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Perspective

The electric vehicle transition: A blessing or a curse for improving extractive industries and mineral supply chains?

Festival Godwin Boateng [a,b,*], Jacqueline M. Klopp [b]

[a] Transport Studies Unit, School of Geography and the Environment (SOGE), University of Oxford, UK
[b] Center for Sustainable Urban Development (CSUD), Columbia Climate School/Earth Institute, Columbia University, United States of America

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ABSTRACT

Concern is growing that new mineral demand pressures associated with transport electrification will exacerbate existing supply chain sustainability and resiliency risks and escalate global environmental injustices. In response, private and public actors in the extractive sector have signaled that they are retooling mineral production, sourcing and stewardship governance systems, practices, and processes to meet the sustainability demands of the electric vehicle (EV) transition. Currently, however, the specific components of many of these initiatives remain less well known, with little scholarly review of their potential to address the longstanding systemic deficiencies in mineral supply chains. Instead, research and policy conversations are oriented largely towards what can be described as a *demand-reduction approach*, focused on minimizing the intensity of metal mining as a strategy for ensuring the sustainability imperatives of the transition. This Perspective argues that 1) the EV transition offers a critical impetus for tackling head-on longstanding systemic deficiencies in responsible global mineral production, sourcing, and stewardship 2) addressing the deficiencies will also better position *mineral demand-reduction* measures to yield their intended sustainability outcomes and 3) historically, new initiatives introduced to reform the extractive sector rarely address the root problems that first gave impetus to the initiatives. Accordingly, questions about retooling existing mineral procurement governance systems, practices and processes should be an integral part of EV transition research. It recommends moving research, policy, action, and investment towards prioritizing addressing persisting systemic deficiencies in global mineral supply chains as part of strategies for ensuring ethical transport decarbonization.

1. Introduction

Currently, the world's transportation systems rely on burning fossil fuels, contributing to alarming amounts of air pollution and greenhouse gas emissions [1]. Policy and industry leaders have made shifting to electric vehicles (EVs) a high-level strategy for decarbonizing the transport sector. A crucial aspect of transport electrification, however, is the new demand for minerals. Without urgent corrective measures, the new mineral demand pressures associated with transport electrification will exacerbate existing supply chain sustainability and resiliency risks and escalate global environmental injustices [2] which in turn could slow down urgently needed decarbonization efforts.

In response, private and public actors in the extractive sector have signaled that they are retooling mineral production, sourcing and stewardship governance systems, practices, and processes to meet the sustainability demands of a global EV future [3]. Currently, however, the specific components of many of these initiatives remain less well known, with little scholarly review of their potential to address the longstanding systemic deficiencies in mineral supply chains. Instead, research and policy conversations are oriented largely towards what can be described as a *demand-reduction approach*, focused on minimizing the intensity of metal mining as a strategy for ensuring the sustainability imperatives of the transition [4].

This Perspective argues that the EV transition offers a critical impetus for tackling head-on longstanding systemic deficiencies in responsible global mineral production, sourcing, and stewardship. Second, addressing the deficiencies will also better position *mineral demand-reduction* measures to yield their intended sustainability outcomes. Third, historically, new initiatives introduced to reform the extractive sector rarely address the root problems that first gave impetus to the initiatives. Accordingly, questions about retooling existing mineral procurement governance systems, practices and processes should be an

* Corresponding author at: Transport Studies Unit, School of Geography and the Environment (SOGE), University of Oxford, UK.
E-mail addresses: festival.boateng@ouce.ox.ac.uk (F.G. Boateng), jk2002@columbia.edu (J.M. Klopp).

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integral part of EV transition research and we recommend moving research, policy, action, and investment towards prioritizing addressing persisting systemic deficiencies in global mineral supply chains as part of strategies for ensuring ethical transport decarbonization.

The paper makes three intricately related contributions to the ongoing policy and research conversations on the mineral supply chain sustainability demands of a global EV future. First, it shows that, although profoundly important, a timely positive-sum EV transition will require more than reducing the mineral requirements, which is a key focus of most policy and research approaches to addressing the extraction-related harms of the transition. Second, it raises the need for careful sustained monitoring and scrutiny of the potential effectiveness of the new regulatory and other initiatives being introduced by states and multi-lateral organizations, firms and standard setting bodies to support ethical, equitable and sustainable acquisition of minerals to decarbonize the transport sector. This is necessary for reducing the risks of the initiatives replicating existing patterns of abuse, deepening the longstanding vulnerabilities and systemic deficiencies they are supposed to address as well as bogging down decarbonization efforts in legitimate environmental and human rights disputes [5].

Third, the paper offers directions for future EV transition and mineral supply chain sustainability research and policy, outlining some critical areas that can benefit from further learning and knowledge building as well as policy attention. Therefore, in terms of overall original contributions to the emerging energy social science research and policy on the mineral supply chain sustainability demands of the EV transition, this Perspective highlights the limitations of the dominant *mineral demand-reduction approach,* analyzes the potential patterns of change and continuity in the move towards addressing systemic deficiencies, and systematically develops future policy and research directions for overcoming problematic patterns.

