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Regionalizing "Green" Transition Minerals for Structural Transformation in Africa

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ABSTRACT

The global shift to a low-carbon economy has intensified the demand for green transition minerals, including lithium, cobalt, nickel, and rare earth elements. These minerals are essential for manufacturing green technologies such as electric vehicles, solar panels, and wind turbines. The surge in demand presents new opportunities for structural transformation, particularly in developing and emerging economies such as those in Africa. This study critically examines Africa's role and potential in leveraging its green transition minerals for structural transformation. The findings show that although the continent collectively holds substantial green transition mineral reserves, it remains largely marginalized in global green mineral and technology value chains. Most African countries individually contribute minimally to global reserves, production, and trade, limiting their strategic leverage—a structural and geological constraint. This is further compounded by the underdeveloped technological and industrial capabilities, political and financial risks, energy shortages, and inadequate infrastructure that plague many African economies. Although several African states have introduced policy reforms to promote local value addition, prevailing dynamics still mirror historical patterns of resource extraction, with China emerging as the continent's mineral processing and refining hub. In response, the study proposes a developmental regionalism framework as a strategic option for Africa to leverage its green transition minerals for sustainable structural transformation in the new industrial age.

Keywords: Green transition minerals; Green transition technologies; Developmental regionalism; Structural transformation; Broad-based development; Africa

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1. INTRODUCTION: AFRICA'S GREEN MINERAL MOMENT

The global shift toward a low-carbon economy is reconfiguring industrial systems, technological frontiers, and geopolitical alignments. At the heart of this transformation lies an increasing demand for a specific class of critical minerals: green transition minerals (GTMs) such as cobalt, nickel, lithium, rare earth elements (REEs), graphite, and manganese. These minerals underpin the production of green transition technologies (GTTs) such as electric vehicles (EVs), wind turbines, solar panels, and battery and energy storage systems. As the race for green technologies accelerates, control over the supply and value chains of these minerals is increasingly becoming a central determinant of industrial competitiveness, national resilience, and economic sovereignty. Hence, GTMs are not only industrial inputs; they are strategic assets in the emerging green industrial order (IEA, 2021, UNCTAD, 2021, OECD, 2023).

This study assesses Africa's current position within this emerging green industrial order through the lens of the continent's GTMs, outlining how it can turn its vast GTM reserves into a springboard for structural transformation.[1] Two defining characteristics of GTMs amplify their strategic importance for structural transformation. First, their unique physical and chemical properties make them difficult to substitute, ensuring their indispensability and sustained demand across multiple clean technologies. Second, several GTMs are geologically concentrated to a striking degree, often more so than oil and gas, with a handful of countries controlling the majority of global reserves and production (IEA, 2022a). These characteristics generate a double-edged dynamic: they offer GTM-rich countries a rare opportunity to reposition themselves as indispensable players in global green value chains. However, high concentration and limited substitutability expose economies to geopolitical risks and new forms of dependence, especially if upstream control is not matched by downstream value addition and governance capacity.

Africa is exceptionally well-endowed with GTMs, but remains structurally marginalized in the global green economy. Africa holds over 30 percent of the global reserves of key GTMs, including over 50 percent of the world's cobalt, over 96 percent of platinum group metals (PGMs), 77 percent of phosphate, and substantial shares of graphite, chromium and manganese. Thus, Africa has a clear comparative advantage in the supply of raw materials for low-carbon technologies. However, the vast majority of these minerals are exported in raw or semi-processed form, primarily for refining and manufacturing in Asia–especially China–where downstream value is captured (UNCTAD, 2023; IEA, 2023; Evans, 2022). This reflects a persistent structural question: How can Africa avoid reproducing the extractive growth model of the past and instead turn its endowment of resources into an engine for long-term transformation? This study addresses this question within the context of GTM.

Africa's historical experience with resource-based development reveals a persistent challenge to transform mineral wealth into economic transformation. Despite decades of policy reform, most African economies remain locked into upstream supply roles, with limited success

[1]Here, structural transformation is defined as a compositional shift in economic structures as well as social and technological change that reshapes the organization of production, labor, and institutions in a society.

in capturing value through beneficiation or manufacturing. Commodity dependence has entrenched low-productivity structures and crowded-out investment in tradable sectors, particularly manufacturing (Auty, 2001; Hausmann, 2007). The prevalence of enclave extractive industries, with limited backward or forward linkages in the domestic economy, has left most African countries positioned at the periphery of global value chains (GVCs), dependent on primary exports, and vulnerable to external shocks (Signe & Johnson, 2021; Anyanwu, 2017).

The fundamental challenge is not resource scarcity, but institutional and productive capacity. Participation in upstream resource segments, without upgrading, limits value capture and learning opportunities. African countries need coherent trade, industrial, and innovation strategies to break free from the status quo and unleash the much-needed resource-based development. Strategically governed mineral rents are also needed because it can finance infrastructure, develop skills, and enable technology upgrading (Khan, 2000; Amsden, 2001). These possibilities underscore the urgency of crafting and implementing strategic industrial policies that move beyond extraction toward beneficiation, technology development, and regional value chain (RVC) integration. Africa stands at a crossroads in the evolving green mineral landscape: it can either remain a passive mineral supplier or emerge as an active architect of its own green industrial future.

Unlike past commodity booms, the current moment presents a qualitatively different opportunity. What distinguishes the current moment is the confluence of global demand pressures, shifting geoeconomic priorities, and institutional momentum on the continent. The surge in the demand for GTMs—especially for battery minerals like lithium, cobalt, and graphite—has heightened the strategic value of Africa's reserves. At the same time, rising tensions between China and Western economies have elevated the urgency of supply chain diversification, with multiple global actors courting African countries (Ndubuisi & Avenyo, 2024, p. 5). In contrast to past commodity booms, Africa now possesses regional policy platforms that can anchor industrial strategy. The African Continental Free Trade Area (AfCFTA), the African Mining Vision (AMV), the African Green Mineral Strategy (AGMS), and the African Minerals Strategy Group (AMSG) offer a rare opportunity for African countries to coordinate their mineral strategies and industrial ambitions.

Although GTMs have introduced new geopolitical dynamics and technological urgency, the fundamental challenges to value capture remain strikingly familiar. These include infrastructure deficits, weak regional integration, and underdeveloped institutional frameworks. The high capital intensity and technical complexity required for mineral processing and manufacturing GTT components demand strong state capability and strategic industrial coordination. Most African countries face persistent infrastructure deficits, especially in energy and transport, which inflate production costs and undermine competitiveness. At the same time, shortages of technical skills constrain efforts toward technology upgrading, especially in more advanced value chain segments (Karkare & Medinilla, 2023).

Although mineral beneficiation policies have gained traction, success remains largely elusive. Countries such as South Africa, Ghana, and Botswana have pursued policies to promote local value addition. However, progress has been slow due to institutional weaknesses, technology gaps, and fragmented regional approaches (Fessehaie & Rustomjee, 2018). Recent interventions, such as Zimbabwe's ban on raw lithium exports, Namibia's export restrictions on graphite and co-

balt, and the Democratic Republic of Congo's regulations on artisanal cobalt, signal an emerging political will to capture more value domestically. However, their transformative potential remains constrained by a lack of complementary investments in infrastructure, input industries, and regulatory enforcement needed to alter entrenched industrial trajectories. Without robust ecosystems to support industrial upgrading and stronger coordination across borders, these policies risk becoming symbolic rather than catalytic. Ultimately, value capture will depend not only on political intent but also on the ability to build institutions, capabilities, and cross-country synergies that sustain structural transformation.

This study delves into the emerging green industrial order, with a focus on how Africa can harness its GTMs for structural transformation. Taking both analytical and normative perspectives, the study investigates how the continent can shift from a pit-to-port extractive model to one anchored in high-value-added production. GTMs are defined as minerals that are essential for producing GTTs. Relying on this definition, the study maps Africa's geography of GTM reserves and production, analyzes the structure of GTM exports, and tracks the spatial distribution of value-added processing. It also assesses Africa's current participation in GTT value chains and evaluates the policy instruments that have been deployed to capture greater value locally.

The study finds the following:

- **Africa's GTM wealth is significant, but its distribution is uneven and fragmented.** While the continent holds a significant share of the global GTM reserves, most African countries possess only marginal portions. This limits their leverage and competitiveness in the emerging green industrial order without regional coordinated strategies.
- **Africa remains locked in low-value positions within GTM value chains.** The continent's export structure is overwhelmingly composed of raw or semi-processed GTMs, with limited local beneficiation or downstream value addition. This entrenched position constrains Africa's ability to capture greater economic returns from its mineral wealth.
- **China dominates in processing of Africa's GTMs.** High-value processing activities mostly take place outside Africa, with China emerging as the continent's primary mineral processing and refining hub. This asymmetry reinforces Africa's dependence on external partners for value-added mineral outputs.
- **Despite vast GTM wealth, Africa's participation in GTT value chains remains limited, even at the continental level.** At best, African countries have only peripheral roles in GTT value chains. Although a few countries, like Morocco, South Africa, and Tunisia, are emerging as the continent's GTT hubs and could offer potential entry points for higher-value participation, they remain globally uncompetitive.
- **Policy reforms to promote local value addition are increasing but lack sufficient impact.** Several African countries have adopted export restrictions, beneficiation mandates, and industrial policies aimed at fostering local processing. However, these efforts remain piecemeal and under-resourced, and have yet to produce structural shifts away from extractive dependence.
- **Global interest in Africa's GTMs is rising, but so are strategic risks.** Heightened geopolitical competition between China and Western powers over access to GTMs and GTTs has intensified the global focus on Africa's mineral potential. Although this presents new opportunities for

investment and strategic partnerships, it also requires stronger African agency to avoid being sidelined in the emerging green industrial order.

To seize the moment and turn it into a catalyst for structural transformation, this study proposes a GTM-led developmental regionalism framework. The newly proposed strategy recognizes that GTMs present a transformative window of opportunity in the new industrial era, but contends that mineral abundance alone is not enough. Without scale, strategic coordination, regional integration, and investment in productive capabilities, Africa's GTMs will not drive the much-needed structural transformation on the continent. Africa needs a decisive shift from fragmented national efforts to integrated regional strategies that connect mineral wealth to industrial development, technology upgrading, and infrastructure development. A national strategic vision, embedded and anchored in regional integration, is key. Hence, this study offers an integrated framework that links critical GTMs to structural transformation, industrial policy, and regional cooperation.

The study makes four distinct contributions:

- **A strategic shift from a national lens to a regional lens:** It shows that Africa's mineral strength lies not in any single country, but in collective endowments that require developmental regionalism to harness economies of scale, align infrastructure, and negotiate in global markets.
- **A structural transformation perspective:** Rather than treating minerals as mere trade opportunities, it anchors them in a broader development agenda, connecting them to productivity upgrading, industrial capabilities, and economic diversification.
- **Empirical synthesis of Africa's green mineral and technology GVC positions:** It combines geological, trade, and production data to diagnose Africa's current role in global green mineral and technology supply chains, and its prospects for functional upgrading.
- **A policy framework for action:** Drawing from global experiences and African initiatives, the study proposes a four-lever policy framework–value capture, capability development, strategic partnerships, and regional integration.

The study proceeds as follows: Section 2 conceptualizes GTMs and presents global trends in demand, supply, and investment. Section 3 analyzes the geography of Africa's GTM endowments, production, and trade flows. It also examines geopolitical dynamics, focusing on China-Africa GTM relations. Section 4 assesses Africa's position in global GTM and GTT value chains. Section 5 reviews emerging policy responses. Section 6 develops a "developmental regionalism" framework for coordinated value addition. Section 7 concludes.

2. FROM GREEN TRANSITION TECHNOLOGIES TO GREEN TRANSITION MINERALS: CONCEPTS AND PATTERNS

2.1 Defining and Identifying Green Transition Minerals (GTMs)

The global transition to a low-carbon economy has catalyzed unprecedented growth in a wide array of clean energy technologies, such as solar panels, wind turbines, EVs, and energy storage systems, collectively referred to as Green Transition Technologies (GTTs). These technologies are highly mineral-intensive, both in terms of quantity and diversity (Arrobas et al., 2017; IEA, 2022a; Hund et al., 2023; Ndubuisi & Avenyo, 2024). For intance, an EV requires six times more mineral inputs than a conventional car, and an onshore wind plant demands nine times more mineral inputs than a gas-powered plant (IEA, 2022a).

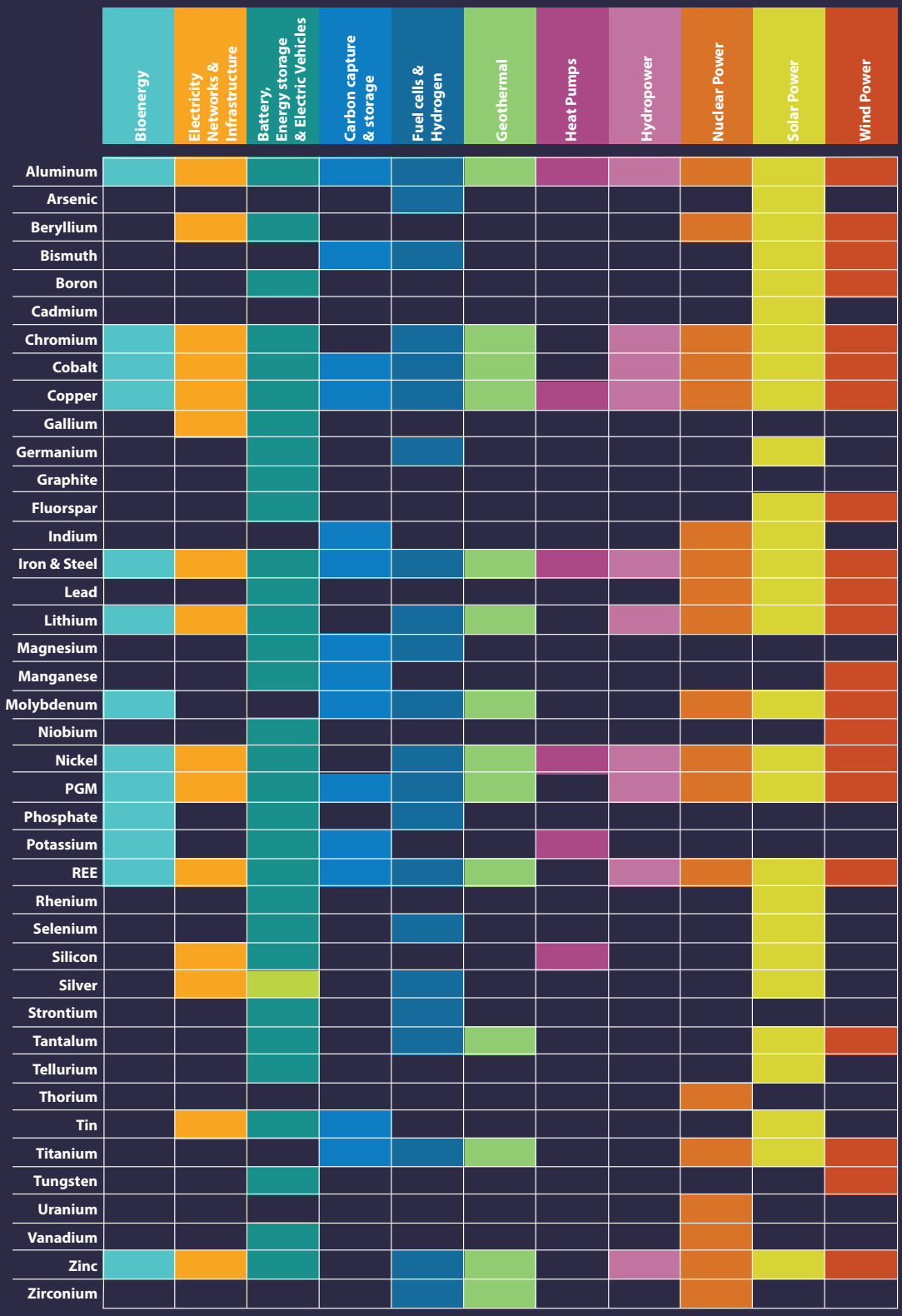
The performance of GTTs also relies heavily on minerals. For example, lithium, cobalt, and nickel are essential for the manufacture of high-capacity batteries used in EVs and grid storage. Copper, valued for its excellent electrical conductivity, plays a key role in wind turbines, solar panels, and electric power distribution. Similarly, REEs like neodymium and dysprosium are indispensable for producing the high-performance permanent magnets used in wind turbines and electric motors. Along this line, mineral intensity is not only a question of volume, but also one of criticality, as many of these minerals are difficult to substitute due to their unique chemical and physical properties. At the same time, their geographical distribution is highly concentrated, with a handful of countries controlling the majority of known reserves and production in the world (IEA, 2022a).

This study defines GTM as essential minerals for the production and deployment of GTT. This definition differs from the broader concept of critical raw materials (CRMs).[2] CRMs encompass minerals considered important for economic security, which may serve a wide range of industrial applications beyond the green transition. They are typically identified by individual countries or regional blocs as materials that are economically significant but exposed to high risks of supply disruption—risks arising from scarcity, concentration of supply, or geopolitical dependence. In this case, CRM classification varies between jurisdictions due to differences in industrial specialization and supply dependencies. In contrast, GTMs are defined solely by their functional role in enabling the green transition, irrespective of whether they are nationally designated as "critical."

Two distinctions are particularly important. First, CRMs are inherently context-dependent and politically constructed. A mineral may be considered critical in one country but not in another, depending on industrial structure, technological specialization, and domestic endowments. The U.S and EU publish national CRM lists, updated periodically based on industrial needs and geopolitical risks (EU, 2023, USGS, 2023). Second, CRMs span a wider industrial scope than GTMs. While GTMs are defined exclusively by their role in enabling green technologies, CRMs include minerals used in a wide range of sectors, including those unrelated to decarbonization. For example, a mineral deemed essential to a country's aerospace or defense sector may qualify as a CRM, even if it has no bearing on the green transition. However, some minerals, such as cobalt, REEs, nickel, and PGMs, qualify as both. GTMs that are also CRMs may represent the subset of greatest economic and political salience in the evolving mineral economy.

[2]In principle, it could well be that some minerals when applied to a technology increase the technology's efficiency level, such that the carbon footprint of the technology reduces. Although this will have implications for the global green transition, this study only considers as GTMs those minerals that are directly applied to GTTs as defined above.

Figure 1: Mapping of Green Transition Minerals across Green Transition Technologies.



Source: Original figure for this study
Note: PGM = platinum group metals; REE = rare earth elements.

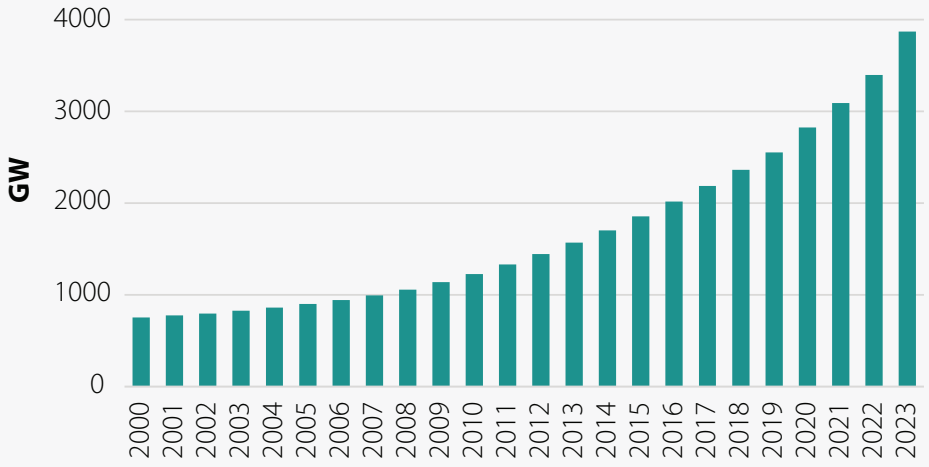
This study focuses specifically on this overlapping subset: GTMs that are also classified as CRMs in multiple jurisdictions. The first step compiles critical mineral lists from 15 countries and regional bodies, including China, the European Union, Japan, the Republic of Korea, the United Kingdom, and the United States, and harmonizes them to identify 50 unique minerals frequently designated as CRMs (see Table A1 in the Appendix). The second step assesses the role of each of these minerals in supporting 11 broad categories of GTTs, drawing on academic literature, institutional reports, and grey literature. This mapping identifies 41 minerals that are simultaneously CRMs and serve as key material inputs for at least one green technology system. These 41 minerals constitute the "critical GTMs" that anchor the analysis in this study.

Figure 1 presents the mapping between these 41 GTMs and the green technologies they support, illustrating the density of mineral-technology relationships and the cross-cutting importance of specific GTMs—particularly cobalt, nickel, copper, lithium, REEs, and PGMs. This taxonomy provides a systematic foundation for analyzing both Africa's resource endowments and the policy frameworks needed to leverage them for green industrialization.

2.2 GTMs and GTTs: A Trend Analysis

The production and deployment of GTTs have reached unprecedented levels in recent years. In 2022 alone, EV sales jumped by 60 percent, while solar photovoltaic (PV) sales rose by 35 percent (IEA, 2023a). Figures 2 and 3 provide an overview of the scale and speed of global energy transition trends, based on data from the International Energy Agency (IEA) and the International Renewable Energy Agency (IREA). Figure 2 shows the absolute increase in global installed renewable energy capacity between 2000 and 2023, while Figure 3 shows the share of renewables in global electricity generation over the same period.

Figure 2: Global Installed Renewable Energy Capacity



Source: Original figure for this study based on data from "Our World in Data"
Note: The original series was retrieved from OurWorldinData.org/energy. RThe data cover total renewable (on- and off-grid) electricity installed capacity, measured in megawatts. This includes bioenergy, geothermal, hydropower (excluding pumped storage), solar, wind, and marine energy. GW = gigawatts.

Between 2000 and 2023, global installed renewable energy capacity surged from 752.2 GW to 3,869.7 gigawatts (GW)–an absolute increase of 3,117.5 GW and a relative growth of 414 percent (see Figure 2). During the same period, the share of electricity generated from renewables grew from about 19 percent to 30 percent, marking a 62 percent relative increase (see Figure 3). This highlights the growing role of clean energy in the global power mix.

Figure 3: Global Electricity Production from Renewables

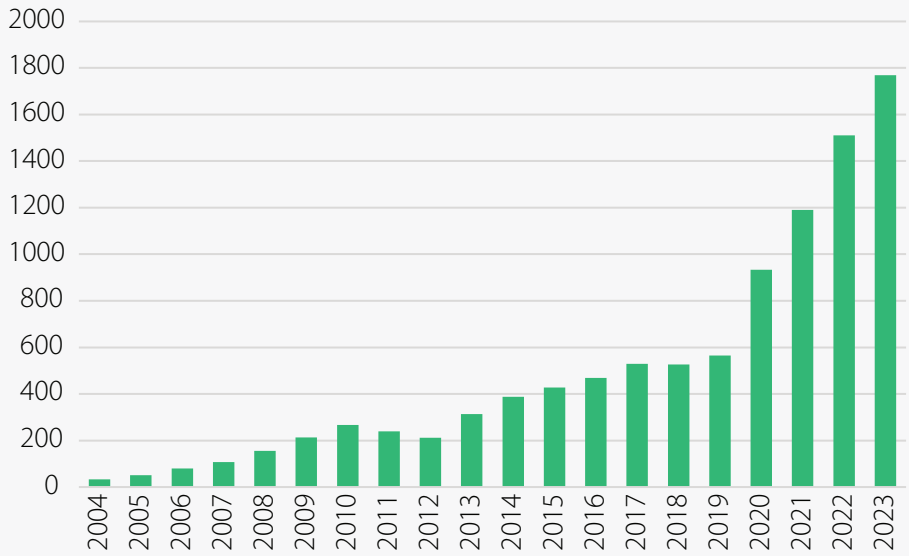
Source: Original figure for this study based on data from "Our World in Data"
Note: The original series was retrieved from OurWorldinData.org/energy. Renewables include electricity production from hydropower, solar, wind, biomass and waste, geothermal, wave, and tidal sources

The global GTT market is poised for further significant growth in the coming decade. The IEA has projected that by 2028, renewable energy will generate more than 42 percent of global electricity, with wind and solar PV alone doubling their share to 25 percent (IEA, 2023b, p.8). The clean technology market is also expected to accelerate sharply. According to the 2024 ***Energy Technology Perspectives*** report by IEA, the global market for six mass-produced clean technologies including solar PV, wind turbines, EVs, batteries, electrolyzers and heat pumps–will grow from US$700 billion in 2023 to more than US$2 trillion in 2035. This will put the global GTT market on par with the global crude oil market in recent years. Additionally, international trade in clean technologies will more than triple within a decade, reaching US$575 billion—over 50 percent higher than current global trade in natural gas (IEA, 2024a).

Global investment in GTTs is surging alongside the rapid growth of the market. Between 2019 and 2023, annual clean energy investment increased sharply across multiple regions, including Africa, where it reached US$10 billion in 2022 (IEA, 2023d). In 2023 alone, global investment in clean energy technologies reached a record US$1.78 trillion—up 17 percent from the previous year (see Figure 4). Since 2019, investments in clean energy technologies have consistently outpaced fossil fuel investments. Recent trends suggest that this gap will continue to widen, with clean energy technology spending expected to double fossil fuel investment in the coming years, driven by stronger supply chains and declining technology costs (IEA, 2023c; IEA, 2024b).

This surge in investment signals growing confidence in the GTT markets and presents a strategic opportunity for mineral-rich African economies to align their domestic industrialization strategies with emerging global investment flows.

Figure 4: Global Investment in Energy Transition Technologies



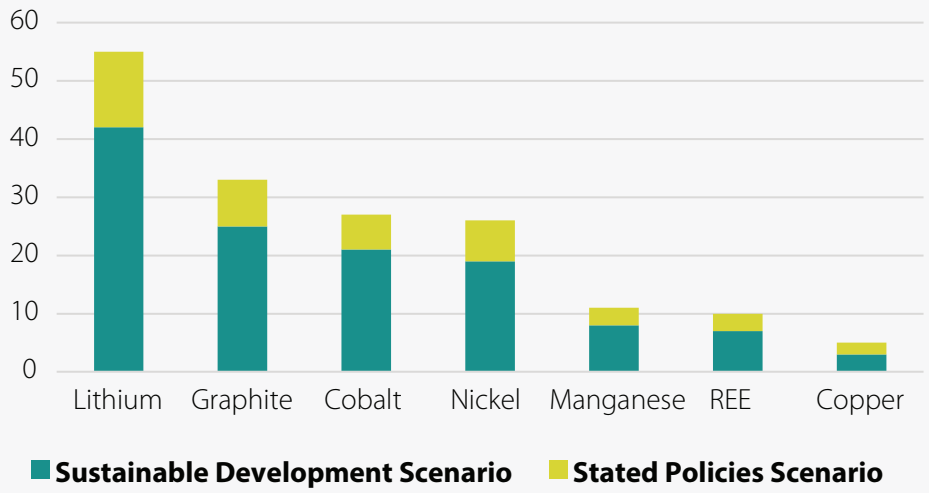
Source: Original figure for this study, based on data from Statista

The rise of GTTs has reshaped mineral demand trends over the past two decades, with significant implications for global production systems and supply chains. The rapid growth of the global GTTs market has intensified demand for a class of minerals embedded in renewable energy systems, energy storage, and electrified transport. According to the IEA's Critical Minerals Market Review 2023, the market size of key energy transition minerals doubled between 2017 and 2022, reaching US$320 billion in 2022 (IEA, 2023a). Projections shown in the review also suggest that the demand for GTMs will increase significantly in the coming decades. The World Bank also estimates that the cumulative demand for 17 energy transition-related minerals could exceed 3 billion tons by 2050 in a scenario aligned with the Paris Agreement (Hund et al., 2020). Altogether, these trends reflect deepening linkages between technology pathways and commodity markets.

Global demand for GTMs is rising, although growth is uneven across mineral types. The mineral-specific trends in Figure 5 show lithium leading in relative growth, followed by graphite, cobalt, and nickel. In the IEA's Sustainable Development Scenario (SDS), which is consistent with limiting warming to below 2 degrees Celsius (°C), the demand for lithium is expected to grow more than 40 times between 2020 and 2040, and the demand for graphite, cobalt, and nickel is projected to rise by factors of 20 to 25 over the same period (IEA, 2022a). Even under more conservative policy environments, such as the Stated Policies Scenario (STEPS), demand for these minerals is projected to double or triple. Forecasts by Statista also show a steady demand increase for most GTMs, with the respective global demand for graphite and lithium poised to grow by nearly 500 percent and 491 percent by 2050 (in a two-degree scenario) compared to the 2018

production volume (Statista, 2025). These differentiated projections are not theoretical. Between 2017 and 2022, the global demand for lithium tripled and the global demand for cobalt and nickel increased by 70 and 40 percent, respectively, over the same period (IEA, 2023a). Taken together, these trends suggest that the global economy is entering a new mineral-intensive phase of development, where strategic control over a narrow band of inputs, GTMs may prove as consequential as oil was in the twentieth century.

Figure 5: Green Transition Mineral Demand Growth



Source: Original figure for this study, based on data from IEA
Note: The figure shows growth in demand for selected minerals for clean energy technologies, by scenario, 2040 relative to 2020. REE = rare earth elements.

However the increase in mineral demand is not evenly distributed across all technologies. EVs and battery storage account for the most dramatic increases, especially in the cases of lithium, cobalt, nickel, and graphite, where energy storage technologies represent over 50 percent of projected use by 2040 (IEA, 2022a). Solar PV systems contribute significantly to demand for copper, aluminum, and silver, and wind technologies rely heavily on REEs such as neodymium and dysprosium, due to their role in high-efficiency permanent magnets. Hydrogen technologies continue to drive demand for PGMs, including platinum and iridium, as electrolysis and fuel cell applications scale up. PGMs such as platinum and palladium, essential for hydrogen fuel cells, will also see increased demand.

