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Article

Boafo, J, Obodai, J, Stemn, E and Nkrumah, PN (2024) The race for critical minerals in Africa: A blessing or another resource curse? Resources Policy, 93. ISSN 0301-4207

Resources Policy 93 (2024) 105046

Contents lists available at ScienceDirect

Resources Policy

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

The race for critical minerals in Africa: A blessing or another resource curse?

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ARTICLE INFO

Keywords:
Climate change
Critical minerals
Lithium
Clean energy
Africa

ABSTRACT

There is currently an exponential growth in the global demand for critical minerals, particularly lithium, to meet clean energy and decarbonisation objectives. However, sustainable supply of these minerals is at risk due to declining ore grades, available extraction and processing technologies, socio-environmental concerns, and geopolitical challenges. Africa hosts substantial critical minerals resources, and the continent is currently being positioned as a major global player in the critical minerals supply chain. As a result, there is a rush for Africa's critical mineral resources through investment in exploration activities and license acquisition by foreign mining companies. Drawing on the case of lithium mining in Africa, we analysed the urgency claims of critical minerals in the African context and assessed the inherent socio-ecological impacts. We found that the urgency claims of critical minerals largely serve the geostrategic and economic interests of western countries and China. The rush for Africa's critical minerals is producing significant socio-ecological impacts, including driving loss of rich biodiversity, displacement of communities and breeding new forms of illegalities in the resource sector. Based on our findings, we argue that the current race for Africa's critical mineral resources does not serve the interest of Africa and it is likely to create adverse long-term socio-ecological impacts rather than benefits for the continent unless appropriate sustainable measures, including strategic planning, are carefully considered, and fully implemented. Our findings have implications for policies seeking to promote sustainable and responsible mining in Africa, and elsewhere with similar challenges.

1. Introduction

There is currently a high global demand for critical minerals as more industries and economies are transitioning to cleaner energy sources and low carbon technologies (Calderon et al., 2024; Watari et al., 2019). So far, there are nearly 200 national policies and strategies on critical minerals needed to transition to a low-carbon global economy (International Energy Agency, 2022). According to the 2023 Critical Minerals Market Review by the International Energy Agency (IEA), demand for lithium tripled, and that of cobalt and nickel rose by 70% and 40%, respectively, from 2017 to 2022 (International Energy Agency, 2023). Similarly, the market size of critical minerals doubled over the past five years, reaching $320 billion in 2022 (International Energy Agency, 2023). The demand for critical minerals is projected to increase sharply, more than doubling by 2030 and quadrupling by 2050, with annual revenues reaching $400 billion (International Energy Agency, 2022; Holechek et al., 2022). In response to the high global demand, investment in critical minerals development also rose by 20% in 2021 and 30% in 2022 (International Energy Agency, 2022,2023; Liu et al., 2024). Investment in lithium saw the sharpest increase, reaching 50%, followed by copper and nickel (International Energy Agency, 2023). Critical minerals exploration spending likewise rose by 20% in 2022, driven by record growth in lithium exploration around the world (International Energy Agency, 2023).

Currently, China dominates the critical minerals market, producing 29 commodities, including 22 metals and 7 industrial minerals (Renneboog et al., 2022). Although China does not produce the most essential battery materials such as lithium, cobalt, and graphite, it buys, refines, and exports them to western economies, making China the singularly most important customer and supplier of critical minerals in

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https://doi.org/10.1016/j.resourpol.2024.105046
Received 3 February 2024; Accepted 28 April 2024
Available online 8 May 2024

the world (Renneboog et al., 2022). The dominance of China in the critical minerals supply chain poses geopolitical and mineral security threats to western countries. China is already using this market power in coercive ways by putting restrictions on its critical minerals' exports, cutting off supply to Japan and threatening U.S defense contractors' supply chains (Hine et al., 2023). Western economies are now shifting attention to African countries, a region already dominated by China, for the supply of critical minerals.

There have been recent policy announcements from the European Union (EU) and the United States to source critical minerals from African countries as a way of mitigating commodity supply chain risks (Zhang et al., 2023; Müller, 2023). In December 2023, the EU passed the Critical Raw Materials Act (CRMA) aimed at ensuring that Europe is a manufacturing base for electric vehicles, wind turbines and other green goods. The Act would also ensure that the EU reduces its reliance on China for the supply of green products and key minerals they contain (European Union's Critical Raw Minerals Act, 2023). Reflecting this, the EU already has an agreement with Namibia to supply them critical minerals (European Commission, 2022). Moreover, the EU recently announced it was negotiating to source critical minerals from Democratic Republic of Congo and that it intends to do the same with other African countries such as Rwanda, Gambia, and Zambia. Currently, extraction of critical minerals in Africa is dominated by Chinese mining companies, who most often do not adhere to international standards for sustainable mining and human rights. Already, there have been reports of illegalities, environmental dagradation, human rights abuses, corruption, evictions of local residents, loss of livelihoods and conflicts *etc.* engulfing lithium and cobalt mining in Zimbabwe, Namibia, and Democratic Republic of Congo (Global Witness, 2023; Müller et al., 2023).

Despite the race for Africa's critical mineral resources by EU, US, and China, little is known about how this is reinforcing existing socio-ecological problems in Africa's mining sector. This review is one of the first studies to contribute to recent scholarship and discourses on Africa's critical minerals. We analyse the urgency claims of critical minerals in the African context and how the scrambling for Africa's critical minerals is driving and/or could escalate socio-ecological problems within the resource and mining sector in Africa. First, we define critical minerals and analyse why they are classified as 'critical' and 'urgent.' We then analyse lithium projects and mining in Africa and present the associated existing and potential socio-ecological implications. The review concludes by arguing that the current scramble for Africa's critical minerals does not serve the interest of Africa, and could create adverse long-term socio-ecological impacts rather than benefits on the continent, unless sustainable measures, including strategic planning, are implemented.