Following a narrative review approach [see Sovacool et al., 6], we draw on and synthesize insights from a variety of perspectives and sources. Thus, in addition to the critical peer reviewed materials on global mineral supply chain governance, the paper relies on grey materials from some of the key public and private actors at the heart of the carbon neutral mobility transition including *governments* (e.g., the US, UK, Canadian, Chinese and South African governments); regional bodies (e.g., the European Union); the *media* (e.g., New York Times; Reuters) and *automobile companies* (e.g., General Motors, Honda, Tesla and Volkswagen). The paper also relies on materials from *transnational multi-stakeholder standard setting bodies* which often comprise representatives of governments, industries, and civil society groups. This includes the Initiative for Responsible Mining Assurance; the International Council on Minerals and Metals; the Aluminum Stewardship Initiative and the Global Battery Alliance. Key documents analyzed from these multiple public and private actors include their EV policies, laws and other initiatives to improve equity and other mineral extraction sustainability values. Together, these materials help situate the paper's argument within multiple stakeholder perspectives within ongoing global policy and research conversations on reducing the extraction-related harms of the EV transition.

After this overview, the rest of the paper is structured as follows: Section 2 considers the prioritization of EVs as a high-level strategy for decarbonizing the transport sector, and the related concern that the mineral demand pressures are likely to deepen longstanding sustainability and resiliency risks in the mineral supply chain. Section 3 details and critiques the mineral *demand-reduction approach* to addressing the mining related socio-environmental harms of decarbonizing the transport sector. The section argues that the approach does not go far enough to address the longstanding systemic deficiencies in the global mineral supply chain. Section 4 considers the growing momentum for restructuring extractive governance systems to support a more sustainable and just energy transition. The section argues that, while a refreshing development, the new initiatives meant to reform the global mineral supply chain risk replicating existing patterns of abuse, and deepening the vulnerabilities they are supposed to address. The paper concludes in Section 5 with recommendations for reducing these risks associated with both change and continuity.

2. Mineral demands of EV transition and mining's noxious reputation

EVs are increasingly being pushed as critical for mitigating the deepening climate crisis. The UK and Canada plan to end the sale of new gas-powered vehicles by 2030 and 2035, respectively. China has recently extended its EV purchase subsidy program to 2027, aiming for an EV market share of 40 % of all car sales by 2030 [7]. The European Union has a target of ending sales of new internal combustion engine vehicles by 2035. The United States' federal government plans to build a network of 500,000 chargers by 2030 to support EV uptake [8]. South Africa's *Electric Vehicle White Paper* aims to set a course to transition its auto industry from primarily producing internal combustion engine vehicles to a dual platform that includes EVs by 2035 [9].

The global auto industry is adjusting to meet the growing shifts towards EVs. For instance, Bentley has announced that all its cars will be plug-in hybrid electric vehicles (PHEVs) or all-electric by 2026 and that it will end tailpipe manufacturing by 2030. BMW says half of its global sales will be battery-electric vehicles (BEVs) by 2030. Other major automakers including Ford, General Motors, Honda, and Nissan have announced similar plans to discontinue producing internal combustion engine vehicles [10]. Interestingly, some automotive companies are also exploring mining contracts to ensure steady mineral supplies for their EV production [11].

Overall, EVs are receiving high level attention in both policy and industry circles as critical for transport decarbonization. However, the components necessary for scaled EV adoption–batteries, drivetrain, and vehicle components, as well as charging infrastructure–all have individual mineral requirements that must be met. EV batteries require lithium, nickel, cobalt, and iron. Electric vehicle motors need a significant amount of rare earth element for permanent magnets to transfer stored battery power into movement. Charging infrastructure needs extensive copper wiring to provide confidence to consumers in their ability to access charging points and travel safely [12].

Thus, increased deployment of EVs and related infrastructure to decarbonize the transport sector will cause a massive uptick in demand for metals, especially if efforts to reduce personal vehicle use via land-use and shared mobility changes are not intensified. A 2021 *White House Task Force* report estimated that the US will require 25 %, 49 %, and 22 % of the total nickel, lithium, and cobalt mined globally in 2019 to electrify just 20 % of the existing domestic light-duty vehicles stock. The report also projects that the federal government's goal of deploying 500,000 new charging stations by 2030 could immediately add 4,000,000 kgs of infrastructure-related copper demand to the market [13].

Globally, the International Energy Agency predicts that current EV deployment rates will create demand for 43, 41 and 28 times as much lithium, nickel, and copper, respectively, in 2040 compared to 2020 [14]. In the same report, overall global demand for EV-related minerals is projected to increase by 30 times the current rate by 2040. Other studies including De Blas et al. [15] and Benchmark Mineral Intelligence [16] also project a substantial need for more minerals to electrify the transport sector.