Parallel to investments in GTTs, upstream investments in mineral development have also intensified. In response to rising global demand for GTMs, investment in critical mineral extraction and processing increased by 20 percent in 2021 and further accelerated by 30 percent in 2022 (IEA, 2023a). Investment in lithium development showed the fastest growth, increasing by 50 percent, followed by copper and nickel. Exploration spending for battery and energy transition minerals rose by 20 percent globally, with lithium exploration alone expanding by 90 percent in one year. Uranium and nickel exploration spending also grew significantly, by 60 and 45 percent, respectively (IEA, 2023a). These trends suggest a reshaping of upstream capital allocation, with GTMs rapidly displacing traditional commodities as the focal point of resource investment strategies. These shifts reflect not only market dynamics, but also a new industrial geography.

China has gained strategic dominance in GTMs. The geography of GTM production and investment is heavily skewed, with China commanding a dominant position across nearly all stages of the value chain. As of 2022, China controlled approximately 60 percent of global production and over 85 percent of global processing capacity for key GTMs such as cobalt, lithium, and REEs (IEA, 2022a; Evans, 2022). China's dominance is not limited to processing. It also accounts for the majority of new investment in mineral development globally, nearly doubling its spending in 2022 alone (IEA, 2023a). This centralization of supply chains in a single country creates structural vulnerabilities for all mineral-exporting economies, including Africa. Africa risks remaining an upstream supplier while rents, learning effects, and industrial capabilities accrue elsewhere. Chinese companies are expanding both upstream and midstream capacity through state-backed financing, overseas mergers and acquisitions, and long-term offtake agreements. The result is a deeply integrated supply chain that connects raw mineral extraction, refining, component manufacturing, and final product assembly, often within Chinese borders. This integrated dominance poses challenges for supply diversification and has catalyzed countervailing policy strategies in the European Union, the United States, and other regions.

3. AFRICA'S GREEN TRANSITION MINERALS: ENDOWMENT, PRODUCTION AND TRADE

Africa's GTM endowment is significant in scale but structurally asymmetric in its geographic and economic manifestation. This section presents a data-driven assessment of the continent's mineral reserves and production profile, identifying core structural features that shape Africa's current role in the GTM economy.

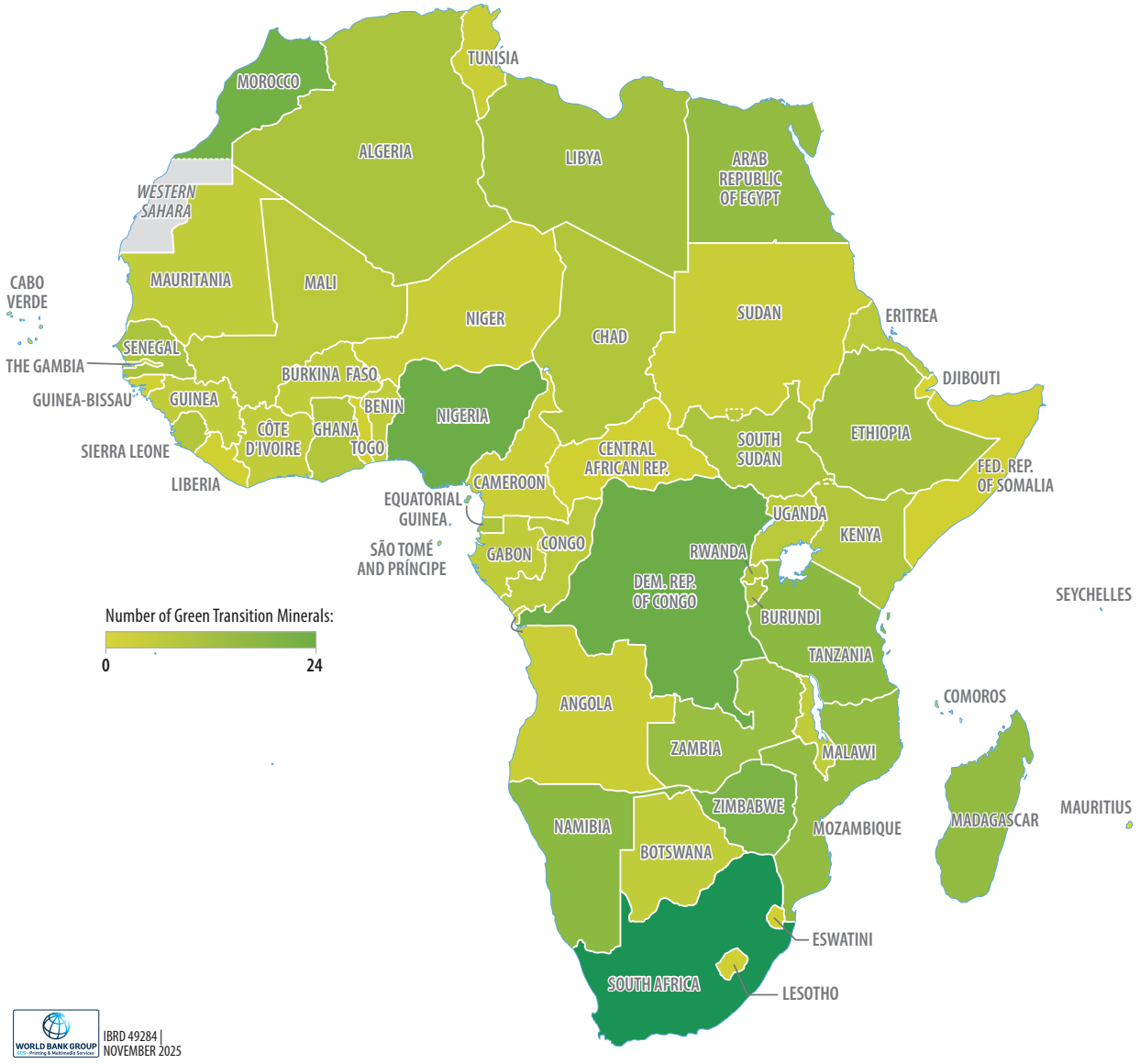
3.1 Africa's GTM Endowment Landscape

Africa is home to numerous natural resources, including metals and minerals. It has been estimated that Africa produces more than 60 metal and mineral products (AfDB, 2023). These numbers are expected to increase as the region has a huge and diverse mineral potential that remains either underexplored or untapped compared to other mining regions – such as Latin America, North America, and Australia (Signé & Johnson, 2021; Cust & Zeufack, 2023).[3] Africa's inability to exploit fully its mineral resources is attributed to limited systematic geological mapping and exploration, driven by lack of investment, geological complexity, regulatory and policy barriers, infrastructure deficits, and limited technology adoption. Despite these constraints, Africa's mineral resource abundance has long been recognized and is a critical component of the continent's economic landscape.

GTMs constitute an essential component of Africa's vast mineral and metal wealth. By some estimates, the continent holds over a fifth of the world's reserves of a dozen metals essential to the green energy transition, including 19 percent of those required for EVs (UNCTAD, 2024). The study reviewed databases, academic literature, and grey sources and found that Africa possesses known deposits, reserves, or active production of most GTMs. Map 1 shows the number of GTMs per African country. Of the 41 identified GTMs, only five—boron, cadmium, gallium, indium, and rhenium—could not be linked to any African country based on credible available sources. Conversely, only six African countries (Cabo Verde, Comoros, Djibouti, Mauritius, São Tomé and Príncipe, and the Seychelles) do not appear on the GTM map, either due to a lack of verified deposits or absence of production activity. The remaining 48 countries in the sample have deposits of or produce at least one of the GTMs. South Africa leads the continent with 24 different GTMs, followed by Nigeria and the Democratic Republic of Congo, each with 14. Together, Africa's diverse GTM positions it as a vital node in the global green transition and formed the basis of a widely shared view that African countries can leverage their transition mineral wealth for structural transformation and broad-based development (Andreoni and Avenyo 2023; Chandler 2022; Diene et al. 2022).

[3]This argument aligns with several mineral discoveries that have emerged on the continent as demand has intensified for various minerals to power the new industrial age intensifies.

Map 1: Number of Green Transition Minerals in Africa, by Country

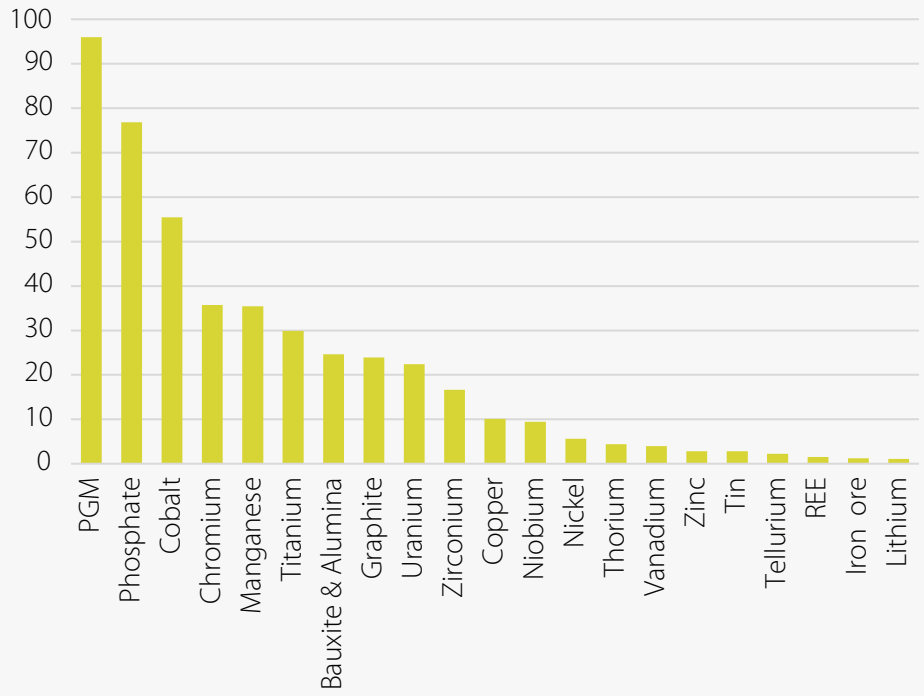


Source: Original map for this study
Note: Mineral counts were based on known deposit, reserves, and production

3.2 Africa's GTMs: From Reserves to Production

Africa holds significant global reserves of several key GTMs, but this prominence is not uniform across all minerals. Figure 6 shows Africa's global shares of reserves of selected GTMs, based on available data. Africa holds the largest global reserves of PGMs, phosphate, and cobalt—accounting for 96 percent of global PGM reserves, 77 percent of phosphate, and 55 percent of cobalt. Africa also accounts for over 10 percent of the global reserves of eight other GTMs—chromium, manganese, titanium, bauxite and alumina, graphite, uranium, zirconium, and copper. However, the continent has a modest share of reserves of certain minerals critical to the future of mobility and energy storage. It holds only 1.1 percent of global lithium reserves, 1.2 percent of iron ore, and 1.5 percent of REEs.

Figure 6: Africa's Reserve Shares of Global Green Transition Minerals



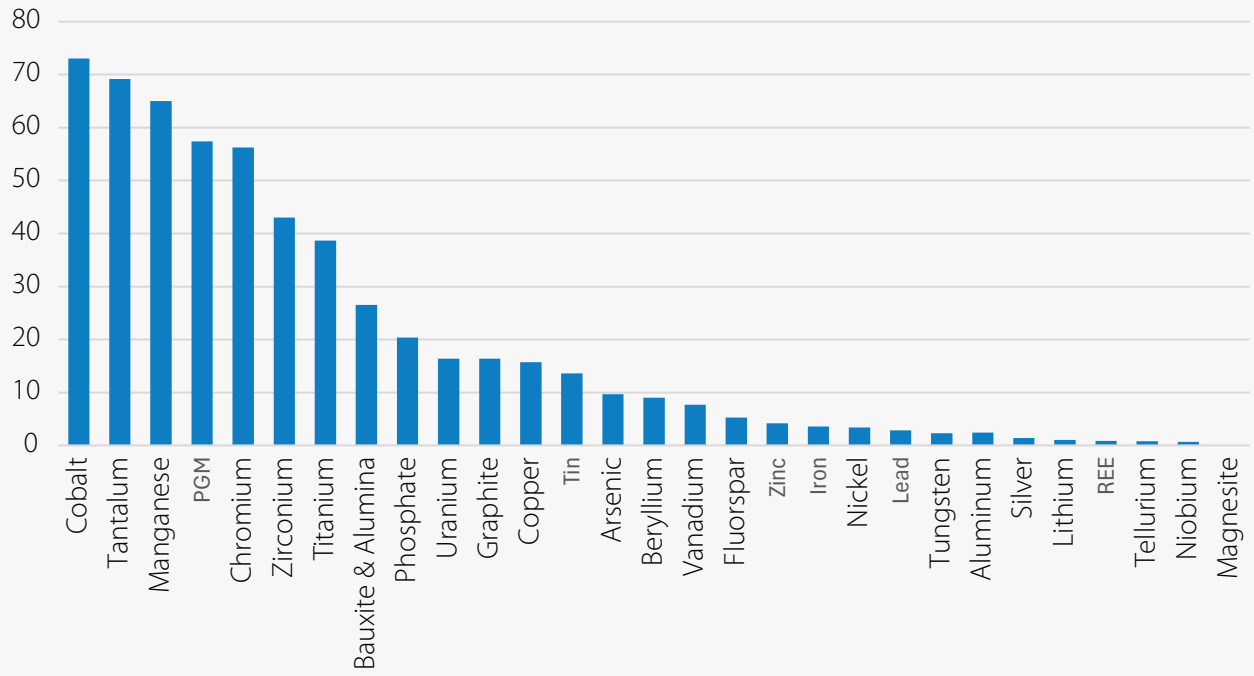
Source: Original figure for this study
Note: Except for PGM, nickel, thorium, and uranium, the original data used to compute the reserve shares were sourced from the US Geological Survey. Africa's global reserve shares of PGM and nickel were directly sourced from Diene et al. (2022) and UNCTAD (2024), respectively. The data used to compute Africa's global reserve shares of thorium and uranium were sourced from the World Population Review.
PGM=platinum group metals; REE=rare earth elements.

Africa's limited reserve of some GTMs reflect both geological endowments and historical underinvestment in mineral exploration. Although low shares of certain minerals may indicate natural scarcity, they are also a function of limited exploration. Many mineral-rich regions in Africa remain underexplored due to financing constraints, insufficient geological mapping, inadequate data infrastructure, and governance risks that deter investment (Andreoni and Avenyo 2023; Cust and Zeufack 2023; Signé and Johnson 2021). This suggests that the continent's full GTM poten-

tial is likely underestimated. Enhanced geological survey, improved transparency, and strategic investment in exploration could uncover new reserves, particularly of minerals like lithium and REEs, for which global demand is projected to surge. In this context, building national and regional capacities for mineral intelligence is essential to inform policy, attract investment, and expand the known mineral resource base.

Africa also plays a significant role in the global production of GTMs, although this mirrors its reserve base in an uneven and mineral-specific pattern. Figure 7 illustrates Africa's global production shares of selected GTMs based on available data. The continent's production profile generally aligns with its reserve base, showing exceptional strength in some minerals and weakness in others. Notably, Africa accounts for over a 10 percent share in fourteen GTMs, including cobalt (73 percent), tantalum (69 percent), manganese (65 percent), PGM (57 percent), chromium (56 percent), zirconium (43 percent), titanium (38.7 percent), bauxite (27 percent), phosphate (20.4 percent), graphite (16.4 percent), uranium (16.4 percent), copper (15.7 percent), and tin (14 percent). These production figures reflect Africa's existing extraction infrastructure and relative competitiveness in specific GTMs, especially those already embedded in GVCs. Minerals such as cobalt from the Democratic Republic of Congo and PGMs from South Africa have become central to the global energy and automotive sectors. However, for some other minerals, such as lithium, REEs, nickel, and zinc, Africa remains a marginal producer despite growing global demand. This divergence underscores the need to enhance technical capacity, the investment environments, and value chain integration to convert mineral wealth into production capabilities.

Figure 7: Africa's Production Shares of Global Green Transition Minerals



Sources: Data used to compute the productions shares were sourced from World Mining Data. Africa's global production shares of PGM and tellurium were sourced from the British Geological Survey and the US Geological Survey.
Note: PGM = platinum group metals; REE = rare earth elements.

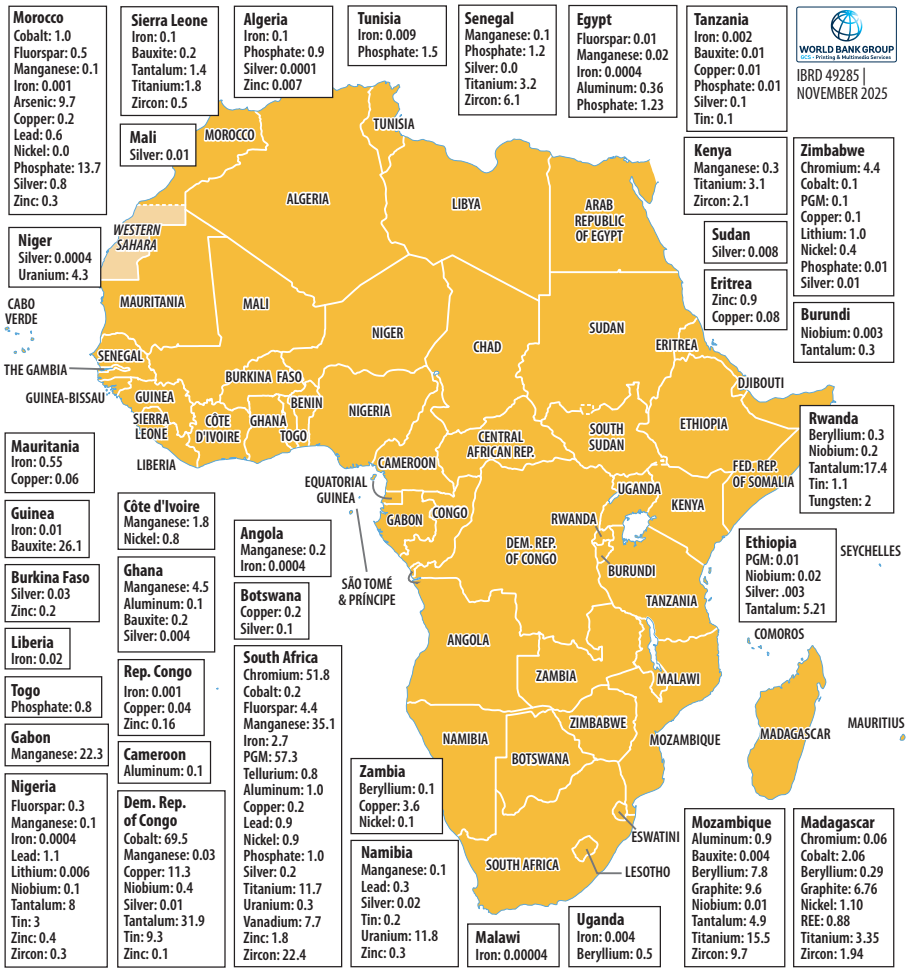
Africa's uneven production landscape in GTMs has been shaped by both geological factors and constraints in extraction capacity. While abundant reserves provide a foundation, translating these into production requires substantial investment in infrastructure, regulatory clarity, skilled labor, and technological capability. In many countries, these enablers remain weak or underdeveloped. Limited domestic industrial capabilities, outdated mining technologies, and high operational risks have hampered the continent's ability to exploit fully its resource base. Furthermore, global mining firms often focus on a narrow set of minerals based on current market demand, leaving other resources underutilized. For Africa to become a more balanced and competitive producer of a broader range of GTMs, targeted strategies are needed to reduce production bottlenecks, improve institutional capacity, and attract diversified investment in mining and processing.

Africa's overall mineral strength lies in regional aggregation rather than individual country dominance. Despite Africa's impressive continental footprint of GTM reserves and production, these figures mask significant disparities at the national level. Map 2 shows the geography of Africa's GTMs' production. Only a few countries, such as South Africa, Democratic Republic of Congo, and Guinea, contribute substantially to the global production of key GTMs. The majority of African countries have production volumes that are too small to register individually on the global scale. For example, the continent's 16.4 percent share of global graphite production is primarily driven by just two countries: Mozambique (9.61 percent) and Madagascar (6.76 percent). Similarly, Africa's 9 percent global share of beryllium production is a cumulative figure comprising minor contributions from Mozambique (7.8 percent), Uganda (0.51 percent), Madagascar (0.3 percent), Rwanda (0.3 percent), and Zambia (0.10 percent). A similar pattern emerges when considering the GTM reserves. This fragmented reserve and production landscape undermines the strategic leverage of individual states when engaging with global lead firms, many of which can easily diversify or shift their sourcing to alternative suppliers. In this context, mineral-rich countries with small global market shares face difficulty asserting influence over pricing, contract terms, or the localization of processing activities. This underscores the reality that Africa's collective strength in GTMs depends on regional synergies, rather than any single national powerhouse.

The limited global reserve and production shares of most African countries constrain their ability to capture higher value from GTMs individually. The fragmented reserves and production landscape weaken individual countries' strategic leverage and bargaining positions in global GTM supply chains, particularly when dealing with multinational firms that can easily shift sourcing to other regions. Hence, the marginal global role of several individual African countries undermines their respective ability to beneficiate minerals or demand improved terms in GTM value chains. Without sufficient leverage, the primary benefit for these countries remains limited to fiscal revenues from raw mineral extraction and exports (such as royalties and export taxes) rather than a catalyst for broader industrial development or technology upgrading. Put differently, due to their limited global significance, most countries are unable to compel downstream actors to invest in beneficiation, technology transfer, or industrial upgrading. Thus, many African countries, risk being confined to low-value extraction roles with limited prospects for industrial upgrading or domestic value addition. This reinforces dependency on volatile commodity markets and weakens the long-term developmental benefits of mineral wealth.

Regional cooperation is vital for building industrial ecosystems and unlocking the full development potential of Africa's GTMs. To mitigate the limitations of fragmentation and small market size, regional integration offers a pathway to pool resources, harmonize policies, and enhance collective bargaining power in global GTM supply chains. By pooling their resources and aligning their policies, African countries with modest or unexploited GTM deposits can negotiate more favorable trade terms, secure better access to global markets, and co-develop regional processing and manufacturing hubs. Such cooperation would help unlock economies of scale, reduce intra-African competition, and enhance collective resilience in global markets. Beyond joint negotiations, regional integration can foster shared infrastructure development and coordinated investment in refining, manufacturing, and research and development (R&D) capabilities. This is particularly important given the lack of regional public goods, such as transport corridors, reliable energy supply, and cross-border regulatory harmonization, which currently undermines the competitiveness of Africa's mining sector. Strategically leveraging GTMs via regional cooperation channels could ensure that Africa's GTM wealth not only supports the global green transition, but also drives transformative change across the continent.

Map 2: The Geography of Africa's Green Transition Mineral Production



Source: Original figure for this study, based on data from World Mining Data, U.S Geological Survey, and British Geological Survey

Despite low global shares at the continental or individual country levels, Africa's GTM reserves and production present a strategic opportunity to build regionally integrated value chains. Several African countries' GTM capacities may be regionally sufficient to serve as the basis for RVCs. This is especially relevant for GTMs that support technologies with immediate application and rising local demand in African markets, such as solar PV, e-mobility solutions, and off-grid energy systems. Leveraging this regional potential would allow African countries to align mineral production with local manufacturing and consumption needs, thereby fostering homegrown self-reinforcing industrial ecosystems. This approach reduces reliance on imported technologies, lowers logistical and transaction costs, and supports the development of technical skills and local enterprises. It also allows mineral-rich but globally small producers to retain more value within the continent, generate employment, and stimulate cross-border investment in infrastructure and innovation.

3.3 Africa's Trade in GTMs

Africa's role in the global green transition is defined not only by its resource base but also by how those resources enter the global economy. This subsection examines the volume, variety, and structure of Africa's GTM exports and their developmental implications. The inferences made based on the export data should be interpreted cautiously, as these data are prone to re-exports. In addition, some minerals share Harmonized System (HS) codes, making it difficult to determine which minerals were exported in those cases. One notable example is HS 811292 and HS 811299, which aggregate minerals such as gallium, germanium, hafnium, indium, niobium, rhenium, and vanadium. Another example is HS 261590, which has the title "Niobium, tantalum, vanadium ores and concentrates." In such instances, the study arbitrarily used the first mineral name that appeared in the description of the HS code when identifying and categorizing GTM-related export products. Using the 6-digit HS4 codes, the study identified 40 broad product categories associated with GTMs in a processed or unprocessed form. Table A2 in the appendix lists these minerals and their corresponding HS codes.

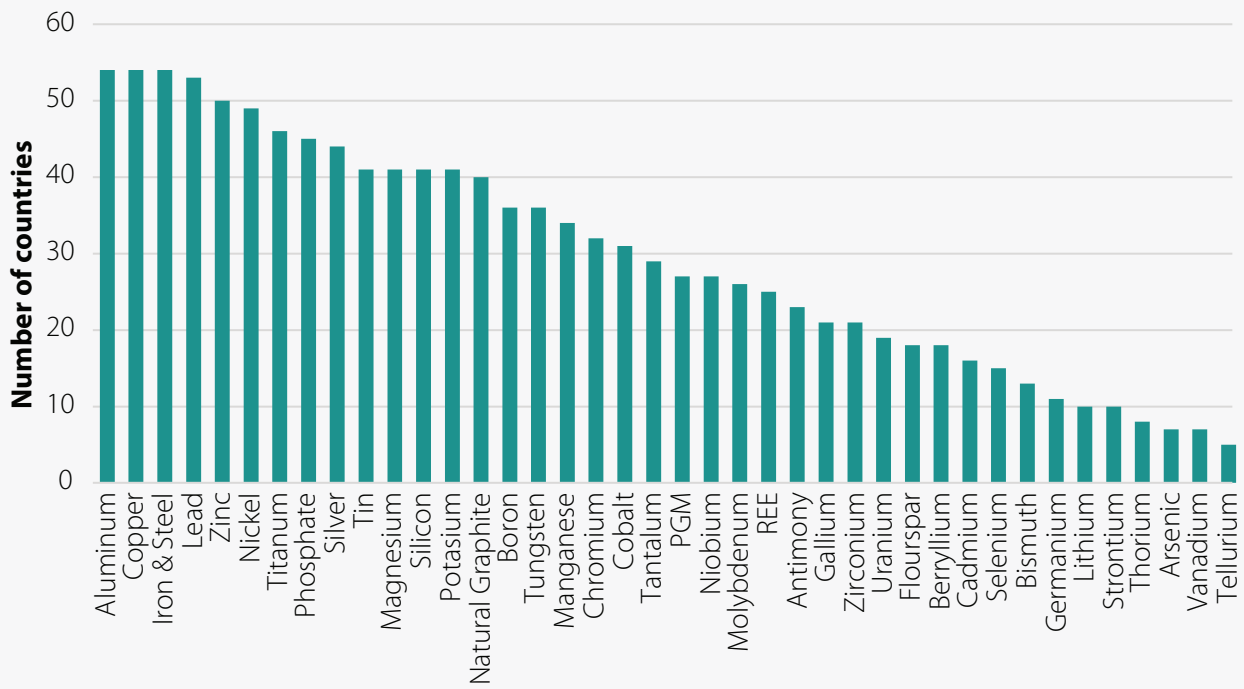
3.3.1 Africa's Global GTM Export

Africa participates extensively in GTM trade, although export activity remains uneven across minerals. Figure 8 illustrates the number of African countries exporting each GTMs. All 40 identified GTMs are exported from Africa, and every African country exports at least one. On average, 29 countries export at least one mineral, and the average African country exports 22. This widespread export activity underscores Africa's substantial global trade engagement in GTMs. However, the depth and breadth of export participation differ notably across minerals. Aluminum, copper, and iron are the most widely exported, with all 54 African countries involved in their trade. Lead and zinc follow closely, with 53 and 50 exporters, respectively. At the opposite end, more specialized minerals like tellurium, vanadium, and arsenic are exported by only five to seven countries. These disparities reflect both differences in geological endowment and the uneven development of extraction and export infrastructure.

Export diversification at the country level is highly concentrated, with a few countries dominating GTM trade. Map 3 highlights the variety of products related to GTMs exported by

individual African countries in 2017-22. Export activity was not only uneven across minerals but also heavily concentrated in a few key African countries. On average, African countries exported 22 GTMs. South Africa stands out as the most diversified exporter, exporting all 40 of the identified GTMs. This is followed by Nigeria and Morocco, each exporting 38 GTMs. Along with Mozambique, these four countries account for a significant share of the continent's GTM exports. In contrast, countries such as the Comoros and South Sudan exported only one or two products. Compared to the mineral occurrence shown in Map 1, the findings confirm a clear positive correlation between resource endowment and export diversity. Countries with more extensive or better-explored deposits are more likely to exhibit export diversity, suggesting that resource endowment remains the primary determinant of GTM trade in Africa (see Figure A1 in the appendix).