2. Conceptual clarification of critical minerals

The minerals or metals necessary for the manufacturing of green or clean energy technologies such as solar panels, wind turbines, electric vehicles, battery storage, hydrogen electrolysers and fuel cells are widely known as 'green minerals or metals' (Hammond and Brady, 2022). 'Green minerals or metals' are essential to achieve decarbonisation and climate objectives, especially in the transport and industrial economy sectors. Examples of 'green metals' includes cobalt, copper, bauxite, chromium, high purity iron ore, platinum group metals, lithium, and rare earth metals, among others (Kalantzakos, 2020; Hammond and Brady, 2022). Critical minerals are types of 'green minerals' with two main defined characteristics: (1) they are essential for the functioning of modern technologies, economies, or national security, and (2) there is a risk that their supply chains could be disrupted (Hine et al., 2023; Pitron, 2022). Thus, not all green metals are classified as critical minerals unless they meet these two criteria.

It is important to note that assessments of mineral's criticality reflect market and geopolitical conditions at a particular point in time and are subject to change. Reflecting this, countries and regional blocs around the world are constructing their own lists of critical minerals using different parameters, although decarbonisation goals are common among the indicators. For instance, Australia has classified 47 minerals as critical, consisting of two mineral groupings — rare-earth elements and platinum-group elements, for which Australia has significant potential to be a major global supplier (Hine et al., 2023; Hofstra et al., 2021; Australia's Critical Minerals Strategy, 2023–2030). Moreover, the European Union has identified a list of 34 critical raw materials, which are important to the EU economy but face a risk of disruption, of which 17 are designated "strategic" because of their importance and global demand and supply imbalances. The strategic materials include base metals aluminium, copper, and nickel, along with key battery material lithium and rare earth elements used in permanent magnets for wind turbines or in electric vehicles (European Union's Critical Raw Minerals Act, 2023). The US has also defined its critical minerals using different parameters, with key emphasis on supply risk through natural hazards or human-made disruptions, trade exposure, and economic vulnerability (Kelley et al., 2021). Using these parameters the US critical minerals list contains 50 elements, 45 of which are also considered strategic minerals of interest by the US Defense Logistics Agency (USDLA), the arm of the Department of Defense that manages US global defense supply chains (Burton, 2022; Pitron, 2022).

Although Africa accounts for about 30% of the world's critical mineral reserves (see Fig. 1), many of which are essential for developing renewable and low-carbon technologies, the African Union do not yet have a strategy on critical minerals, neither have they developed a comprehensive list of critical minerals based on well-defined parameters. However, the African Development Bank is currently developing an African Green Minerals Strategy. In the approach paper to guide preparation of the strategy, 13 core minerals were identified as Green minerals using the following three indicators (1) minerals that are used in clean energy technologies and green industries; (2) minerals that maximise the benefits of Africa's mineral endowment; and, (3) minerals that are feedstocks for resource-based industrialisation of clean energy industries (Africa Natural Resources Management and Investment Center, 2022). In addition, 19 minerals were identified as watch list minerals for future changes in technology, mineral discoveries on the continent or the advent of new industries such as the fabrication of semiconductor material for solar PV panels (ANRC, 2022ANRC, 2022). Africa is already a major producer of several minerals and metals classified as critical minerals by the western world (see Table 1). The growth of global renewable energy sector is expected to continue to drive a high demand for Africa's critical minerals.

The 'criticality' of critical minerals is context specific, as each country or region has reasons why these minerals are classified as 'critical'. For instance, Europe, the US, and Australia classified some minerals as 'critical' because they are deemed essential to transitioning to low carbon economy or national security, have no viable substitutes, and are vulnerable to supply chain disruption (Hine et al., 2023; Kalantzakos, 2020; Hammond and Brady, 2022). The serious push towards developing critical minerals strategies in these countries increased substantially after supply chain disruptions during COVID-19 pandemic. The pandemic had significant impacts on critical minerals supply chains, as mines and refineries around the globe were temporarily closed, leading to material shortages at the manufacturing stage (Dyatkin, 2020). These disruptions have exacerbated the drive towards national securitisation of critical minerals that has been growing in urgency after COVID-19 pandemic.

However, minerals for the development of low carbon technologies may not be so 'critical' within the context of Africa, considering their local demand and supply. Majority of African countries do not process or use critical minerals to produce low carbon technologies nor depend on global supply chains for critical minerals (Müller et al., 2023; Müller, 2023). There is low demand for critical minerals in Africa to transition to a low carbon economy, as the continent is less industrialised and contributes less to global carbon emissions. Moreover, these minerals are

Table 1
Critical Minerals deposit in Africa.

Mineral	Africa's share	Major Producers	Use
Lithium	Africa accounts for 5% of the world's lithium reserves	Democratic Republic of Congo, Zimbabwe, Namibia, Ghana	Lithium is used in lithium-ion batteries, making it crucial for electric vehicles and energy storage
Cobalt	Africa accounts for 47% of the world's cobalt reserves	Democratic Republic of Congo	Cobalt is a vital component in lithium-ion batteries used in electric vehicles and renewable energy storage systems.
Copper	Africa accounts for 6% of the world's copper reserves	Zambia	Copper is used in the wiring and other components of electrical equipment
Graphite	Africa accounts for over 21% of the world's reserves	Madagascar, Mozambique, Tanzania	Graphite is used in lithium-ion batteries and is essential for electric vehicles and energy storage systems.,
Chromium	Africa is home to about 80% of the world's chromium reserves	South Africa	Chromium is used in a variety of applications, including stainless steel, pigments, and refractory materials
Rare Earth Elements	Africa accounts for 15% of the world's rare earth reserves	Democratic Republic of Congo	Rare Earth Elements are used in green technologies i.e. wind turbines, solar panels, electric vehicle components.
Manganese	Africa accounts for about 85% of the world's manganese reserves	South Africa, Gabon	Manganese is essential for several industrial applications, including the production of steel, batteries, and fertilizers.
Platinum Group Metals	Africa accounts for about 80% of the world's Platinum Group Metals reserves	South Africa, Zimbabwe	Platinum, palladium, and rhodium, are used as catalysts in fuel cells for hydrogen-based energy systems

Source: Compiled by Authors. These estimates may not be accurate as exploration activities in Africa are ongoing

abundant in Africa, albeit not fully explored and exploited. However, within the global critical mineral value chain, African countries are important suppliers rather than consumers of critical minerals. Therefore, these minerals (Table 1) may be considered critical in Africa because they are essential to achieving global climate and decarbonisation objectives. Owing to the substantial unrealised opportunities for critical minerals in Africa and the growing global demand, many African countries are intensifying their efforts by developing and investing in mining activities for these minerals. Although global demand for all critical minerals is increasing, demand for lithium in particular, has been growing steadily in recent years, driven by the increasing popularity of electric vehicles and the transition towards renewable energy sources. The global lithium market has experienced significant growth, with lithium demand expected to increase 10-fold by 2033 (International Energy Agency, 2023).