Increased demand for minerals means more mining. Benchmark Mineral Intelligence [16] estimates that meeting global EV demands by 2035 will require some 384 new mines for graphite, lithium, nickel, and cobalt. The challenge, however, is that the extractive industry has a notorious reputation for environmental destruction, corruption, human rights abuse, and violence [17,18]. Thus, globally, mining activities frequently produce large scale socio-environmental harms, with some of the implicated firms often holding *sustainability compliance accreditations* from the many transnational multi-stakeholder standard setting bodies

proliferating across the globe [19,20]. The troubling legacies of the mining sector have generated intense concerns that pressures of increased global minerals demand in response to transport electrification will exacerbate existing mineral supply chain sustainability and resiliency risks, deepen the biodiversity crisis and foster conflict and rights abuses, making for difficult trade-offs [2,4].

3. Doing the least harm while going EV: beyond the mineral demand-reduction approach

Reducing mineral demand is gaining traction as a potential pathway for lowering the extraction-related socio-environmental harms of electrifying the transport sector. The premise of this *demand-reduction approach* is that minimizing the quantity of minerals necessary for transport decarbonization will, in turn, reduce supply chain pressures and, therefore, the potential of environmental degradation, social injustices, and conflicts associated with mining [4].

Some of the key measures that frequently feature in the *demand-reduction approach* include reducing car dependency. Here, emphasis is placed on reforming current dominant approaches to societal organization that align spatial planning, land use systems and transport investments towards upgrading and expanding roads, parking and other infrastructures that prioritize, encourage, and legitimize private motorized travel [2]. Advocates argue that reprioritizing spatial planning, land-use, and transport investments to support public transportation, shared mobility, and active travel modes will reduce demand for personal vehicles generally, and private electric cars in particular [2]. This, in turn, will result in declines in the quantity of minerals required for deploying EVs and the related infrastructure to decarbonize the transport sector.

Another strategy that often features in the *demand-reduction approach* is decreasing the size of EV components (particularly batteries). The argument here is that bigger batteries require more minerals and, therefore, reducing the size of EV batteries will bring down the mineral requirements of the transition [4]. Also, in line with the emerging discourses on circular economy [21], there have been calls for investing in recycling and mineral component substitution to reduce the need to mine more metals [22].

Researchers have begun publishing models to show the scale of mineral demand reduction that strategies such as recycling, car dependency and battery size reductions could yield. For instance, scenario modeling by Riofrancos et al. [4] suggests that the US can lower its lithium demand in 2050 between 18 and 66 % by reducing car dependency, and lowering EV battery size. Their model shows further that just lowering EV battery size, even without reducing car dependency, can bring US lithium demand down by as much as 42 %. Other models take a more global outlook. For instance, Dominish et al. [22] found that recycling has the potential to reduce primary demand compared to total demand in 2040, by approximately 25 % for lithium, 35 % for cobalt and nickel and 55 % for copper.

Some analysts and key actors in the auto industry are also promoting hybrid vehicles as another potential strategy that can reduce the mineral requirements of transport decarbonization [23]. They argue that the metal requirements of producing hybrid vehicles are lower than all-electric ones. Therefore, they suggest that hybrid vehicles—at least in the short term—can reduce the mineral demand pressures of decarbonizing the transport sector [23].

Reducing the amount of minerals necessary for transport electrification can lower mining related socio-environmental harms. However, mining will still need to expand. What is more, it is highly doubtful that the current state of the health of the global mineral supply chain can support effective and responsible procurement of even the comparatively lower quantity of metals that mining-reduction advocates estimate as necessary for decarbonizing the transport sector. Thus, a recent US Government review of the global mineral supply chain concluded that *"the strategic and critical materials market does not yet place a premium on a 'sustainably produced' strategic and critical material"* [13]. Hence, we cannot avoid the challenging work of improving transparent resource governance and compliance with high human/labor rights and environmental protection standards in procuring minerals in a geopolitically complex world.

4. A move towards addressing systemic deficiencies and concerns about change and continuity

There appears to be growing momentum for restructuring extractive governance systems to support a more equitable, just and sustainable energy transition. These efforts include the *Clean Energy Minerals Reform Act* currently under consideration by the US Congress [24]. The proponents argue that while *"transition minerals will help power our shift to clean energy, current mining laws and regulations fail to protect the communities, sacred sites, and water resources most impacted by mining practices"* [25]. They argue that the new bill is intended to cure these deficiencies in the current laws and regulations to avoid problems escalating with the mineral demand pressures of the energy transition [25].

The *Critical Raw Materials Act* the European Union is seeking to pass has similar social and environmental sustainability aims. It has provisions requiring member-states to invest in efforts to better mitigate the adverse impacts of mineral sourcing, both within the EU and in third countries, regarding labor rights, human rights, and environmental protection [26].