Figure 8: Variety of Green Tansition Minerals-Related Products Exported from Africa, 2017-2022

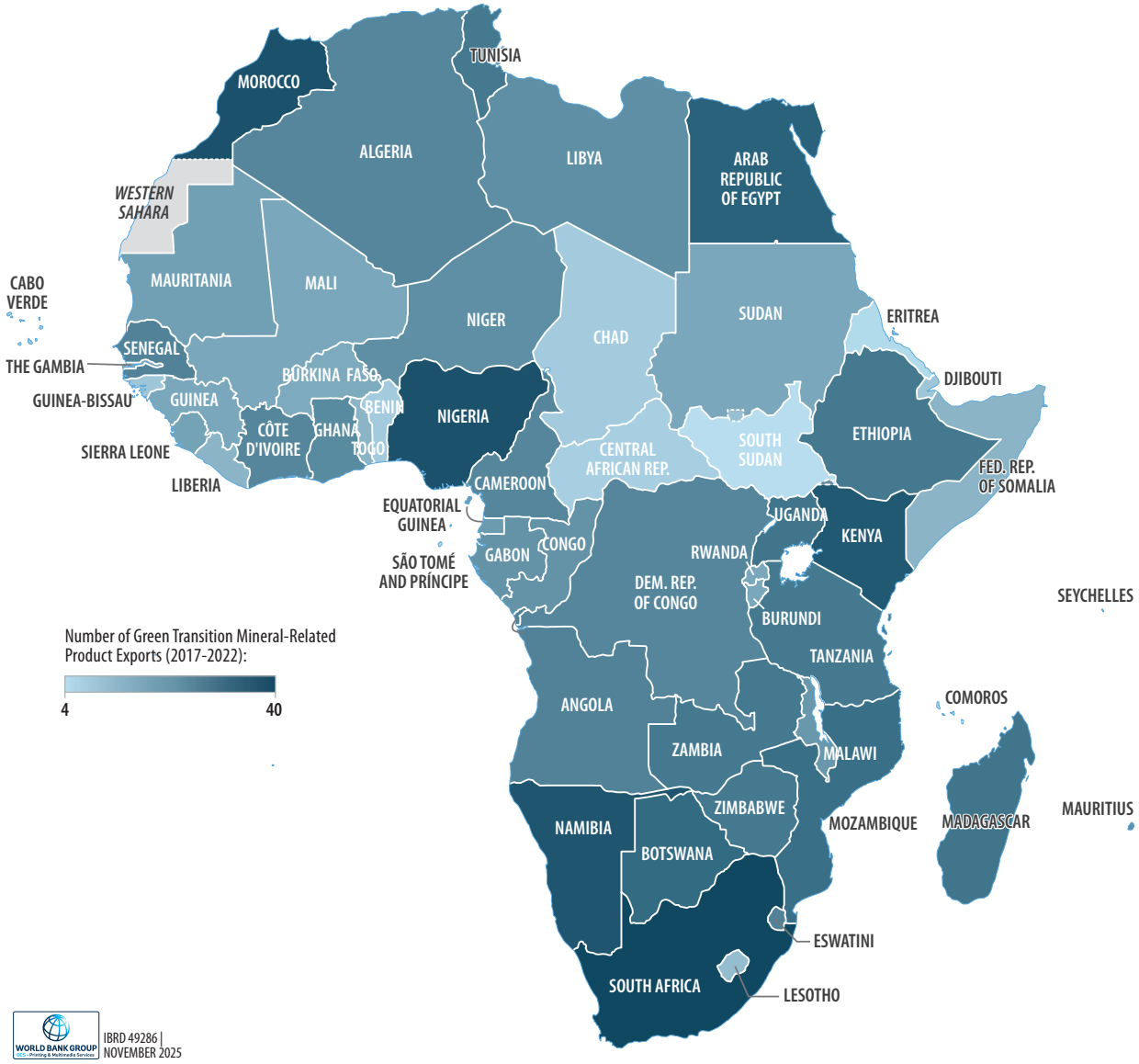


Source: Original figure for this study, based on data from BACI-CEPII.
Note: PGM = platinum group metals; REE = rare earth elements.

Africa holds competitive global export shares of a select group of high-volume GTMs. Figure 9 provides an overview of Africa's global export shares across all identified GTMs. The continent reported positive export values for all the minerals in 2022, reaffirming its active participation in global GTM value chains. Yet, export intensity varied sharply. Africa's global export share ranged from just 0.01 percent for tellurium to a commanding 62 percent for cobalt and niobium. The continent's weakest global positions are found in 12 minerals—including silicon, arsenic, gallium, REEs, and lithium—where export shares fell well below 5 percent. Conversely, Africa's share exceeded 10 percent in 15 minerals—cobalt, niobium, manganese, zirconium, chromium, phosphate, thorium, PGMs, tantalum, graphite, titanium, vanadium, fluorspar, copper, and tin. These are typically the same minerals for which Africa is a major producer, reinforcing the continent's dual

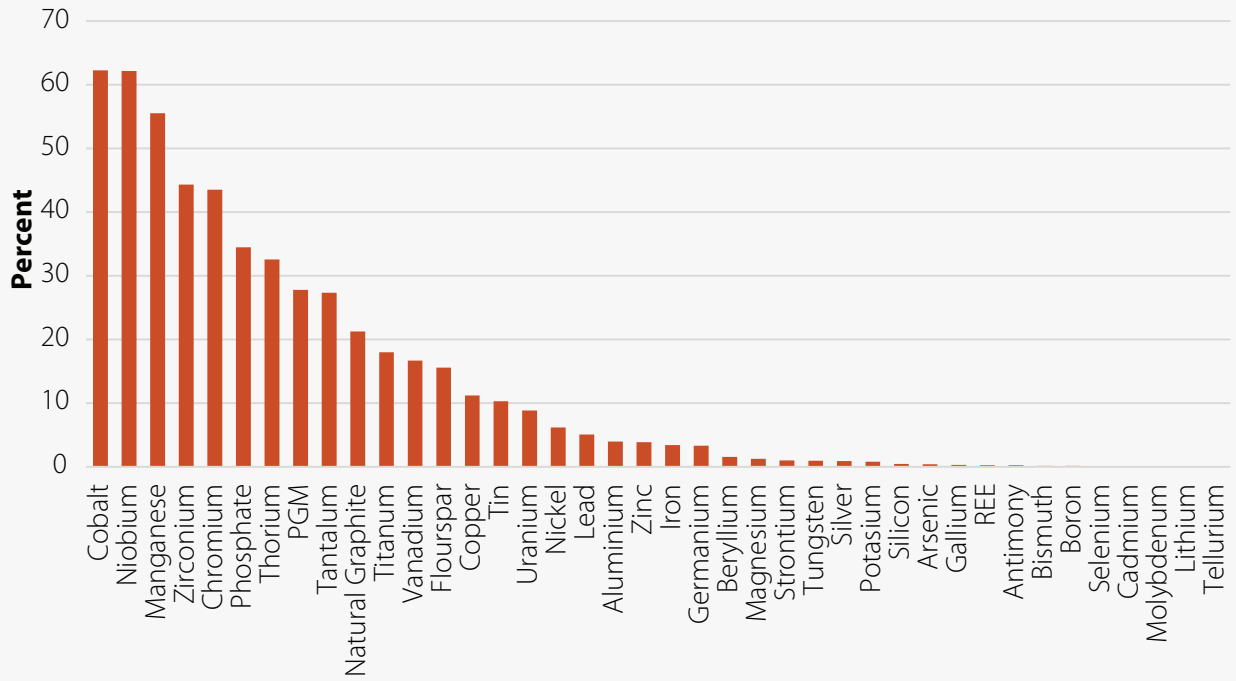
role as both a resource base and global supplier in critical GTM categories.

Map 3: Number of Green Transition Mineral-Related Products Exported from Africa, by Country, 2017-2022



Source: Original figure for this study, based on data from BACI-CEPII

Figure 9: Africa's Global Export Shares of Green Transition Minerals



Source: Original figure for this study, based on data from BACI-CEPII.
Note: PGM = platinum group metals; REE = rare earth elements.

Africa's trade competitiveness is led by a small group of dominant exporters. Table 1 identifies the top five African exporters for each GTM. South Africa leads the continent by a wide margin, ranking first in 17 minerals and second in 12 others. For several minerals, South Africa holds export shares of over 10 percent of the global totals—such as zirconium (27 percent), vanadium (16.7 percent), PGMs (27.7 percent), manganese (30.8 percent), fluorspar (12.5 percent), and chromium (41.4 percent). Beyond South Africa, only a few countries show similar levels of global competitiveness: Madagascar leads in thorium (20.1 percent), Morocco in phosphate (18.7 percent), Gabon in manganese (18.2 percent), Mozambique in graphite (12.4 percent), and the Democratic Republic of Congo in cobalt (56.1 percent). Outside the leading exporters, most African countries exhibit low global export shares of their respective GTMs—often below 1 percent. In many instances, the combined global export share of the top five African exporters is below 10 percent. This fragmentation suggests that significant global presence often requires aggregation across multiple African exporters. Consequently, Africa's true competitive strength in GTMs appears more prominent at the continental level than at the level of individual countries, similar to what the evidence in reserve and production show.. This calls for stronger regional coordination and integration to scale competitiveness and enhance Africa's bargaining power in the global GTM markets.[4]

[4]The uneven distribution of trade capabilities also highlights challenges for RVC development, where scale and specialization are critical. Without coordinated strategies, many countries risk remaining marginal players in GTM trade, dependent on a narrow set of exports with limited value addition.

Table 1. Top Five African Green Transition Mineral-Related Product Exporters, 2022

Zirconium	South Africa (27%)	Senegal (6%)	Mozambique (5.6%)	Kenya (2.6%)	Madagascar (1.3%)
Zinc	South Africa (1.4%)	Eritrea (0.8%)	Burkina Faso (0.4%)	Namibia (0.3%)	Nigeria (0.3%)
Vanadium	South Africa (16.7%)	Zambia (0.02%)	Nigeria (0.00001%)	Not Available	
Uranium	Namibia (6.2%)	Niger (2.1%)	South Africa (0.6%)	Senegal (0.0002%)	Egypt (0.0001%)
Tungsten	South Africa (0.4%)	Rwanda (0.3%)	Burundi (0.1%)	Congo (0.04%)	Nigeria (0.01%)
Titanum	South Africa (6.1%)	Mozambique (3.2%)	Kenya (2.7%)	Sierra Leone (2.1%)	Senegal (1.8%)
Tin	DR Congo (4.9%)	Nigeria (2.5%)	Congo (1.2%)	Rwanda (0.8%)	Tanzania (0.3%)
Thorium	Madagascar (20.1%)	Nigeria (9.3%)	DR Congo (3.1%)	South Africa (0.001%)	Tanzania (0.00002%)
Tellurium	South Africa (0.009%)	Mozambique (0.00003%)	Not Available		
Tantalum	DR Congo (6.4%)	Rwanda (6.4%)	Congo (5.9%)	Mozambique (2.2%)	Nigeria (1.8%)
Strontium	South Africa (1%)	Namibia (0.02%)	Gambia (0.00005%)	Morocco (0.00001%)	Zimbabwe (0.005%)
Silver	South Africa (0.4%)	Morocco (0.4%)	Namibia (0.04%)	Egypt (0.03%)	Chad (0.02%)
Selenium	South Africa (0.1%)	Ghana (0.02%)	Zambia (0.001%)	Nigeria (0.0002%)	Kenya (0.0002%)
Silicon	Egypt (0.3%)	South Africa (0.1%)	Equatorial Guinea (0.1%)	Tanzania (0.1%)	Kenya (0.04%)
REE	Nigeria (0.1%)	South Africa (0.1%)	Kenya (0.001%)	Tunisia (0.0001%)	Morocco (0.00002%)
Potassium	Egypt (0.4%)	South Africa (0.1%)	Mauritius (0.1%)	Morocco (0.04%)	Mozambique (0.04%)
Phosphate	Morocco (18.7%)	Senegal (5.3%)	Egypt (2.8%)	South Africa (2.4%)	Tunisia (2.4%)
PGM	South Africa (27.7%)	Zimbabwe (0.04%)	Kenya (0.01%)	Egypt (0.001%)	Zambia (0.0005%)
Niobium	Burundi (1.7%)	Not Available			
Nickel	Zimbabwe (2%)	South Africa (1.8%)	Madagascar (1.6%)	Zambia (0.4%)	Cote d'Ivoire (0.3%)
Molybdenum	Ethiopia (0.002%)	South Africa (0.008%)	Botswana (0.004%)	Equatorial Guinea 0.0001%)	Kenya (0.00004%)
Manganese	South Africa (30.8%)	Gabon (18.2%)	Ghana (4.4%)	Cote d'Ivoire (0.9%)	Morocco (0.04%)
Magnesium	Tanzania (0.8%)	South Africa (0.11%)	Namibia (0.08%)	Egypt (0.07%)	Zambia (0.07%)
Lithium	Zimbabwe (0.0013%)	Nigeria (0.0078%)	South Africa (0.0008%)	Kenya (0.0004%)	Morocco (0.00002%)
Lead	Nigeria (1.5%)	South Africa (1.0%)	Morocco (0.6%)	Ghana (0.3%)	Tanzania (0.3%)
Iron	South Africa (2.2%)	Egypt (0.23%)	Mauritania (0.23%)	Algeria (0.14%)	Sierra Leone (0.07%)
Graphite	Mozambique (12.4%)	Madagascar (8.3%)	Tanzania (0.5%)	South Africa (0.02%)	Ethiopia (0.01%)
germanium	South Africa (3.3%)	Egypt (0.00361%)	Seychelles (0.00164%)	Uganda (0.00001%)	
gallium	South Africa (0.2%)	Ethiopia (0.1%)	Namibia (0.00001%)	Nigeria (0.00003%)	Angola (0.000002%)
Flourspar	South Africa (12.5%)	Morocco (1.1%)	Mozambique (0.6%)	Nigeria (0.5%)	Zambia (0.46%)
Copper	DR Congo (4.7%)	Zambia (2.8%)	Congo (1.1%)	South Africa (0.8%)	Tanzania (0.7%)
Cobalt	DR Congo (56.1%)	South Africa (2.1%)	Madagascar (1.6%)	Namibia (1.1%)	Morocco (0.8%)
Chromium	South Africa (41.4%)	Zimbabwe (1.5%)	Mozambique (0.4%)	Madagascar (0.1%)	Botswana (0.03%)
Cadmium	Botswana (0.054%)	Nigeria (0.013%)	Madagascar (0.005%)	South Africa (0.004%)	Mauritius (0.003%)
Boron	Kenya (0.006%)	South Africa (0.1%)	Egypt (0.013%)	Ethiopia (0.011%)	Mauritius (0.006%)
Bismuth	Guinea (0.1%)	South Africa (0.04%)	Equatorial Guinea (0.0002%)	Not Available	
Beryllium	Botswana (1.3%)	Nigeria (0.1%)	Madagascar (0.1%)	South Africa (0.1%)	Zambia (0.002%)
Arsenic	South Africa (0.4%)	Not Available			
Antimony	Mozambique (0.1%)	South Africa (0.1%)	Morocco (0.01%)	Nigeria (0.005%)	Zimbabwe (0.03%)
Aluminum	Guinea (1.6%)	South Africa (0.8%)	Egypt (0.3%)	Mozambique (0.7%)	Nigeria (0.1%)

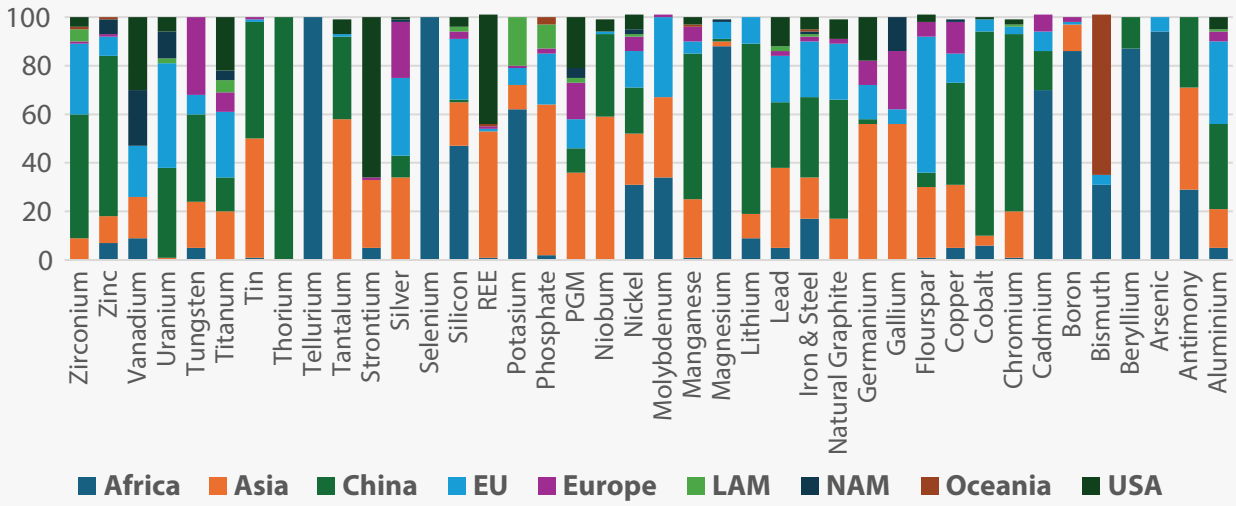
Source: Original table for this study, based on data from BACI-CEPII.
Note: The values in parentheses are percents of Africa's total green transition mineral exports
PGM = platinum group metals; REE = rare earth elements.

3.3.2 Export Destinations and Trade Partners

Asia, and especially China, dominates as the primary export destination for Africa's GTMs. Figure 10 illustrates the 2022 export destinations of Africa's GTMs across nine regions: intra-Africa, China, Asia (excluding China), the European Union, Europe (excluding the European Union), Latin America and the Caribbean, the United States, North America (excluding the United States), and Oceania. China emerges as the top most export destination, accounting for a substantial share of Africa's GTM exports. The EU ranks as the second-largest market, followed by other European countries and the United States. China's role is particularly dominant, serving as the top destination for 16 out of 40 GTMs with an export share averaging over 30 percent across these minerals (see Table A4 in the appendix). China is also the second-largest importer of six additional GTMs–uranium, titanium, nickel, cadmium, beryllium, and antimony. Other Asian countries such as India, Japan, Malaysia, and Thailand appear prominently as major African mineral importers. In contrast, Africa's GTMs trade with the USA and Europe is relatively limited, both in volume and breadth.

The United States plays a marginal role in Africa's GTM exports, and the EU's engagement is limited to a few key countries. Table A4 in the appendix lists the top five export destinations for each mineral. The United States ranks as the top export destination for only two GTMs: strontium (66.3 percent) and titanium (21.6 percent). It appears among the top five destinations for a few other minerals, but its export share exceeds 10 percent in three additional cases—PGM (20.6 percent), lead (11.9 percent), and germanium (18 percent). This reflects a relatively narrow GTMs trade profile between Africa and the United States. The European Union's involvement is similarly limited. Only a handful of countries—Germany, Spain, Italy, and Belgium—appear consistently among the top European importers of African GTMs. The United Kingdom also plays a modest role among the broader European region but does not feature prominently as a top destination across most minerals. Overall, Africa's GTMs trade with the U.S and Europe is concentrated in a few minerals and limited in both depth and diversification.

Figure 10: Africa's Green Transition Mineral–Related Products' Export Destinations, 2022



Source: Original figure for this study, based on data from BACI-CEPII.
Note: The values in the figure are percents of Africa's green transition mineral exports. <is this note correct?> EU = European Union; LAM = Latin America and the Caribbean; NAM = North America; PGM = platinum group metals; REE = rare earth elements.

Intra-African trade in GTMs is highly fragmented and concentrated in a limited set of minerals. While intra-Africa trade exists, its significance varies widely across GTMs. Among the 40 GTM,, intra-African trade has the highest export share in only 11 minerals, including selenium (100 percent), tellurium (99.6 percent), arsenic (94 percent), beryllium (87 percent), magnesium (88 percent), boron (86 percent), cadmium (70 percent), potassium (62 percent), silicon (47 percent), molybdenum (34 percent), and nickel (31 percent). In contrast, for the majority of the remaining 29 minerals, intra-African trade accounts for less than 8.5 percent of exports. Some exceptions include modest intra-African trade shares for iron and steel (17 percent), bismuth (31 percent), and antimony (29 percent). These patterns suggest that regional GTMs trade is not only underdeveloped but also highly concentrated in just a few minerals. Fragmentation in trade routes and infrastructure, coupled with limited industrial capacity, partly explains the uneven nature of intra-African GTM flows.

Only a few African countries serve as key intra-African trade hubs for GTMs. Only a handful of African countries consistently rank as top destinations for specific minerals. Zimbabwe is the leading destination for tellurium (64 percent) and boron (26.1 percent), while Mozambique accounts for a dominant share of selenium imports (48.8 percent). South Africa emerges as the top importer of nickel (31.1 percent) and cadmium (68 percent), and the Democratic Republic of Congo leads in magnesium (74.9 percent). Botswana and Kenya also appear as major importers for arsenic and selenium, respectively. Other countries with notable import shares include Zambia (potassium, 11.7 percent), Djibouti (boron, 15 percent), and Swaziland (arsenic, 17.1 percent). Interestingly, these are the same minerals that Figure 10 identifies as having the highest intra-Africa export shares, underscoring the concentration of regional trade activity in a narrow set of countries and mineral products. In this case, Table A4 in the appendix, reinforces the narrow footprint of intra-African GTMs trade.

Figure 10 and Table A4 demonstrate that intra-African trade constitutes only a minor share of total GTMs exports—both in terms of trade value and the range of mineral products involved. Despite the continent's potential for regional integration and industrial cooperation, Africa's GTMs trade is overwhelmingly directed toward external markets. Asia, and particularly China, emerges as the primary destination, followed by the European Union. China alone accounts for a dominant share of both the volume and diversity of GTMs exported from the continent. This underscores Africa's strategic reliance on extra-continental demand for its critical mineral resources.

3.4 Unpacking the Pattern of China-Africa GTM trade

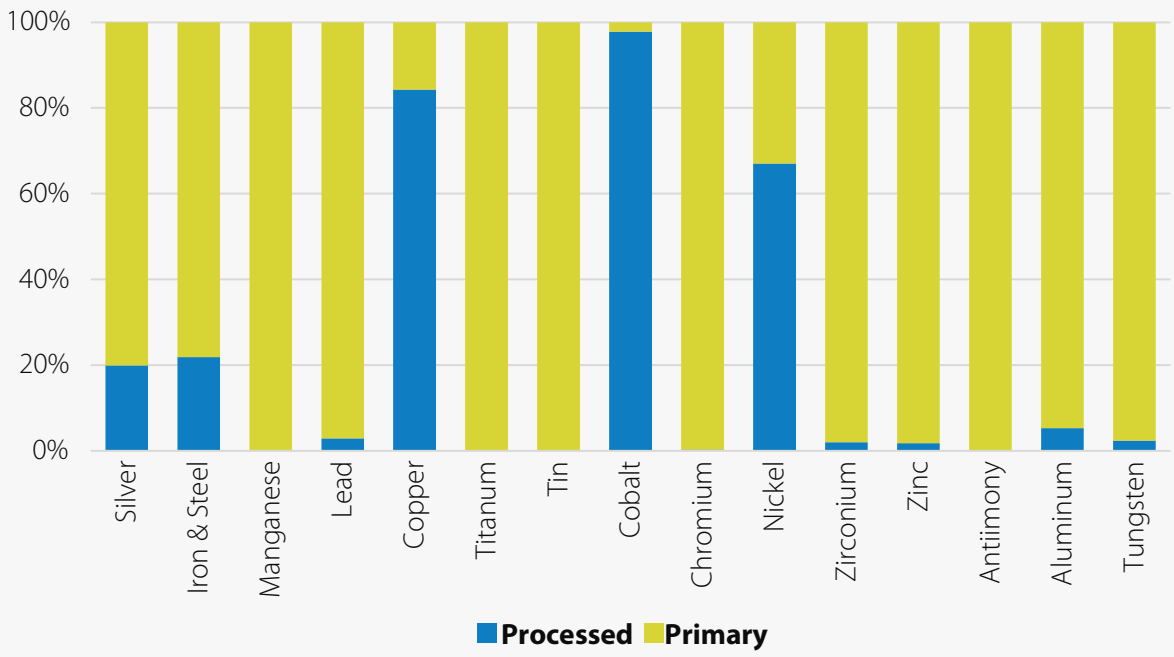
3.4.1 Patterns of China-Africa GTM Trade

Building on the previous section's insights, this section uses the Broad End Category 4 classification to assess the composition of Africa's GTMs exports to China—specifically distinguishing between processed and unprocessed forms. The analysis focuses on 15 GTMs that meet two criteria: (1) China must be among the top five export destinations of those GTMs (see table A4 in the appendix), and (2) the associated HS codes must clearly differentiate between processed and unprocessed forms. These constraints ensure the robustness of the categorization and highlight the minerals that are most relevant to both Africa's industrial potential and China's demand patterns.

Africa primarily exports unprocessed GTMs to China, with the limited exceptions of a few minerals. Figure 11 shows the composition of Africa's GTMs exports to China in 2022. The data show a heavy concentration of unprocessed materials across most mineral types. However, three minerals—cobalt, copper, and nickel—stand out, with a majority of their exports to China arriving in processed form. Specifically, 98 percent of cobalt, 84 percent of copper, and 67 percent of nickel exports were classified as processed. While this suggests some movement up the value chain, the underlying reality is more nuanced.

Even where minerals are processed, Africa remains confined to low-value, intermediate stages of production. A closer examination of the minerals reveals that what is labeled "processed" GTMs exported from Africa to China typically involve only rudimentary or intermediate-level transformation. These limited stages of processing leave substantial value addition and economic benefits to be captured by the importing country. For instance, approximately 63 percent of the processed mineral exports fall under "HS Code 7403", covering refined copper and unwrought alloys. Another 33.5 percent of processed mineral exports fall under "HS Code 7402", representing unrefined copper (blister). The production stages of these minerals reflect intermediate production processes, which offer lower value than semi-finished stages (e.g., copper wires, plates, sheets, tubes, and pipes) or finished products, such as copper-based electrical equipment. We observe similar patterns for nickel and cobalt. Notably, 97 percent of the processed nickel exports to China are associated with the "HS Code 7502", which includes nickel unwrought–an intermediate product. Ninety-nine percent of processed cobalt exports to China, on the other hand, are concentrated on the "HS code 810520", which includes both cobalt mattes and other intermediate products of cobalt

Figure 11: Composition of Africa's Green Transition Mineral Exports to China, 2022



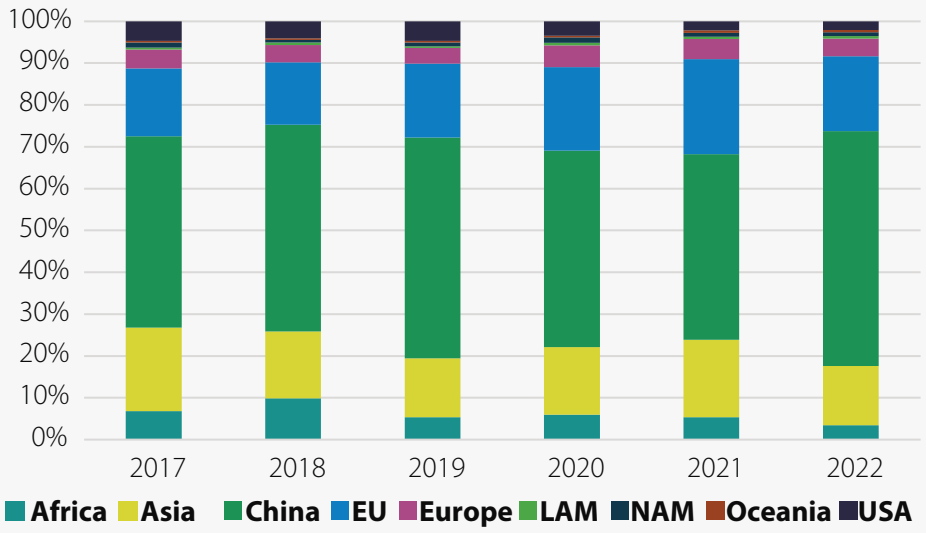
Source: Original figure for this study, based on data from BACI-CEPII

metallurgy, unwrought cobalt, and cobalt powders. Therefore, taken together, the emerging evidence indicates that although China is a dominant trade partner for African GTM, the structure of trade is disproportionately skewed toward unprocessed or minimally processed exports. This reinforces Africa's position as an upstream supplier in GVCs and the continent's limits in capturing downstream value, generating industrial spillovers or developing globally competitive supply chains.

China dominates as a destination not only for Africa's GTMs but also for the continent's broader mineral ore exports. Figure 12 tracks the evolution and distribution of Africa's total mineral ore exports across nine major market destinations. It reveals that over 70 percent of these exports leave the continent annually, with China absorbing more than 40 percent of the total mineral ore volume. The European Union and other Asian countries follow, with each accounting for approximately 16 percent of Africa's ore exports. This pattern illustrates a deep dependency on extra-African demand, with China clearly positioned as the central processing hub for Africa's raw mineral flows.

The concentration of Africa's GTM exports in raw or minimally processed form has deep structural implications. The prevailing trade configuration reflects two interrelated dynamics. First, China has emerged as the undisputed center of gravity for processing Africa's GTMs, entrenching a model of resource extraction and offshore transformation. Second, the fact that most of Africa's GTMs are exported in unprocessed form highlights the continent's continued role as a primary supplier in the global resource economy. These patterns reproduce long-standing asymmetries in Africa's external trade and limit the continent's ability to benefit from value-added manufacturing and technology upgrading. They also raise important questions about the viability and urgency of developing beneficiation strategies within Africa as the green industrial transition accelerates globally.

Figure 12: Africa's Annual Total Mineral Ore Export Destination Shares



Source: Original figure for this study, based on data fron BACI-CEPII

Note: EU = European Union; LAM = Latin America and the Caribbean; NAM = North America.

3.4.2 The Geoeconomics of Africa-China GTM Trade Relation

The emerging evidence that China is the processing hub for Africa's GTMs is not entirely surprising. China currently controls the global processing and refining stages of several GTMs and significantly increased its influence in Africa's mining sector over the past two decades (Ericsson, Lof & Lof, 2020). Notably, while China had modest mining investments in African countries such as Ghana, South Africa, Zambia, and Zimbabwe in 2010, it significantly expanded mining investment in 2013, with copper mines in the Democratic Republic of Congo and manganese production in Gabon. The Chinese government and private mining companies currently engage in mining activities across several African countries, with operations highly highly concentrated in five countries: Democratic Republic of Congo, Guinea, South Africa, Zambia, and Zimbabwe (Risi & Doyle, 2023; Egyin, 2024).

China is currently estimated to account for about 8 percent of Africa's total mine production value, significantly higher than the 0.5 percent it accounted for around 2010 (Ericsson, Lof & Lof, 2020; Risi & Doyle, 2023). While significant, the Chinese share of Africa's total value of mine production remains relatively low as traditional multinational corporations, such as Glencore and Anglo-American, continue to dominate, accounting for two-thirds of Africa's total mining output (Ericsson, Lof & Lof, 2020; Andreoni & Roberts, 2022).