3. The case of lithium mining in Africa

Although Africa presently has little engagement with the global lithium supply chain, it hosts significant lithium reserve, which is presently under exploration with only a limited production (Moreno-Brieva and Merino, 2020). Globally, lithium deposits are classified into three different types, namely, pegmatites and granites, sedimentary deposits, and brines (Bowell et al., 2020). Currently, pegmatites and granites are the only known major lithium deposits in Africa (Wilde et al., 2021). There are about eleven African countries in the lithium supply chain, although some activities are taking place in several others (Goodenough et al., 2021). The major countries in Africa's lithium supply chain, together with the localities where activities are occurring and the stage in the lithium mining of those activities, are shown in Fig. 2. Activities are at advanced stages (beyond the resource definition stage) in five African countries, including Zimbabwe, Namibia, Democratic Republic of Congo (DRC), Mali and Ghana (Barich, 2022). These countries altogether host lithium resources of 4.38 million tons, with the DRC alone having >60% (Barich, 2022; US Geological Survey, 2022). However, exploration is the dominant stage for most of the countries (Fig. 2). Across Africa, Zimbabwe is the only country with an active lithium mine, where production is ongoing at its Bikita Project, and lithium mining has been occurring there since 1940s (Goodenough et al., 2021). However, the Bikita Project, recognised as the world's largest known lithium deposit, with a reserve of 11 million tons (Holland, 2023), presently only produces lithium for the ceramics and glass industry, since it does not contain spodumene pegmatites, which are considered suitable for the battery supply chain (Goodenough et al., 2021). Zimbabwe boasts of other lithium projects with capacity to contribute to the battery supply chain, including the Arcadia, Kamativi and Zulu projects. Development at the Arcadia project has commenced and in 2023, there was trial production of lithium concentrate (Reuters, 2023).

In Namibia, the Karibib Project is the most advanced lithium project in the country, which is presently at the development stage, with production expected to start in the second half of 2025. In Mali, construction has started at the Goulamina Project, with the project expected to come online in the first half of 2024 to be West Africa's first spodumene producer (Rogan, 2023). The Ewoyaa Project in Ghana has recently become topical after Atlantic Lithium was granted a 15-year mining permit by the Ghanaian Ministry of Lands and Natural Resources (Jamasmie, 2023; Ministry of Lands and Natural Resources, 2023; Phillips, 2023). These and several other lithium projects shown in Fig. 2 show a growing interest and investment in the lithium resources of Africa, creating a rush for lithium in Africa. Whilst such interests present some opportunities, some notable challenges remain to be addressed.

First, Africa's participation in the lithium supply chain does not go beyond extraction. More recently, Zimbabwe and Ghana are demanding for processing of the lithium ore into concentrate before exporting. It is expected that lithium from the Karibib Project in Namibia will be exported to a chemical plant in the United Arab Emirates for processing (Reuters, 2023). As with all mineral resources, the economic benefits increase at the latter stages of valuation, such as processing, refining, and manufacturing. Thus, limiting participation to the lower stages of the supply chain also limits the economic benefits a country can derive. Therefore, most African countries will not be able to fully attain the expected economic benefits from lithium mining if they only participate in upstream activities.

Considering the power/energy crisis in most African countries, the complexity and unavailability of the technology to mine and process lithium, it appears that Africa's participation in the downstream lithium supply chain is a distant dream (Barich, 2022). Moreover, unlike the other major lithium producing countries, where producing companies are indigenous to the countries where production is occurring, all the companies investing in Africa's lithium resources are foreign multinationals, limiting the economic benefits African countries can accrue from the production of lithium. Africa, therefore, requires strategic planning to overcome these challenges.

