United Nations
Economic Commission for Africa

Lithium in Nigeria: enhancing sustainable production, processing and value addition

A case study of the practical application of the United Nations Resource Management System and Africa's Green Minerals Strategy to lithium production in Nigeria

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Executive summary

Global demand for critical energy transition minerals is increasing, owing to the worldwide drive towards decarbonization. Critical minerals must be extracted and managed efficiently and in an environmentally friendly and socially responsible way, such that the benefits are shared equitably among all producer and consumer countries. Such forms of extraction and management constitute the primary means of preventing negative consequences for communities, development and the environment.

The present case study was commissioned by the Economic Commission for Africa for the assessment of sustainable production of lithium in Nigeria. Several different research and analysis methods were used, including a review of existing literature, public consultations with stakeholders throughout the sector and expert analysis of a real-life project that is under development in Nigeria. In the study, the context of lithium production in Nigeria is described, linkages with the principles of the United Nations Resource Management System and the pillars of Africa's Green Minerals Strategy are analysed and policy recommendations for enhancing the sustainable production of critical minerals are identified.

The study indicates that by adopting a number of important policy measures, including the incorporation of elements of the United Nations Resource Management System and Africa's Green Minerals Strategy, Nigeria can benefit from the critical minerals boom to achieve circular and minimally invasive exploitation of its lithium resources. A specific lithium exploitation project has the potential to contribute significantly to combating climate change by reducing emissions, both directly, through a circular approach in which waste is minimized, and indirectly, through the production of more materials for electric vehicle batteries. Such projects should be central to new investment, in which compliance with environmental, social and governance standards is targeted.

Acknowledgements

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1. Introduction

Critical Energy Transition Minerals are defined as "the minerals necessary to construct, produce, distribute and store renewable energy" (United Nations, 2024). The specific detailed list of these minerals varies depending on the organization compiling them. Global economies will require a shift from short-term economic considerations to long-term and broader-based benefits associated with sustainable production of critical minerals required for low-carbon energy transition, that include social, environmental and cultural externalities.

A rush for mineral resources is not a new phenomenon, and robust international and regional frameworks exist to assist policymakers in making the most of a minerals boom and ensuring that their countries extract the greatest possible value from their resources. The 2009 Africa Mining Vision serves as the framework for priorities for a mineral sector that contributes to the inclusive development of the region, building linkages with the broader economy. In Africa's Green Minerals Strategy, published in 2024, these aspirations are brought to the context of the current critical minerals boom. The United Nations Resource Management System is a comprehensive framework for enhancing integration of sustainability practices in global resources management (United Nations, 2021). The United Nations Secretary General's Panel on Critical Energy Transition Minerals (2025), with its seven voluntary guiding principles and five actionable recommendations, drew heavily from these frameworks.

Nigeria, like other mineral-producing countries in Africa, possesses significant deposits of critical minerals, including lithium, nickel and cobalt; such minerals typically occur in hard rock. The continent remains a commodity exporter, however, largely confined to the mining of such minerals. Its companies are thus unable to engage in the higher value added segments of the global battery and electric vehicle value chain, which is likely to have reached an estimated total valuation of $8.8 trillion in 2025 (Ahadjie and others, 2023).

In 2025, the International Energy Agency reported that over 70 per cent of global processing and refining capacity for critical minerals is concentrated in Asia and that a high degree of market concentration results in increased vulnerability to supply shocks (International Energy Agency, 2025). To move their companies up this value chain, African States, including Nigeria, will need to create more value on the continent by fostering sustainable industrialization, increasing domestic production, and expanding exports and intra-African trade.

Several different research and analysis methods were used in the preparation of the present case study, including a review of existing literature, public consultations with stakeholders throughout the sector and expert analysis of a real-life project that is under development in Nigeria. The study includes a description of the context of lithium production in Nigeria, an analysis of linkages with the principles of the United Nations Resource Management System and the pillars of Africa's Green Minerals Strategy and policy recommendations for enhancing the sustainable production of critical minerals.