However, China is entrenching itself as a critical player in Africa's mining industry through state-backed investments, bilateral agreements, and commodity-backed deals. Chinese foreign direct investment (FDI) into Africa has targeted the mining sector, surpassed only by the construction sector (Baskaran, 2023; Chen, Fornino, & Rawlings, 2024). These investments have received large state support as their stock value is often dominated by large investments made by Chinese state-owned companies (Chen, Fornino, & Rawlings, 2024). Chinese state-owned enterprises such as China Molybdenum and Zijin Mining have acquired significant stakes in African mining operations, often backed by favorable financing from Chinese banks. Except for Eswatini, China has established strategic partnerships with the remaining 53 African countries and the African Union through its Forum on China-Africa Cooperation. China has also developed and entered into bilateral investment treaties with several African countries (Cotula et al., 2016; Owusu, Tang & Ndubuisi, 2025).

In countries such as Angola, the Democratic Republic of Congo, Ghana, Guinea, and Uganda, China has built or committed to building infrastructure such as railways, ports, and power plants in exchange for access to mineral resources–a development financing strategy that is popularly known as the Angola model or commodity-backed loans. In Ghana, for instance, Sinohydro is investing US$2 billion in infrastructure development in return for refined bauxite over 15 years (Purwins, 2023). Another prominent example is the controversial US$6 billion "minerals-for-infrastructure" Sicomines deal signed in 2007, in which Chinese lenders agreed to fund critical infrastructure projects in exchange for profits from the Sicomines copper and cobalt mines in the Democratic Republic of Congo (Reale, 2021; Baskaran, 2023). China has gained political leverage across Africa, at both the continental and national levels, through extensive financing of public infrastructure projects (Foreign Affairs Committee, 2022).[5]

[5]Although China's political ties with several African nations date back to the Mao Zedong era, economic inter- actions have only surged after China's growth takeoff (Chen, Fornino, & Rawlings, 2024)

Overall, China's geoeconomic approach in Africa revolves around leveraging its economic power to secure long-term resource access. On the one hand, this view is corroborated by the large concentration of Chinese investment in resource-rich African countries. On the other hand, this strategic positioning aligns with China's broader ambition to achieve technological self-sufficiency and reduce reliance on Western-controlled supply chains.[6] Hence, China's engagement in Africa has assumed a state-owned enterprise model detached from multilateral alliances with other international partners to meet this ambition. This has not only ensured a steady supply of raw materials for Chinese industries but has also enabled China to have a stronghold over Africa's resource wealth. This dominance is particularly bolstered by the Belt and Road Initiative, a global infrastructure and investment strategy aimed at enhancing trade connectivity and geopolitical influence. About 49 African countries are currently part of this initiative,[7] which is financing Africa's infrastructure projects in exchange for resource access.

China's dominance in Africa's mineral sector is both an opportunity and a concern. On the positive side, Chinese investments have facilitated the exploitation of minerals that might have remained untapped due to financial and technical barriers. For example, China's involvement in Democratic Republic of Congo's cobalt mines has boosted production, making the country a global leader in cobalt supply.[8] Chinese investments and, more broadly, its development finance into Africa have also helped the continent in overcoming several infrastructure constraints, due largely to the investments being readily available and demand-driven, which appeals to several African countries. Indeed, recent evidence has indicated that China's development finance in several developing countries currently trumps Western donors (Horn, Carmen, & Trebesch, 2019) and has become a predictor of growth in most of these countries (Dong & Fan, 2020; Konte & Ndubuisi, 2024).

However, concerns have arisen about Chinese exploitative practices in Africa, especially those related to labor practices and environmental degradation (Risi & Doyle, 2023; Baskaran, 2023; Burrier & Sheehy, 2023; Owusu, Tang, & Ndubuisi, 2025). Critics argue that China has prioritized resource extraction with limited transfer of skills and technology to local communities (Benabdallah, 2024). This has contributed to the erosion of local industries across Africa while increasing Africa's heavy reliance on China. This is corroborated by the fact that Africa consistently runs a bilateral trade deficit with China. Even worse, while the volume of Chinese-Africa trade has increased markedly over the years, it has been characterized by uneven patterns that undermine Africa's global competitiveness and the prospects of long-term industrial development. That is, while Africa's exports to China are predominantly mineral ores and fuels, China's exports to Africa are predominantly manufactured goods and machinery and items that are generally further along the GVCs (Chen, Fornino, & Rawlings, 2024).

[6]China's "go out" strategy, formulated in 1999, has encouraged Chinese companies to become globally competitive, and it could successfully expand China's influence in critical mineral supply chains (Press et al., 2023).

[7]This excludes the Central African Republic and Niger, whose status is unclear (see Nedopil, 2023).

[8]Currently, China controls over 72 percent of the cobalt and copper mines in the Democratic Republic of Congo, including the Tenge Fungurume Mine, which generates around 12 percent of the world's cobalt production.

4. BETWEEN GREEN TRANSITION MINERALS AND TECHNOLOGIES: NORMATIVE ASSESSMENT OF VALUE ADDITION AND CAPTURE IN AFRICA

Leveraging GTMs for structural transformation requires functional upgrading along the mineral value chains (MVCs) and diversification into the GTT value chains. The evidence presented so far underscores Africa's vast and diverse GTMs, placing the continent at the heart of the green transition revolution. The growing demand for GTMs and the deployment of GTTs present a historic opportunity for Africa to scale up industrialization and unleash a wave of structural transformation in the region. However, having a huge geological mineral deposit does not automatically confer prosperity and shared benefits.

Harnessing mineral potential requires a mineral producer to go beyond the geological fortune to add value to the extracted minerals, use the proceeds effectively, and diversify within the value chain and other linked sectors (Grynspan, 2024). The prospect of Africa taking advantage of its GTMs for structural transformation thus entails two value chain–related upgrading strategies: functional upgrading along the MVCs and diversification into GTT value chains as component producers rather than as mere material suppliers, which is currently the case. The rest of this section provides a normative assessment of these two value-addition and capture strategies.

4.1 Africa's Integration in GTM Value Chains

The MVCs encompass the entire process from discovery of minerals to end-use and reuse. This comprises a sequence of activities that can be broadly classified into three segments: upstream (exploration and extraction), midstream (processing and beneficiation), and downstream (product development and recycling). Although all mineral-related activities can be carried out in a country, they are often globally fragmented, with factors such as endowment of natural resources, production and technological capability, capital and labor cost, and market extent determining the country's specialization in a MVC. Each segment of the value chain commands value, varying both within and across the MVC segments. These values are rents and, therefore, serve as incentives for countries to integrate into the value chain or upgrade functionally for those that are already integrated.

Functional upgrading—moving from extraction to higher-value activities—is key to capturing mineral wealth. From a dynamic perspective, this means moving from lower value-added functions such as extraction to focus on higher value-added activities in the intermediate and final stages of mineral production, which have a higher potential to generate and capture greater value. Local processing and refining capabilities are therefore not just desirable—they are indispensable. For instance, the Democratic Republic of Congo has shown the transformative impact of functional upgrading. By refining cobalt locally, the the country increased its unit price from US$5.8 per kilogram at extraction to US$16.2 per kilogram after processing. This value addition translated into export revenues of US$6 billion for processed cobalt in 2022, compared to only US$167 million for unprocessed exports (UNCTAD, 2023a).

Local mineral processing generates broader economic benefits beyond higher revenues, including job creation, economic diversification, and resilience. The benefits of functional upgrading are not limited to higher revenues as demonstrated by the case of the Democratic Republic of Congo. It unlocks broader economic and social benefits. For example, local beneficiation insulates economies from the commodity price volatility often associated with raw minerals. Local beneficiation also creates quality jobs, develops supply chains, and stimulates downstream industries that rely on mineral inputs (Hirschman, 1958; Bocoum, 2000; Li et al., 2022; Ojaleye & Narayanan, 2022; Lopes et al., 2023). Local refining capabilities can serve as a nucleus for industrialization (Kaplinsky, Morris & Kaplan, 2011; Li & Zhou, 2024), encouraging domestic entrepreneurship and innovation. In this regard, mineral processing is not just about adding value—it is a key pillar of structural transformation and industrial upgrading. This raises a critical question: "***To what extent are Africa's vast GTMs processed locally to add value?***"

Processed GTM exports exist but remain limited in scope. The trade diagnosis in the previous section offered insights into Africa's processed GTM landscape, revealing both emerging capabilities and enduring constraints in mineral value addition. A number of African countries currently export processed GTMs such as cadmium, tellurium, and platinum group metals (PGMs), as shown in figure 10. Further analysis, reflected in figure 11, shows processed mineral exports for silver, iron, lead, cobalt, copper, zirconium, zinc, aluminum, and tungsten. These exports confirm that there are some mineral processing capabilities across the continent. However, the scale and distribution of these processed exports remain uneven, with significant disparities across countries and mineral categories.

Africa's processed GTM exports are highly concentrated and technologically shallow. A closer examination of trade patterns reveals two critical limitations. First, Africa's processed GTM exports represent only a minor share of the continent's total mineral trade and are largely concentrated in a few countries, notably the Democratic Republic of Congo, Morocco, South Africa, and Zambia. This suggests that few African countries have reached the necessary thresholds in infrastructure, policy coherence, and industrial capacity to sustain mineral processing at scale. In contrast, many other African countries exhibit sporadic or low-volume processed exports, underscoring a disconnect between resource endowments and industrial capabilities. Second, the level of processing embedded in these exports is limited in terms of technological sophistication and local value capture. Many so-called "processed" GTMs exported from Africa still require significant additional refining or transformation in foreign markets before they can be used in high-tech industries. This indicates missed opportunities for Africa, as a considerable portion of the value of its minerals is captured by the foreign market. The pattern reflects a limited structural shift away from Africa's traditional role as a supplier of raw or semi-processed materials, which limits the region's ability to drive development through resource-based industrialization.

GTM processing capacity exists but remains modest and geographically uneven. Data from the British Geological Survey (2017–2022) confirm that several African countries have engaged in mineral processing. Between 2017 and 2022, Cameroon, the Arab Republic of Egypt, Ghana, Mozambique, and South Africa consistently produced aluminum, the processed form of bauxite.[9] The

[9] Over this period, Cameroon produced an average of 67,850 metric tons of aluminum; Egypt, 276,500 metric tons;

Democratic Republic of Congo consistently produced smelted copper from 2019 to 2022, and Namibia, Tanzania, and Zambia did so between 2017 and 2022.[10] Furthermore, Morocco, Madagascar, and South Africa regularly produced refined cobalt during the same period.[11] While promising, the number of players and processing volumes across these minerals remain modest. This is further corroborated in a recent study by de Oliveira et al. (2023). The study identified 215 mineral processing facilities across the continent that are engaged with minerals critical to the European Union. However, they found that while mineral processing is occurring, it is heavily concentrated in key countries such as South Africa, Democratic Republic of Congo, Zambia, Morocco, and Zimbabwe (see Figure 16). Approximately half of these facilities are involved in comminution—which is the initial stage of the beneficiation process (see Figure A2 in the appendix). This raises important questions about the depth of Africa's value addition. Furthermore, many of these facilities focus primarily on copper processing (refer to figure A3 in the appendix), limiting the potential benefits of processing a wider range of minerals.

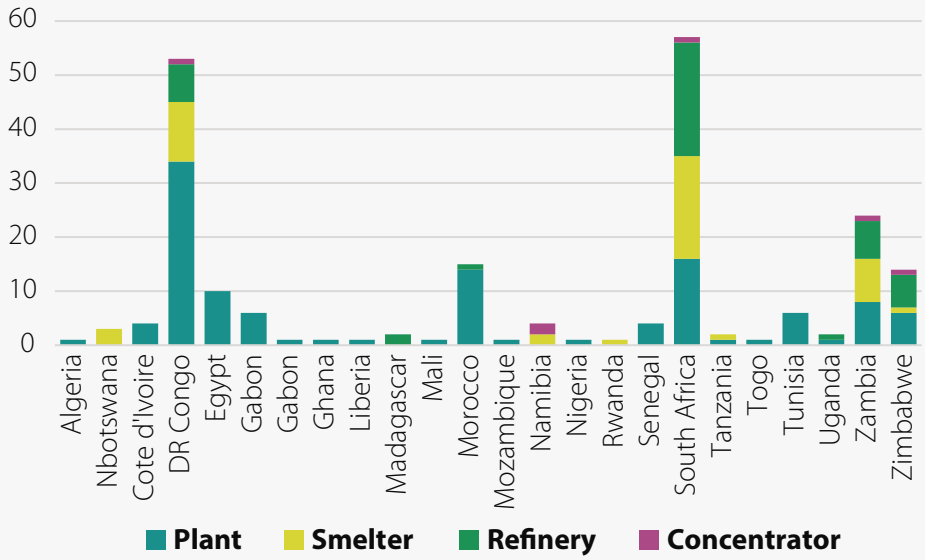
Structural barriers continue to inhibit Africa's ability to scale up mineral processing. The preceding discussion affirmed the existence of GTM processing in Africa, but also underscored a paradox at the heart of Africa's mineral economy: Despite Africa's vast resource base and the growing international demand for GTMs, the continent has yet to achieve the scale and complexity of mineral processing necessary to drive structural transformation. This is further corroborated by the fact that Africa's contribution of processed minerals to global production is considerably low. Africa's limited mineral processing capacity stems from several intertwined challenges–underdeveloped technological and industrial capabilities, high political and financial risks, energy shortages, and inadequate transportation networks (Hendrix, 2022). Although they are important, FDI inflows have disproportionately targeted extraction rather than processing. A key reason is the vertically integrated nature of global mining companies that prefer to ship raw inputs to overseas processing hubs. Another major impediment is the fragmented nature of African markets, which makes it difficult for firms to achieve economies of scale. This issue is even more pronounced for green minerals, as the continent has not yet developed widespread markets for GTTs that use these processed materials. As a result, global firms prefer to invest in regions where upstream supply and downstream demand are co-located, further marginalizing Africa in the higher-value segments of MVCs. Africa's challenge is not only one of capacity, but one of limited local demand, strategic coordination and regional integration. To move beyond scattered efforts and marginal export shares, Africa must embrace regional integration as the foundation for green industrialization and broad-based resource-led structural transformation.

Ghana, 42,089 metric tons; Mozambique, 570,913 metric tons; and South Africa, 716,000 metric tons.

[10]Over these periods, the Democratic Republic of Congo smelted an average of 62,492 metric tons of copper; Namibia, 37,490 metric tons; South Africa, 16,800 metric tons; Tanzania, 50,286 metric tons; and Zambia, 647,959 metric tons.

[11]Madagascar refined an average of 2,550 metric tons of cobalt over this period. The averages for Morocco and South Africa were 2,005 and 787 metric tons, respectively.

Figure 13: African Countries with the Most Mineral Processing Facilities



Source: Original figure for this study, based on data from de Oliveira et al. (2023)
Note: A "plant" is a general term for various industrial facilities, while a "smelter" focuses on extracting metals, a "concentrator" enhances the concentration of valuable minerals within raw ore and a "refinery" mostly deals with refining petroleum or chemicals (de Oliveira et al. 2023)

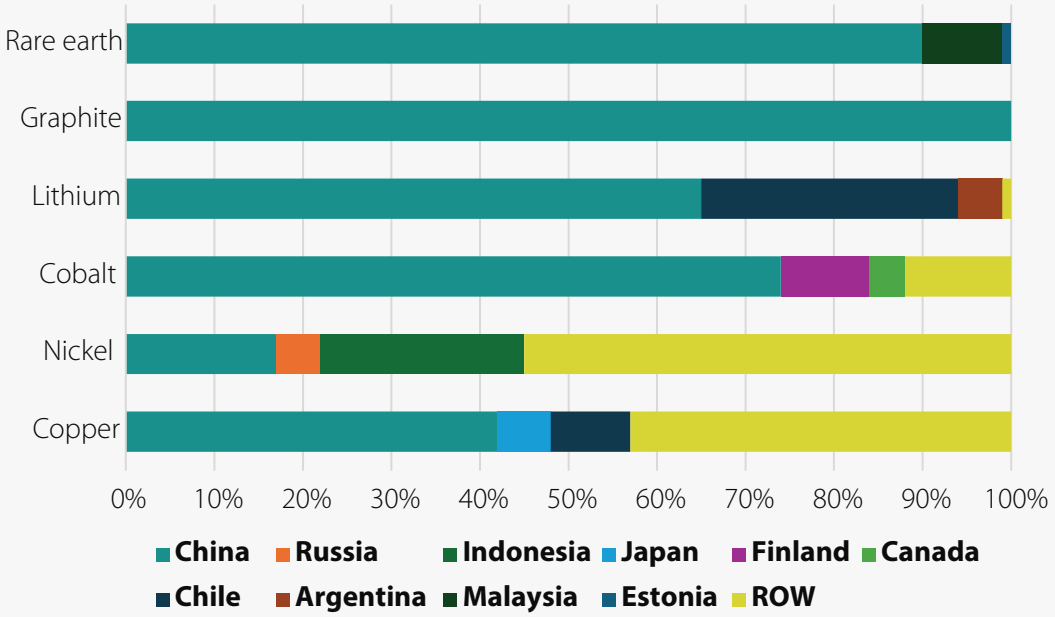
Africa's current position in the global GTM value chains is peripheral and economically marginal. Taken together, despite evidence of some mineral processing activity, Africa remains engaged in low value-added tasks such as raw material extraction and the export of semi-processed minerals. A significant share of minerals mined in Africa are exported to China and Europe for processing. The continent's participation in the downstream segments of the MVCs is minimal. This includes copper processing–an area where African countries are most active (refer to figure 14). The global processing segment of most MVCs is dominated by China, advanced economies, and a few emerging economies, leaving African nations with a marginal role. Since the largest economic benefit from these minerals is derived from processing and refining, it implies that the greatest economic gains from the vast and abundant wealth of the GTMs in Africa are realized elsewhere. Addressing this imbalance requires urgent policy focus, regional collaboration, and investment in infrastructure and human capital to develop a robust, diversified, and competitive mineral processing industry in Africa.

4.2 Africa's Integration in GTT Value Chains

A strategic avenue for increasing value capture would be for African countries to integrate and participate intensively in global GTT value chains. This integration would offer far-reaching benefits, including job creation, revenue growth, and the development of local industries through backward and forward linkages. A recent McKinsey report underscores these gains, estimating that a thriving green manufacturing sector in Africa could generate between US$200 million and US$2 billion in additional annual revenue. Furthermore, it could cut the continent's supply chain-related greenhouse gas emissions by up to 60 million metric tons of carbon dioxide equiv-

alent (MtCOe) annually by 2030, while creating approximately 700,000 direct and indirect jobs—with greater employment impacts expected beyond 2030 (McKinsey, 2021).

Figure 14: Share of Top Three Producing Countries in the Processing of Selected Minerals, 2022



Source: Original figure for this study, based on data from the International Energy Agency
Note: ROW=rest of the world

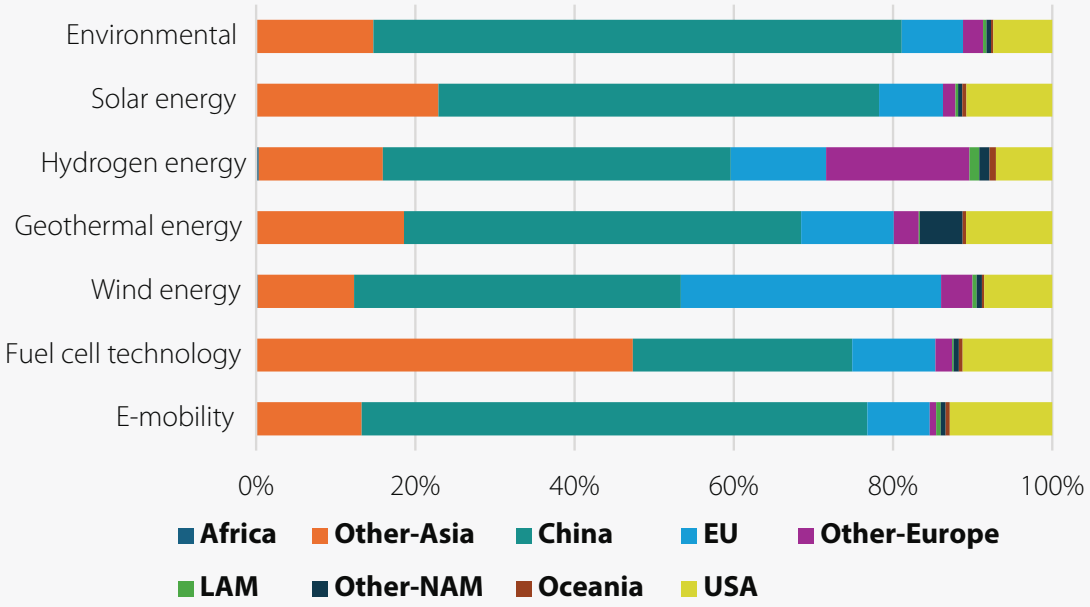
Positioning within GTT value chains is the key to securing long-term industrialization opportunities. Participating in global GTT production networks is not just a technological or economic imperative, it is a geopolitical and developmental necessity. Active participation in GTT production networks offers African countries an opportunity to future proof their economies and industrialization strategies in the face of rapidly evolving global green markets. Unlike passive adoption of GTTs, which risks making Africa a net importer of low-carbon technologies, producing these technologies or their components would allow African countries to leapfrog into green industrialization. This can support structural transformation and technological upgrading, anchored in mineral endowments. This subsection examines Africa's current position within the GTTs value chains to understand the scope for industrial upgrading and structural transformation.

Africa's role in the global GTT value chains is marginal and peripheral. Figure 15 shows the distribution of GTT patent shares across different regions, including Africa. Patent data, which are commonly used to proxy technological innovation and strategic positioning, highlight Africa's limited role in global GTT ecosystems. Between 2017 and 2023, the continent's global patent share across major GTTs was below 0.4 percent. In hydrogen energy, where Africa had its highest visibility, the average share was only 0.31 percent, compared to China's 50 percent. This weak positioning extends to production capacity: Figure 16 reveals that Africa holds a negligible share of global installed manufacturing capacity for GTTs. An unreported analysis also shows that while African countries export some GTTs, global export shares remain under 1 percent across all the

considered technologies. These findings confirm that Africa is neither a significant producer nor a competitive exporter of GTTs.

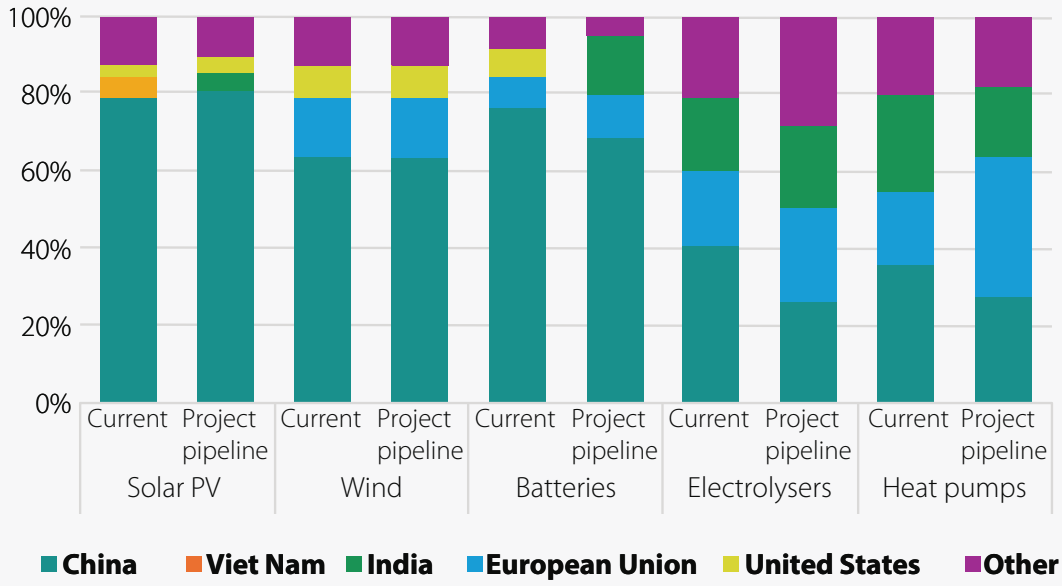
Emerging green tech activity is concentrated in a few countries. Despite the overall weak performance, a few African countries are beginning to show promise in green technology development. Patent data at the country level reveal that Morocco, South Africa, and Tunisia are emerging as continental leaders in GTT innovation. Although the number of patents these countries have is low compared to those of frontier countries such as China, the three countries possess a significant number of patents compared to other countries in Africa (refer to Figure 20). For instance, South Africa accounts for 69 percent of all regional patents in e-mobility, and Morocco follows with a 32 percent share. In hydrogen technologies, South Africa holds 33 percent, Morocco 28 percent, and Tunisia 13 percent of regional patents (refer to figure 17).

Figure 15: Global Patent Shares of Green Transition-Enabling Technologies, 2017-23



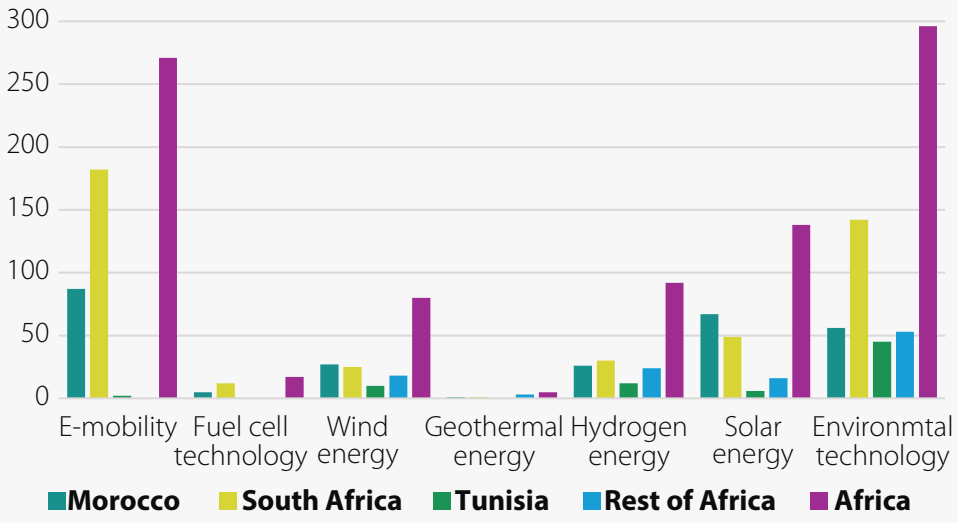
Sources: Original figure for this study, based on data from theInternational Renewable Energy Agency; World Intellectual Property Organization.
Note: EU = European Union, LAM = Latin America & the Caribbeans; NAM = North America.

Figure 16: Geographic Concentration of Manufacturing Operations for Key Green Transition Technologies



Source: International Energy Agency (2023f)
Notes: Wind refers to onshore wind nacelles in this analysis. For electrolyzers, the analysis only includes projects for which location data were available. Shares are based on manufacturing capacity. 'Current' refers to installed capacity data for 2022 and the first quarter (Q1) of 2023 where available. "Project pipeline" refers to the sum of current installed capacity and all announced manufacturing capacity additions (as of end-Q1 2023) through to 2030. "Other" refers to the aggregate of all capacity other than that of the top three countries/regions for each technology and timeframe. PV = photovoltaic.

Figure 17: Africa's Patent on Green Transition Technologies, 2017-23



Sources: Original figure for this study, based on data from the International Renewable Energy Agency; World Intellectual Property Organization.

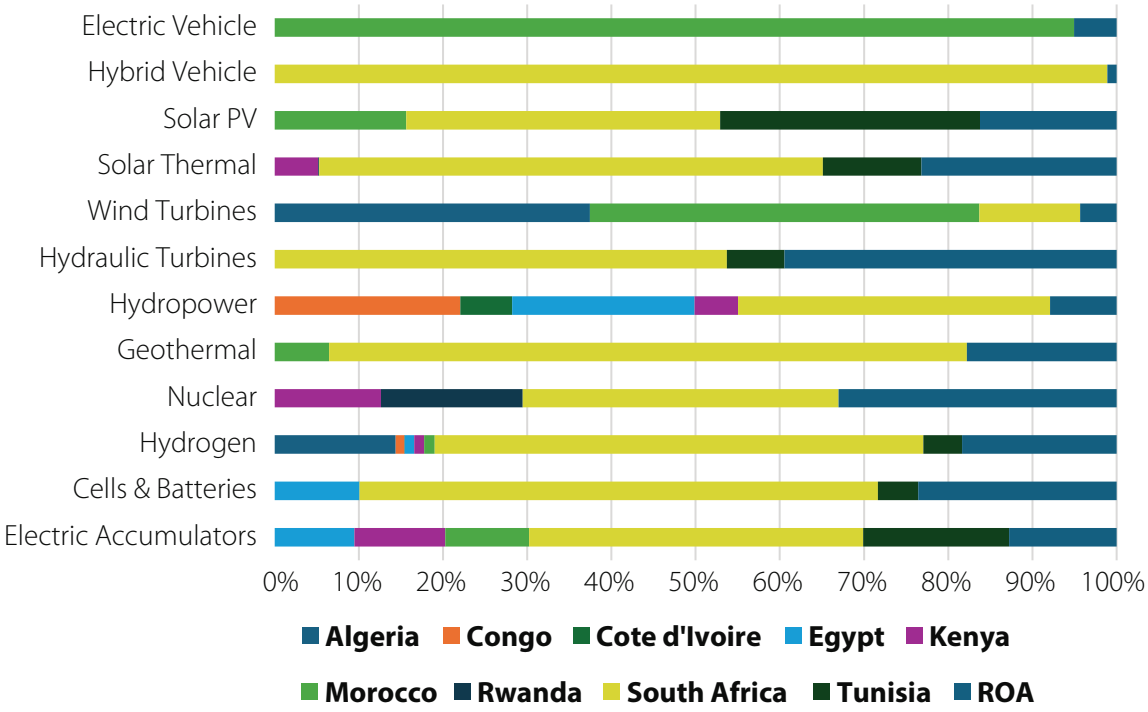
GTT exports are also concentrated in a few countries, with limited global competitiveness. Figure 18 shows the contribution of African countries to regional GTT exports.[12] The export data largely mirror the trends observed in the patent data: GTT manufacturing is highly concentrated in a few African countries, yet it remains globally marginal. For example, Morocco accounts for approximately 95 percent of Africa's EV exports, and South Africa is responsible for around 99 percent of hybrid vehicle exports and significant shares of other clean technologies. Apart from some isolated cases —such as Côte d'Ivoire, the Democratic Republic of Congo, and Egypt in hydropower and battery-related technologies, most countries show negligible participation. This pattern indicates that green manufacturing in Africa is neither widespread nor deeply embedded in GVCs.