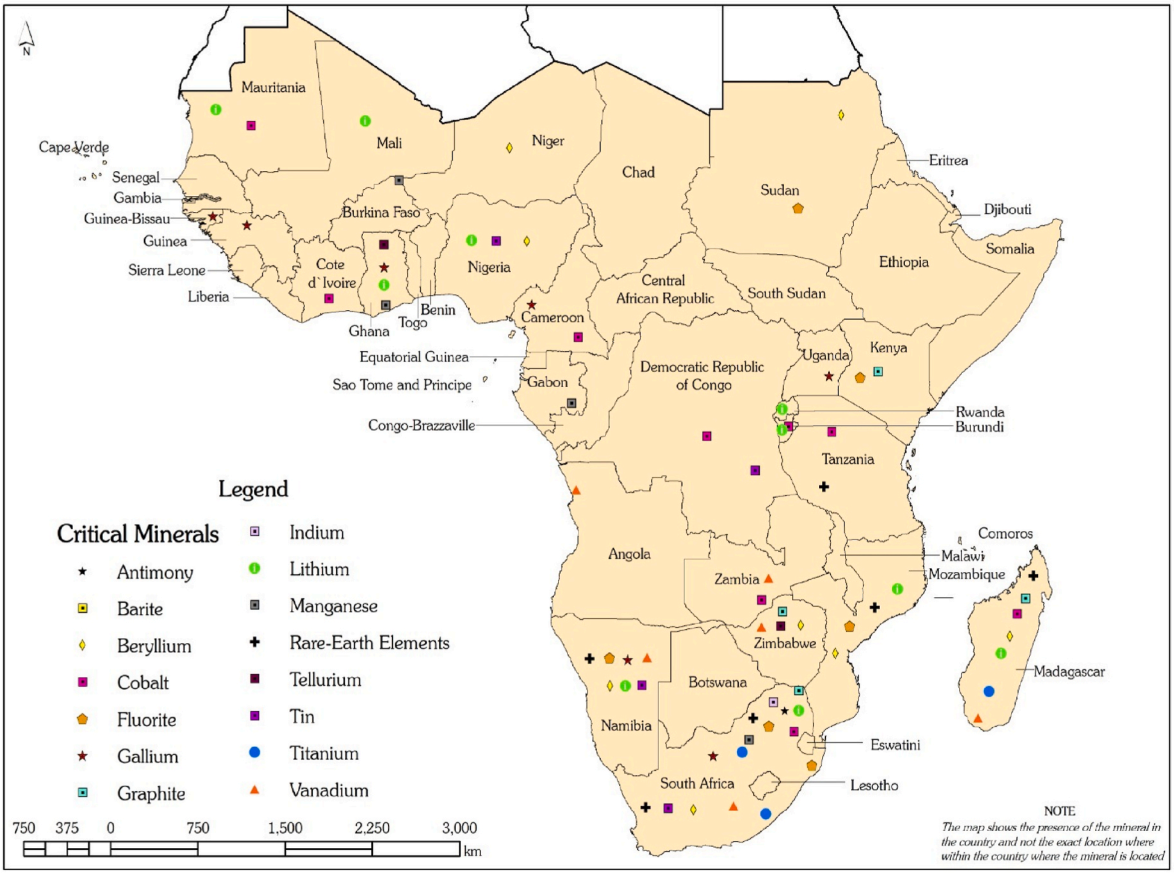

Fig. 1. A Map showing the presence of critical minerals in sub-Saharan Africa.
Source: Constructed by Authors based on data from the US Geological Survey

3.1. Ecological impacts of lithium mining

This section assesses the ecological impacts of hard rock lithium mining in Africa. It mainly focuses on the environmental footprints during operations and post-closure, highlighting significant impacts associated with (i) vegetation clearing, (ii) open-cut mining, including drilling, blasting, loading, and hauling of geologic materials, (iii) processing of mined materials to produce lithium oxide concentrate, and (iv) mine rock stockpiles and tailings storage facilities (TSFs).

3.1.1. Vegetation clearing

Hard rock lithium mining typically involves clearing of several hectares of vegetation, which could result in significant loss of biodiversity (Sonter et al., 2020). Vegetation clearing exposes large areas of soil surface to severe weather events, leading to intense runoff and erosion, with associated adverse environmental impacts on rich biodiversity and other ecosystems (UNEP, 2000). In addition to direct impact of mining at the site of extraction, negative impacts of hard rock mining on biodiversity can occur across landscapes and regions (Raiter et al., 2014; Sonter et al., 2018). The Cape Coast Lithium Portfolio (including the Ewoyaa Lithium Project and Egyasimanku Hill Lithium Project) in Ghana, Uis Lithium Project in Namibia, Manono Project in southern DRC, Goulamina Lithium Project in Mali, Karibib Lithium Project in Namibia and Arcadia Lithium Project in Zimbabwe cover 509, 308, 188, 100, 68 and 9 km^2, respectively (Askari Metals Ltd, 2023; Atlantic Lithium Ltd, 2023; AVZ Minerals,2023; Leo Lithium Ltd, 2023; Lepidico Chemicals Namibia (Pty) Ltd, 2023). These potential and existing hard rock lithium mining locations in Africa host some of the most biodiverse flora and fauna species in the world, with some species not found anywhere else on Earth while others are at risk of extinction (Fig. 3).

Mining in Ghana's rainforest poses enormous risks to the nation's rich biodiversity and natural environment (Attuquayefio et al., 2017; Owusu et al., 2018). The naturally occurring intact forest ecosystems in some of these regions are some of the oldest in the world, providing important habitats for humans, wildlife, and billions of microorganisms. These forests are also major carbon sinks and storage for the planet, protecting the earth from climate change and associated impacts. Moreover, these forests are 'oxygen factories' supporting life on Earth. The Central African forests, which is the planet's second largest rainforest block after the Amazon Forest, are key to global environmental health (Abernethy et al., 2016). The recent surge in hard rock lithium mining in Africa for global renewable energy production will intensify threats to biodiversity, and these new threats to biodiversity may surpass those averted by climate change mitigation without strategic planning and effective implementation of sustainable measures (Sonter et al., 2020).

3.1.2. Open-cut mining

The drilling and blasting method typically employed in hard rock lithium mining generates large volumes of geologic materials, exposes intact and fragmented rocks to air and water, and create a landform that is significantly different from the natural landscape. The blasting process potentially generates significant noise, air, and soil pollution. The dust generation presents increased respiratory risks on-site and nearby communities, with potential impacts on human, fauna, flora, and other environmental health. In addition to air quality deterioration, the dust generation could impair soil and water quality, with significant impact on nearby farming and sensitive ecosystems. The vibration from the blasting process could dislocate local wildlife, affect safety of structures in nearby communities and affect sensitive organisms. Blasting, which