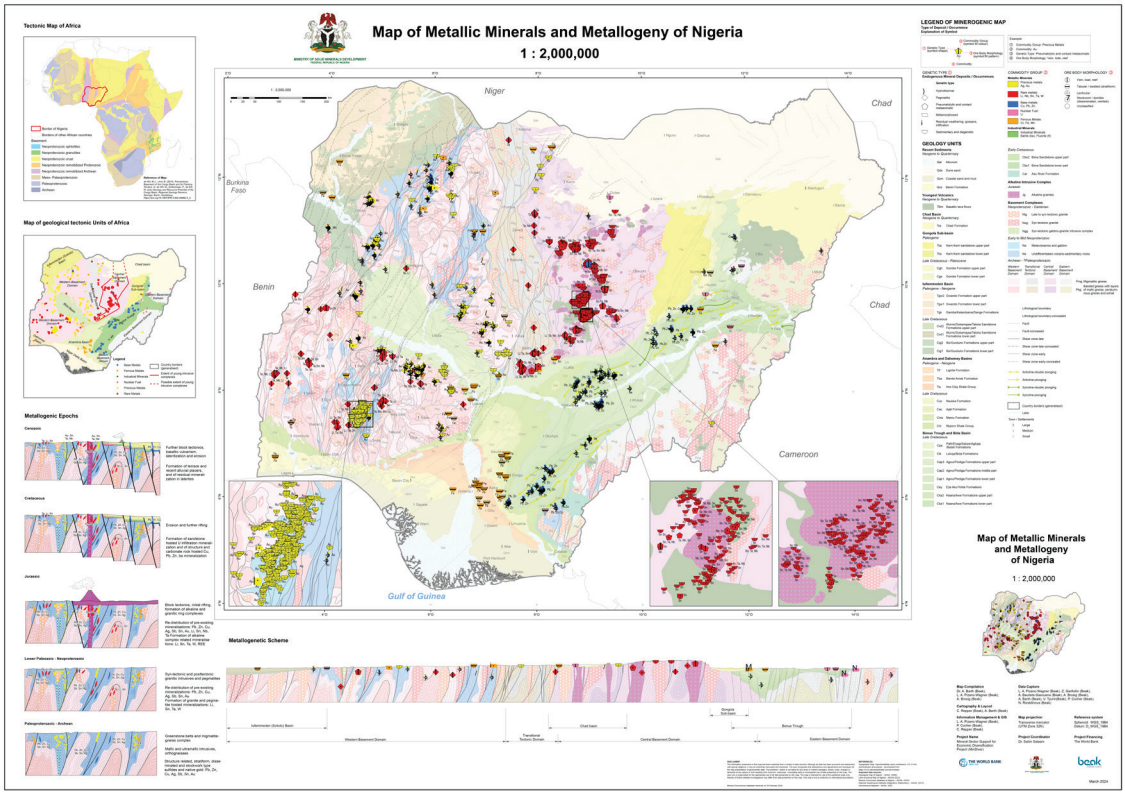
2. Lithium development in Nigeria

Lithium is one of the most important critical minerals. It is used in the manufacture of batteries for energy storage systems in off-grid, mini-grid and grid-connected applications; electric vehicles; consumer electronics, such as cellular phones and laptops; and telecommunications and data centre infrastructure. Between 2024 and 2030, global production of lithium is expected to double, mainly driven by increasing uptake of clean energy technologies and electric vehicles (International Energy Agency, 2025). In the light of widespread efforts to meet global energy transition and net zero targets, the demand for lithium is expected to increase almost sixfold between 2021 and 2030; in 2021, batteries accounted for 74 per cent of global lithium consumption (Bhutada, 2022).

In 2022, global attention was attracted to Nigeria, where significant deposits of high-grade lithium had been discovered in several of its states (Nigeria, 2023). In the same year, over 744 million kg of lithium-bearing ore was extracted from mines in Nigeria, representing an increase of more than 1,000 per cent on output in 2022 (Nigeria Extractive Industries Transparency Initiative, 2023). As of mid-2025, a lithium processing plant was scheduled to be commissioned in Kaduna State, a refinery on the outskirts of Abuja was nearing completion and two additional processing plants were expected in Nasarawa State; a total of over $800 million in investment had been channelled into the projects, mainly from investors in Asia (Nigeria, 2024b; Anyaogu, 2025).

In the Nigeria Energy Transition Plan, the Government of Nigeria has set out a road map for achieving carbon neutrality by 2060, through strategic initiatives that include the sustainable industrialization of critical minerals (Nigeria, 2024a). In a 2025 report, the need for a national critical minerals strategy, reforms in mining and land laws to improve efficiency and increased funding for exploration, geological mapping and refining capacity in Nigeria was identified (Oluwatola, 2025). Figure I comprises a map of Nigeria, on which indicative locations of lithium-caesium-tantalum pegmatite occurrences are shown.

Figure I Map of metallic minerals and metallogeny of Nigeria, with locations of lithium-caesium-tantalum pegmatite occurrences



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Source: Barth and Pizano, 2024.

2.1. Lithium supply chain overview

Supply chains for critical minerals, including lithium, typically comprise (Barlow and Pai, 2025; Rocky Mountain Institute, 2023; EMBS, 2025):

- **Upstream**: Extraction from hard rock mines in Africa or brine sources in Australia and South America. Basic processing of the minerals extracted from hard rock consists of mining, crushing, cleaning and concentration stages.
- **Midstream**: Processing or refining of raw material to higher-grade products, such as Lithium spodumene concentrate and battery-grade lithium carbonate or lithium hydroxide, using metallurgical, chemical or casting mineral separation methods
- **Downstream**: Utilization of the refined or processed mineral in industrial processes, construction or manufacturing of battery precursors, battery cells, energy storage systems and other components.

These supply chain segments are often diverse, specialized and overlapping, which is the reason for the production, sometimes, of certain minerals at the midstream stages of producing other minerals.

Spodumene concentrate, shown in figure II, is the most common lithium-bearing hard rock in the world. Supplied to offtakers, including refiners and commodity traders, spodumene concentrate is the starting material for further processing to achieve downstream products like lithium carbonate or lithium hydroxide (AMG Lithium, 2024).

Figure II Spodumene concentrate

Source: AMG Lithium, 2024.

Battery cathodes are made from either lithium carbonate (shown in figure III) or lithium hydroxide (Targray, n.d.(a) and n.d.(b)).

Figure III **Battery-grade lithium carbonate**

Source: Targray, 2026a.

2.2. Lithium potential in Nigeria

Nigeria has extensive basement rock formations, covering over 325,000 km2, with high potential for the occurrence of lithium-caesium-tantalum pegmatites (Nigeria, 2023). In its 2023 Solid Minerals Industry Report, the Nigeria Extractive Industries Transparency Initiative (2023) outlines some of the most significant lithium mining areas in the country. In table 1, a summary is presented of lithium mineral exploration, production and licenses in Nigeria in 2023, as well as of recent developments in lithium processing in the country.