Automakers, mining, technology, and other metals-reliant firms are increasingly arguing that they are also taking steps, at the industry level, to better integrate sustainability considerations more strongly in their supply chains. For instance, General Motors has announced that it is integrating stricter supplier contract measures to forbid the use of *"forced or involuntary labor, abusive treatment of employees or corrupt business practices in the supplying of goods and services to GM."* Honda has indicated that it will deepen its engagements *"with policymakers to [better align its supply chain procurement processes] with Global Sustainability Guidelines."* Volkswagen AG too has made commitments to *"review and actively use our existing processes and seek new solutions to prevent forced labor in our supply chain"* [27]. Other global automakers and mining firms have announced similar commitments [28,29].

Many of the transnational multi-stakeholder standard setting bodies whose endeavors are germane to mineral extraction have also announced similar restructuring exercises to support equity and improved respect for ecological systems and human rights in mineral production, sourcing, and stewardship globally. For instance, the Initiative for Responsible Mining Assurance and the International Council on Minerals and Metals have updated its *Human Rights Due Diligence Guidance* [30]. They claim that the updated *Guidance* will position mining companies to better integrate human rights into existing risk management approaches. This includes having robust policies and processes in place to assess actual and potential human rights impacts, act upon the findings, track responses, and transparently communicate how impacts have been addressed [30].

The Initiative for Responsible Mining Assurance and the Aluminum Stewardship Initiative have made similar updates to their performance standards guidance, and now oblige their accredited members to comply with increased sustainability requirements [31,32]. Also, the *Global Battery Alliance* has launched a program towards a circular economy of EV batteries. The program's overall aim is to ensure that the EV battery value chain is socially responsible, environmentally and economically sustainable and innovative. Key strategies they intend to employ to achieve this goal include sustained evaluation of the EV circular economy market and its potential evolution over time; exploration of opportunities to lower repurposing and re-use costs for batteries; quantification of barriers to recycling of EV battery and testing of scalable solutions [33].

It is promising to see some of the key industry actors themselves

appearing to take steps to address the sustainability deficiencies in the global mineral supply chain and improve transparency, security, human rights impacts, and environmental management. However, a review of the governance literature on the extractive sector raises a need for careful, sustained monitoring and interrogation of these developments.

Acosta [34], Burchardt and Dietz [35], Gudynas [36] and, recently, Le Billon and Spiegel [17] have shown that historically, new initiatives introduced to reform the extractive sector rarely address the root problems that first gave impetus to these initiatives. Thus, as Szablowski and Campbell [18] concluded from their recent review of extractive governance initiatives introduced over the past two decades, "pressures for change often translate into governance reforms that deliver little in terms of substantive change" (p.636).

Research to date shows further that, in some cases, such initiatives end up being captured or weaponized by military and state elites generally as well as corporations to advance their interests, creating even more socio-environmental harm. For instance, Saunders & Nyamunda [37], Spiegel [38] and recently Le Billon and Spiegel [17] have shown that for several years, Zimbabwean state officials continued to use the Kimberley Process Certification Scheme (KPCS)-meant to 'clean' global diamond supply chain-to justify large scale military interventions, leading to sexual violence, forceful eviction of local populations from their lands and sources of livelihood generally.

The accounts of Diemel & Hilhorst [39], Wakenge [40] and Le Billon and Spiegel [17] show that similar dynamics played out in DR Congo where the government and military officials used 'implementation' of 'conflict minerals' certification schemes as a tool to extort bribes as well as to drive local artisanal miners out of their 'concessions' for the benefit of large-scale foreign mining companies, while diverting attention from poorly negotiated (and potentially corrupt) deals with these industrial mining companies. Katz-Lavigne [41] recent review shows that these dynamics persist in the country.

The systemic deficiencies in the mineral supply chain that undermine transnational, national and local reform efforts are multifaceted and complex. Nonetheless, the literature shows that mining companies' structural or holding power over compliance monitoring and evaluation systems plays key roles in undermining their efficacy [38,39]. Thus, for instance, the monitoring of compliance with set mineral sourcing norms and regulations tends to rely heavily on evidence from the extractive companies themselves, often with little community, worker, and other forms of consultation. In addition, auditors undertaking the evaluations are also paid by the very companies they audit [42,43]; this results in inherent real and potential conflict of interests that compromise the independence and integrity of compliance monitoring, evaluation and reporting in the sector.

Another issue is overemphasis on technical fixes (e.g., 'formalization' and 'licensing'), within governance initiatives and interventions rather than navigating the varied types of power relations or political economies in the mining sector through long-term community-based approaches [44,45]. Le Billon and Spiegel [17] and other studies (see e.g., Hilson et al. [46]) have shown that this narrow technical fix mindset and rhetoric often prioritize the interests of the more economically well-off and elite actors, creating room for governments and large-scale firms to weaponize 'clean' minerals initiatives, subjecting economically, socially, spatially and historically marginalized artisanal miners and other similarly situated actors to political violence.