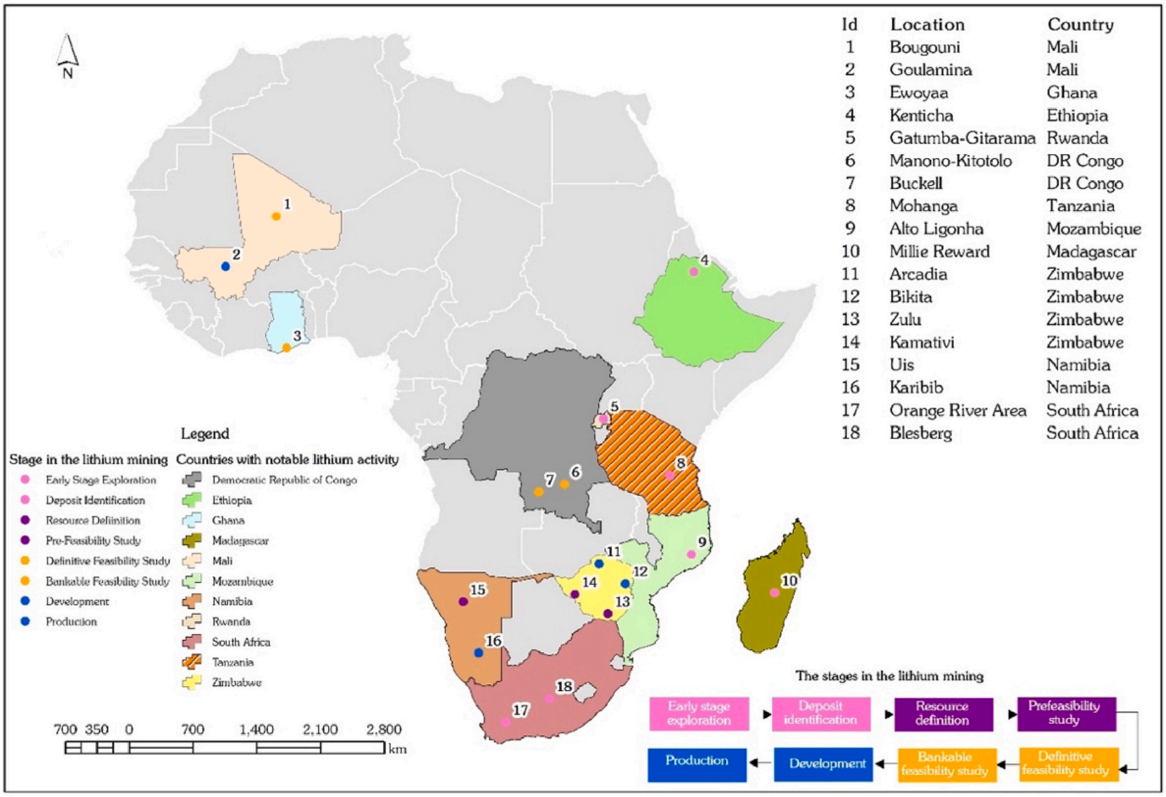

Fig. 2. Distribution of lithium deposit in Africa.
Source: Modified from Goodenough et al. (2021); Shaw (2021).

typically uses explosives such as Ammonia Nitrate Fuel Oil (ANFO) for hard pegmatite and emulsion for wet areas, could potentially release toxic chemicals into the environment with detrimental effect on land and water quality. For the Ewoyaa Lithium Project in Ghana (Fig. 4), the sea is located less than 2 km away from the mine site (Atlantic Lithium Ltd, 2023). Considering that mining threats to biodiversity can occur over several kilometres (~50 km) (Sonter et al., 2017, 2020), the proximity of the Ewoyaa Lithium Project to the marine ecosystem is concerning.

Substantial volumes of geologic materials generated from the conventional drill and blast process constitute waste rocks (>90% of geologic material), with potential adverse impacts on the environment. The drill and blast process also creates open pits, which drastically deform the natural landscape, alter local surface and groundwater flows, and pose danger to wildlife and the public. The pit walls and floors are potential sources of saline drainage, with potential pit lake formation further aggravating local and regional water quality issues. The use of heavy equipment for drilling, blasting, loading, and hauling also causes severe physical disturbance, with adverse impacts on local biodiversity. This equipment also releases substantial carbon dioxide into the atmosphere, if operated on fossil fuels.

3.1.3. *Processing*

Water usage – the processing aspect of hard rock lithium mining utilises substantial quantities of water, causing significant impacts on surface water and groundwater resources, affecting their dependent ecosystems and availability for nearby communities. Water is vital for life, and access to potable drinking water is a basic human right (UN, 2010). However, the intense use of water for mining activities substantially limit availability for drinking purposes, potentially exacerbating challenges with access to safe drinking water in these regions. Water is also useful for domestic, irrigational, and recreational purposes, and depleting this resource for mining activities could pose severe challenges. There is currently no existing water supply for the Ewoyaa Lithium Project in Ghana but the raw water requirement for the project is estimated to be 24.1 m^3/h, which will potentially be sourced from passive pit inflows, runoff inflows to the water storage dam and tailings storage facility, and Lake Agege (Atlantic Lithium Ltd, 2023). These water supply strategies for the mining industry may significantly disrupt the water cycle, with potential impacts on local and regional ecological processes. Moreover, harvesting limited available freshwater for mining activities will affect water supply for domestic, irrigational, and other purposes, exacerbating the growing challenge of access to quality water in Ghana. Similarly, the Goulamina Lithium Project in Mali will source water mainly from an existing water dam (Sélingué Dam), which is 25 km away from site, augmented by harvesting rainwater and limited groundwater extraction (Leo Lithium Ltd, 2023). The potential sources of water for the Lepidico Karibib Lithium Project in Namibia include existing borefields, mine dewatering and NamWater supply pipeline (Lepidico Chemicals Namibia (Pty) Ltd, 2023). Namibia is one of the driest countries in sub-Saharan Africa and could potentially face eminent water stress by 2040 (Maddocks et al., 2015; World Bank, 2021). Considering the intensive demand of water for mining, with mines located in water-stressed areas, there exists potential risks to the security of water supply.

Energy usage – The processing phase of hard rock lithium mining requires intense energy input. The African countries where these mining operations are proposed or ongoing are already struggling to achieve sustainable energy supply. The Manono Lithium Project in DRC has limited infrastructure in the surrounding areas, with power being generated in the Manono township using diesel generators and a recently commissioned solar power system, and potential hydroelectric power (AVZ Minerals, 2023). Notably, less than 10% of the population in DRC has access to electricity, making DRC the country with the highest number of people without electricity access in Africa (IEA, 2019). Power for the Goulamina Lithium Project will be supplied from a