Table 1 Status of lithium exploration, production and processing developments in Nigeria

Quantity of lithium produced in 2023	Number of issued licences valid in 2022	States
744 502 000 kg	823	Nasarawa, Kwara, Kogi, Ekiti, Cross River

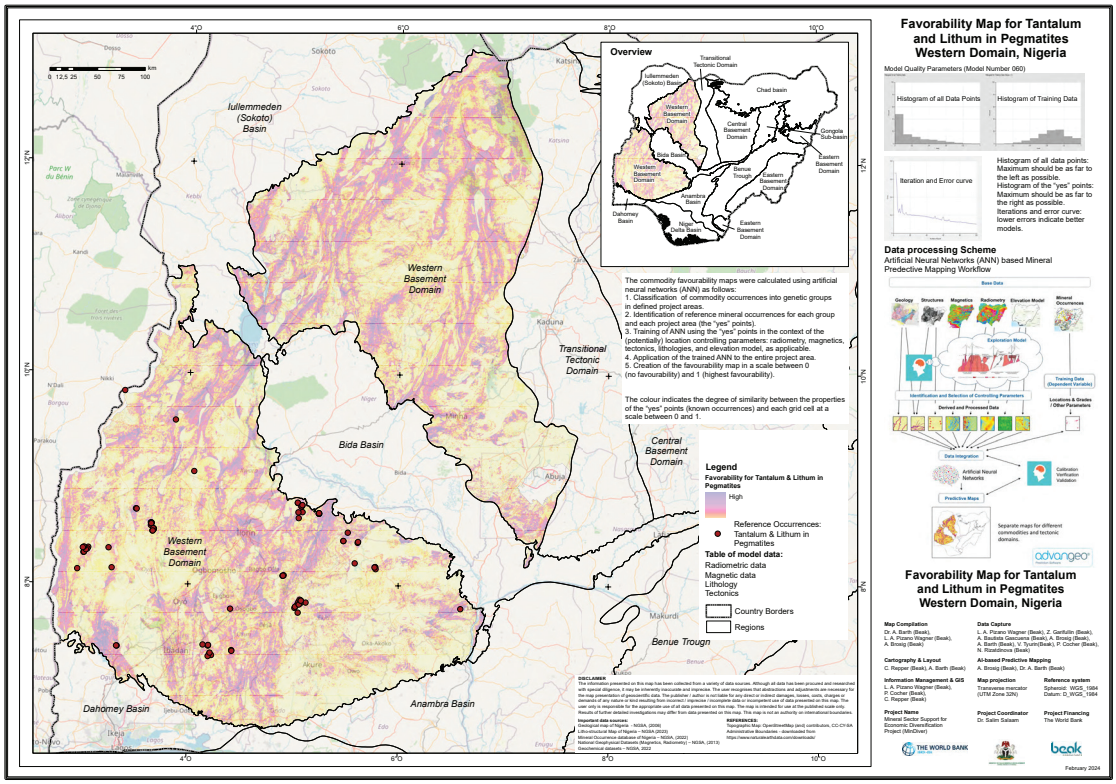
Recent developments in lithium exploration and processing in Nigeria:

- 2021: Regulations enacted, requiring value addition through local processing of minerals, catalysing the development of lithium processing plants in Nasarawa and Kaduna States (Alake, 2025)
- 2022–2023: National Integrated Mineral Exploration Project, including "Rare metal pegmatite projects" study (Nigeria, 2023)
- First quarter of 2024: first industrial lithium processing complex commissioned in Nasarawa State (Nigeria, 2024b)
- 2024: Launch of the Mining Sector Investment Facilitation project, supported by the World Bank and the Federal Ministry of Solid Minerals Development (Barth and Pizano, 2024).
- Fourth quarter of 2024: Solid Minerals Development Fund launched to pursue investments that would de-risk the Nigerian mining sector (Nigeria, 2024b)
- 2024–2025: Four additional lithium processing facilities under construction in Kaduna, Abuja and Nasarawa States (Anyaogu, 2025)

In a 2024 study commissioned by the World Bank and the Federal Ministry of Solid Minerals Development as part of the Mining Sector Investment Facilitation project, Barth and Pizano (2024) assessed the favourability of the occurrence of lithium and other critical minerals in Nigeria. They used artificial neural networks to analyse and process geological and geophysical data sets, thereby generating predictive maps of mineral potential. Mineral potential maps represent a tool for facilitating investment in critical minerals projects, which is an essential step towards the detailed estimation of mineral reserves and, thus, the sustainable development of the sector.

Figure IV comprises a favourability map of lithium occurrence across the western basement domain in Nigeria. Purple shading is used to denote high potential areas, yellow shading to denote low potential areas and red dots to denote areas of existing lithium mining activity.

Figure IV Map of potential lithium and tantalum occurrence, western basement domain, Nigeria



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Source: Barth and Pizano, 2024.

Note: Under the Mineral Sector Support for Economic Diversification Project, the scope of the map was limited to the area where pegmatites were already known. By no means, however, does it follow that the other areas of Nigeria are devoid of pegmatites. On the contrary, the findings of the study potentially constitute evidence of the presence of many hidden pegmatites across the country, in contrast to the western basement domain, where deposits had become known as a result of erosion.

The Mining Cadastre Office plays a crucial role in the management and regulation of the critical minerals sector in Nigeria. This includes license issuance and management, regulatory compliance, data management, revenue collection, conflict management, public awareness and education. Field development plans must be compiled before the Office issues mineral licences. In the plans, mineral reserves – proven and unproven – in the field are examined and production strategies for a mining project are outlined. The plans typically include sections on resource assessment, mining methods and infrastructure development, along with an environmental impact assessment and an economic feasibility analysis (Nigeria Extractive Industries Transparency Initiative, 2023).

2.3. Evolution of critical minerals strategy and demand

In the light of recent geopolitical trends, there is increasing focus on the sourcing, by companies worldwide, of energy transition minerals and battery precursors from Africa and on the drive to diversify global supplies of critical minerals. Many States and regional organizations have developed critical mineral strategies aimed at securing access to raw materials from around the globe, in particular from Africa (United Kingdom of Great Britain and Northern Ireland, 2025; United States of America, 2021; European Commission, 2023a and 2023b).

The European Union is aiming to have 30 million electric vehicles on the road by 2030, up from 1.4 million in 2023 (Krukowska and Patel, 2020), and, as from 2023, the Government of the United States of America was seeking to achieve 50 per cent electric vehicle sales by 2030, and is currently pursuing critical minerals deals globally (International Energy Agency, 2023). One electric vehicle manufacturer aims to sell 20 million electric vehicles in 2030, representing a 13-fold increase on its 2022 sales forecast of 1.5 million sales (Lienert and White, 2022).