Africa has yet to to capitalize fully on its GTM wealth for transformative green industrialization. Taken together, the emerging evidence paints a clear picture. Africa remains largely in the periphery of the global green economy despite its GTM base. A few countries in Africa are beginning to leverage their GTMs for green innovation and manufacturing; however, this early momentum remains fragmented and uncoordinated, suggesting that Africa's green tech landscape is dominated by isolated national champions rather than a cohesive regional strategy. Without deliberate coordination, these scattered pockets of innovation risk remaining disconnected from broader continental development goals, thus limiting the transformative potential of African GTMs.

No single African country possesses the full set of capabilities—technological, financial, infrastructural, and institutional—needed to compete in complex GTT value chains. However, through pooled investment, harmonized standards, regional innovation hubs, and shared infrastructure, African countries can collectively create a viable green manufacturing ecosystem. The AfCFTA offers a timely and strategic platform to facilitate this integration, enabling intra-African value chains, reducing trade barriers, and expanding regional markets for green technologies. For example, cobalt mined in the Democratic Republic of Congo could be processed in Zambia, and components manufactured in South Africa could be assembled into batteries or EVs in Morocco—creating an interconnected, continentwide value chain that elevates Africa's role in the global green economy.

[12]The GTTs that were considered are listed in Table A5 in the appendix.

Figure 18: Contribution to Regional Export of Green Transition-Enabling Technologies, 2017-22



Source: Original figure for this study, based on data from BACI-CEPII.
Note: PV = photovoltaic; ROA = rest of Africa.

5. CHANGING THE TIDES: AFRICA'S AGENCY FOR HIGHER VALUE ADDITION AND CAPTURE

Africa's mineral sector has long been criticized for its "enclave" character—an extractive, pit-to-port model that exports raw minerals with minimal domestic value addition and weak linkages to the broader economy. For decades, mineral-rich African countries have largely functioned as suppliers of unprocessed ores, capturing only a small slice of the total value generated across the global MVCs. This pattern—marked by limited beneficiation, heavy reliance on foreign corporations, and underdeveloped industrial ecosystems—has entrenched a cycle of jobless growth, stunted industrialization, and deep vulnerability to commodity price shocks. In essence, it is a textbook manifestation of the "resource curse."

The accelerating global demand for GTMs presents another once-in-a-generation opportunity for Africa to rewrite its story. The continent's rich endowments of cobalt, lithium, REEs and other critical minerals could catalyze a new era of industrial development—if harnessed strategically. With rising international competition for these resources, African countries now have unprecedented leverage to shape more equitable deals. Countries could attract investment while insisting on stronger terms that emphasize transparency, environmental safeguards, local content requirements, technology transfer, infrastructure development, and skills upgrading.

Many African governments are signaling their resolve to break free from the extractivist trap.[13] Countries are increasingly adopting policy frameworks aimed at retaining a greater share of the value of their mineral wealth. Some are enacting bold reforms, such as re-evaluating national mining codes, while others are taking more incremental steps, including harmonizing regulations, streamlining permitting processes, and reducing bureaucratic inefficiencies. ***Collectively, these efforts represent a new wave of "green value capture initiatives" (GVCIs)—government strategies, measures, or interventions aimed at capturing more value from GTMs, directly or indirectly.***[14]

This study distinguishes GVCIs from green industrial policies (GIPs). While GVCIs may fall under the broader umbrella of GIPs, the reverse is not always true. GIPs are typically focused on decarbonizing domestic industry and building green manufacturing capacity—for example, climate change through support for solar panel, EV or wind turbine production.[15] These policies link GTMs to national efforts to mitigate climate and grow the green sector. In contrast, GVCIs are primarily focused on the the MVCs. Their objectives may be driven by economic development goals or stra-

[13]Although these policies are discussed here in the context of Africa, the trend is also observable across several mineral-producing countries in other regions.

[14]Most of these policies, especially the mining codes, are generic to the mining sector rather than specific to the GTMs. Nevertheless, this study associates them with "green" initiatives. This decision comes from the fact that we have already established that almost all African countries produce and export one of the identified GTM. In this case, the GTMs are affected regardless. Most of these policies are occurring in an era of green transition, in which the demand for most minerals has intensified, making these policies more of a reaction to this market trend.

[15]This could include energy efficiency strategies or policies promoting the adoption and application of low-carbon technologies across the industrial sector.

tegic interests rather than environmental imperatives. While GIPs are inherently aligned with the goals of the green transition, GVCIs may be more market-driven and may operate independently of broader sustainability frameworks.

In Africa, GVCIs are being pursued at the national, regional, and continental levels. At the national level, countries like Namibia and Zimbabwe have enacted export restrictions on unprocessed minerals while promoting domestic processing and refining. Nigeria has expressed similar ambitions. Regionally, blocs such as the Southern African Development Community (SADC) have developed collective strategies for green industrialization and are actively engaging in cross-border industrial partnerships—for example, the Democratic Republic of Congo-Zambia EV battery value chain initiative. Strategic partnerships with global actors are also emerging, such as the European Union–Democratic Republic of Congo strategic partnership on sustainable raw materials value chains. At the continental level, the African Union continues to champion long-standing frameworks like the AMV and its more recent articulation in the African Green Minerals Strategy, both of which advocate for value addition, resource sovereignty, and industrial diversification.

GVCIs in Africa can be broadly categorized into five main types, based on their nature and intent, irrespective of the level at which African countries have pursued them. Figure 19 provides a visual overview of these categories. Although the figure presents these initiatives in grouped typologies, it is important to emphasize that many are derived from a single policy instrument, especially at the country-level. However, these policy documents or instruments are rarely limited to a singular objective. This is particularly the case for most of the new mining codes that have emerged recently across African states. Notably, they tend to have elements of resource nationalism and local-based value addition. In such cases, the study focused on the objectives described in the relevant documents, classifying and discussing them under the categories. The following subsections synthesize and discuss some of these policies.

Figure 19: Categorization of Africa's Green Value Capture Initiatives

Source: Original figure for this study

5.1 Mineral Exploration and Extraction-Seeking Initiatives

Mineral exploration and extraction constitute the upstream segment of any MVC. Exploration is cost-intensive and associated with several uncertainties. Mineral extraction is also cost-intensive; even worse, most are burned as sunk costs. Therefore, investment protection is of utmost importance to foreign multinational companies. More broadly, these companies are especially interested in a good business environment and opportunities to repatriate profits, which determine the value of their investment. Africa's GVCIs intended to drive mineral exploration and extraction have appeared primarily to react to these needs, as they have largely focused on boosting the confidence of foreign investors.

Table A6 in the appendix highlights policy provisions or strategies that African countries have used to attain this goal. The table identifies African countries that have employed strategies such as fiscal relief (tax breaks or royalty reductions), policy and data harmonization (especially by streamlining mining laws and licensing departments), investment-friendly initiatives, and infrastructure development. Ghana's Minerals and Mining Act (as amended in 2015) is a notable example of a policy that provides both fiscal relief and investment-friendly initiatives. It allows the government to enter long-term agreements with mining companies, shielding them from intermediate policy changes. At the same time, it offers tax exemptions to both mining expatriates and imported mining equipment. Botswana and Ethiopia offer examples of data harmonization, with both countries having digitalized their respective geological databases.

In addition to these national strategies, in January 2024, 16 African countries formed the AMSG, an intergovernmental organization.[16] The group promotes mineral exploration, extraction, production, local beneficiation, and commercialization for member countries. In collaboration with the United Nations Economic Commission for Africa–Southern Africa, SADC member states have also developed and adopted a framework for harmonizing mining policies, standards, and legislative and regulatory framework in Southern Africa to reduce bureaucratic hurdles and boost mining investments in the region.

National infrastructure development policies have also been identified for increasing mineral exploration and extraction in Africa. South Africa's "Exploration Strategy for the Mining Industry of South Africa" is an example of such a policy strategy. In addition to offering investment-friendly initiatives to attract local and international investors, it supports the development of requisite mineral exploration and extraction infrastructure. At the regional level, the Lobito Corridor project is also another notable example, which, when finalized, would unbind several infrastructural constraints in the region.

5.2 Local Beneficiation and Value Addition Initiatives

Beneficiation refers to the processing of raw minerals into semi-finished or finished products. The primary objective of such initiatives is to move mineral-producing African countries up the MVC by promoting domestic mineral processing. To achieve this, mineral producing African countries

[16]Botswana, Burundi, Chad, the Democratic Republic of Congo, Guinea-Bissau, Liberia, Malawi, Nigeria, Sierra Leone, Somalia, South Africa, South Sudan, Tanzania, Uganda, Zambia, and Zimbabwe.

have adopted various strategies, including trade restrictions, public-private partnerships, regional cooperation, and environmentally sustainable (green) partnerships. Among these, trade restrictions have emerged as the most prominent tool.

Map 4 shows that about 21 African countries are currently known to have placed trade restrictions on different essential minerals. Zimbabwe, Namibia, and Ghana have all imposed export bans on several unprocessed mineral ores (refer to table A7 in the appendix). These trade restrictions are expected to develop local MVCs by attracting FDI and compelling mining companies to invest in local mineral beneficiation rather than exporting raw materials where the benefits accrue externally. However, is this generating the needed outcomes? According to a study by Fliess, Idsardi, and Rossouw (2017), such trade restrictions often fail to stimulate local mineral processing effectively and may even harm the overall competitiveness of the mineral sector. Nevertheless, more recent anecdotal evidence suggests a more nuanced picture. In Zimbabwe, for example, the ban on unprocessed lithium exports has reportedly led to the establishment of lithium concentrators producing concentrated spodumene—an essential step in the initial processing of lithium ore (Neema & van Staden, 2024). Similarly, Indonesia's well-documented mineral export ban has catalyzed downstream investments in nickel processing. These emerging cases indicate that, under the right conditions, trade restrictions can indeed trigger positive structural changes—although not without trade-offs and implementation challenges.

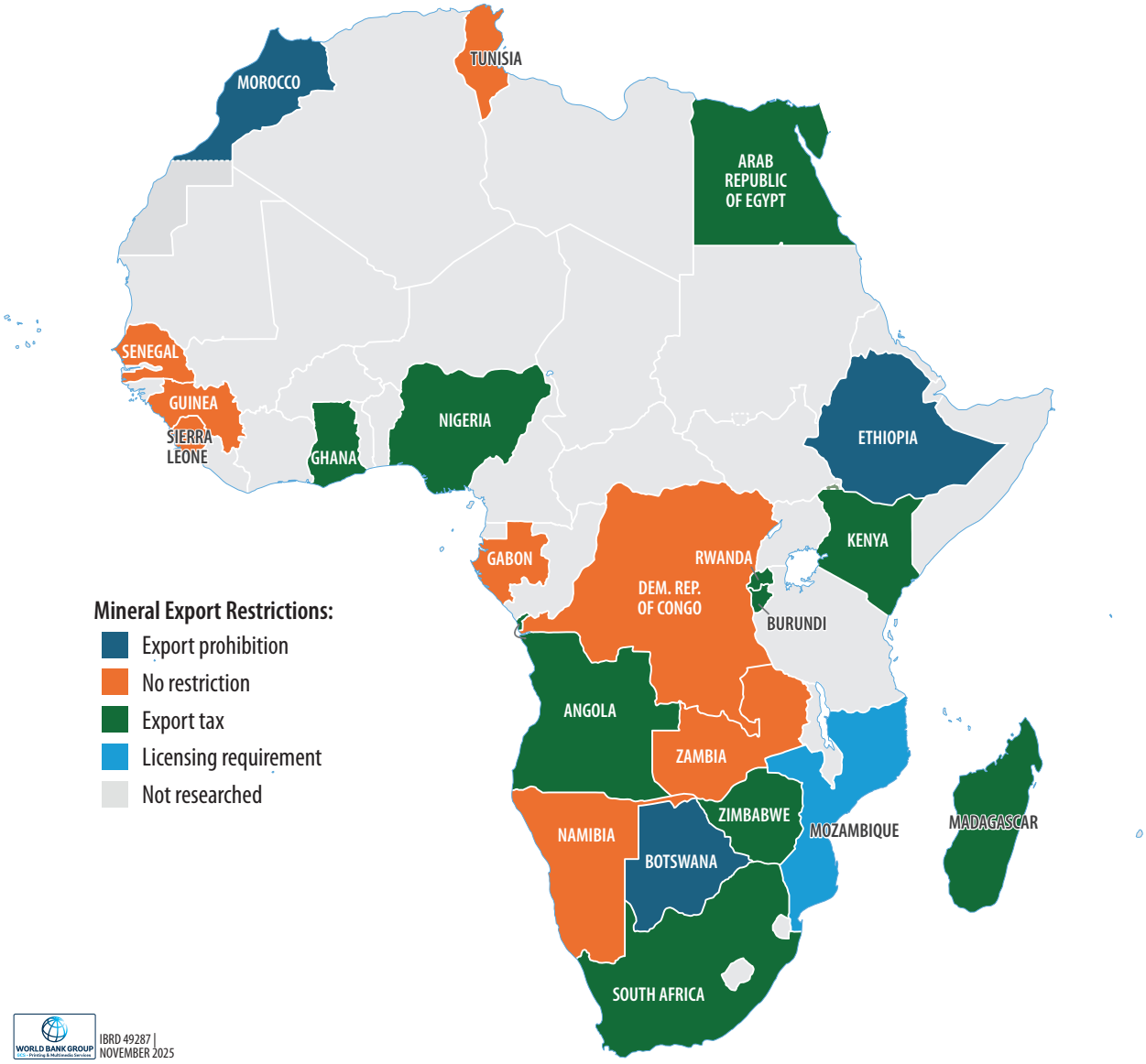
Several factors could explain such policy failures and successes, with the two most profound factors being a lack of complementary resources and market power. For example, compared to mineral extraction, mineral processing is energy intensive, which, given the level of energy poverty in several African countries, makes it a challenge. This was an underlying element in the central argument of Zhejiang Huayou Cobalt in 2022 following Zimbabwe's ban on unprocessed lithium (Neema & van Staden, 2024). Other complementary factors, such as skills and effective institutions, also play important roles. Export restrictions lead to two immediate responses: stockpiling by local producers and trade redirection by buyers. If a country's mineral can be easily substituted with alternatives from other countries, the trade restriction is unlikely to meet the intended objective. This underlines one of the significant reasons Indonesia's export ban on unprocessed nickel successfully bolstered local nickel processing, while its export ban on bauxite was largely unable to achieve the same result for aluminum (Press et al., 2023). Together, the degree to which export restriction policies realize their potential depends on the country's global production share (market power).

The "Democratic Republic of Congo–Zambia partnership" to establish an EV battery value chain is one of the notable examples of inter-country alliances in Africa towards local beneficiation and value addition. The cooperation agreement was first signed in April 2022. In December 2022, the USA entered into a trilateral memorandum of understanding with both countries to support the initiative. However, to date, the partnership is not yet operational.

The AMSG and AMV are other notable intercountry alliances. One of the goals of the AMSG is to promote local beneficiation. Moreover, in September 2024, the AMSG joined the Council for Critical Minerals Development in the Global South, an initiative led by Sustainable Energy for All; the Institute of Transportation Studies at the University of California, Davis; and Swaniti Global.

This partnership aims to strengthen African governments' efforts to leverage their critical mineral resources to build local value chains for energy transition technologies, thereby creating jobs and supporting industrialization. The AMV was adopted in 2009 to enable African countries to leverage their minerals for industrialization and economic diversification. Implementation of the goals and

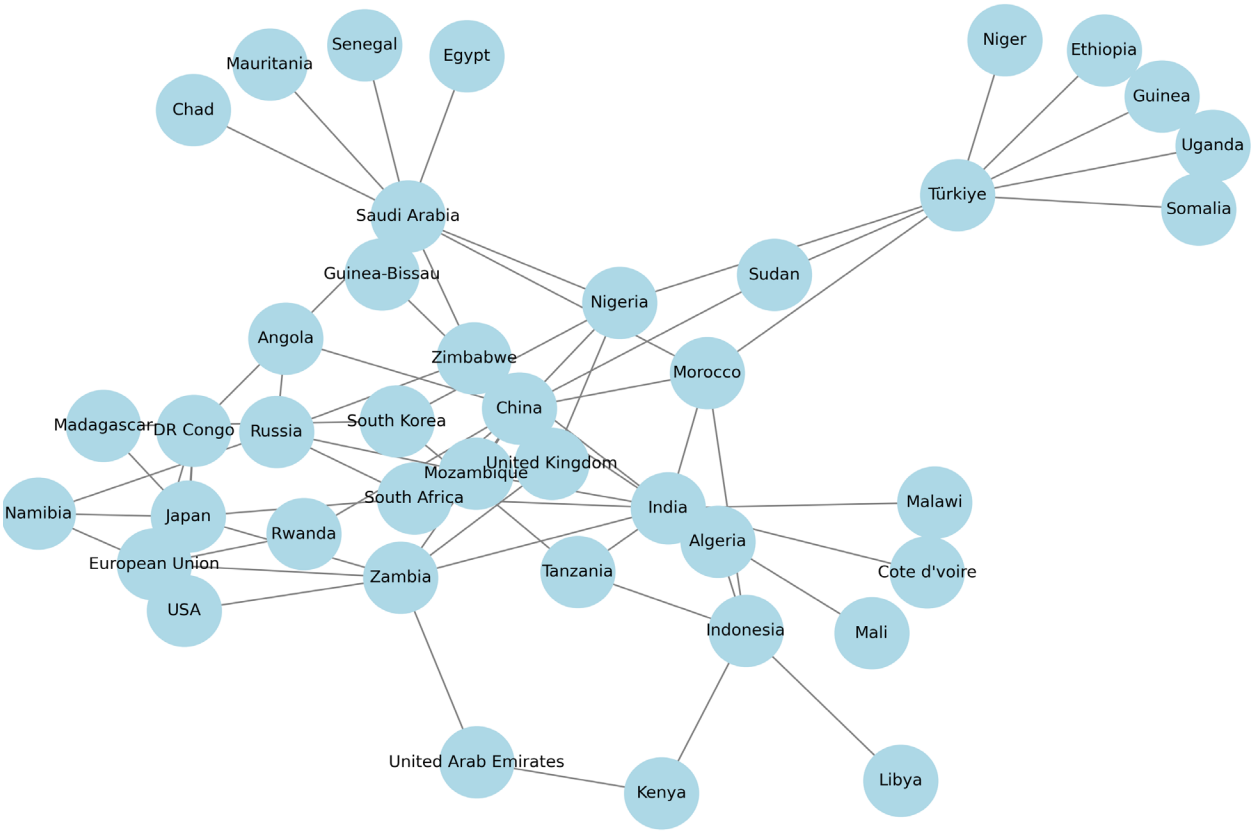
Map 4: Mineral Export Restrictions in Africa, 2022



Source: Original map for this study, based on data from the Organization for Economic Cooperation and Development's trade in raw material database

strategy was voluntary and left to the hands of the national government, leading to the so-called Country Mining Vision, a bottom-up process rooted in collective national ownership. This has led to complexities and divergence in the extent and patterns of implementation across countries. Although many observers have applauded the AMV, others have criticized it, mainly for not realizing much-needed value creation.

Figure 20: Africa's Green Mineral Partnerships



Source: Original figure for this study, based on data from Beuter et al. (2025)

In addition to these regional examples, several African countries are working on or forming partnerships with global stakeholders to promote value addition. This is exemplified by African countries' numerous multilateral and bilateral green partnerships with different mineral-sourcing countries. Figure 20 shows a network of green mineral partnerships with African countries. Several African countries have committed to one form of these agreements. Democratic Republic of Congo, South Africa, and Zambia have each committed to at least six of such agreements. Outside China and Russia, countries and regions such as the United Kingdom, India, South Korea, United States, the European Union, and Japan constitute known state actors that have entered such green alliances with African countries.

These agreements and partnerships contain many provisions, including MVC integration, promotion of joint ventures and investments, knowledge sharing, and capacity building in the mineral sector and are expected to drive local beneficiation and value additions (Beuter et al., 2025). However, most of these agreements are shrouded in secrecy and often contain vague and cryptic provisions, are not legally binding, and have a predetermined period of validity (Beuter et al., 2025).

5.3 Resource Nationalism

Resource nationalism involves governments exercising control over resource industries through selective and discretionary resource policies designed to achieve some political and/or economic benefits that would otherwise not be obtained. Notable specific resource nationalism strategies that are often deployed include government policies targeting ownership of resource industries or policy changes in fiscal regimes or industry requirements that alter the operations of resource firms (Wilson, 2015).

Policies of mineral-producing African countries share characteristics or elements of resource nationalism (refer to table A8 in the appendix). Notably, the newly emerging mining acts/codes across mineral-producing African countries have increased their royalties and/or introduced (higher) state stakes in mining companies, all geared towards ensuring greater national control over mineral wealth and economic benefits.

For instance, Burkina Faso's new mining code in 2024 mandates partial local ownership of mining firms and granted the state rights to acquire mining shares. Cameroon, through its Law No. 2023/014, mandates the state to acquire up to 10 percent of the total shares in companies engaged in various mining activities at no cost. In Burundi and Uganda, nationalism laws mandate the state to hold a 15 percent stake in all mining projects. In Tanzania, the law grants the government stakes of at least 16 percent in mining companies operating in the country, with the option to acquire up to 50 percent in some cases. In the Democratic Republic of Congo, by law, strategic minerals such as cobalt and copper are traded under a taxation framework that requires any producer to pay 10 percent of the gross value of the commodities in tax. The mining code also mandates the state's free share in mining projects up to 10 percent and higher royalty rates and taxes on cobalt and copper mining, ensuring that a significant portion of the profits is reinvested into local development projects.

5.4 Local Content and Development Initiatives

Local content and development requirements are policies designed to ensure that businesses, specifically in extractive industries, contribute to the economic and social development of the host country. The policy may assume different forms reflecting different economic priorities, governance structures, and the implementing country's level of industrialization. For instance, the requirements could mandate the use of local labor, goods, and services; promote knowledge and skills transfer; or support local enterprises. Like in the case of resource nationalism, most newly emerging mining codes across mineral-producing Africa also emphasize increasing local content for local development.

Table A9 in the appendix summarizes key country policies related to employment mandates, procurement obligations, and community development commitments. South Africa, through its

"Black Empowerment Mining Charter," requires, among others, that Black ownership of mining companies be raised to 30 percent . In addition, it requires mining firms to procure 70 percent of goods and 80 percent of services from Black-owned companies. In Tanzania, the mining regulations give preference to local service providers and locally manufactured goods. Tanzania also requires the use of local insurance and financial services and stipulates that only local legal practitioners or law firms should provide legal services. In the Democratic Republic of Congo, the mining code requires mining companies to contribute to local community development. Burkina Faso requires locals employment in mining companies.

5.5 Environmental and Social Sustainability Initiatives

A feature of the newly emerging initiatives across mineral-producing countries is the emphasis on sustainability or, more broadly, the so-called environmentals, social and governance goals. This reflects a concerted effort to ensure that mineral exploration contributes to long-term economic growth, environmental sustainability, and social development. Table A10 in the appendix provides notable examples of these initiatives.

One of the ways African countries are tilting toward environmental and social sustainability is by joining the ***Extractive Industries Transparency Initiative***, which is a global initiative that seeks to establish a global governance and standards for the extractive industries. About 27 African countries have joined this initiative.[17] However, four of the countries–Cameroon, the Central African Republic, Ethiopia, and São Tomé and Príncipe—have been suspended.[18]

Local policies are also beginning to pay attention to environmental issues. For instance, Ethiopia's "Mining Code 2018" introduced stricter environmental safeguards and community compensation programs. Ghana's "Minerals and Mining Act (2006, amended in 2015)" mandates that mineral rights holders must obtain environmental permits from the Environmental Protection Agency before commencing operations. For mining leases covering areas exceeding 10 hectares, an environmental impact assessment must be submitted to the Environmental Protection Agency.

Other African countries have also partnered with global stakeholders. Examples include the Zambia-European Union Strategic Partnership on sustainable raw materials value chains and the Democratic Republic of Congo–European Union Strategic Partnership on sustainable raw materials value chains. A key area covered in these partnerships is cooperation to leverage environmental, social, and governance criteria and align with international standards, including through increased due diligence and traceability.

[17]Angola, Burkina Faso, Cameroon, the Central Africa Republic, Chad, Côte d'Ivoire, the Democratic Republic of Congo, Ethiopia, Gabon, Ghana, Guinea, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, the Republic of Congo, Senegal, the Seychelles, Sierra Leone, São Tomé and Príncipe, Tanzania, Togo, Uganda, and Zambia.

[18]Equatorial Guinea was also a member.

6. STRUCTURAL TRANSFORMATION IN THE GREEN INDUSTRIAL ORDER: A DEVELOPMENTAL REGIONALISM APPROACH

6.1 Risks, Vulnerabilities, and Strategic Options: Toward a Regionally Coordinated Strategy

Africa is geologically rich but risks losing out in the emerging green industrial order. Despite its abundant reserves of GTMs, Africa's participation in global GTM markets reveals a paradox of potential without power. The continent remains overwhelmingly confined to upstream extraction. Even where processing occurs, it is rudimentary—producing intermediate forms like cobalt hydroxide or blister copper—while the final stages of refinement and integration into high-tech manufacturing are outsourced to industrial powers such as China. This structural configuration undermines the continent's ability to leverage its mineral wealth for broad-based industrial development and technological upgrading.

The structure of Africa's GTM trade underscores several vulnerabilities. Exports are heavily concentrated in a single market: China. Although Chinese investment has facilitated mineral extraction, it has not driven significant local beneficiation or value addition. The result is a persistently asymmetric relationship—Africa exports raw or semi-processed minerals, while China supplies high-value manufactured goods. This pattern exacerbates trade imbalances and reinforces Africa's subordinate role in GVCs. Intra-African trade, which could offer a counterbalance, remains marginal. For most minerals, intra-continental exports account for less than 10 percent of total trade. Even in regions with natural mining corridors—such as PGMs in Southern Africa or cobalt in Central Africa—cross-border value chains are weak or absent. Poor infrastructure, misaligned regulations, and limited policy coordination have splintered what could be a coherent continental GTM economy (UNECA, 2023).

These structural weaknesses expose Africa to a range of strategic risks. First, overdependence on a single export destination leaves economies vulnerable to external shocks—whether through geopolitical tensions, as evidenced by China's mineral export controls, or through global price volatility. China's past use of mineral export controls as a strategic tool raises the risk of revenue instability for African suppliers. Second, the limited domestic or regional processing capacity prevents African countries from moving up the value chain, leading to forgone jobs, innovation, and learning in high-value segments. Third, policy and regulatory fragmentation undermines investor confidence and coordination efforts. Section 5 showed that most African countries have introduced diverse initiatives to facilitate a shift away from historical patterns of raw material exports and resource dependency. These efforts signal a growing awareness of the opportunities presented by the green transition. However, most initiatives remain nascent and unevenly implemented. Moreover, they are pursued largely at the national level with limited coordination across borders. Mining codes, export regimes, and local content policies vary significantly across countries, creating a disjointed landscape that frustrates regional integration and industrial plan-

ning. Policy frameworks such as the AMV and the AfCFTA offer a blueprint for coordination, but implementation has been slow. Without decisive action, Africa's GTM endowment could repeat the extractive patterns of the past, enriching others while leaving the continent locked in low-value-added positions.

Africa's GTM wealth presents a unique opportunity for regionally anchored industrial transformation. Africa's GTM base is not just a challenge—it is a strategic opportunity. The key lies in converting geological wealth into productive advantage through coordinated regional strategies, infrastructure investment, and targeted industrial policy. No single African country possesses all the capabilities—technological, financial, logistical, and institutional—required to compete in complex GTM value chains. Therefore, the answer is regional integration. Africa's bargaining power will grow not through isolated national efforts, but through collective action along mineral corridors. Infrastructure must be built to connect mining zones with regional processing hubs. Countries with complementary resources—like the Democratic Republic of Congo and Zambia for cobalt, or South Africa and Zimbabwe for PGMs—should co-invest in refining facilities and harmonize regulatory regimes. This integration can unlock economies of scale, enhance bargaining power, and support regional industrial ecosystems. Such a strategy requires not only technical cooperation but political coordination around shared industrial goals.

Diversification of trade and strengthening intra-African value chains are equally critical. Africa must reduce its dependence on China by building strategic partnerships with the European Union, India, Latin America, Southeast Asia, and the United States. Simultaneously, intra-African trade must be deepened through RVCs anchored in the AfCFTA and regional economic communities. Establishing regional manufacturing hubs for batteries, solar panels, fertilizer, and EV components can stimulate internal demand and build regionally scaled industrial capabilities (ACET, 2024). Such developments would not only improve Africa's GTM utilization but also enhance resilience to global market disruptions.

Strategic coordination, not geology, will determine Africa's role in the global green economy. Africa's minerals must not merely power the world's green transition—they must fuel a new era of industrial transformation on the continent. This will require aligning trade, investment, and industrial policy at the regional level. Without such coordination, national strategies will be competing with instead of complementing one another, eroding Africa's collective leverage and potential. If African countries can develop regional infrastructure, harmonize policies, and integrate value chains, even smaller producers—those with deposits of graphite, phosphate, or bauxite—could contribute meaningfully to regional green manufacturing ecosystems. The choice is thus stark. Africa can remain a supplier of raw materials or become a strategic actor in the global green economy. The difference lies not in geology, but in governance, integration, and vision.