There is also the issue of inadequate guarantees and protections for free, prior, and informed consent. Most local, national, and international laws and regulatory initiatives governing the extractive sector recognize resource-rich communities' inherent rights over their lands and to govern themselves. The challenge, however, is that the regulations and the relevant enforcing bodies often create backdoors for waiver justifications that end up undermining the protected rights [19]. For instance, in East Africa, the World Bank granted leave for the Tanzanian Government to sidestep its extractive governance policies protecting indigenous communities, and only walked back on the decision after fierce protests from human rights groups [19,47]. These practices, when combined with deceit, subterfuge and the legally sanctioned (or otherwise) use of force, create room for firms, governments, private investors and some of the international development establishment to impose mining and other similar projects on indigenous and resource-rich communities generally. The urgency around addressing the climate crisis may deepen this problematic dynamic.

Overall, this suggests that the regulatory initiatives being introduced by states and multilaterals, firms and standard setting bodies to address long-standing systemic mineral supply chain deficiencies need to be carefully and rigorously interrogated. Otherwise, the initiatives risk replicating existing patterns of abuse, deepening longstanding vulnerabilities and systemic deficiencies and accelerating environmental damage, including worsening the biodiversity crisis which a UN expert panel suggests must be dealt with simultaneously with carbon reduction efforts [48]. Another key concern is the concentration of negative impacts in the Global South, compounding an already unequal distribution of climate change losses and damages. These concerns raise a need for a deeper research focus on the planned and ongoing institutional changes and initiatives meant to smoothen a timely and equitable positive–sum EV transition; although profoundly important, the transition will require more than reducing the mineral demands [49].

5. Conclusion: directions for future research

The paper has raised the need for deeper research focus on the potential effectiveness of the new regulatory and other initiatives being introduced by states and multilaterals, firms and standard setting bodies to support ethical, equitable and sustainable acquisition of minerals for transport electrification. One way to go about this is for researchers to begin systematically exploring how the *new* initiatives differ from *existing* ones and evaluate their potential to address well-documented systemic deficiencies in the global mineral supply chain. This can include exploring the built-in mechanisms to address the loopholes in existing frameworks and, hence, improve the integrity and independence of compliance monitoring and evaluation systems as well as provide adequate guarantees and protections for free, prior, and informed consent in mineral production, sourcing, and stewardship.

Future research can also explore the initiatives' sensibility to contested realities and local political economies, and, hence, their potential to address the systemic deficiencies that create room for governments and large-scale mining firms to weaponize 'clean' mineral governance initiatives and subject local artisanal miners and marginalized communities to political violence. Related to this is the endemic issue of corruption in the mining sector, which privatizes mineral developments for the benefit of a privileged minority of elite actors while socializing the negative impacts for the majority in the form of environmental damages, human rights abuses, violence, and destruction of livelihoods [50,51].

The concentration of the critical minerals needed for electrified transportation in countries with weak, poor, and failing resource governance and the fast pace of dealmaking and pressure for companies and countries to develop mining are likely to exacerbate the corruption in the extractive sector [50,51]. Future research should, therefore, explore the potential of new initiatives for ethical and sustainable transport decarbonization to better address mining and minerals development corruption and the related socio-environmental harms. This includes exploring the extent to which these initiatives provide new and better tools for leveraging community-led initiatives and activism to ensure more just, equitable and environmentally sustainable outcomes.

Some scholars assert the functional potential of private voluntary governance initiatives to check corporate environmental behavior in the absence of and/or beyond traditional government-directed 'command-and-control' regulations [52–54]. They suggest that such initiatives, often in response to activists and other pressures, can play a role in the globalization of standards and the mobilization of more monitoring of business for improved sustainability performance in the mining and

extractive sector generally [55–57].

The perceived potential of private initiatives to support ethical and sustainable extraction has meant that such programs are increasingly facing demands to include goals often not intended in their initial design. For instance, Auld et al. [54] show that initiatives originally designed for ameliorating environmental and social externalities of corporate behavior are facing pressures to expand their focus to accommodate other goals including the empowerment of marginalized actors in the extractive sector, and vice versa.

While these developments suggest an increasing demand for comprehensive, multipronged responses to longstanding systemic deficiencies in the extractive sector, concerns are emerging that accommodating or balancing multiple and, in some cases, competing values and goals in one program or initiative often result in tensions and contradictions with distributional consequences for wealth, power, and regulatory capabilities that the initiatives seek to overcome in the first place [54]. Also, Sovacool and Andrews [57] have shown that subscribing to such initiatives can, in some cases, result in declines in the quality of mineral governance. Further, empirical work by Schiavi and Solomon [56] suggests that the components of such *'voluntary'* initiatives with the most potential for success appear to be those that are, effectively, *'compulsory'*. It will be worthwhile for future research to explore how the various actors in the extractive sector are learning from these emerging findings and the extent to which the findings are informing the new initiatives they are developing to uphold the mineral supply chain sustainability demands of electrifying the transport sector.