The International Energy Agency (2025b) reports that lithium remains a vital precursor in battery manufacturing for electric vehicles. Although not yet commercially available, the report noted solid-state battery moved closer to reality and attracted some manufacturing investments in 2024. The International Energy Agency (2025b) identifies Sodium ion battery as an emerging technology that could be 30 per cent cheaper than the existing lithium ion battery (International Energy Agency, 2023). They reported that in 2022, some 30 sodium ion battery manufacturing factories existed, mainly in China, with a combined capacity of 100 GWh, compared with the current lithium battery manufacturing capacity of 1,500 GWh. In 2022, batteries on the basis of lithium nickel manganese cobalt oxide accounted for 60 per cent of the market, followed by lithium iron phosphate, with 30 per cent and nickel cobalt aluminium oxide with about 8 per cent (International Energy Agency, 2023). Responsible sourcing of lithium and other battery precursors in Nigeria and elsewhere in Africa could improve the environmental credibility, traceability and sustainability of the global supply chain for critical minerals.

3. Principles for the sustainable production of critical minerals

This section comprises analysis of the chief considerations for the sustainable production of critical minerals in Nigeria, which are based on the sustainable production principles outlined in the United Nations Resource Management System (ECE, 2022) and in Africa's Green Minerals Strategy (African Minerals Development Centre, 2024a).

The project is focused on the sustainable production of lithium battery materials and of innovative circular economy approaches, with a view to:

- Supply chain optimization in the extraction of critical minerals (lithium) from mining waste or low-grade material
- Repurposing of existing assets for the processing of critical minerals, by means of the refurbishment of brownfield sites and the fitting-out of such sites with flotation equipment to purify and concentrate lithium-bearing ore, powered by innovative clean energy sources
- Reuse of industrial waste in the production of dry-stack tailings for the manufacture of environmentally friendly products or bricks for construction or for the filling-in of disused mines, thereby reducing demand for virgin mined materials

The principal findings are presented as a generic and conceptual tool for assessing the performance of potential projects involving critical minerals.

3.1. Application of the United Nations Resource Management System

The United Nations Resource Management System comprises fundamental principles and requirements that, together, form a structured approach to efficient resource management by Governments, companies and communities worldwide. In Africa, it is implemented through the African Mineral and Energy Resources Classification and Management System (African Minerals Development Centre, 2019) and the Pan-African Public Reporting Standard for Minerals and Energy Resources (African Minerals Development Centre, 2023), through which accountability, governance and public disclosures about resource projects are ensured.

The central themes of the United Nations Resource Management System are governance and economic, technological and environmental considerations. By gauging the degree of attainment of measurable indicators related to those themes, it is possible to conduct empirical evaluations of resource projects in Nigeria and worldwide. In table 2, a summary is set out of the main considerations to be taken into account for projects pertaining to critical minerals in Africa, in general, and lithium projects in Nigeria, in particular. In addition, table 2 contains the conceptual tools that can be used for demonstrating that the principles established in the United Nations Resource Management System have been applied to such projects.

Table 2 Analysis of the application of United Nations Resource Management System principles to critical mineral development projects in Nigeria

Principles	Considerations	Indicators
Principle 1: State rights and responsibilities in the management of resources	• Nigeria Energy Transition Plan, reflecting cross-government coordination among the ministries responsible for mines, energy, the environment and finance • Sourcing of mining waste or low-grade materials for government-licensed operators • Acquisition of government-issued permits, certificates, etc. from regulatory authorities, in order to secure mineral or mining lease required for mineral processing and export • From 2024, value addition plan required for all new mining lease applications	• National Energy Transition Plan document (Sustainable Energy for All, 2024) • Business registration or export certificate • Mining lease or small-scale mining lease • License to possess or purchase minerals • License to process and refine minerals
Principle 2: Responsibility to the planet	• Detailed environmental and social impact assessment in consultation with principal stakeholders • Implementation of environmental management plan • Continuous monitoring of environmental performance throughout project	• Impact assessment reports • Environmental management plan • Public advertisements of environmental impact assessment process in radio or newspapers
Principle 3: Integrated management of resources	• Nigeria Energy Transition Plan, representing a holistic and interministerial approach, aimed at the integrated and indivisible management of resources • Holistic feasibility study to assess resource management throughout project duration • Financial model for the whole project duration, covering integrated resource management • Detailed economic, social and environmental impact assessment	• Nigeria Energy Transition Plan document • Detailed business plan or feasibility report • Financial models for assessment of project throughout its duration • Impact assessment report
Principle 4: Social engagement	• Establishment of community development agreement framework • Setting up of fund and governance for community or social engagement projects • Training, outreach and capacity-building in host communities and promotion of gender equality and social inclusion	• Community development agreements • Minutes of meetings held with host communities on development agreement framework • Continuous social engagement plan • Gender equality and social inclusion policy
Principle 5: Service orientation for use and reuse of resources	• Processing or reuse of mining waste or low-grade materials to produce battery materials • Retrofitting of existing brownfield sites with innovative clean energy sources for processing of minerals • Reuse and repurposing of tailings for bricks or dry-stack materials for mine refilling, or both	• Detailed business proposal • Design report on innovative clean energy source • Feasibility study report or equipment list
Principle 6: Comprehensive resource recovery	• Engineering design for flotation process and reagent design to optimize resource recovery from low-grade ore • Testing of resources at sourcing location (preloading) and at processing sites (pre-offloading) to verify target ore grade, specification and volume • Reuse and repurposing of tailings for bricks or dry-stack materials for mine refilling, or both	• Flotation equipment or reagent design studies • Independent laboratory test results, on the basis of global standards • Flotation equipment list