6.2 A New Multilayer GTM-led Developmental Regionalism Framework

Africa needs to make a strategic shift toward shared industrial and resource strategies to seize the emerging green industrial opportunities. To guide such a coordinated approach, this study recurs to the ***developmental regionalism model*** —a strategic framework that links regional integration explicitly to socioeconomic transformation by leveraging regional resources, industrial capaci-

ties, and trade networks (Ismail, 2021). Foundational contributions to this model emphasize four key pillars: mutually beneficial trade integration, industrial transformation via RVCs, cross-border infrastructure investment, and governance and security reform (Davies, 1996; UNECA, AU, & AfDB, 2017, Adejumobi & Obi, 2020; Ismail, 2021). Although the existing frameworks provide evidence, for instance, on how to align and leverage trade policies, industrial objectives, and RVCs, they remain prescriptive and broad, and lack specific contexts for new sources of growth and development, specifically GTMs.

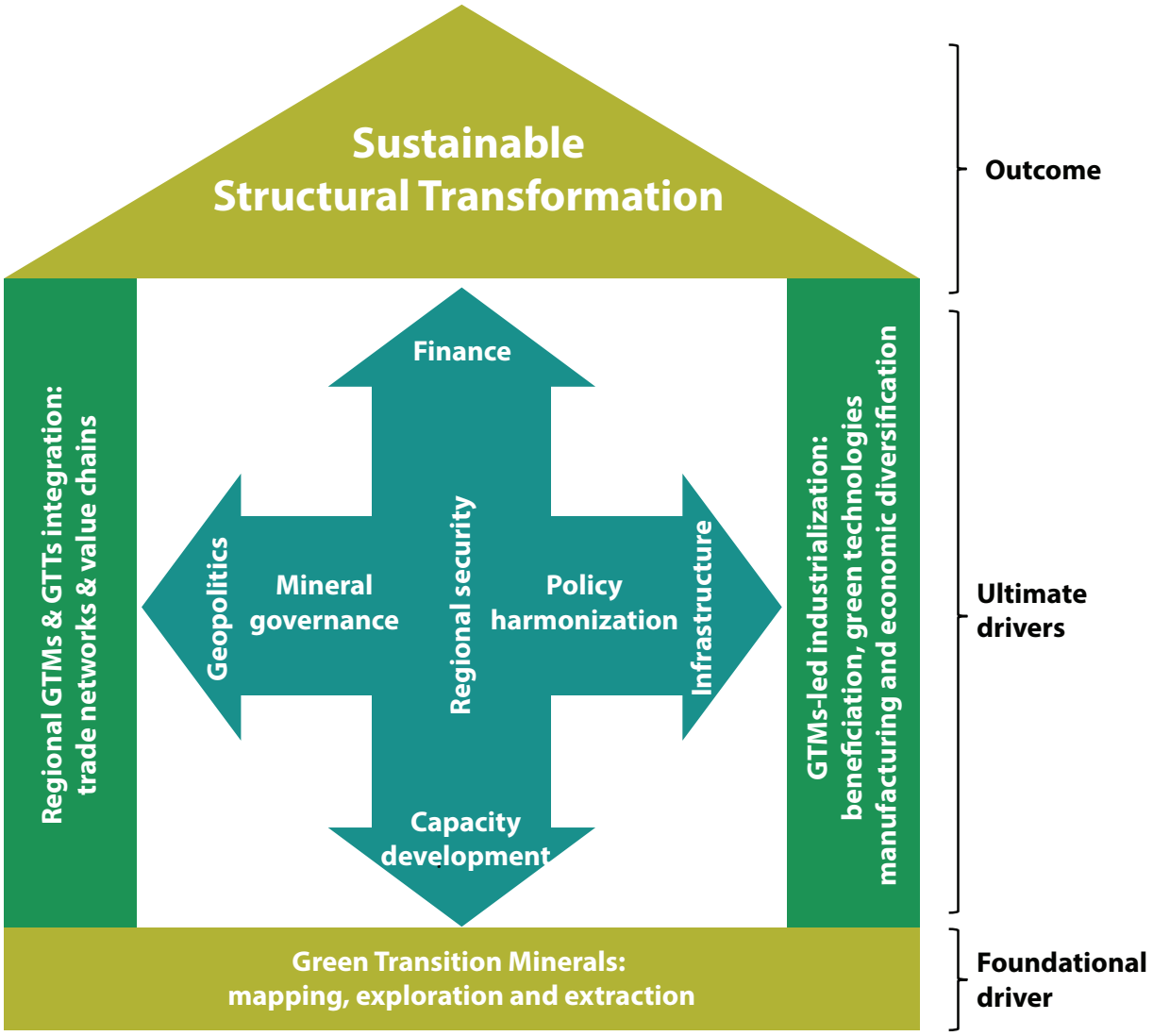
This study proposes a comprehensive framework that centralizes GTMs as a strategic vehicle for Africa's structural transformation in the green transition era. At its core, the framework centers GTMs as a foundational entry point for integrating and upgrading African countries into higher-value segments of the global GTT value chains. It identifies critical areas where strategic coordination—ranging from joint exploration and beneficiation to shared R&D and manufacturing—can unlock transformative potential. This vision responds to two core empirical insights elaborated throughout this study. The first insight is that, despite their mineral endowments, most African countries remain locked in the low-value segments of both GTM and GTT value chains. Only through regional cooperation can they overcome fragmentation, aggregate bargaining power, and attract investment at scale—particularly amid the intensifying geopolitical rivalry between China and the West over critical minerals.

Africa's competitive advantage in GTMs is continental, not national, and regional collaboration can mobilize dispersed capabilities toward end-to-end green value chains. The second insight underpinning the proposed framework is that Africa possesses latent but scattered technological, human capital, and industrial capabilities necessary for upgrading in the GTM and GTT value chains. Many of these capabilities exist across both mineral-rich and non-mineral-rich countries, and are currently underutilized due to policy silos and weak regional coordination. A continental strategy that aligns exploration, processing, manufacturing, and technology deployment—anchored in existing institutions and trade agreements like the AfCFTA—can help build a localized, integrated value chain for green technologies. This would ensure not only that value is retained within the continent, but also that Africa plays a proactive, not peripheral, role in the global green economy.

The newly proposed framework is structured around four interconnected layers— foundational driver, ultimate drivers, enablers, and the outcome—capturing the systemic dynamics needed to achieve sustainable structural transformation. As illustrated in figure 21, the framework's outcome is "sustainable" structural transformation.[19] The foundational driver is Africa's endowment of GTMs, which anchors the entire transformation agenda. This layer encompasses the mapping, exploration, and extraction of GTMs, discussed in section 3.

[19]Sustainability is embedded as the defining criterion to emphasize that the framework does not merely pursue industrial upgrading or economic growth, but a transformation pathway that aligns with inclusive development and ecological stewardship. In this case, the dynamic processes that underpin the framework must be socially and environmentally sustainable.

Figure 21: Multilayer GTMs-Led Developmental Regionalism Framework



Source: Original figure for this study
Note: The figure shows a three-layer framework: foundational driver (GTMs), ultimate drivers (regional integration and industrialization), and enabling factors (infrastructure, policy, governance, etc.), culminating in sustainable structural transformation.

The ultimate drivers consist of two structural pillars: a coordinated regional integration of GTMs and GTTs, and a GTM-led industrialization model. These pillars form the strategic backbone of Africa's transition from extractive dependence to value-added manufacturing and green technology production. The enablers at the heart of the framework ensure dynamic reinforcement of the foundational and structural layers. They facilitate progress, manage risks, and sustain momentum across national and regional efforts toward achieving the intended outcome of sustainable structural transformation. This study identifies and considers six enablers: geopolitics, finance, infrastructure, regional security, capacity development and strengthening, and mineral governance and policy harmonization.

The following subsections provide a detailed unpacking of each layer, clarifying their roles, interdependencies, and policy implications within the broader vision of a regionally coordinated, GTM-led green transformation in Africa.

6.2.1 Green Transition Minerals: Mapping, Exploration and Extraction

African countries remain heavily dependent on foreign firms for upstream activities in the GTM value chains, undermining their ability to shape downstream industrial outcomes. As discussed in section 4, GTM-producing African countries primarily specialize in the upstream segment of the MVCs, particularly in exploration and extraction. Although these activities are low value-added tasks, they are largely dominated by foreign companies that bring the capital and technology necessary for large-scale operations (Ericsson, Lof & Lof, 2020). This dependence stems from limited fiscal space and technical capacity, but it serves as one of the key factors that perpetuates Africa's marginal position in global mineral-industrial networks.

Control over upstream mineral activities is central to determining how and where minerals are processed. The upstream segment serves as the gateway to the entire MVC, and the entity that controls extraction wields significant influence over subsequent decisions related to refining, processing, and manufacturing. When foreign firms dominate this stage, raw minerals are typically exported to processing hubs abroad, locking African countries into low-value roles. In contrast, domestic or state ownership creates space for more strategic decision-making—enabling countries to insist on local beneficiation, promote industrial linkages, and channel revenues into domestic development. Botswana's success in retaining value through state participation in diamond mining exemplifies this model, while countries like the Democratic Republic of Congo, where foreign actors dominate cobalt mining, illustrate the pitfalls of relinquishing upstream control.

African collaboration in the upstream segment of the GTM value chains is essential to overcome structural constraints and assert collective ownership over the continent's mineral wealth. The first layer of the proposed framework therefore calls for a coordinated approach to exploring, mapping, and extracting GTMs. Practically, this means pooling national resources and expertise—such as the creation of regional mineral exploration funds or joint ventures—to finance and empower indigenous companies. Such regional consolidation would reduce duplication, facilitate economies of scale, and strengthen African countries' bargaining power in negotiating contracts and joint investments. It would also promote peer learning and the development of locally embedded technological capabilities that are often withheld by foreign firms.[20]

A regionalized approach to upstream GTM governance is a prerequisite for Africa to build a sustainable foundation for green structural transformation. By asserting greater control at the entry points of the MVCs, African countries can direct how their mineral resources are integrated into the broader industrial ecosystem. This shift is vital to ensuring that the continent moves beyond extractivism and builds a domestic base for processing, manufacturing, and innovation. Although the AMV and its implementing body, the African Minerals Development Centre (AMDC), have long advocated for this agenda, implementation has been slow and fragmented.

[20] An exception is South Africa, which has technological proficiency and skills from several years of mining.

Realizing the vision of sustainable structural transformation requires moving from rhetorical commitments to operational strategies that embed upstream collaboration into the heart of Africa's structural transformation agenda.

6.2.2 GTM-Led Industrialization: Beneficiation, Green Technologies Manufacturing and Economic Diversification

Africa must leverage its GTM endowments to move beyond raw mineral exports and drive localized beneficiation and green technology manufacturing. The global shift toward GTTs presents a strategic opportunity for Africa to capture more value from its natural resources. Localizing GTM processing and mineral beneficiation is essential not only to reduce dependency on volatile global commodity markets, but also to stimulate upstream and midstream industrial development. Simultaneously, expanding into localized manufacturing of GTTs—including solar panels, wind turbines, and battery components—offers a path toward deeper economic diversification, employment generation, and technology upgrading across the continent.

Regional cooperation offers a cost-effective and strategic response to the capacity and infrastructure constraints faced by individual African countries. Barriers such as limited technical expertise, financial capital, and industrial infrastructure continue to hinder individual countries from realizing their GTM-led industrialization potential. However, many of these challenges can be addressed collectively through a regional industrial strategy that leverages the comparative advantages of different countries. For instance, nations with mineral extraction capacity can partner with those developing processing infrastructure or emerging as knowledge hubs in green technologies. Joint investment in beneficiation hubs and integrated supply chains will enable shared value creation while reducing duplication of efforts. A regional resource-based industrial strategy should match Africa's mineral endowments with the global demand for specific GTTs and ensure that upstream activities are systematically connected to downstream manufacturing and services.

A regionalized GTM industrialization pathway requires the strategic redirection of mineral flows and targeted investment in existing processing hubs. From a practical standpoint, this calls for a redirection of mineral trade toward the emerging GTTs knowledge hubs in Africa that were identified in subsection 4.2. Concurrently, it also calls for regional investment in existing processing plants as identified in subsection 4.1, to expand the scale, capacity, and operation of those plants to enable a full-cycle beneficiation and manufacturing. Redirecting GTM trade toward regional manufacturing and processing hubs, and mobilizing regional resources to upgrade existing plants will strengthen the continent's industrial backbone and lay the groundwork for competitive participation in global green technology markets

The AfCFTA can serve as a powerful enabler of regional GTM-led industrialization by creating a unified market for minerals and manufactured goods. By reducing intra-Africa trade barriers and improving policy coherence across borders, the AfCFTA provides the institutional platform to consolidate Africa's mineral-industrial value chains. A harmonized regional market will not only expand domestic demand and improve economies of scale, but also increase Africa's competitiveness in GVCs. Through this platform, Africa can better retain mineral value within its borders, stimulate investment in downstream industries, and foster the emergence of a green industrial ecosystem that supports inclusive development and climate resilience.

6.2.3 Regional Integration: Trade Networks and Value Chains

Rather than striving for greater integration into GVCs, African countries should prioritize the development of RVCs for GTMs and GTTs. As discussed in section 4, Africa's GTM sector is dominated by unprocessed mineral export to countries outside the continent, implying that a significant portion of their GTMs is reaped elsewhere. In addition, despite possessing essential minerals, African countries remain poorly integrated into global GTT value chains, serving primarily as suppliers of unprocessed raw materials. Arguably, integration into GVCs has yielded only modest development benefits over the past decades. This layer of the framework emphasizes a counter-strategy: rather than striving for greater integration into GVCs, African countries should prioritize the development of RVCs for GTMs and GTTs, which could integrate resource production, processing, and manufacturing across member states, thereby enhancing economies of scale and fostering collaborative industrial ecosystems.

A strategic regional approach provides the continent an easier route to trade-led diversification, shielding its local firms from the structural imbalances inherent in GVCs that have historically relegated them to low-value-added tasks. As several global GTT value chains are concentrated and characterized by strong entry barriers, establishing RVCs appears to be the most viable and rewarding option. This argument aligns with Franssen (2020), who found that firms engaged in South-South value chains capture higher value-added shares. In the textile and apparel sector in East Africa, Boys and Andreoni (2023) also found that RVCs have the potential to serve as "learning grounds," or "stepping stones" to more demanding but potentially lucrative global markets. Among others, these benefits occur because, unlike GVCs, power and knowledge are less concentrated in RVCs (Keane, 2015; Paremoer, 2018; Ndubuisi & Owusu, 2022).

Regional integration through trade networks and value chains also provides a key mechanism to realize the transformative role of GTM-led industrialization on the continent. From a practical perspective, this entails integrating resource production, processing, and manufacturing across member states, thereby enhancing economies of scale and fostering collaborative industrial ecosystems. Specifically, African countries could develop strategic GTM processing and GTT manufacturing hubs in different regions, leveraging resource availability and industrial capacity to create specialized centers for various stages of value addition. The mineral and GTTs mappings in sections 3 and 4 provide a foundation for identifying suitable regional hubs. For example, Southern African countries (South Africa, Zambia, and Zimbabwe) could collaborate on lithium and cobalt processing, establishing a regional EV battery supply chain by leveraging South Africa's productive capabilities in the automotive sector, for instance, instead of exporting raw materials to China or Europe.

6.2.4 Framework Enablers

A critical dimension of the framework is the cross-cutting factors, which serve as enablers. These factors dynamically and iteratively reinforce the other parts of the framework toward achieving the intended outcome: sustainable structural transformation. This subsection discusses each of these enablers—geopolitics, mineral governance and policy harmonization, infrastructure, finance and investment, regional security, and capacity development and strengthening.

Geopolitics

Africa must adopt a coordinated geopolitical strategy to secure its interests in the global mineral economy. Africa's GTMs occupy a central position in the evolving global geopolitical landscape, with major powers—such as China, the European Union, and the United States—competing for control over critical supply chains. While this rivalry creates opportunities for investment and partnership, it also exposes African nations to heightened risks. Most African countries are late industrializers, limiting their capacity to negotiate fair terms with powerful multinational corporations and advanced economies. This reflects long-standing historical patterns in which unilateral mineral agreements have often led to external exploitation. As shown in section 3, Africa's mineral wealth tends to be globally competitive only when aggregated at a regional level, rather than leveraged by individual states. These dynamics highlight the urgent need for a unified African geopolitical approach to mineral governance.

Given the limited bargaining power of individual African countries and the continent's historical experience with fragmented and extractive mineral agreements, pursuing uncoordinated negotiations weakens Africa's collective position. This risks reinforcing past models of resource extractivism, characterized by unequal trade deals, minimal technology transfer, and heightened geopolitical vulnerability. In the context of rising global interest in Africa's minerals, a coherent regional approach is essential to secure more equitable and strategic outcomes.

Geopolitics, as a key enabler within Africa's mineral strategy, must strengthen collective bargaining power and support long-term transformation. Within the proposed framework, a unified geopolitical approach would include coordinated mineral export policies—similar to the Organization of the Petroleum Exporting Countries' influence in oil markets—to regulate supply and pricing. It would also involve a continent-wide strategy for mineral diplomacy and strategic partnerships that emphasize technology transfer, infrastructure development, and local value addition over raw material exports. Such a strategy would significantly enhance Africa's leverage in global negotiations, reduce dependency on external actors, and position the continent as a decisive player in global GTM and GTT value chains. Ultimately, this approach is crucial for achieving Africa's broader goals of sustainable structural transformation and economic sovereignty.

Mineral Governance and Policy Harmonization

Africa's mineral governance is fragmented and misaligned with the continent's structural transformation agenda. Across many African countries, mineral governance frameworks suffer from weak institutional capacity, poor enforcement, and limited alignment with broader industrialization strategies. National policies remain fragmented, and regulatory inconsistencies between jurisdictions undermine cross-border collaboration and integration. Although the AMV was introduced to address these governance gaps, its implementation has been sporadic and largely ineffective. As a result, African countries have struggled to build integrated value chains and faced persistent inefficiencies, illicit mineral flows, and a diminished capacity to leverage their mineral wealth for sustainable development.

A regionalized approach to mineral governance is essential for transforming Africa's mineral wealth into long-term development gains. To unlock the full potential of GTMs, African countries must go beyond national reforms and adopt a harmonized, continent-wide governance framework that is explicitly linked to structural transformation objectives. This requires aligning

mineral policies with regional industrial goals and strengthening institutional capacity to enforce common standards. A shared legal and regulatory framework—including provisions for local content, environmental safeguards, and transparent revenue management—would enhance the continent's bargaining power with multinational corporations and foster value addition within African economies. Furthermore, coordinated regional policies could help stabilize mineral prices, reduce exposure to global market shocks, and improve oversight of mining operations. Achieving this vision will require close collaboration among governments, regional bodies, and private investors to ensure policy coherence, regulatory compliance, and institutional accountability.

Infrastructure

Infrastructureis a critical enabler of mineral extraction, processing and trade; however,, Africa's infrastructure remains severely underdeveloped. Efficient movement of minerals—from extraction to intermediate processing and final production—relies on robust infrastructure systems, including energy, transport, telecommunications, and water. Yet, most African countries face infrastructure deficits and, when available, the infrastructure is usually not fit for purpose.

This limits the performance of the mineral sector. As Signe and Johnson (2021) noted, poor infrastructure is one of the main reasons some mineral-rich African countries have not explored or fully commercialized their resources. The African Development Bank estimated that Africa's annual infrastructure financing gap is between US$68 billion and US$108 billion (AfDB, 2023). In addition, the cost of infrastructure services in Africa is significantly higher than in other regions (Tayo, 2024), while public access and perceptions of infrastructure quality are among the lowest globally (Afrobarometer, 2024; Tayo, 2024). These constraints undermine the continent's ability to support the development of GTM value chains.

Bridging Africa's infrastructure gap is essential to unlock the full potential of GTMs and enable a structural transformation agenda. Addressing deficits in the quantity, quality, and affordability of infrastructure services is a prerequisite for building resilient GTM value chains. While national governments must play a central role in developing local infrastructure, regional collaboration is equally critical. Shared investments in cross-border transport corridors, energy grids, and digital networks can enhance mineral production, processing, and trade. Such collaborative infrastructure development can also reduce transaction costs, facilitate market access, and boost competitiveness across African economies.[21]

Targeted investments in regional infrastructure—particularly shared transport, energy, and processing facilities—can catalyze GTM-led structural transformation. Developing regionally integrated infrastructure, such as renewable-powered energy grids and processing hubs supported by minerals like lithium and cobalt, will unlock the performance of emerging industrial parks and the technology hubs proposed across the framework's pillars. These shared facilities not only optimize resource use but also support economies of scale, strengthen intra-African trade, and improve the commercial viability of value addition activities. Thus, within the proposed framework, coordinated infrastructure investments are foundational to the success of regional integration, industrial clustering, and long-term competitiveness in global GTM and GTT value chains.

[21] Elabbas, de Vries, and Correljé (2023) showed how to design a regional power pool in Africa to address the energy deficit.

Finance and Investment

Limited access to finance is a major constraint on Africa's structural transformation and green industrial ambitions. The continent's domestic financial markets remain among the least developed globally (UNECA, 2020). Africa's equity markets are generally small, illiquid, and characterized by limited listings and narrow investor bases (CFA Institute, 2024). These features limit their capacity to support long-term industrial investments. Although many African countries rely on external finance, this dependence exposes them to global economic shocks, volatile interest rates, unfavorable credit ratings, and currency depreciation. FDI has also been skewed toward resource extraction, with minimal investment in manufacturing or downstream processing (Andreoni and Avenyo 2023; Ericsson, Lof, and Lof 2020). This financing pattern reinforces Africa's traditional role as a raw material exporter rather than an industrial value creator.

Access to affordable, long-term capital is essential to drive GTM-led structural transformation across the continent. The exploration, extraction, and processing of GTMs, as well as the development of GTTs, are highly capital-intensive and require sustained financial investment (Ndubuisi & Avenyo, 2024). In addition to infrastructure and technology needs, the creation of regional MVCs demands large-scale, coordinated investment. Addressing these challenges at the national level is difficult given limited fiscal space, but a regionalized financing approach offers strategic advantages.

A regional financial architecture is needed to mobilize capital and de-risk investment in Africa's mineral-based industrialization. Establishing regional financial instruments—such as sovereign wealth funds, regional development funds, and green bonds—can help pool resources and target them toward high-impact sectors in GTMs and GTTs. Innovative tools like blended finance and diaspora bonds could complement these efforts by attracting private sector capital and tapping into Africa's global diaspora and sustainability-focused investors. A practical step would be to create an African Green Minerals Investment Fund, jointly financed by the African Union member states, development finance institutions, and private sector partners. This fund would support infrastructure development, technology transfer, and industrial capacity building. In parallel, integrating capital markets across African countries could create a larger, more efficient financing ecosystem, enabling the continent to raise capital at scale for transformational investments.

Regional Security

Mineral-rich regions are often hotspots of instability and governance breakdown, which are an anathema to structural transformation goals. Across Africa, mineral wealth has often correlated with insecurity, not prosperity. The ongoing conflict in the Democratic Republic of Congo exemplifies this trend. Similar patterns of insecurity and unregulated extraction can be found in the Sahel, northern Mozambique, and Central Africa. In these contexts, insurgents, criminal networks, and unregulated actors exploit governance gaps, smuggle resources across porous borders, and deprive states of revenue. These dynamics weaken formal institutions, deepen social grievances, and perpetuate a vicious cycle of fragility and underdevelopment. Without urgent intervention, such conditions will severely compromise the potential of GTMs to drive inclusive and sustainable structural transformation.

Mineral security in Africa requires a combination of national and regional efforts. Securing Africa's mineral wealth requires more than policing mine sites—it necessitates addressing the deeper political, economic, and social drivers of insecurity. These include tackling corruption, promoting inclusive governance, improving local livelihoods, and integrating artisanal and smallscale miners into formal value chains. However, given the transboundary nature of many mineral flows and security threats, national interventions alone are insufficient. Regional cooperation must be elevated to the center of Africa's mineral governance and development strategy. Doing so can reinforce national efforts through shared intelligence systems, joint border patrols, and harmonized enforcement of anti-smuggling laws.

Regional mineral security requires a dedicated framework. Within the newly proposed framework, a dedicated regional security framework is particularly needed to protect critical infrastructure and curb illicit mineral trade within the broader agenda of regionalized GTM-led structural transformation. Hence, rather than piecemeal security responses, the continent should institutionalize a comprehensive, proactive, and regionally integrated mineral security strategy. Such a strategy should include (1) a regional security alliance to protect mineral-rich areas from insurgencies, illegal mining, and foreign exploitation; (2) a pan-African mineral security task force to monitor and safeguard critical mineral supply chains; and (3) community-based early warning and response systems, especially in artisanal mining zones, to prevent the escalation of local conflicts and promote socially inclusive mineral development. Integrating these mechanisms into Africa's broader GTM and GTT industrialization strategy would provide a protective foundation for longterm development. A secure operating environment is not just a governance imperative—it is an economic necessity. Without peace and stability, Africa risks forfeiting control over its mineral destiny to external actors and illicit networks, repeating the extractive patterns of the past rather than forging a sustainable, sovereign future.

Capacity Development and Strengthening

Africa's GTM-led structural transformation is constrained by weak human, technological, and institutional capacities. Successful mineral development and value addition—from exploration to downstream manufacturing—require a well-developed skills base, advanced technological capabilities, and effective institutional governance. Yet, many African countries face serious capacity limitations in all three areas. Empirical research has underscored that countries with robust human capital and strong institutions are more likely to convert resource wealth into productive transformation and inclusive development outcomes (Shao & Yang, 2014; Zalle, 2019). Unfortunately, for many African economies, the discovery and exploitation of mineral resources have occurred in contexts of institutional fragility and weak human capital development. As a result, foreign companies dominate the high-value segments of the MVCs—such as processing, technology innovation, and equipment manufacturing—while African states remain locked in low-value extraction. This dynamic contributes to a persistent cycle of dependency and missed opportunities for technology transfer, industrial diversification, and economic upgrading.

Developing a coordinated regional capacity agenda is critical to break Africa's dependency trap and unlock transformative opportunities in GTM and GTT value chains. While individual governments are responsible for shaping national education, technical training, and

innovation systems, their efforts are often hampered by scale limitations, inadequate funding, and fragmented strategies. A regional approach can overcome these limitations by pooling resources, standardizing curricula, and building economies of scale in capacity development. This involves harmonizing educational and vocational qualifications across countries, encouraging student and faculty mobility, and developing shared centers of excellence focused on GTMs and GTTs. Pan-African research institutes and universities can be equipped to offer specialized training in mineral geology, extractive metallurgy, battery chemistry, and circular economy practices. Crosscountry collaboration can also facilitate knowledge exchange and reduce duplication of effort.

Continental institutions must lead and coordinate efforts to build Africa's skills and technology ecosystems for the mineral-industrial transition. Among others, organizations such as the AMDC, the African Union Development Agency, the African Capacity Building Foundation, and the AfCFTA Secretariat are well-positioned to lead a continent-wide push for capacity development. These institutions can help design and implement regional frameworks that link industrial policy, R&D, and higher education. For example, the AMDC could be tasked with curating a continental database of mineral expertise, facilitating industry-academic partnerships, and supporting the creation of regional training hubs in mining engineering and sustainable mineral development. The AfCFTA, in turn, can promote regional recognition of technical qualifications and support the mobility of skilled labor within the continent. Public-private partnerships can also play a role by involving major mining and manufacturing firms in training programs, apprenticeships, and curriculum development. This collaboration would ensure that Africa's capacity-building efforts are industry-relevant and globally competitive.

7. CONCLUSION

Africa's vast endowment of GTMs positions the continent as a key player in the global shift toward renewable energy and low-carbon technologies. The global green transition is fueling an unprecedented surge in demand for GTMs such as cobalt, nickel, graphite, manganese, and lithium—essential inputs for renewable energy systems and EVs. Africa is uniquely positioned to contribute significantly to this transition due to its substantial mineral wealth. However, an assessment of past development efforts in mineral-rich African countries revealed a consistent pattern of underperformance. Previous resource-led development strategies have often failed to deliver broad-based structural transformation, instead reinforcing commodity dependence and vulnerability to global market volatility. This study critically examines Africa's current role in the evolving green minerals economy vis-a-vis how the continent can strategically leverage its GTMs to drive industrial development and structural transformation.

Despite collective GTM abundance, African countries remain fragmented, and marginalized within global mineral and technology value chains. This study has shown that although Africa commands a considerable share of global GTM reserves and production, these resources are unevenly distributed across the continent. Most African countries hold only modest shares, limiting their bargaining power and influence in global markets. In addition, Africa continues to operate predominantly in the upstream segment of the value chain, exporting raw materials with limited local processing or manufacturing. China has established itself as the dominant external player, refining a significant proportion of Africa's GTMs and integrating them into its own green technology industries. More broadly, heightened global interest in Africa's mineral resources—driven by intensifying geopolitical rivalry between China and the West—presents both opportunities and risks. Without proactive strategies and institutional capacity, Africa risks remaining a peripheral supplier in a high-stakes global competition for green technologies.

To reposition Africa within the global GTM economy, this study proposed a GTM-led developmental regionalism framework focused on coordinated action, regional integration, and sustainable industrialization. This approach calls for a shift away from fragmented national efforts toward a more unified regional strategy anchored in shared beneficiation, value chain development, and policy harmonization. Through regional cooperation, African countries can pool mineral resources, consolidate processing and manufacturing capabilities, and scale investments in enabling infrastructure. Such a coordinated strategy would enhance the continent's competitiveness, attract strategic investments, and support inclusive industrial development. Ultimately, a GTM-led regional strategy offers a credible and timely pathway to overcome Africa's historic resource trap and drive a socially and environmentally sustainable structural transformation.

REFERENCES

ACET (African Center for Economic Transformation). 2024. "Battery Minerals and Industrial Vision for Africa." ACET, Accra, Ghana.