Finally, there are growing calls to align the decision–making processes and remuneration systems of senior managers operating in mining and other hazardous industries to human rights, environmental protection, and transparent governance performance [58]. These calls are informed by the notion that since senior management and executives set both formally mandated and implicit organizational priorities, and, therefore, influence the behaviors of all other organizational actors, aligning their decision–making processes and remuneration systems to sustainability performance can potentially induce overall sustainable organizational outcomes/behaviors [59,60].

The challenge, however, is that attaching financial rewards to sustainability performance can also encourage senior managers to deploy 'creative' means to 'game the system' in such a way as to gain the desired reward without achieving the intended ends [58]. Future research should, therefore, explore the extent to which the idea of tying financial rewards to sustainability performances of senior executives and managers is seeping into the new initiatives to support ethical acquisition of minerals for transport decarbonization and whether these measures work at all. Further what safeguards might be built into these new initiatives to avoid potential unintended and perverse consequences stemming from deepening the very systemic deficiencies these new measures are supposed to address?

Exploring questions like these and their corollaries can help generate much-needed data and systematized evidence to inform strategies for seizing the EV transition as an opportunity to tackle long standing systemic vulnerabilities in the global mineral supply chain and improve mineral procurement governance and monitoring standards and systems. This in turn will help with the urgent work of ensuring equity, minimizing ecological degradation, and maximizing respect for human rights within what is a complex but profoundly necessary decarbonization process.

CRediT authorship contribution statement

Festival Godwin Boateng: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Jacqueline M. Klopp:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

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

Data availability

No data was used for the research described in the article.

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References

[1] Intergovernmental Panel on Climate Change (IPCC), Climate Change 2023 Synthesis Report Summary for Policymakers. Geneva: Switzerland, 2023.
[2] K. Hosseini, A. Stefaniec, A wolf in sheep's clothing: exposing the structural violence of private electric automobility, Energy Res. Soc. Sci. 99 (2023) 103052.
[3] Global Battery Alliance (GBA), Global Battery Alliance Launches World's First Battery Passport Proof of Concept. https://www.globalbattery.org/press-releases/global-battery-alliance-launches-world%E2%80%99s-first-battery-passport-proof-of-concept/, 2023.
[4] T. Riofrancos, A. Kendall, K.K. Dayemo, M. Haugen, K. McDonald, B. Hassan, X. Lillehei, Achieving zero emissions with more mobility and less mining, in: Climate and community project, 2023.
[5] M.B. Gerrard, A Time for Triage, Envtl. F. 39 (6) (2022) 38.
[6] B.K. Sovacool, J. Axsen, S. Sorrell, Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design, Energy Res. Soc. Sci. 45 (2018) 12–42.
[7] PRC Ministry of Finance, Announcement on Continuing and Optimizing the Vehicle Purchase Tax Reduction and Exemption Policy for New Energy Vehicles. http://szs.mof.gov.cn/zhengcefabu/202306/t20230620_3891500.htm, 2023. Accessed: July 28, 2023.
[8] N. Rubio-Licht, S. Roach, Here are the main electric vehicle goals set by automakers and major markets. https://www.protocol.com/climate/electric-vehicle-automaker-goals, 2022.
[9] Republic of South Africa, Electric Vehicle White Paper November 2023, Department of Trade, Industry and Competition (DTIC). DTIC, Pretoria, 2023.
[10] J. Motavalli, Every Automaker's EV Plans Through 2035 and beyond. https://www.forbes.com/wheels/news/automaker-ev-plans/, 2023.
[11] The New York Times, Lithium Scarcity Pushes Carmakers into the Mining Business. https://www.nytimes.com/2023/07/02/business/lithium-mining-automakers-electricvehicles.html#:~:text=But%20lithium%20shortages%20have%20forced,lithium%20ions%20to%20conduct%20energy, 2023. Accessed: July 28, 2023.
[12] R. Blakemore, The Role of Minerals in Realizing US Transportation Electrification Goals, Atlantic Council, Washington, 2021.
[13] White House, Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth: 100-Day Reviews under Executive Order 14017, The White House, Washington, 2021.
[14] International Energy Agency (IEA), The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions, IEA, Paris, 2022.
[15] I. De Blas, M. Mediavilla, I. Capellán-Pérez, C. Duce, The limits of transport decarbonization under the current growth paradigm, Energ. Strat. Rev. 32 (2020) 100543.
[16] Benchmark Mineral Intelligence, More than 300 new mines required to meet battery demand by 2035. https://source.benchmarkminerals.com/article/more-than-300-new-mines-required-to-meet-battery-demand-by-2035, 2022. Accessed: July 28, 2023.
[17] P. Le Billon, S. Spiegel, Cleaning mineral supply chains? Political economies of exploitation and hidden costs of technical fixes, Rev. Int. Polit. Econ. 29 (3) (2022) 768–791.
[18] D. Szablowski, B. Campbell, Struggles over extractive governance: power, discourse, violence, and legality, The Extractive Industries and Society 6 (3) (2019) 635–641.
[19] A. MacInnes, M. Colchester, A. Whitmore, Free, prior, and informed consent: how to rectify the devastating consequences of harmful mining for indigenous peoples, Perspectives in Ecology and Conservation 15 (3) (2017) 152–160.
[20] S. Bijlmakers, The dynamic evolution and resilience of SSBs in theory and practise: The empirical case studies of the Forest Stewardship Council and the Initiative for Responsible Mining Assurance, in: IASC 2021 Polycentricity Virtual Conference, 2021.

