusted supply chain for Australian battery minerals and products*. https://fbicrc.com.au/wp-content/uploads/2022/10/WEB_FBICRC-Provenance-Scene-Setting-Report-single-pages-VFINAL-25-October.pdf.

Vivoda, V., & Matthews, R. (2023). "Friend-shoring" as a panacea to Western critical mineral supply chain vulnerabilities. *Miner. Econ. : Raw Materials Rep.*. https://doi.org/10.1007/s13563-023-00402-1.

Wills, R., Buckley, H., & Prentice, N. (2018). *Future smart strategies*. https://www.dropbox.com/s/6tygmylf8i3xezf/FSS%20AMEC%20VALUE%20CHAIN%20ANALYSIS%20REPORT.pdf?dl=0.

Wired. (2022). *Europe's biggest lithium mine is caught in a political Maelstrom*. https://www.wired.com/story/serbia-europe-lithium-mining-electric-cars.

Wohlin, C., Kalinowski, M., Romero Felizardo, K., Mendes, E., 2022. Successful combination of database search and snowballing for identification of primary studies in systematic literature studies. Inf. Softw. Technol. 147, 106908. https://doi.org/10.1016/j.infsof.2022.106908.

Young, S.B., Fernandes, S., Wood, M.O., 2019. Jumping the chain: how downstream manufacturers engage with deep suppliers of conflict minerals. Resources 8 (1), 26. https://www.mdpi.com/2079-9276/8/1/26.

Zainuddin Rela, I., Awang, A.H., Ramli, Z., Taufik, Y., Md Sum, S., Muhammad, M., 2020. Effect of corporate social responsibility on community resilience: empirical evidence in the nickel mining industry in southeast Sulawesi, Indonesia. Sustainability (Basel, Switzerland) 12 (4), 1395. https://doi.org/10.3390/su12041395.