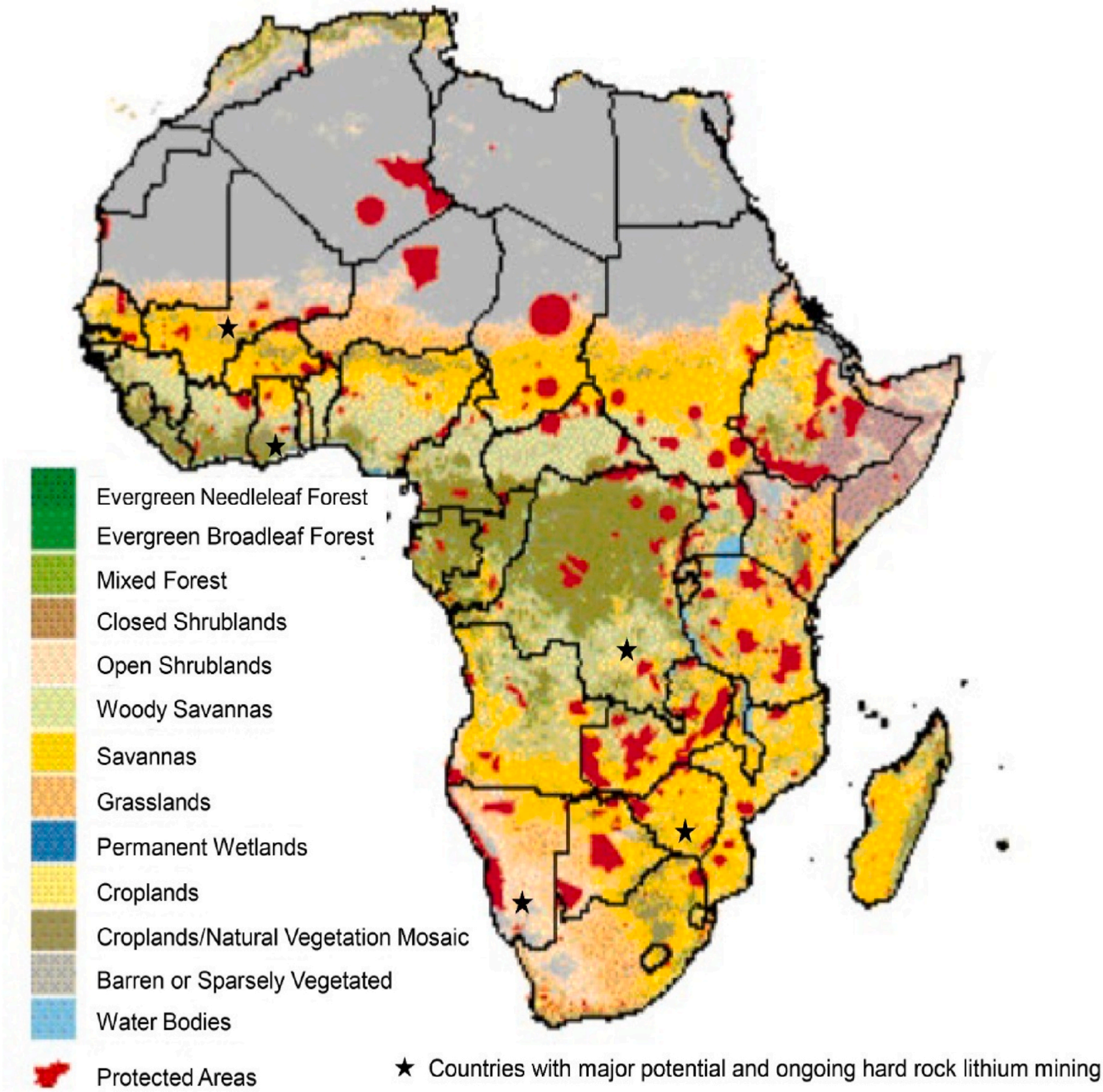

Fig. 3. Biodiversity-rich ecoregions in Africa showing protected areas and major pegmatite lithium mining countries. (Adapted from UNEP, 2000).

15 MW on-site power station with Build-Own-Operate strategy – fuel sources to include diesel and could be part of a solar-hybrid solution (Leo Lithium Ltd, 2023). The Karibib Lithium Project in Namibia will be supplied by a 66 kV (to be stepped down to 11 kV for use in the process plant) powerline to be built by Lepidico Chemicals Namibia (Pty) Ltd and operated by Namibia Power Corporation (NamPower) (Pty) Ltd, with expectation to generate 80% from renewable energy sources by 2025 (Lepidico Chemicals Namibia (Pty) Ltd, 2023). Power for the Ewoyaa Lithium Project, estimated at 8,500 kW will be supplied by the existing grid in Ghana. Ghana currently has 12 commercial power generation facilities with total installed capacity of 4,210 MW, including hydro power plants (56%), an array of thermal plants including combined cycle gas turbines, simple cycle gas turbines and diesel generators (44%) and solar power (<0.1%) (Atlantic Lithium Ltd, 2023).

3.1.4. Mine rock stockpiles and tailings storage facilities

Mine rock stockpiles (traditionally called waste rock dumps) host large volumes of waste rocks, as a large proportion of excavated rocks (>90%) end up in a waste dump facility. In addition, processed rocks (tailings) are discharged into tailings storage facilities. These storage facilities pose significant impacts to surface water and groundwater dependent ecosystems, affecting their quality. Hard rock lithium mining could generate saline drainage, owing to the inherent geochemical properties of lithium ore deposits. The waste rocks and tailings may contain residual lithium, which could easily leach into solution and generate saline drainage. Potential saline drainage could affect sensitive ecosystems, with impacts remaining in the environments for thousands of years. As lithium is relatively mobile, excess in sensitive ecosystems could result in bioaccumulation with adverse health impacts. Plant lithium uptake, and fauna and human consumption of lithium contaminated food and water could cause osmotic imbalance, which could lead to death. Surface water and groundwater dependent ecosystems may be significantly impacted by saline drainage. The potential pathways for saline drainage to reach receptors include runoff, infiltration, and seepage, largely driven by climatic conditions. In the tropical setting such as Ghana and DRC, intense rainfall during wet season could leach potential salts from these storage facilities into sensitive ecosystems, whereas in the dry season, the intense heat could lead to the generation of dust particles (salts) that could affect surrounding ecosystems. In addition to salts, the waste rocks and tailings may contain other