Principle 7: Value addition	• Value chain regulations require local processing before export, catalysing lithium processing plants in Nasarawa and Kaduna	• 2021 regulations on value chains
	• Since 2024, granting of mining leases only to companies with clear local processing plans	• Government-issued mining leases
	• Beneficiation of 1.5 per cent lithium-bearing ores to 5 or 6 per cent spodumene concentrate	• Flotation equipment supply contracts
	• Supply of battery materials or concentrate to offtakers worldwide	• Product offtake agreement or export certificate
	• Development of refinery to add further value to concentrate and process it into battery-grade lithium	• Refinery partnerships
Principle 8: Circularity	• Extraction of battery material from mining waste or low-grade materials	• Detailed feasibility study report
	• Repurposing of brownfield site equipment with flotation equipment for critical mineral processing	• As-built engineering drawings or flotation process flowsheet
	• Reuse of tailings for bricks in construction sector, promoting circularity	• Percentage of secondary feedstock used
Principle 9: Health and safety	• Implementation of health and safety procedures in line with health and safety policy and global best practices	• Approved health and safety policy
	• Design of engineering controls, such as noise damping enclosures around crushers and mills, and scheduling of high-noise activities for daytime hours only	• Environmental or transport management plans
	• Provision of personal protective equipment for staff	• Standard operating procedures with personal protective equipment specified
Principle 10: Innovation	• Use of innovative clean energy sources for powering critical mineral processing and decarbonizing existing infrastructure	• Innovative energy system contracts with warranty
	• Organization of youth innovation contests with critical mineral processing track to stimulate the suggestion of innovative, youth-led approaches	• Innovation contest call for proposals or impact report
	• Development of knowledge management tools on the basis of artificial intelligence, for training educators, pupils and future staff	• Number of local enterprises that participate in call for proposals and capacity building trainings.
	• Introduction of process optimization on the basis of artificial intelligence	
Principle 11: Transparency	• Ensuring of competitive process in material sourcing and equipment procurement and comparison of quotations from at least two different suppliers	• Supplier onboarding or know your customer process
	• Product pricing reference linked with spot price for transparency	• Ore supply or product offtake agreement with clear pricing terms
	• Independent testing of materials, using global testing standards and logging of material sourcing for traceability	• Assay test results from reputable firms
Principle 12: Continuous strengthening of core competencies and capabilities	• Value addition policy, reflecting the Government's focus on knowledge transfer	• Existing and new policy instruments
	• Inclusion of multi-year training and maintenance agreement in engineering, procurement and construction contracts	• Maintenance contract with equipment suppliers
	• Hosting of study tours at project sites for facilitation of cross-industry knowledge exchanges and fostering of gender equality and social inclusion	• Training certificates or gender equality and social inclusion policy
	• Expanded reach of knowledge management tools on the basis of artificial intelligence, for sharing lessons learned with a wider audience worldwide	• Knowledge management tool impact report

3.2. Africa's Green Minerals Strategy: the context for critical mineral production in Nigeria

The guidance contained in Africa's Green Minerals Strategy represents a timely blueprint for assessing the context and potential of priority measures to contribute to industrial projects in Nigeria, including those related to critical minerals, in particular lithium development. In table 3, the Strategy is analysed through the lens of its four pillars, each of which is subdivided into distinct sections.

Table 3 Assessment of the pillars of Africa's Green Minerals Strategy in relation to industrial projects

Pillars	Context and considerations
I: Advancing mineral development Pillar	Nigeria has a holistic governance process for the solid minerals sector (Nigeria Extractive Industries Transparency Initiative, 2023), selected major players in which are as follows: • The Federal Ministry of Solid Minerals Development, comprising over 15 administrative subdivisions, including: - Mining Cadastre Office - Nigerian Geological Survey Agency - Mines Inspectorate - National Metallurgical Development Centre - Investment Promotion and Mineral Trade Department - Metallurgical Inspectorate and Raw Material Development Department • All government revenue, including solid mineral royalties and taxes, is remitted to a treasury single account. Under the Nigeria Revenue Service (Establishment) Act, 2025, the Service is the sole central authority responsible for the assessment, collection, accounting and enforcement of taxes and other designated revenue, for both the Federal Government and state governments. • At both the federal and the state levels, ministries are responsible for environmental affairs. In addition, the National Environmental Standards and Regulations Enforcement Agency is the federal agency responsible for enforcing environmental laws and regulations. Established in 2007, its purpose is to protect the environment by preventing individuals, companies and other organizations from causing pollution or environmental degradation. • The Federal Ministry of Industry, Trade and Investment is responsible for investment promotion. • Other industrial oversight is provided by the Council of Nigerian Mining Engineers and Geoscientists, established by Act No. 40 of 1990 and operational since 2000. Its role is to set standards, register professionals, and regulate practices pertaining to mining and geoscience, including those related to solid minerals, petroleum and water resources. Recent activities related to mineral resource mapping studies and projects and to mineral development funds are summarized in table 2. Budgets for such activities are part-funded by federal and state government bodies, in collaboration with development finance institutions, including the World Bank and the Africa Finance Corporation. The main considerations for project developers are as follows: • Increased demand for critical minerals worldwide is accelerating mineral exploration, extraction and development. • Beneficiation of critical minerals sourced in Africa, including lithium development in Nigeria, would unlock sustainable mineral development, create high-quality jobs and increase government revenue. • Domestic value addition avoids the greenhouse gas emissions associated with the current approach of shipping unprocessed ore – over two thirds of which will end up as waste material – from Africa to Asia for processing.