Adejumobi, S., and C. Obi, eds. 2020. Developmental Regionalism and Economic Transformation in Southern Africa. London: Routledge.

AfDB (African Development Bank). 2023. "Africa's Infrastructure: Great Potential but Little Impact on Positive Growth." AfDB, Abidjan, Côte d'Ivoire. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/ 2018AEO/African_Economic_Outlook_2018_-_EN_Chapter3.pdf.

Afrobarometer. 2024. "Water and Sanitation Still Major Challenges in Africa, Especially for Rural and Poor Citizens." https://www.afrobarometer.org/publication/ad784-water-and-sanitation-still-major-challenges-in-africa-especially-for-rural-and-poor-citizens/.

Amsden, A. H. 2001. The Rise of "The Rest": Challenges to the West from Late-Industrializing Economies. Oxford University Press.

Andreoni, A., and E. K. Avenyo. 2023. "Critical Minerals and Routes to Diversification in Africa: Linkages, Pulling Dynamics and Opportunities in Medium-High Tech Supply Chains." Economic Development in Africa Report, United Nations Trade and Development, Geneva.

Andreoni, A., and S. Roberts. 2022. "Geopolitics of Critical Minerals in Renewable Energy Supply Chains: Assessing Conditionalities on the Use of Technology, Market Capture and the Implications for Africa." Policy Report, African Climate Foundation, Cape Town, South Africa.

Anyanwu, J. C. 2017. "Manufacturing Value Added Development in North Africa: Analysis of Key Drivers." Asian Development Policy Review 5 (4): 281–98.

Arrobas, D. L. P., K. L. Hund, M. S. Mccormick, J. Ningthoujam, and J. R. Drexhage. 2017. The Growing Role of Minerals and Metals for a Low Carbon Future. Washington, DC: World Bank Group.

Auty, R. M. 2001. "The Political Economy of Resource-Driven Growth." European Economic Review 45 (4-6): 839–46.

Baskaran, G. 2023. "A Window of Opportunity to Build Critical Mineral Security in Africa." Center for Strategic and International Studies, Washington, DC (accessed January 29, 2025), https://www.csis.org/analysis/ window-opportunity-build-critical-mineral-security-africa.

Bekele 2019

Benabdallah, L. 2024. "China's Role in Africa's Critical Minerals Landscape: Challenges and Key Opportunities." Africa Policy Research Institute, Berlin, Germany. https://afripoli.org/chinas-role-in-africas-critical-minerals-landscape-challenges-and-key-opportunities.

Beuter, P., R. Bhuee, L. Gabadadze, A. Gnanguênon, and J. Hofmeyr. 2025. "Mapping Africa's Green Minerals Partnerships." Africa Policy Research Institute, Berlin, Germany. https://afripoli.org/ mapping-africas-green-mineral-partnerships.

Bocoum, B. 2000. "The Mineral and Energy Sectors and Stages of Economic Development: A Comparative Input-Output Analysis." Working Paper 59, African Development Bank, Abidjan, Côte d'Ivoire.

Boys, J., and A. Andreoni. 2023. "Upgrading through Global, Regional or National Value Chains? Firm-Level Evidence from the East African Textiles & Apparel Sector." Geoforum 144: 103809.

Burrier, E. A., and T. Sheehy. 2023. "Challenging China's Grip on Critical Minerals Can Be a Boon for Africa's Future." United States Institute of Peace, Washington, DC (accessed January 27, 2025), https://www.usip.org/publications/2023/06/challenging-chinas-grip-critical-minerals-can-be-boon-africas-future.

CFA Institute. 2024. "How Capital Market Development Can Help Shape Africa's Future." CFA Institute, Charlottesville, VA (accessed March 30, 2025), https://www.cfainstitute.org/insights/articles/ capital-market-development-africa-future.

Chandler, B. 2022. "Africa's Critical Minerals: Africa at the Heart of a Low-Carbon Future." Mo Ibrahim Foundation, London. https://mo.ibrahim.foundation/sites/default/files/ 2022-11/minerals-resource-governance.pdf.

Chen, W., M. Fornino, and H. Rawlings. 2024. "Navigating the Evolving Landscape between China and Africa's Economic Engagements." International Monetary Fund, Washington, DC.

Cotula, L., X. Weng, Q. Ma, and P. Ren. 2016. China-Africa Investment Treaties: Do They Work? London: International Institute for Environment and Development.

Cust, J., and A. Zeufack, eds. 2023. Africa's Resource Future: Harnessing Natural Resources for Economic Transformation during the Low-Carbon Transition. Washington, DC: World Bank.

Davies, R. 1996. "Promoting Regional Integration in Africa: An Analysis of Prospects and Problems from a South African Perspective." African Security Review 5 (5): 27–38.

de Oliveira, D., C. Fortes, P. Patinha, M. Le Gleuher, H. Cornelissen, N. Christou, J. Vasters, and P. Schütte. 2023. "Pan-African Inventory of Existing Ore Processing and Refining Capacities." Horizon Europe Framework Programme, AfricaMaVal, Paris.

Diene, P. D., D. Manley, S. Olan'g, and T. Scurfield. 2022. "Triple Win: How Mining Can Benefit Africa's Citizens, Their Environment and the Energy Transition." Natural Resource Governance Institute, New York.

Dong, Y., and C. Fan. 2020. "The Role of China's Aid and ODI in the Economic Growth of African Countries." Emerging Markets Review 44: 100713.

Egyin, D. 2024. "Addressing China's Monopoly over Africa's Renewable Energy Minerals." Africa Up Close Blog, May 2, 2024 (accessed January 27, 2025), https://www.wilsoncenter.org/blog-post/ addressing-chinas-monopoly-over-africas-renewable-energy-minerals

Elabbas, M. A. E., L. de Vries, and A. Correljé. 2023. "African Power Pools and Regional Electricity Market Design: Taking Stock of Regional Integration in Energy Sectors." Energy Research & Social Science 105: 103291.

Ericsson, M., O. Lof, and A. Lof. 2020. "Chinese Control over African and Global Mining—Past, Present and Future." Mineral Economics 33: 153–81.

ETK 2024

EU (European Union). 2023. Critical Raw Materials Act: Ensuring Secure and Sustainable Supply Chains for Europe's Green and Digital Future. Brussels, Belgium: EU.

Evans, S. 2022. "China's Dominance in Clean Energy Value Chains: Risks and Responses." Policy Brief, Nature Energy, Odense, Denmark.

Fessehaie, J., and Z. Rustomjee. 2018. "Resource-Based Industrialisation in Southern Africa: Domestic Policies, Corporate Strategies and Regional Dynamics." Development Southern Africa 35 (3): 404–18.

Fliess, B., E. Idsardi, and E. Riaan Rossouw. 2017. "Export Controls and Competitiveness in African Mining and Minerals Processing Industries." OECD Trade Policy Papers 204, Organisation for Economic Co-operation and Development, Paris.

Foreign Affairs Committee. 2022. "China Regional Snapshots: Sub-Saharan Africa." Foreign Affairs Committee, Washington, DC (accessed January 29, 2025), https:// foreignaffairs.house.gov/china-regional-snapshot-sub-saharan-africa/.

Franssen, L. 2020. "Capturing Value in South-South and South-North Value Chains: Evidence from East Africa." European Journal of Development Research 32 (4): 939–75.

Gereffi, G., J. Humphrey, and T. Sturgeon. 2005. "The Governance of Global Value Chains." Review of International Political Economy 12 (1): 78–104.

Grynspan, R. 2024. "How Critical Energy Transition Minerals Can Pave the Way for Shared Prosperity." United Nations Trade and Development, Geneva. https://unctad.org/news/ blog-how-critical-energy-transition-minerals-can-pave-way-shared-prosperity.

Hausmann, R., J. Hwang, and D. Rodrik. 2007. "What You Export Matters." Journal of Economic Growth 12: 1–25.

Hendrix, C. S. 2022. "Building Downstream Capacity for Critical Minerals in Africa: Challenges and Opportunities." Policy Brief, 22-16, Peterson Institute for International Economics, Washington, DC.

Hirschman, A. O. 1958. The Strategy of Economic Development. New Haven, CT: Yale University Press.

Horn, S., M. R. Carmen, and C. Trebesch. 2019. "China's Overseas Lending." NBER Working Paper 26050, National Bureau of Economic Research, Cambridge, MA.

Humphrey, J., and H. Schmitz. 2002. "How Does Insertion in Global Value Chains Affect Upgrading in Industrial Clusters?" Regional Studies 36 (9): 1017–27.

Hund, K., D. La Porta, T. P. Fabregas, T. Laing, and J. Drexhage. 2023. Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. Washington, DC: World Bank Group.

IEA (International Energy Agency). 2021. The Role of Critical Minerals in Clean Energy Transitions. Paris: IEA. https://www.iea.org/reports/ the-role-of-critical-minerals-in-clean-energy-transitions.

IEA (International Energy Agency). 2022a. "The Role of Critical Minerals in Clean Energy Transitions." World Energy Outlook Special Report, IEA, Paris.

IEA (International Energy Agency). 2022b. The Role of Critical Minerals in Clean Energy Transitions. Paris: IEA. https://iea.blob.core.windows.net/assets/ffd2a83b-8c30-4e9d-980a-52b6d9a86fdc/ TheRoleofCriticalMineralsinCleanEnergyTransitions.pdf.

IEA (International Energy Agency). 2023a. "Critical Minerals Market Review 2023: Key Market Trends." IEA, Paris. https://www.iea. org/reports/critical-minerals-market-review-2023/key-market-trends.

IEA (International Energy Agency). 2023b. "Global Supply Chains of EV Batteries and Critical Minerals." IEA, Paris.

IEA (International Energy Agency). 2023c. "Increase in Annual Clean Energy Investment in Selected Countries and Regions, 2019-2023." IEA, Paris (accessed January 10, 2025), https://www.iea.org/data-and-statistics/charts/

increase-in-annual-clean-energy-investment-in-selected-countries-and-regions-2019-2023.

IEA (International Energy Agency). 2023d. "Renewables 2023: Analysis and Forecast to 2028." IEA, Paris. https://www.iea.org/ reports/renewables-2023.

IEA (International Energy Agency). 2023e. The State of Clean Technology Manufacturing. Paris: IEA. https://iea. blob.core.windows.net/assets/32e7d448-4f0b-4ae8-85c4-d72924bf8a4f/ TheStateofCleanTechnologyManufacturing.pdf.

IEA (International Energy Agency). 2023f. "World Energy Investment 2023." IEA, Paris. https://www.iea.org/reports/world-energy-investment-2023/overview-and-key-findings.

IEA (International Energy Agency). 2024a. Energy Technology Perspectives 2024. Paris: IEA. https://www.iea.org/news/global-market-for-key-clean-technologies-set-to-triple-to-more-than-2-trillion-over-the-comi.

IEA (International Energy Agency). 2024b. World Energy Investment 2024. Paris: IEA. https://www.iea.org/news/investment-in-clean-energy-this-year-is-set-to-be-twice-the-amount-going-to-fossil-fuels-htt//www.iea.org/reports/world-energy-investment-2024.

Ismail, F. 2021. The AfCFTA and Developmental Regionalism: A Handbook. Pretoria, South Africa: Trade & Industrial Policies Strategies. April 2021. https://www.tips.org.za/research-archive/books/item/4121-the-africancontinental-free-trade-area-afcfta-and-developmental-regionalism-a-handbook.

Kaplinsky, R., M. Morris, and D. Kaplan. 2011. "A Conceptual Overview to Understand Commodities, Linkages and Industrial Development in Africa." Africa Export Import Bank, Abuja, Nigeria.

Karkare, P., and A. Medinilla. 2023. "Green Industrialisation: Leveraging Critical Raw Materials for an African Battery Value Chain." ECDPM Discussion Paper 359, European Centre for Development Policy Management, Maastricht, Netherlands.

Keane, J. 2015. "Firms and Value Chains in Southern Africa." ODI Working Paper, Overseas Development Institute, London.

Khan, M. H. 2000. "Rent-Seeking as Process." Paper presented at the Development Studies Association Annual Conference, University of Manchester, England.

Konte, M., and G. Ndubuisi. 2024. "Chinese Development Finance and Labor Productivity Growth in Developing Countries." https://ssrn.com/abstract=4989817orhttp://dx.doi.org/10. 2139/ssrn.4989817.

Li, A., and S. Zhou. 2024. "Role of Mineral-Based Industrialization in Promoting Economic Growth: Implications for Achieving Environmental Sustainability through Financial Management." Resources Policy 92: 105020.

Li, W., A. Wang, W. Zhong, W. Xing, and J. Liu. 2022. "The Role of Mineral-Related Industries in Chinese Industrial Pattern." Resources Policy 76: 102590.

Long, J., and T. Tong. 2024. "Four Key Critical Minerals in China Likely to Be under the Spotlight at AFA 2024." Fastmarkets (accessed January 11, 2025), https://www.fastmarkets.com/insights/four-key-critical-minerals-in-china-likely-to-be-under-the-spotlight-at-afa-2024/ #:~:text=In%20addition%20to%20manganese%2C%20chrome,potassium%2C%20rare% 20earths%2C%20rhenium%2C.

Lopes, A., R. Ruiz, R. Ribeiro, and W. Cantelmo. 2023. "Linkages in the Metal Mining Industry: Local Job Multipliers in Brazil." Resources Policy 82: 103545.

McKinsey. 2021. "Africa's Green Manufacturing Crossroads: Choices for a Low-Carbon Industrial Future." McKinsey, New York.

Ndubuisi, G., and E. K. Avenyo. 2024. "Solar Photovoltaic Manufacturing in Africa." Africa Policy Research Institute, Berlin, Germany.

Ndubuisi, G., and S. Owusu. 2022. "Sub-Saharan Africa's Prospect of Economic Development through Global Supply Chains." Sustainable Global Supply Chain Report. https://ssrn.com/abstract=4116677 or http://dx.doi.org/10.2139/ssrn.4116677.

Nedopil, C. 2023. "Countries of the Belt and Road Initiative." Green Finance & Development Center, FISF Fudan University, Shanghai, China (accessed January 30, 2025), https://greenfdc.org/ countries-of-the-belt-and-road-initiative-bri/.

Neema, G., and C. van Staden. 2024. "Africa's Critical Minerals: Boosting Development amid Geopolitical Challenges." Policy Insights 155. South African Institute of International Affairs, Johannesburg, South Africa.

OECD (Organisation for Economic Co-operation and Development). 2023. "Critical Minerals for the Green Transition." OECD Green Growth Papers, OECD, Paris.

Ojaleye, T., and B. Narayanan. 2022. "Input-Output Table Construction and Mining Sector Linkages in Nigeria." Resources Policy 79: 102966.

Owusu, S., K. Tang, and G. Ndubuisi. 2025. "Chinese Ties and Low-Carbon Industrialization in Africa." Energy Economics 144: 108352.

Paremoer, T. 2018. "Regional Value Chains: Exploring Linkages and Opportunities in the Agro-Processing Sector across Five SADC Countries." CCRED Working Paper No. 2018/4, Centre for Competition, Regulation and Economic Development, Johannesburg, South Africa.

Press, E., T. Van de Graaf, M. Lyons, I. E. Garcia, E. Rath, and B. Gibson. 2023. "Geopolitics of the Energy transition: Critical Materials." International Renewable Energy Agency, Abu Dhabi, United Arab Emirates.

Purwins, S. 2023. "Same, but Different: Ghana's Sinohydro Deal as Evolved 'Angola Model' ?"

Insight on Africa 15 (1): 46–70.

Reale, H. 2021. "China's Stake in Africa's Mines." The Wire China (accessed January 29, 2025), https://www. thewirechina.com/2021/06/27/chinas-stake-in-africas-mines/.

Risi, H., and C. Doyle. 2023. "Examining China's Impact on Mining in Africa: Critiques and Credible Responses." Wilson Center, Washington, DC (accessed January 27, 2025), https://www.wilsoncenter.org/blog-post/ examining-chinas-impact-mining-africa-critiques-and-credible-responses.

Shao, S., and L. Yang. 2014. "Natural Resource Dependence, Human Capital Accumulation, and Economic Growth: A Combined Explanation for the Resource Curse and the Resource Blessing." Energy Policy 74: 632–42.

Signé, L., and C. Johnson. 2021. "Africa's Mining Potential: Trends, Opportunities, Challenges and Strategies." Policy Paper 21/10, Policy Center for the New South, Rabat, Morocco.

Statista. 2025. "Mining, Metals & Minerals: Demand Increase Forecast for Minerals for Energy Technologies Worldwide in 2050 in the Two-Degree Scenario." Statista, London (accessed January 10, 2025), https://www.statista.com/statistics/1264891/forecast-global-mineral-demand-increase-for-energy-technologies-in-the-two-degree-scenario/.

Tayo, T. 2024. "Trade Infrastructure Financing in Africa: An Exploration of Geopolitical Funds for Private Sector Participation." African Policy Research Institute, Abuja, Nigeria.

UNCTAD (United Nations Trade and Development). 2021. "Commodities at a Glance: Special Issue on Strategic Minerals." UNCTAD, Geneva.

UNCTAD (United Nations Trade and Development). 2023. "Commodities at a Glance: Special Issue on Strategic Minerals." UNCTAD, Geneva. https://unctad.org.

UNCTAD (United Nations Trade and Development). 2024. "Critical Minerals Boom: Global Energy Shift Brings Opportunities and Risks for Developing Countries." UNCTAD, Geneva (accessed February 10, 2025), https://unctad.org/news/critical-minerals-boom-global-energy-shift-brings-opportunities-and-risks-developing-countrie.

UNECA (United Nations Economic Commission for Africa). 2020. "Innovative Finance for Private Sector Development in Africa." Economic Report on Africa 2020. UNECA, Addis Ababa, Ethiopia. https://uneca.org/era2020.

UNECA (United Nations Economic Commission for Africa). 2023. "AfCFTA and Industrialization: Policy Tools for Africa's Economic Transformation." UNECA, Addis Ababa, Ethiopia.

UNECA, AU, and AfDB (United Nations Economic Commission for Africa, African Union, and African Development Bank). 2017. Bringing the African Free Trade Area—Assessing Regional Integration in Africa VIII. Addis Ababa: Ethiopia: UNECA, AU, and AfDB.

USGS (United States Geological Survey). 2023. "USGS 2023 List of Critical Minerals." USGS, Reston, VA.

Wilson, J. D. 2015. "Understanding Resource Nationalism: Economic Dynamics and Political Institutions." Contemporary Politics 21 (4): 399–416.

World Bank. 2023a. Africa's Critical Minerals: Mobilizing Investment and Strengthening Governance. <please check this – I could not find it. Is it a book or a paper?>

World Bank. 2023b. Leveraging AfCFTA to Boost Regional Value Chains in Africa. <please check this – I could not find it. Is it a book or a paper?>

Zallé, O. 2019. "Natural Resources and Economic Growth in Africa: The Role of Institutional Quality and Human Capital." Resources Policy 62: 616–24.

APPENDIX: ADDITIONAL TABLES AND FIGURES

Table A1: Critical Raw Materials

Abrasives	Copper	Lead	Quartz	Uranium
Aluminum	Diamond	Lime	Rhenium	Vanadium
Antimony	Diatomite	Limestone	Rubidium	Vermiculite
Arsenic	Electrical Steel	Lithium	Salt	Wollastonite
Asbestos	Feldspar	Magnesium	Sand & Gravel	Xenon
Barium/Baryte	Fluorine	Manganese	Selenium	Zeolites
Bauxite	Fluorspar	Mercury	Silicon	Zinc
Beryllium	Gallium/Gallium nitrate	Mica	Silver	Zirconium
Bismuth	Garnet	Molybdenum	Soda Ash	
Boron	Gemstones	Natural gas	Stone	
Bromine	Germanium	Nickel	Strontium	
Butyllithium	Gold	Niobium	Sulfur	
Cadmium	Graphite	Nitrogen	Talc	
Carbon Fiber	Gypsum	Peat	Tantalum	
Cement	Hafnium	Perlite	Tellurium	
Cesium	Helium	Phosphate	Thallium	
Chromium	Indium	Phosphorus	Thorium	
Clays	Iodine	Polyvinylidene fluoride	Tin	
Cobalt	Iron and Steel	Potash/Potassium	Titanium	
Coking Coal	Kyanite	Pumice	Tungsten	

Platinum Group Metal (PGM)	**Rare Earth Element (REE)**
Iridium	Cerium
Palladium	Dysprosium
Platinum	Erbium
Rhodium	Europium
Ruthenium	Gadolinium
	Lanthanum
	Lutetium
	Holmium
	Neodymium
	Praseodymium
	Samarium
	Scandium
	Terbium
	Thulium
	Yttrium
	Ytterbium

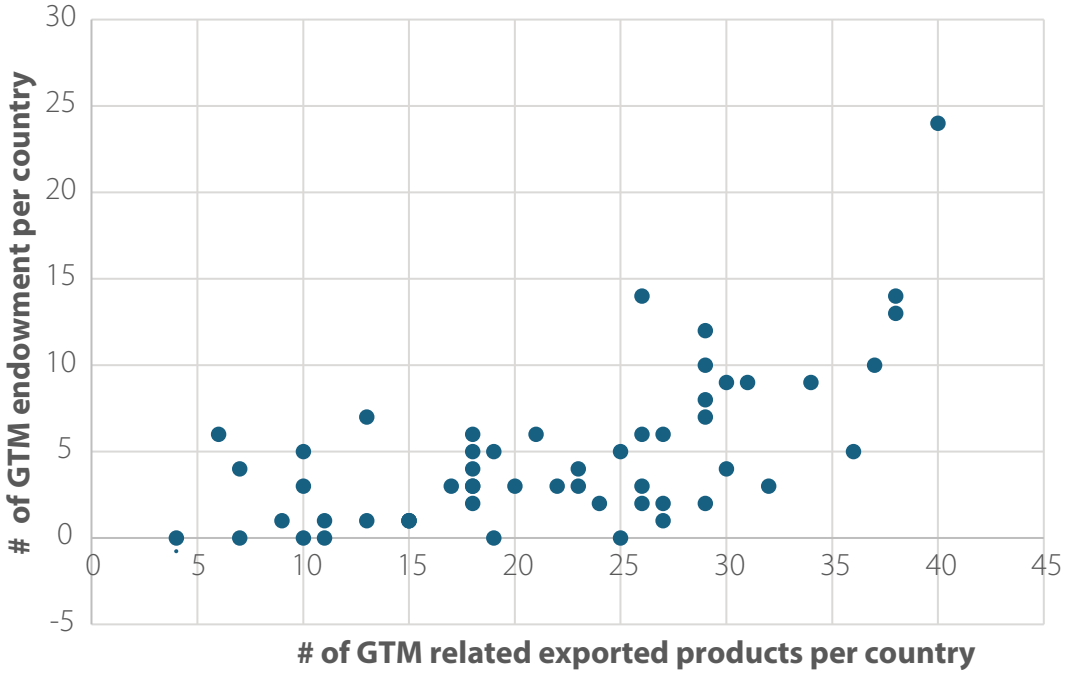
Source: Original table for this study, based on the critical material lists of Australia, Canada, China, the European Union, India, Japan, the Republic of Korea, South Africa, the United Kingdom, and the United States; data from the International Energy Agency, the International Renewable Energy Agency, and the European Union; Long and Tong (2024)

Table A2: Mapping of Green Transition Minerals to Export Data

Minerals	HS codes
Aluminum	"260600"; "262040"; "281810"; "281820"; "281830"; "283322"; "283330"; "283332"; "282612"; "76"
Antimony	"261710"; "262091"; "282580"; "811010"; "811020"; "811090"
Arsenic	"280480"; "262060"
Beryllium	"262091"; "811212"; "811213"; "811219"
Bismuth	"810600"; "262060"
Boron	"252800"; "281000"; "284011"; "284019"; "284020"; "284030"
Cadmium	"262091"; "810720"; "810730"; "810790"
Chromium	"261000"; "262091"; "281910"; "281990"; "811221"; "811222"; "811229"
Cobalt	"260500"; "282200"; "810520"; "810530"; "810590"
Copper	"260300"; "262030"; "282550"; "282741"; "283325"; "74"
Fluorspar	"252921"; "252922"; "252930"
Gallium	"811292"; "811299"
Germanium	"282560"
Natural Graphite	"250410″; "250490"
Iron & Steel	"260111″; "260112"; "260120"; "250200"; "261800"; "261900"; "282110"; "72"
Lead	"260700″;"262021"; "262029"; "282410"; "282490"; "78"
Lithium	"282520″; "283691"; "284530"
Magnesium	"251910"; "251990"; "253020"; "281610"; "283321"; "810411"; "810419"; "810420"; "810430"; "810490"
Manganese	"260200"; "282010"; "282090"; "811100"
Molybdenum	"261310"; "261390"; "284170"; "282570"; "810210"; "810294"; "810295"; "810296"; "810297"; "810299"
Nickel	"260400"; "282540"; "282735"; "283324"; "282735"; "75"
Niobium	"261590"
PGM	"711011"; "711019"; "711021"; "711029"; "711031"; "711039"; "711041"; "711049"
Phosphate	"251010"; "251020"; "283510"; "283522"; "283524"; "283525"; "283526"; "283529"; "280470"; "281212"; "281213"; "281214"; "280920"; "283531"; "283539"
Potassium	"281520"; "281530"; "283640"; "310420"; "310430"; "310490"
REE	"280530"; "284610"; "284690"
Silicon	"280461"; "280469"; "281122"; "283911"; "283919"; "283990"; "284210"; "284920"
Selenium	"280490"
Silver	"261610"; "284321"; "284329"; "710610"; "710691"; "710692"
Strontium	"281640"; "283692"
Tantalum	"261590"; "810320"; "810330"; "810391"; "810399"
Tellurium	"280450"
Thorium	"261220"
Tin	"260900"; "800110"; "800120"; "800200"; "800300"; "800700"
Titanum	"261400"; "282300"; "810820"; "810830"; "810890"
Tungsten	"261100"; "284180″; "810110"; "810194"; "810196"; "810197"; "810199"
Uranium	"261210"; "284410"; "284420"; "284430"
Vanadium	"282530"
Zinc	"260800"; "281700"; "262011"; "262019"; "790111"; "790112"; "790120"; "790200"; "790310"; "790390"; "790400"; "790500"; "790700"
Zirconium	"261510"; "810920"; "810930"; "810990"

Source: Original table for this study

Figure A1: Correlation Between GTM Endowment and Exported GTM variety per African Country



Source: Original figure for this study
Note: GTM= green transition minerals

Table A3: List of Economies, by Region

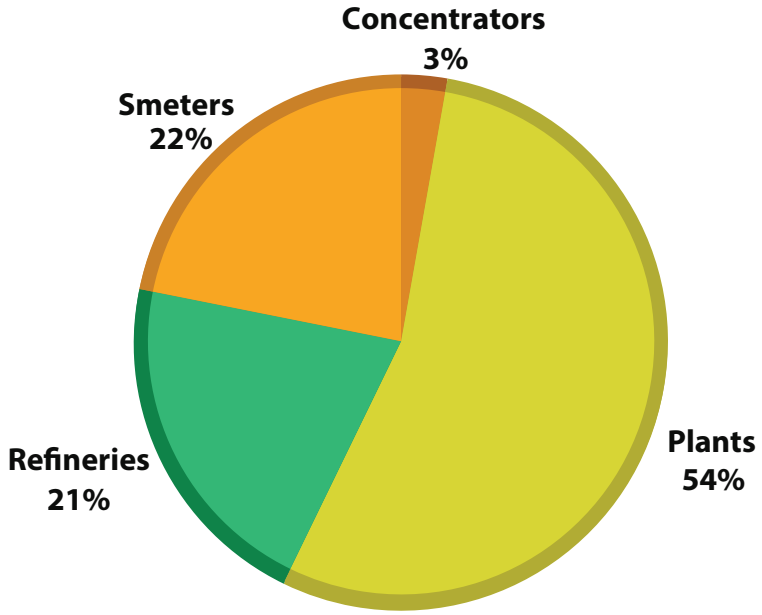
Africa		LAM	Europe	Asia	
Mozambique	Gambia	Mexico	Luxembourg	Georgia	Tajikistan
Ghana	Botswana	Cayman Isds	Serbia	Indonesia	Malaysia
Kenya	Rwanda	Grenada	Montenegro	Iran	Pakistan
South Africa	Sudan	St. Vincent & Grenadines	Croatia	Turkmenistan	China, Macao SAR
Uganda	Eswatini	Bahamas	Denmark	Armenia	Cambodia
DR Congo	Niger	El Salvador	Lithuania	Sri Lanka	United Arab Emirates
Mali	Nigeria	Dominica	Ireland	Hong Kong	Iraq
Djibouti	Guinea-Bissau	Falkland Isds	Netherlands	Azerbaijan	Singapore
Senegal	Sao Tome & Principe	Aruba	Germany	Yemen	Brunei Darussalam
Zambia	Tunisia	Panama	Ukraine	Lebanon	Thailand
Namibia	Mauritius	Colombia	Portugal	Oman	Syria
Morocco	Congo	Argentina	Belarus	Mongolia	Qatar
Sierra Leone	Burundi	Dominican Rep.	San Marino	Uzbekistan	Nepal
Madagascar	Zimbabwe	Peru	Hungary	Maldives	Korea, DPR
Burkina Faso	Cabo Verde	Antigua & Barbuda	Bulgaria	China	Saudi Arabia
Cameroon	Malawi	Brazil	Italy	Israel	Kazakhstan
Mauritania	Lesotho	Cuba	North Macedonia	Turkey	Japan
Somalia	Chad	Anguilla	Andorra	Lao	Viet Nam
Guinea	Ethiopia	Costa Rica	France	Kuwait	Philippines
Angola	Central African Rep.	Jamaica	Bosnia Herzegovina	Myanmar	India
Eritrea	South Sudan	Venezuela	Latvia	Bhutan	Timor-Leste
Egypt	Comoros	Paraguay	Russia	Jordan	Bahrain
Gabon	Liberia	Br. Virgin Isds	Moldova	Korea	Afghanistan
Togo	Algeria	Nicaragua	Czechia	Bangladesh	Kyrgyzstan
Equatorial Guinea	Tanzania	Belize	Estonia	Cyprus	
Benin	Seychelles	Honduras	United Kingdom		
Libya	Cote d'Ivoire	Haiti	Switzerland	**North America**	
		Guatemala	Romania	Greenland	
Oceania		Barbados	Albania	Bermuda	
Tonga	Australia	Ecuador	Norway	Canada	
Solomon Isds	Niue	Bolivia	Sweden	USA	
Kiribati	Nauru	Turks and Caicos Isds	Poland		
Vanuatu	Papua New Guinea	Guyana	Spain		
Samoa	Fiji	Trinidad & Tobago	Malta		