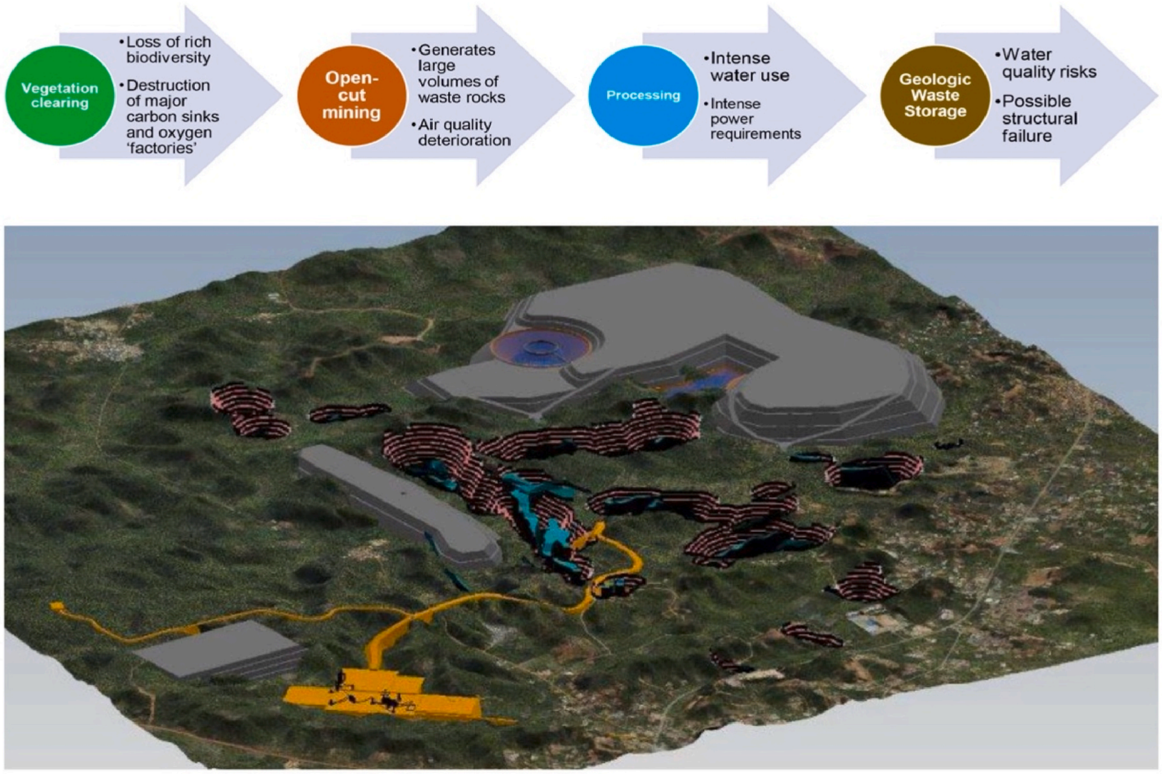

Fig. 4. Overview of potential environmental impacts during operation and post-closure of hard rock lithium mining in Africa. The background image showing the ultimate mining operation overview of the Ewoyaa Lithium Project in Ghana was adapted from London Stock Exchange (2022)

contaminants such as metal(loid)s that can have adverse impacts on the environment once they are released into the environment.

3.2. *Social impacts of lithium mining*

This section provides a critical analysis of the social impacts arising from lithium extraction in Africa. Key documented effects encompass land rights disputes and corruption, displacement, and loss of livelihoods among local communities, health, and safety concerns.

3.2.1. *Mine land right disputes and corruption*

Access to mineralised lands in Africa remains entangled in conflicts despite substantial efforts towards robust resource governance intended to address associated land access issues (Hilson, 2002; Dietz and Engels, 2018; Van Bockstael, 2019; Obodai et al., 2023). These conflicts involve various stakeholders, including state and non-state actors, alongside with tensions between large-scale and small-scale miners or participants within the agricultural sector (Hilson, 2002; Yankson and Gough, 2019; Obodai et al., 2023). The root of these conflicts stems from the coexistence of a dualised land access governance system governed by both state policies and customary laws (Boafo et al., 2019; Mamdani, 2018). The ownership of mineral resources by the state on behalf of the populace introduces complexities in the implementation and interpretation of state and customary laws, contributing significantly to ongoing resource-related disputes in many African countries (Boafo et al., 2019). These conflicts are further intensified by the pursuit of critical minerals and the accompanying geopolitics. A prominent illustration of these complexities lies in the prolonged disagreements between Australian-listed AVZ Minerals and the Chinese conglomerate Zijin Mining companies vying for mining rights in the Manono region of the Democratic Republic of Congo, renowned for housing one of the world's largest lithium deposits (Global Witness., 2023; Surma, 2023).

Currently, there is a notable influx of over 5000 artisanal miners moving towards informal lithium mining locations in Zimbabwe to extract chunks of lithium ore (Surma, 2023; Zimbabwe Environmental Law Association, 2023). The participation of artisanal miners in lithium extraction is exacerbating ongoing conflicts between small-scale miners and established large-scale corporations due to the illegal nature of the former's operations (Zimbabwe Environmental Law Association, 2023). Evidently, a subsistence miner fell victim to a fatal shooting outside an industrial lithium mine in Zimbabwe, perpetrated by a security guard employed by the mining company (Surma, 2023). These clashes signify a concerning trajectory that suggests an escalation of conflicts in the foreseeable future and mirrors the prevalent issues observed in mineral extraction in Africa, where artisanal miners trespass onto areas designated for international and large-scale mining companies (Hilson, 2002).

Allegations of corruption involving foreign mining companies and governmental officials in lithium-rich African countries also fuel ongoing conflicts in the mining industry. According to the anti-corruption body of the Democratic Republic of Congo, in 2022, Zijin, a company involved in the Manono project, acquired shares at a price below the market value. Furthermore, suspicions arose when Zijin reportedly disbursed $1.6 million to a consultancy firm purportedly owned by a political aide (Global Witness., 2023). This substantial payment to a politically affiliated individual in a mining transaction raised concerns regarding potential corruption in the resources sector in the Democratic Republic of Congo (Global Witness, 2023). Furthermore, in Namibia, allegations have surfaced regarding the utilisation of small-scale mining permits by firms to operate industrial lithium mines, purportedly involving instances of bribery (Global Witness, 2023; Hairsine, 2023). These identified patterns of corruption echo similar issues prevalent in the gold mining sector in Africa, wherein collaboration between traditional authorities, state officials, and artisanal miners fosters illegal small-scale mining practices (Crawford et al., 2016; Crawford and Botchwey, 2017). Emerging evidence of corruption and illegalities in the critical minerals sector in Africa underscore the lack of heed to historical lessons, highlighting a disconcerting cycle of repetition without meaningful learning from past experiences.

3.2.2. Displacement and destruction to livelihoods

In many African countries, the ownership of mineral resources is typically vested in the state, while surface rights are predominantly governed by customary laws, resulting in local communities owning the land above these mineralresources (Boafo et al., 2019). Consequently, the exploration and extraction of critical minerals such as lithium will often lead to the displacement of communities, depriving them of their livelihoods. Although governance structures dictate the implementation of a compensation system for those displaced by mining activities, practical application faces considerable challenges. Local communities and existing land users frequently encounter difficulties and are sometimes coerced into vacating their land. According to a Director at the Centre for Natural Resource Governance in Harare, families residing near a lithium mine in Zimbabwe were offered contracts requiring them to relocate in exchange for approximately $1900 or face eviction without compensation if they declined to sign (Surma, 2023). Similarly, in Ghana, communities within the Ewoyaa Lithium Project have already raised concerns about the damage inflicted on their farmlands and food crops due to prospecting activities, coupled with insufficient compensation (Wolf et al., 2023). Additionally, the rapid destruction of trees used for firewood and charcoal has been reported (Wolf et al., 2023). Despite promises of employment opportunities arising from lithium mining ventures, past experiences with mineral extraction, such as gold mining, suggest that job prospects, particularly with large-scale operations, are limited. This situation contrasts starkly with the significant sacrifices made in local livelihoods, potentially leading to an increase in illegal small-scale mining activities (Afriyie et al., 2016; Yankson and Gough, 2019).