Pillar II: **Develop people and technological capability**	The Council of Nigerian Mining Engineers and Geoscientists organizes capacity-building for people working in the critical minerals sector. Operators in the sector are required to provide evidence of technically competent personnel, such as geologists with accreditation from the Council, when applying for a mineral title (Nigeria Extractive Industries Transparency Initiative, 2023). Based in Onitsha, the Metallurgical Training Institute was established in 1980, under a bilateral agreement between the Federal Government of Nigeria and the Government of Germany. It is focused on training highly skilled technical workers for the solid minerals sector in Nigeria (Metallurgical Training Institute, 2024). The Nigerian Institute of Mining and Geosciences, based in Jos, was established as a centre of excellence for professional training on and research into all aspects of mining and geoscience. It conducts research into exploration, extraction and value addition, develops equipment and tools for the industry, delivers continuous professional development courses and offers postgraduate diploma programmes in mining engineering, mineral engineering and mineral exploration (Rock Post, 2021). In 2019, the Solid Mineral Machinery and Equipment Development Institute was established in Nasarawa State, as part of the National Agency for Science and Engineering Infrastructure. It is responsible for the design, development and production of machinery and equipment for solid mineral exploration and processing, as well as for the provision of capacity-building in the form of training and research and development. It also acts as a business hub, selling its innovations and manufacturing mining equipment to generate revenue and create jobs (Daily Trust, 2025). The main considerations for project developers are as follows: • Implementation of continuous technology training in contracts or service agreements fosters the development of talent. • The sharing of lessons learned from projects at cross-industry events and hosting study tours of project sites enhances the professional development of stakeholders throughout the sector worldwide. • Given that the use of flotation technology for ore beneficiation and spodumene concentrate production is well established and that numerous global suppliers have extensive international experience of this technology, using it avoids more complex equipment certification or intellectual property licencing processes typically associated with more recent technologies (Andreonia and Avenyo, 2023).
Pillar III: **Building key value chains**	The Solid Minerals Development Fund was established to drive and catalyse investment in the mining industry, which should be led by the private sector (Nigeria, 2023). In 2024, the first industrial lithium processing complex was commissioned in Nasarawa State (Nigeria, 2024b). As from 2025, four additional lithium processing facilities were under construction in Kaduna, Abuja and Nasawara States, attracting over $800 million in private investment, mainly from Asia (Anyaogu, 2025; Omotere, 2025). Nigeria has established six mineral processing centres focused on value addition, which form part of the Government's strategy to formalize and develop the solid minerals sector: - Processing centre for pharmaceutical inputs, Bauchi State - Lead and zinc processing centre, Ebonyi State - Barite processing centre in Cross River State - Gold processing centre, Kogi State - Gold processing hub, Kano State - Gemmological laboratory, training centre and gemstone marketing outlet, Oyo State (Oluwatola, 2025) The main considerations for project developers are as follows: • A favourable opportunity exists for industrial processing of critical minerals in Africa as a means of fostering sustainable critical mineral production and supply chain industrialization (Manufacturing Africa, 2024; BloombergNEF, 2021). • The use of the anchor aggregator model where a centralized processing facility (the anchor) acts as a hub for the processing of raw lithium from multiple smaller surrounding mines, leads to greater economies of scale, higher demand and more predictable revenues, such that small mines can make or attract investments to expand their operations. • Innovative modular design of critical mineral processing lines promotes operational flexibility for processing multiple critical minerals, in response to changes in global demand and industry trends. • Environmental, social and governance implications should be taken into account, in order to unlock investment and circularity in supply chain industrialization.

Pillar IV: **Mineral stewardship**	The Federal Ministry of Solid Minerals Development has a value addition policy, in which responsible sourcing is promoted and environmental, social and governance requirements are strengthened (Alake, 2025; Omotere, 2025). Recently, the Government of Nigeria has undertaken a comprehensive review of all mining licenses and established a mines surveillance task force to foster responsible sourcing, improve security at all mining sites and reduce illegal mining operations (Alake, 2025). The Nigeria Solid Minerals Company is a government-backed institution established to promote the growth, sustainability and global competitiveness of the solid minerals sector. It focuses on the following areas (Nigeria Solid Minerals Company, 2025): - Investment facilitation - Exploration support - Value chain development - Capacity development - Sector governance, for enhancing transparency, accountability, and environmental stewardship in mining operations. The main considerations for project developers are as follows: • Long-term ore supply agreements for various critical minerals incentivize responsible sourcing and improved environmental and social governance practices at mines and aggregator hubs. • Responsible sourcing of low-grade ores and processing of such ores into battery materials in Africa increases revenue for miners, reduces environmental waste on mining sites and promotes circularity in global supply chains. • Government-licensed miners or aggregators, or both, are considered to be in the supply chain, and suppliers in Nigeria and its neighbouring countries have the opportunity to supply ore feedstock, in line with the operational instruments of the Agreement Establishing the Africa Continental Free Trade Area.

3.3. Sustainable Development Goals and co-benefits

The sustainable development of lithium mining and beneficiation projects in Nigeria is aligned with the Nigeria Energy Transition Plan, the national policy on domestic value addition in relation to critical minerals and the Sustainable Development Goals. In table 4, the Goals are linked with principles set out in the United Nations Resource Management System; the associated interdependence and cross-connections are thus evident.

Table 4 Sustainable Development Goals mapped to United Nations Resource Management System principles

Sustainable Development Goal	United Nations Resource Management System principles
Goal 1 (No poverty)	• Principle 1: State rights and responsibilities in the management of resources • Principle 3: Integrated management of resources • Principle 4: Social engagement
Goal 5 (Gender equality)	• Principle 4: Social engagement • Principle 12: Continuous strengthening of core competencies and capabilities
Goal 7 (Affordable and clean energy)	• Principle 2: Responsibility to the planet • Principle 5: Service orientation for use and reuse of resources

Goal 8 (Decent work and economic growth)	• Principle 1: State rights and responsibilities in the management of resources • Principle 7: Value addition • Principle 12: Continuous strengthening of core competencies and capabilities
Goal 9 (Industry, innovation and infrastructure)	• Principle 7: Value addition • Principle 9: Health and safety • Principle 10: Innovation
Goal 10 (Reduced inequalities)	• Principle 4: Social engagement • Principle 12: Continuous strengthening of core competencies and capabilities
Goal 12 (Responsible consumption and production)	• Principle 6: Comprehensive resource recovery • Principle 8: Circularity
Goal 13 (Climate action)	• Principle 2: Responsibility to the planet • Principle 8: Circularity • Principle 11: Transparency

Source: United Nations, n.d.; ECE, 2022.