[21] N.O. Bonsu, Towards a circular and low-carbon economy: insights from the transitioning to electric vehicles and net zero economy, J. Clean. Prod. 256 (2020) 120659.
[22] E. Dominish, N. Florin, R. Wakefield-Rann, Reducing New Mining for Electric Vehicle Battery Metals: Responsible Sourcing through Demand Reduction Strategies and Recycling, Institute for Sustainable Futures, University of Technology, Sydney, 2021.
[23] P. Coy, A Climate Hawk's Issues with Electric Vehicles. https://www.nytimes.com/2023/07/14/opinion/electric-vehicles-toyota-hybrids.html, 2013.
[24] Congress.Gov, H.R.7580–Clean Energy Minerals Reform Act of 2022. https://www.congress.gov/bill/117th-congress/house-bill/7580, 2022. Accessed: July 28, 2023.
[25] Democrats Natural Resources Committee, Ranking Member Grijalva, Sen. Heinrich Introduce Mining Reform Legislation to Protect Communities, Tribal Consultation, and Environment. https://democrats-naturalresources.house.gov/media/press-releases/ranking-member-grijalva-sen-heinrich-introduce-mining-reform-legislation-to-protect-communities-tribal-consultation-and-environment-, 2023. Accessed: December 16, 2023.
[26] European Union (EU), Critical Raw Materials: ensuring secure and sustainable supply chains for EU's green and digital future. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661, 2023. Accessed: July 28, 2023.
[27] L. Feiner, Tesla, GM, Ford questioned by U.S. senator about Chinese supply chains and connections to forced labor. https://www.cnbc.com/2022/12/22/senator-wyden-asks-tesla-gm-ford-about-chinese-supply-chains.html, 2022. Accessed: July 28, 2023.
[28] E. Halper, Is sustainable mining possible? The EV revolution depends on it. https://www.washingtonpost.com/business/2022/08/11/electric-vehicle-nickel-mine/, 2022. Accessd: July 28, 2023.
[29] D. Shepardson, U.S. senate committee asks carmakers about Chinese supply chain. https://www.reuters.com/business/autos-transportation/us-senate-finance-committee-asks-gm-tesla-toyota-about-chinese-supply-chain-2022-12-22/, 2022.
[30] Aluminium Stewardship Initiative (ASI), ASI's commitment to member success: Support tools and platforms for your certification journey. https://aluminium-stewardship.org/asis-commitment-to-member-success-support-tools-and-platforms-for-your-certification-journey, 2023.
[31] Initiative for Responsible Mining Assurance (IRMA), IRMA Standard for Responsible Mining 1.0–Guidance Document. https://responsiblemining.net/wp-content/uploads/2023/07/IRMA-Standard-Guidance-Updated-2023-June-corrected.pdf, 2023. Accessed: July 28, 2023.
[32] International Council on Minerals and Metals (ICMM), ICMM publishes updated guidance to support the mining industry to proactively manage human rights impacts. https://www.icmm.com/en-gb/news/2023/guidance-manage-human-rights-impacts, 2023. Accessed: July 28.
[33] GBA (n.d.). Global Battery Alliance Long term ambition. https://pacecircular.org/global-battery-alliance. Accessed: January 8, 2024.
[34] A. Acosta, Extractivism and neoextractivism: two sides of the same curse, in: M. Lang, D. Mokrani (Eds.), Beyond Development: Alternative Visions from Latin America, Fundación Rosa Luxemburg and Transnational Institute, Quito and Amsterdam, 2013, pp. 61–86 (2013).
[35] H.J. Burchardt, K. Dietz, (Neo-)extractivism – a new challenge for development theory from Latin America, Third World Q. 35 (2014) 468–486.
[36] Gudynas, E., (2018). "Extractivisms: tendencies and consequences." In: Munck, R., Delgado Wise, R. (Eds.), (2018). Reframing Latin American Development, Routledge Critical Development Studies. Routledge, New York, pp. 61–76.
[37] R. Saunders, T. Nyamunda (Eds.), Facets of Power: Politics, Profits, and People in the Making of Zimbabwe's Blood Diamonds, Weaver Press, 2016.
[38] S.J. Spiegel, Contested diamond certification: reconfiguring global and national interests in Zimbabwe's Marange fields, Geoforum 59 (2015) 258–267, https://doi.org/10.1016/j.geoforum.2014.05.008.
[39] J.A. Diemel, D.J.M. Hilhorst, Unintended consequences or ambivalent policy objectives? Conflict minerals and mining reform in the Democratic Republic of Congo, Development Policy Review 37 (4) (2019) 453–469, https://doi.org/10.1111/dpr.12372.