3.2.3. Health and safety concerns

The discourse surrounding the well-being and safety of labourers employed by lithium mining companies has garnered significant attention (UNCTAD, 2020). Reports have highlighted substandard working conditions and instances of child labour within foreign lithium mining companies in Africa. For instance, Xinfeng, a lithium mining corporation situated in Namibia, faced allegations of subjecting its workers to conditions resembling apartheid (Global Witness., 2023). According to Hairsine (2023), the locals employed by the company reside in "tiny, hot shacks made of corrugated zinc and without proper ventilation" (Hairsine, 2023). These accusations highlight the grave conditions under which the employees were said to be housed and worked, raising serious ethical and human rights concerns within the industry. Moreover, a report by the Zimbabwe Environmental Law Association (2023) documented instances of inadequate sanitation, child labour, and hazardous work environments at the Sandawana lithium mine in Zimbabwe. This included a distressing incident where a mine collapse led to the entrapment of nine miners, resulting in one fatality. These instances underscore the urgent need for thorough and systematic reforms within the lithium mining sector in Africa to address the deplorable working conditions and safeguard the fundamental rights and safety of the labour force. It demands immediate attention from regulatory bodies and industry stakeholders to implement stringent measures to prevent such alarming occurrences and ensure ethical and humane practices throughout the lithium mining industry in Africa. The enduring issue of substandard working conditions within the African extractive industry is a longstanding concern. Nevertheless, given the current surge in the demand for critical minerals like lithium, there arises a pressing question: Is there potential for the continent to markedly improve these conditions?

4. Conclusion and way forward

The overall aim of this review was to critically analyse the urgency claims of critical minerals in the African context and assess how the race for critical minerals in Africa is reinforcing existing and breeding new socio-ecological challenges in the extractive and mining sector. Our review highlights two themes that are central to recent scholarship and discourses on critical minerals. First, our review highlights how urgency claims of critical minerals in Africa does not serve the interest of Africa, but it is only serving the economic and geostrategic interests of western countries and China. Second, our review highlights how the race for Africa's critical minerals, particularly lithium is already producing and reinforcing existing socio-ecological problems in the mining sector in Africa. Although, we focused on lithium mining, the extraction of other critical minerals, such as cobalt in the Democratic Republic of Congo, has similar challenges.

We found that the classification of minerals necessary for the development of low-carbon technologies as 'critical' is context specific. For instance, the US, Australia, Europe, and China classified minerals for the manufacturing of low-carbon technologies as 'critical' because 1) they are deemed essential to transitioning to low-carbon economy; 2) they are deemed essential to their national security; 3) they have no viable substitutes; and 4) they are vulnerable to supply chain disruption. These criteria may not be applicable within the context of many African countries. First, Africa is less industrialised, contributes less to global carbon emissions and its economy is not driven by industrialisation, suggesting that transitioning to low-carbon economy is not urgent, although Africans consume many industrial products from the West and China. Second, with over 30% of the world's critical minerals deposits, African countries could supply each other with critical minerals to avoid supply chain disruption or even monopoly by non-African countries. Therefore, the need for minerals for the development of low-carbon technologies is not 'critical' or 'urgent' within the context of Africa. In any case, discourses on Africa's critical minerals have largely been shaped by geostrategic and economic opportunities arising from demands from western countries and China, rather than what supply chains Africa must itself secure for current and future industrial applications. Thus, the urgency claims of critical minerals only serves the geopolitical and economic interests of western countries and China not Africa. However, Africa has unrealised potential as a major supplier of global critical minerals.

Our review further highlights the socio-ecological impacts associated with extraction of critical minerals in Africa, with particular focus on lithium extraction. Hard rock lithium mining involves drilling and blasting, which generates significant pollution, exacerbates biodiversity loss, dislocate fauna, and affects infrastructure of mining communities. In addition to the direct impacts, the ecological impacts could have global implications. Moreover, communities around large lithium deposits in Africa may be displaced to make way for development of large-scale lithium mines. Also, some people who have already lost their livelihoods because of displacement are engaging in illegal lithium mining activities, a predominant social, political, and ecological problem affecting the resource sector in Africa. While we acknowledge that all these socio-ecological problems are not new to Africa's resources sector, we emphasise that the rush for Africa's critical minerals is reinforcing them as well as adding to the complexities and derailing efforts to fight them. In fact, the urgency claims of critical minerals may be an excuse for African governments and foreign mining companies to circumvent mining and environmental regulations to expedite exploration activities and acquisition of mining licenses. Based on our findings, we argue that the race for critical minerals in Africa is likely to create long-term socio-ecological impacts rather than benefit the continent, if appropriate sustainable measures are not taken (also, see Abramova & Sharova, 2023).

Based on these findings, we recommend that the African Union should expedite the development of the Africa Critical Minerals Strategy that will guide member countries on negotiating mining contract and agreements. The Africa Critical Minerals Strategy should draw from good mining practices around the world. We also recommend that African countries should revise their mining policies and regulations to reflect the opportunities and challenges pose by the increasing global demand for critical minerals. Mining campanies should adhere to internationally accepted mining practices and national regulations to minimise the environmental and social impacts of their operations. Finally, for African countries to maximise the economic opportunities arising from the global high demand for critical minerals, African governments must create incentives for the local private sector to be competitive in the industry. Processing of critical minerals in Africa would increase their value on the international market, create jobs, and drive the growth of other sectors of the African economy. Until these are carefully considered and fully implemented, the extraction of Africa's critical minerals by foreign mining companies would create another resource curse.

CRediT authorship contribution statement

James Boafo: Conceptualization, Writing – original draft, Writing – review & editing. **Jacob Obodai:** Writing – original draft, Writing – review & editing. **Eric Stemn:** Writing – original draft, Writing – review & editing. **Philip Nti Nkrumah:** 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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