Lithium processing projects throughout Africa, including Nigeria, that entail the conversion of low-grade lithium-bearing ores to spodumene concentrate on the continent could result in increased carbon emission savings (in line with Sustainable Development Goals 12 and 13), compared with the current approaches: disposal of low-grade materials or direct shipment of unprocessed ore over more than 20,000 km, from Africa to Asia, for beneficiation. Increasing value addition on the continent would also generate additional revenue streams for miners and producers of mining waste or low-grade ores (in line with Goals 1, 8 and 9) and foster the use of innovative clean energy, which will decarbonize existing industrial infrastructure (Goals 7 and 9).

3.4. Environmental impact and socioeconomic sustainability

The environmental and social impact assessment is a pivotal tool and mandatory for critical minerals projects in Nigeria (Nigeria Extractive Industries Transparency Initiative, 2023), which is in line with the principles set out in the United Nations Resource Management System (ECE, 2022). The environmental and social impact assessment process typically encompasses public participation and social engagement, scientific data gathering and technical analysis.

Detailed environmental and social impact assessments of critical minerals projects should include:

- Technical sustainability. Consideration of the technical experience and expertise of project proponents and technology partners in industrial manufacturing and large-scale project delivery, in order to evaluate

their suitability for design, operation, maintenance and management

- Environmental sustainability. Plans and processes to ensure that operations comply with national and international environmental regulations and standards and that environmental management plans are implemented
- Social sustainability. Approaches that ensure periodic engagement with all stakeholders, including community members, throughout the duration of the project
- Economic sustainability. Analysis of the critical mineral products in question, which are in great demand worldwide as pivotal inputs for advancing the energy transition, e-mobility and energy access and for which product offtake agreements are in place with global firms

3.5. Gender equality and social inclusion

Evidence-based action plans for gender equality and social inclusion should be incorporated, as a tool for fostering the sustainable development of critical minerals projects. Under such plans, transparency will be promoted, along with the monitoring of gender equality and social inclusion issues and of the planning, design and implementation outcomes of projects. In addition, project developers could be supported to develop gender equality and social inclusion policies.

A typical gender equality and social inclusion action plan could include:

- Providing training and capacity-building on the processing of critical minerals and on the energy transition for men and women in mining, engineering or energy roles throughout the project, in order to encourage knowledge building, training and awareness-raising about the proposed demonstration project
- Ensuring equal opportunity for members of minorities, young people and women, through women-focused professional institutions and vocational centres, as well as through merit-based processes and support for organizations with the development of policies, which includes creating an enabling environment for all to thrive in the sector
- Building a network of women and young people working in the fields of critical minerals, the energy transition and decarbonization, including by designing and establishing women-focused internships and traineeships within the demonstration project, thereby inspiring, attracting and retaining women and developing a gender-diverse workforce
- Promoting and hosting study tours of project sites for women's groups, in collaboration with associations of women professionals, cooperatives, non-government organizations, tertiary institutions and educators in science, technology engineering and mathematics subjects
- Creating an enabling environment for more women and young people to attend cross-sector capacity-building and awareness-raising workshops, conferences and knowledge-sharing seminars throughout the duration of the critical minerals project

4. Innovation and circular economy approaches to critical minerals projects

Innovative technologies are used in the sustainable production of critical minerals. Such technologies include advances in the use of low Earth orbit satellites for observation, the application of artificial intelligence to mineral exploration, clean energy sources for powering mineral processing equipment, low-carbon heavy-duty equipment, robotics for driverless vehicles and more efficient mineral recovery processes and techniques. The use of innovative technologies is aligned with principle 5 (service orientation for the use and reuse of resources) and principle 10 (innovation) of the United Nations Resource Management System.

Circular economy strategies are employed to process low-grade materials, discarded products and mining waste, with a view to recovering critical minerals and returning them to circulation, thereby strengthening domestic supply chains and reducing reliance on virgin materials and imports (Parker, 2025). Such strategies are closely aligned with pillar IV of Africa's Green Minerals Strategy (mineral stewardship) and with principle 6 (comprehensive resource recovery), principle 7 (value addition) and principle 8 (circularity) of the United Nations Resource Management System.

The application of circular economy approaches to critical minerals production is aimed at reshaping value chains, by replacing materials with lower-impact substitutes, designing out waste and keeping products and materials in use for longer (United Nations Environment Programme, 2024). Such approaches are intended to increase resource efficiency, waste minimization and product reuse, compared with the conventional approach, sometimes called "take-make-dispose" (Akindeju, 2025).

The International Energy Agency has calculated that battery recycling could reduce the demand for mined lithium, nickel and cobalt by about 10 per cent (International Energy Agency, 2022). Accordingly, as the Ellen MacArthur Foundation (2025) argues, circular economy strategies in relation to critical minerals must be scaled up, complemented by responsible mining investments. In addition, the potential impact of recycling on demand for virgin materials must be factored into national strategies for mineral exploitation. Furthermore, projects for the industrial processing of critical minerals in Nigeria – or elsewhere in Africa – could boost intra-African trade, through the processing of mining waste sourced from elsewhere in the country or on the continent into high-grade, low-carbon battery materials.

4.1. Carbon emissions savings analysis

In the present section, the technical parameters of an industrial lithium processing project that is under development in Nigeria are used for the illustrative analytical assessment of circularity and sustainability. The project

is based on the flotation process for converting mining waste or low-grade lithium-bearing ores to spodumene concentrate for use as battery materials. When built, the facility that will result from the project will have an annual production capacity of 150 million kg of spodumene concentrate.