[40] C.I. Wakenge, Referees become players': accessing coltan mines in the eastern Democratic Republic of Congo, The Extractive Industries and Society 5 (1) (2018) 66–72, https://doi.org/10.1016/j.exis.2017.11.008.
[41] S. Katz-Lavigne, Framing spaces as (il) legitimate:"dirty" cobalt and the (mis) uses of artisanal and small-scale mining sites in south-eastern Democratic Republic of Congo, Canadian Journal of African Studies/Revue canadienne des études africaines (2023) 1–23.
[42] European Center for Constitutional and Human Rights (ECCHR), Human Rights Fitness of the Auditing and Certification Industry? A cross-sectoral analysis of current challenges and possible responses, 2021. Wolfgang Kaleck: ECCHR.
[43] Human Rights Watch (HRW), EU's Flawed Reliance on Audits, Certifications for Raw Materials Rules: Questions and Anwers. https://www.hrw.org/news/2023/05/24/eus-flawed-reliance-audits-certifications-raw-materials-rules, 2023.
[44] S. Spiegel, Land and 'space' for regulating artisanal mining in Cambodia: visualizing an environmental governance conundrum in contested territory, Land Use Policy 54 (2016) 559–573, https://doi.org/10.1016/j.landusepol.2016.03.015.
[45] S.J. Spiegel, S. Agrawal, D. Mikha, K. Vitamerry, P. Le Billon, M. Veiga, K. Konolius, B. Paul, Phasing out mercury? Ecological economics and Indonesia's small-scale gold mining sector, Ecol. Econ. 144 (2018) 1–11, https://doi.org/10.1016/j.ecolecon.2017.07.025.
[46] G. Hilson, T.R. Zolnikov, D.R. Ortiz, C. Kumah, Formalizing artisanal gold mining under the Minamata convention: previewing the challenge in Sub-Saharan Africa, Environ. Sci. Policy 85 (2018) 123–131, https://doi.org/10.1016/j.envsci.2018.03.026.
[47] S. Chavkin, D. Ullman, World Bank Allows Tanzania to Sidestep Rule Protecting Indigenous Groups. https://www.icij.org/investigations/world-bank/world-bank-allows-tanzania-sidestep-rule-protecting-indigenous-groups/, 2016.
[48] United Nations (UN), Tackling Biodiversity & Climate Crises Together and Their Combined Social Impacts. https://www.un.org/sustainabledevelopment/blog/2021/06/tackling-biodiversity-climate-crises-together-and-their-combined-social-impacts/, 2021. Accessed: July 28, 2023.
[49] J. Hickel, P. Brockway, G. Kallis, L. Keyßer, M. Lenzen, A. Slameršak, D. Ürge-Vorsatz, Urgent need for post-growth climate mitigation scenarios, Nat. Energy 6 (8) (2021) 766–768.
[50] D. Manley, P.R. Heller, W. Davis, No Time to Waste: Governing Cobalt amid the Energy Transition, Natural Resource Governance Institute, 2022.
[51] E. Elkind, S. Fitzgerald, Corruption Risks in the EV Battery Supply Chain: What Advocates, Automakers and Fleet Purchasers Can Do, Natural Resource Governance Institute, 2023.
[52] T. Bartley, Transnational governance and the re-centered state: sustainability or legality? Regulation & Governance 8 (1) (2014) 93–109.
[53] B. Cashore, J.S. Knudsen, J. Moon, H. van der Ven, Private authority and public policy interactions in global context: governance spheres for problem solving, Regulation & Governance 15 (4) (2021) 1166–1182.
[54] G. Auld, S. Renckens, B. Cashore, Transnational private governance between the logics of empowerment and control, Regulation & Governance 9 (2) (2015) 108–124.
[55] G. Auld, Transforming markets? Activists' strategic orientations and engagement with private governance, Organ. Environ. 33 (1) (2020) 31–55.
[56] P. Schiavi, F. Solomon, Voluntary initiatives in the mining industry: do they work? Greener Manag. Int. 53 (2006) 27–41.
[57] B.K. Sovacool, N. Andrews, Does transparency matter? Evaluating the governance impacts of the extractive industries transparency initiative (EITI) in Azerbaijan and Liberia, Resources Policy 45 (2015) 183–192.
[58] A. Hopkins, S. Maslen, Risky Rewards: How Company Bonuses Affect Safety, CRC Press, 2019.
[59] V. McDermott, R.P. Zhang, A. Hopkins, J. Hayes, Constructing safety: investigating senior executive long-term incentive plans and safety objectives in the construction sector, Constr. Manag. Econ. 36 (5) (2018) 276–290.
[60] S. Maslen, A. Hopkins, Do incentives work? A qualitative study of managers' motivations in hazardous industries, Saf. Sci. 70 (2014) 419–428.