Table A4. Africa's Top Five Mineral Export Destinations, by Mineral

Zirconium	China (51.1%)	Spain (11.5%)	Italy (8.3%)	Netherlands (6.7%)	USA (4.3%)
Zinc	China (65.7%)	Canada (5.5%)	Rep. of Korea (5.5%)	Cote d'Ivoire (3.7%)	Spain (2.8%)
Vanadium	USA (30.4%)	Canada (22.8%)	Netherlands (20.1%)	Japan (14.4%)	Mozambique (8.4%)
Uranium	France (42.3%)	China (36.9%)	Canada (11.3%)	USA (6.5%)	Guyana (1.5%)
Tungsten	China (36%)	UK (31.2%)	UAE (8.9%)	Viet Nam (6.9%)	Malaysia (3.2%)
Titanium	USA (21.6%)	China (14.5%)	Belgium (13%)	Japan (9.8%)	Norway (5%)
Tin	China (48.1%)	Malaysia (28.2%)	Thailand (17.2%)	Myanmar (2.2%)	UK (0.7%)
Thorium	China (99.9%)	DR Congo (0.002%)	Mozambique (0.00006%)	Rep. of Korea (0.00005%)	Not Available
Tellurium	Zimbabwe (64%)	Mozambique (32.4%)	DR Congo (2.1%)	Spain (0.4%)	Namibia (0.2%)
Tantalum	China (33.7%)	Thailand (28.2%)	USA (6.3%)	Malaysia (10.6%)	Kazakhstan (5.9%)
Strontinium	USA (66.3%)	Hong Kong (22.3%)	India (5.3%)	Mozambique (3.7%)	North Macedonia (1.2%)
silver	Germany (21.3%)	Switzerland (22.2%)	UAE (15.5%)	India (14.4%)	China (9.5%)
selenium	Mozambique (48.3%)	Kenya (27.8%)	Botswana (10.9%)	Zambia (4.4%)	Lesotho (2.6%)
silicon	Netherlands (9.2%)	Senegal (8.4%)	Angola (5.1%)	Japan (5%)	Italy (4.9%)
REE	USA (44.8%)	Malaysia (44.2%)	Turket (7.5%)	Germany (0.8%)	Australia (0.6%)
potassium	Zimbabwe (17.2%)	Zambia (11.7%)	Peru (7.1%)	Brazil (7%)	Morocco (6.7%)
phosphate	India (41.4%)	Pakistan (9.6%)	Turkey (5%)	Brazil (4.9%)	Belgium (4.8%
PGM	Japan (30.7%)	USA (20.6%)	UK (13.5%)	China (9.5%)	Germany (8%)
niobium	China (34.1%)	Thailand (28.5%)	Malaysia (10.7%)	Kazakhstan (5.9%)	Japan (5.3%)
nickel	South Africa	China (19.1%)	Japan (12.6%)	USA (6.3%)	Netherlands (5.5%)
molybdenum	Viet Nam (26.2%)	South Africa (25%)	Belgium (14.3%)	Germany (12.6%)	India (6.7%)
manganese	China (60.4%)	India (12.1%)	Norway (5.1%)	Japan (4%)	USA (3.2%)
magnesium	DR Congo (74.9%)	Zambia (6%)	Morocco (3.1%)	France (2.8%)	Germany (1.4%)
Lithium	China (70.3%)	Czechia (10.6%)	India (9.9%)	Angola (2.9%)	Zambia (2.8%)
Lead	China (26.7%)	India (17.1%)	USA (11.9%)	Rep. of Korea (6.7%)	Turkey (5.2%)
Iron & Steel	China (33.3%)	Mozambique (6.8%)	Netherlands (6.3%)	USA (5.4%)	Italy (4.5%)
Graphite	China (48.9%)	India (10.9%)	Germany (8.6%)	USA (8.3%)	Turkey (4.6%)
Germanium	Netherlands (8.8%)	India (33.9%)	Japan (22.2%)	USA (18%)	United Kingdom (9.4%)
Gallium	India (55.8%)	United Kingdom (23.6%)	Canada (13.9%)	Germany (6.3%)	Namibia (0.2%)
Fluorspar	India (24.3%)	Netherlands (16.2%)	Italy (15.9%)	Germany (13.5%)	Luxembourg (9.4%)
Copper	China (42.4%)	Switzerland (12.8%)	UAE (8.8%)	India (7%)	Rep. of Korea (3.8%)
Cobalt	China (84.4%)	Zambia (3.6%)	Finland (2.2%)	Netherlands (1.7%)	Namibia (1.66%)
Chromium	China (73.5%)	Indonesia (6.4%)	Turkey (2.9%)	Hong Kong (4.7%)	India (2.4%)
Cadmium	South Africa (68%)	China (15.5%)	UK (6.6%)	Netherlands (5.5%)	Germany (2.5%)
Boron	Zimbabwe (26.1%)	Djibouti (15%)	Zambia (9.4%)	Israel (7.5%)	Mozambique (6.3%)
Bismuth	Australia (65.8%)	Botswana (30.1%)	Netherlands (3.6%)	Lesotho (0.33%)	Zambia (0.27%)
Beryllium	South Africa (83.2%)	China (12.8%)	Namibia (3.4%)	Germany (0.1%)	UK (0.4%)
Arsenic	Botswana (49.3%)	Kenya (24.3%)	Eswatini (17.1%)	Netherlands (5.8%)	DR Congo (2%)
Antimony	Viet Nam (42.2%)	China (28.7%)	Mozambique (12.8%)	Zimbabwe (11.2%)	Kenya (3.5%)
Aluminum	China (34.8%)	Italy (9.5%)	Netherlands (6.2%)	Spain (5.6%)	Germany (4.8%)

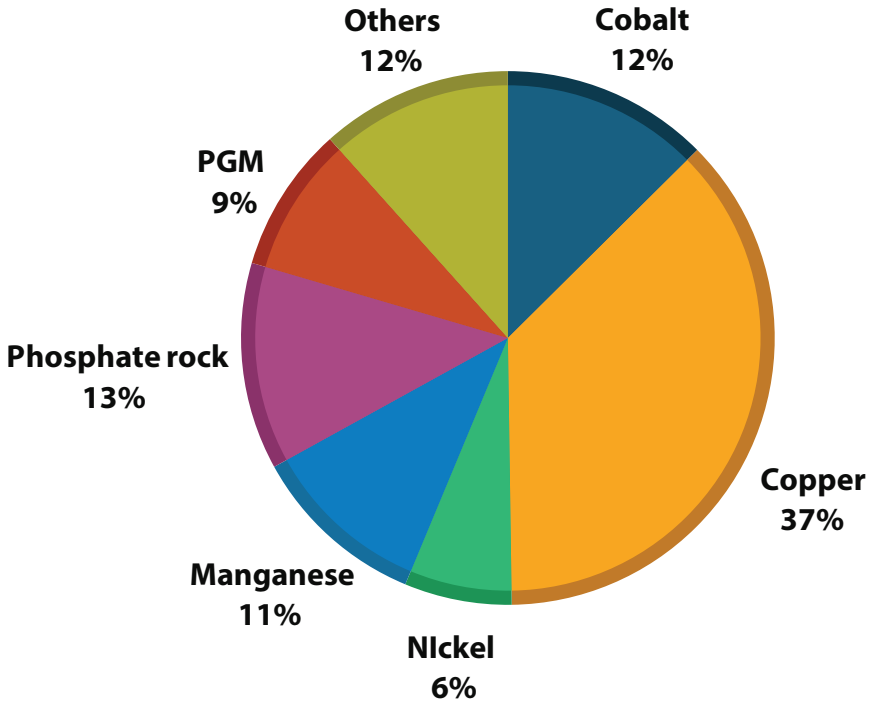
Source: Original table for this study, based on data from BACI-CEPII, 2022

Figure A2: Share of Mineral Processing Facilities in Africa



Source: Original figure for this study based on data from de Oliveira et al. (2023)
Note: A "plant" is a general term for various industrial facilities; a "smelter" focuses on extracting metals; a "concentrator" enhances the concentration of valuable minerals within raw ore; and a "refinery" mostly deals with refining petroleum or chemicals (de Oliveira et al. 2023).

Figure A3: Share of Processed Minerals in Africa



Source: Original figure for this study based on data from de Oliveira et al. (2023)
Note: PGM= Platinum Group Metals

Table A5: Mapping Transition Technologies to the Export Data

Technology	HS codes
Electric Vehicles	"870240"; "870380"
Hybrid Vehicles	"870220"; "870230"; "870340"; "870350"; "870360"; "870370"
Solar PV	"854140"; "850440"
Solar Thermal	"841919"; "850239"; "841950"
Wind Turbines	"850231"
Hydraulic turbines	"850163"; "850164"; "850162"; "850161"
Hydropower	"841090"; "841013"; "841012"; "841011"
Geothermal	"841861"
Nuclear Energy	"840110"; "840120"; "840140"
Hydrogen	"280410"
Fuel cells & Battery	"850610"; "850630"; "850640"; "850650"; "850660"; "850680"; "850690"
Electric accumulators	"850710"; "850720"; "850730"; "850740"; "850750"; "850760"; "850780"; "850790"

Source: Original table for this study.

Table A6: Initiatives Related to Mineral Exploration and Extraction-Seeking

Rwanda	Mining law (as amended, 2014) Source: UNCTAD Investment Policy Monitor	• Provides varying licensing length (5-25 years), depending on the nature and size of mineral deposits, as well as the size of investment to be injected in a concession.
Congo	Law No. 66-2020 Source: UNCTAD Investment Policy Monitor	• Proposed a reduction in the corporate income tax rate from 30% to 28% for mining, quarrying and real estate companies
Cameroon	Law No. 2023/014 Source: UNCTAD Investment Policy Monitor	• Establishes the Mining Sector Development Fund, aimed at financing inventory activities for detecting minerals and other mining and geological activities
Ghana	Minerals and Mining Act (2006, amended in 2015)	• Allows the government to enter into stability agreements with mining companies. • Capital allowance deductions, and exemptions on imported mining equipment to encourage investment in mining.
Nigeria	Roadmap for the Growth and Development of the Nigerian Mining Industry 2016	• Strengthen mining laws, improve licensing processes, and enhanced governance to boost investor confidence. • Develop transport, power, and processing facilities while providing funding support for mining projects. • Conduct surveys, improve data availability, and promote research for better resource management.
	Nigeria minerals & Mining Act 2007	• Establishes a structured licensing system, including exploration licenses, mining leases, and quarrying leases, regulated by the Mining Cadastre Office (MCO). • Provides tax reliefs, customs duty exemptions, and other incentives to attract both local and foreign investors into the mining sector.
South Africa	The Exploration Strategy for the Mining Industry of South Africa	• Aims to attract local and international investors by improving policy certainty, reducing regulatory bottlenecks, and offering incentives. • Enhances geological surveys and data accessibility to provide investors with reliable information on mineral resources. • Streamlines licensing processes, improve governance, and ensure efficient land access for exploration activities. • Supports the development of transport, energy, and water infrastructure while promoting technological advancements in mineral exploration.
South Africa	Geoscience Act, 1993 Source: IEA Policy tracker	• Established the mandate for the Council for Geoscience, with the objective of developing and publishing world-class geoscience knowledge products and to render geoscience-related services to the South African public and industry.
Botswana	Geological Mining Cadastre 2022	• Online platform designed to enhance efficiency and transparency in the management of mineral rights. • Allows stakeholders to interact directly with the Ministry of Minerals and Energy, facilitating processes such as license applications, renewals, and access to geological data
Namibia	Scraping of black ownership rules for mining exploration licenses, 26 Oct 2018 Source: UNCTAD Investment Policy Monitor	• Scrapped the black ownership rules for mining exploration. The previous law required companies seeking mining exploration licenses to be partly owned and managed by black Namibians.
Tanzania	Amendments to the Mining Local Content Regulations, 8 Feb 2019 Source: UNCTAD Investment Policy Monitor	• While the "old" Local Content Regulations required an indigenous Tanzanian company to have at least 51% of its equity owned by Tanzanian citizens, the new rules reduce this share to 20%.
Egypt	Law No. 145 of 2019 (the "Amendment") amending Law No. 198 of 2014 Source: IEA Policy tracker	• Lifted the obligation for foreign companies to form local joint ventures for investments in the Egyptian mining sector. However, foreign investors are still required to involve Egyptian partners.
Guinea	New mining code, 2013 Law L/2013/053/CNT Source: UNCTAD Investment Policy Monitor	• Cuts mining profit tax rates to 30 percent from 35% and reduce the tax rate on bauxite to 0.15% of the international market price for aluminium, from 0.55%. • Increased the number of mining licences that a single company can hold to five from three, a boost to the land area covered by exploration permits, and a lower minimum investment required for certain types of concessions.
Ethiopia	Ethiopia - National Geological Database 2024	• Digitized geological data to attract investors.
Multiple countries	African Mining Vision	• Emphasizes legal and institutional framework (for contracts and licensing) • Emphasizes geological and mineral information system
Multiple parties	Lobito corridor -since 2009	• Aimed at building route for transporting that can facilitate mineral trade, among others
Multiple countries	Africa Minerals Strategy Group (AMSG) – 2024	• Africa Minerals Strategy Group (AMSG) - 2024 • Promotes mineral exploration, extraction, production, local beneficiation, and commercialization of member countries

Table A7: Initiatives Related to Local Beneficiation and Value Addition

South Africa	Export control regulations 2012 (Government Notice R92) Source: IEA Policy Tracker	• Prohibits the export of specified goods except by way of an export permit. • The specified goods include waste and scraps of critical minerals including copper, nickel, lead, zinc, tin, chromium, germanium, vanadium, gallium, hafnium, indium, niobium, cadmium, antimony, manganese, as well as waste and scrap of primary cells, primary batteries and electric accumulators, spent primary cells, spent primary batteries and spent electric accumulators.
Namibia	2022	• Export ban on unprocessed critical minerals, such as lithium ore, cobalt, graphite, manganese and rare earth elements
Zimbabwe	Statutory Instrument 213/2022 Source: Global Trade Alert	• Minister of Mines & Mining Development Export ban on unprocessed lithium • Export ban of unprocessed lithium, with some exceptions allowed by the Ministry of Mines and Mining Development. • The measure affects "unbeneficiated" lithium or lithium-bearing ores. • The exceptions allowed by the Ministry are made on a written application by parts and are granted in exceptional circumstances.
DR Congo	Ministerial Decree #19/15 Source: IEA Policy Tracker	• Establishes that the artisanal production of strategic minerals can only be performed by artisanal operators under the supervision of the strategic minerals markets regulation and control authority, a public organism created by this decree.
Ghana	The green mineral policy, 2023 Source: Ghana Ministry of Lands & Natural Resources	• Amends the Mining and Minerals Policy of 2014 to include robust and progressive regimes that would enable the country to reap optimum benefits from lithium and other green minerals. • A wide range of minerals that fall under the umbrella of green minerals include bauxite, cobalt, copper, lithium, granite, manganese and nickel.
	Ghana Integrated Aluminium Development Corporation Act, 2018	• To develop and promote a globally competitive Integrated Aluminium Industry (IAI) in Ghana.
DR Congo	DRC - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Integration, where feasible, of (critical) raw materials and renewable hydrogen value chains, including networking, new business models and promotion and facilitation of trade and investment linkages. • Mobilisation of funding for the development of infrastructure required for project development. • Co-operation on research and innovation along the raw materials value chain.
Zambia	Zambia - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Integration, where feasible, of (critical) raw materials and renewable hydrogen value chains, including networking, new business models and promotion and facilitation of trade and investment linkages. • Mobilisation of funding for the development of infrastructure required for project development. • Co-operation on research and innovation along the raw materials value chain.
Namibia	Namibia-EU Strategic Partnership on Raw Materials Source: IEA Policy Tracker	• Integration, where feasible, of (critical) raw materials and renewable hydrogen value chains, including networking, new business models and promotion and facilitation of trade and investment linkages. • Mobilisation of funding for the development of soft and hard infrastructure required for project development and for leveraging private sector funding through cooperation to address trade matters and to improve the investment climate. • Capacity building, training and skills development along raw materials and renewable hydrogen value chains. • Co-operation on research and innovation along the raw materials value chain, including on mineral knowledge and circularity, hydrogen technologies and skills;
Regional	African Mining Vision	• Emphasizes linkages, investments and diversifications
Multiple countries	Africa Minerals Strategy Group (AMSG) – 2024	• Promotes mineral exploration, extraction, production, local beneficiation, and commercialization of member countries

Source: Original table for this study.

Table A8: Initiatives Related to Resource Nationalism

Tanzania	Natural Wealth and Resources (Permanent Sovereignty) Act 2017 and Natural Wealth and Resources Contracts (Review and Re-negotiation of Unconscionable Terms) Act 2017 Source: FAOLEX Database	• Grants the government stakes of at least 16% in mining companies operating in the country, with the option to acquire up to 50% in some cases. • Increase the royalty tax on gold, copper, silver and platinum exports from 4% to 6%. • Grants the government the right to review and renegotiate contracts for natural resources like gas or minerals and remove the right to international arbitration.
Mali	Decree No. 2024-0396/PT-RM Source: UNCTAD Investment Policy Monitor	• Grants the government priority in mineral permit allocations, especially for "strategic minerals" like lithium and uranium, and restricts companies to holding a maximum of 3 exploration permits per district. • Upholds the 10% free state share in mining ventures and enables up to 30% total ownership, with priority dividend rights. • Transfers of permits now need multi-ministerial approval, expanding state control over ownership changes.
	New mining code, 2023 Source: UNCTAD Investment Policy Monitor	• Mandates the government to take a 10% stake in mining projects and the option to buy an additional 20% within the first two years of commercial production
Cameroon	Law No. 2023/014 Source: UNCTAD Investment Policy Monitor	• Mandates the National Mining Corporation (SONAMINES) to acquire upto a 10% of the total shares in companies engaged in mining activities free of charge, which shall remain undiluted should the share capital increase.
Burkina Faso	The new Mining Code Source: UNCTAD Investment Policy Monitor and ENSight	• Grants the State the right to own a non-contributing or free-carried shareholding interest (up 15 %) in the mining company holding an exploitation/mining permit. • Allows the State to own a further contributing shareholding interest (up to 30%) in the same mining company, or to allocate it to the "national private sector" • State is vested with a pre-emptive right, which it can exercise in case of a cession of a mineral title, or a cession of shares in the mining company holding such title, or to acquire gold and other mineral substances.
Burundi	New Mining Code (Law No. 1/19), 2023 Source: UNCTAD Investment Policy Monitor	• Mandates that the state holds a 15% stake in all mining projects.
Algeria	Mining law, 2014 Source: UNCTAD Investment Policy Monitor	• It classifies resources into strategic and non-strategic. Any local company with the requisite technical and financial capacity can carry out prospecting and development of non-strategic resources. • Strategic resources can only be developed by state-owned companies or other state-owned entities. These companies can sign contracts with third parties but must retain at least a 51% share in the project.
Uganda	New Mining & Mineral Act, 2022 Source: UNCTAD Investment Policy Monitor	• Establishes the Uganda National Mining Company (UNMC) which is wholly owned by the State to manage Uganda's commercial holding and participating interests in mineral agreements. • Mandates that the government can compulsorily take a 15% free carry stake in all mining operations in the country and are to be managed by UNMC.
Tanzania	Mining Act Amendments, 2017 Source: UNCTAD Investment Policy Monitor	• The government secured a 16% minimum stake in mining companies, ensuring state participation in large-scale projects.
DR Congo	Mining Code, 2018 Source: UNCTAD Investment Policy Monitor and IEA Policy Tracker	• Identifies strategic minerals, which are to be traded under a taxation framework that requires any producer to pay 10% of the gross value of the commodities in tax. • The new law will increase royalties on copper from 2% to 3.5%, on gold from 2.5% to 3.5% and could potentially increase royalties on cobalt from 2% to 10%, if deemed a "strategic substance". • Mandates 50% tax-rate on so-called 'super profits', defined as income realized when commodity prices rise 25% above levels in the project's bankable feasibility study, will be introduced.
Ghana	Minerals and Mining Act (2006, amended in 2015)	• Mandates the Government to acquire a 10% free carried interest in the rights and obligations of the mineral operations. • In addition to the 10% stake, the government can acquire an additional equity participation in mineral operations as may be agreed with the holder.
Sierra Leone	Mines and Minerals Development Act, 2022	• Mandates the State to acquire, in large scale mining firms, a non-dilutable free carried of interest of 10% and up to 35% shares on terms to be agreed with the holder as applicable.
Ethiopia	Mining Operation Regulation No.423/2018 Source: Bekele (2019)	• Mandates the government to acquire 5% participation interest in large scale mining companies. • In addition to the 5% stake, the government can acquire an additional equity participation in large scale mining company.

Source: Original table for this study.

Table A9: Initiatives Related to Local Content and Development

Mali	Decree No. 2024-0396/PT-RM Source: UNCTAD Investment Policy Monitor	• Mandates local hiring and procurement requirements to support Mali's economy directly.
	New mining code, 2023 Source: UNCTAD Investment Policy Monitor	• 5% stake could be ceded to locals
Cameroon	Law No. 2023/014 Source: UNCTAD Investment Policy Monitor	• Established the Special Local Capacity Building Account, primarily aimed at financing Cameroon's economic, social, cultural, and technological development by developing local enterprises
Sierra Leone	Mines and Minerals Development Act, 2022	• Mandates that in procurement, preference be given to Sierra Leonean goods and services provided that they are substantially equivalent to foreign alternatives in terms of quantity, quality, price and delivery dates. • Mandates that all unskilled labour required to implement mining related activities be sourced locally • Mandates employment and training of citizens of Sierra Leone. Notably, citizens of Sierra Leone possessing the necessary knowledge, skills and experience must be prioritized for employment in mining activities
DR Congo	DRC - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Capacity building to enforce laws and regulations and increase training and skills
Namibia	Namibia-EU Strategic Partnership on Raw Materials Source: IEA Policy Tracker	• Capacity building, training and skills development along raw materials and renewable hydrogen value chains;
Zambia	Zambia - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Capacity building to enforce laws and regulations and increase training and skills
Burkina Faso	Act No 017-2024/ALT of 2024	• Introduced progressive quotas for local employment, depending on the different levels of responsibility within companies. • Created a fund to support the development of local content
DR Congo	Mining Code Reform, 2018 Source: UNCTAD Investment Policy Monitor and IEA Policy Tracker	• Requires mining companies to contribute to local community development projects.
South Africa	Mining Charter 2017 Source: UNCTAD Investment Policy Monitor	• Raised the minimum threshold for black ownership of mining companies from 26% to 30%. The 30% shareholding to be apportioned between employees, communities and entrepreneurs in a specific manner. • Requests that a new prospecting right must have a minimum of 50% plus 1 Black Person shareholding, which must include voting rights. • Requires mining firms to procure 70% of goods and 80% of services from black-owned companies. • Moreover, it requires that analysis of 100 per cent of mineral samples be done by South African based companies. • Mandates that half of the members of mining company boards must be black, and 25 per cent of which must be female black representation.
	Beneficiation Strategy for the Minerals Industry, 2011	• Aims to transform South Africa's mineral wealth into a catalyst for industrialization and job creation by promoting the beneficiation of raw minerals within the country.
Tanzania	Amendments to the Mining Local Content Regulations 08 Feb 2019 Source: UNCTAD Investment Policy Monitor	• While the "old" Local Content Regulations required an indigenous Tanzanian company to have at least 51% of its equity owned by Tanzanian citizens, the new rules reduce this share to 20%.
	Mining Regulations on Local Content, 2018 Source: UNCTAD Investment Policy Monitor	• Requires an 'indigenous Tanzanian company' to hold an equity participation of at least 20 per cent in a mandatory joint venture arrangement for supply of goods and services. • Mandates that indigenous Tanzanian companies be given first preference in the granting of a mining license. • Mandates that preference be given to local service providers (such as insurance, financial services, and legal practitioners) and locally manufactured goods. They require the use of local insurance and financial services and stipulate that legal services to be provided only by local legal practitioners or local law firms. • Mandates that priority be given to qualified Tanzanians in employment and on-job training. Importantly, it requires companies to employ only Tanzanians in junior level or middle level positions.

Table A9: Initiatives Related to Local Content and Development continued...

Kenya	New regulation on local content requirements on mining companies 2017 Source: UNCTAD Investment Policy Monitor	• Requires local procurement for goods and services. • Requires support to be provided by mineral rights holders to local providers or suppliers as well as other measures being implemented to develop the supply of local goods and services including broadening access to opportunities and technical support.
Namibia	New mines regulation, 2021 Source: UNCTAD Investment Policy Monitor	• Mandates that mining licence in Namibia must have 15% local owners. • Mandates that all "applications by Namibian nationals for the transfer, cessation and assignment of mineral licences to foreign companies or persons may be granted provided 15% interest in the company is retained locally".
	Black ownership rules for mining exploration licenses, 2015 (scrapped) Source: UNCTAD Investment Policy Monitor	• Mandates companies seeking mining exploration licences to be partly owned and managed by black Namibians. • Mandates the management structure of a company applying for an exploration licence to have a minimum 20% representation of black Namibians. At least 5% of the company also had to be owned by Namibians or by a company wholly-owned by Namibians.

Source: Original table for this study.

Table A10: Initiatives Related Environmental and Social Sustainability

Cameroon	Law No. 2023/014 Source: UNCTAD Investment Policy Monitor	• Established the Mining Site and Quarry Restoration, Rehabilitation and Closure Fund, designed to finance the implementation of environmental conservation and rehabilitation programmes following mining activities, which are known for their significant environmental impacts
Gabon	Law 07/2014 on Environmental Protection Source: IEA Policy tracker	• Defines the principles and means of environmental protection in Gabon, including the preservation and sustainable use of natural resources, pollution control, environmental education, and environmental information and monitoring.
	Law No. 037/2018 Source: FAOLEX Database	• Promotes eco-friendly exploration and limits mining in protected areas. • Mandates holders of a mining permit to repair damages caused to people, property and the environment due to their mining operations
Ethiopia	Mining Operation Regulation No.423/2018 Source: Bekele (2019)	• Mandates that mining license holders, except artisanal license holders, are obligated to contribute to the community development plan and to the environmental impact restoration fund.
Ghana	Minerals and Mining Act (2006, amended in 2015)	• Mandates that holders of mineral rights obtain the necessary environmental permits from the Environmental Protection Agency (EPA) before commencing operations. • For mining leases covering areas exceeding 10 hectares, an environmental impact assessment must be submitted to the EPA prior to the grant of an environmental permit.
Angola	2024 Presidential Decree 51/24 Source: UNCTAD Investment Policy Monitor	• Regulates extractive activities in protective areas
Sierra Leone	Mines and Minerals Development Act 2022	• Mandates environmental consciousness, impact assessment, and reporting • Mandates transparency regarding finances
South Africa	Mineral and Petroleum Resources Development Act, 2002 Source: IEA Policy Tracker	• Reconnaissance, exploration, and production rights are only granted upon the approval of relevant environmental impact assessment and cost analysis documentation. • The regulations of the MPRDA specifically require that building tailings and waste dams are to be designed with oversight functions by competent personnel.
DR Congo	Ministerial Decree #19/15 Source: IEA Policy Tracker	• Aims at better controlling the activities of artisanal mining to improve the working conditions, environmental impacts and economic attractiveness of DRC's strategic minerals, namely cobalt.
Namibia	Namibia-EU Strategic Partnership on Raw Materials Source: IEA Policy Tracker	• Co-operation to leverage environmental, social, and governance (ESG) criteria and align with international standards. • Regulatory alignment, particularly on hydrogen definitions, standards and certification.
Tanzania	Mining (Designated Minerals Certification) Regulations Source: IEA Policy Tracker	• Establish the scope and objectives of mineral traceability from extraction to export. Key Implementation Requirements include • All mining operators must publish their payments, while state services must publish receipts to ensure transparency and good governance in mining revenue management. • Operators must exercise reasonable due diligence to avoid contributing to conflicts or human rights violations in the DR Congo mining sector. • The system implements OECD due diligence guidelines for conflict-free mineral supply chains
Rwanda	Ministerial Regulations No 002/2012/ MINIRENA of 28/03/2012 on the regional certification mechanism for minerals Source: IEA Policy Tracker	• Establishes a regional certification mechanism for minerals in the Great Lakes Region, aiming to prevent illegal mineral exploitation and ensure proper tracking of designated minerals (cassiterite, wolframite, coltan, and gold).
DR Congo	DRC - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Co-operation to leverage ESG criteria and align with international standards, including through increased due diligence and traceability.
Zambia	Zambia - EU Strategic Partnership on sustainable raw materials value chains Source: IEA Policy Tracker	• Co-operation to leverage ESG criteria and align with international standards, including through increased due diligence and traceability.
DR Congo	Traceability Procedures Manual for Tradable Mining Products, 2024 Source: IEA Policy Tracker	• Establishes comprehensive procedures for tracking designated minerals from extraction to export in the DR Congo, defining requirements for operators in the mineral supply chain to ensure transparency and prevent conflict minerals trade.
Multiple countries	Extractive Industries Transparency Initiative (EITI) Standard Source: IEA Policy Tracker	• An international initiative of member countries committed to disclosing information about the extractive industry value chain – from how extraction rights are awarded, to how revenues make their way through government and how they benefit the public.
Regional	African Mining Vision	• Emphasizes environment and social issues

Source: Original table for this study.