A project yielding 150 million kg of spodumene concentrate corresponds to 21 million kg of lithium carbonate equivalent (Savannah Resources, 2025), examples of the possible uses of which include:

- 548,000 electric vehicles, assuming an average of 38.30 kg lithium carbonate equivalent per battery pack (Krishna, 2024)
- 24,000 MWh of battery storage capacity, assuming 0.85 kg lithium carbonate equivalent per kWh (Gielen and Lyons, 2022)

The manufacture of 548,000 electric vehicles could avoid 18 billion kg of additional carbon dioxide equivalent emissions compared with vehicles powered by internal combustion engines, assuming 34,000 kg of avoided carbon dioxide equivalent emissions per electric vehicle after 240,000 km (Reichmuth, 2025). Accordingly, on the basis that each electric vehicle travels 24,000 km per year, 548,000 electric cars could avoid over 1.8 billion kg of carbon dioxide equivalent emissions per year, compared to the business-as-usual case, in which low-grade lithium-bearing ore is disposed of as mining waste.

Furthermore, critical mineral processing of low-grade ore at the case study project in Nigeria could prevent the shipment of more than 850 million kg of mining waste per year over the distance separating Africa and Asia. This will prevent the emission of an additional 51 million kg of carbon dioxide equivalent per year, assuming 0.003 g of carbon dioxide equivalent emissions per kilogram per kilometre (Smart Freight Centre, 2024).

4.2. Design considerations for the processing of critical minerals

The use of modular designs could enable suppliers worldwide to establish flotation processing lines. By opting for these designs, companies would reduce the inherent risk of establishing such lines, ensure their replicability and enable their rapid scaling up to meet the growing demand for critical minerals.

Furthermore, in projects for the processing of lithium-bearing ore, it is essential to use innovative equipment designs, configurations and flowsheets that enable flexibility in the processing of various grades of such ore, as well as the possibility of adaptation to the processing of other critical minerals (including nickel, cobalt and copper), in response to possible future changes in demand levels and other industry trends. Scalability and replicability must be taken into consideration in the industrial design and implementation of the critical minerals project.

4.3. Industrial decarbonization approaches

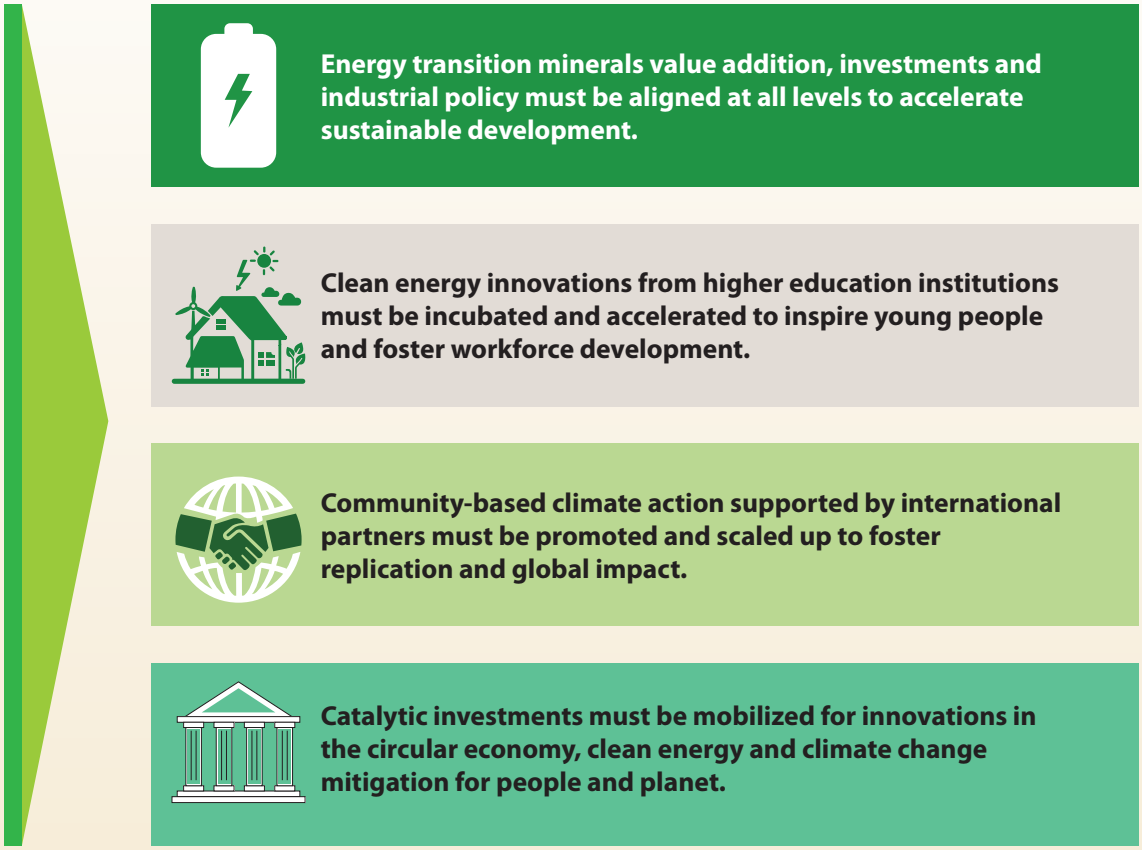
Circularity approaches to industrial decarbonization include the repurposing of existing brownfield sites through the addition of modular flotation equipment. In addition, such sites could be decarbonized, through the installation of such innovative clean energy sources as solar power or battery or grid backup systems, for processing mining waste or low-grade ores into battery materials.

5. Measures at the national level in Nigeria

5.1. Workshop: "Transforming critical minerals value addition"

In Lagos, Nigeria, on Tuesday, 8 July 2025, at the tenth session of the Nigeria Energy Forum, a knowledge exchange workshop was held under the theme "Transforming critical minerals value addition". The aim of the workshop was to raise awareness of the case study report and gather insights from stakeholders throughout the critical minerals sector, including representatives of regulators, investors, project developers, miners and international development partners. Over 200 people from all parts of the sector participated in the workshop, providing further input to the assessment of the potential of lithium development in Nigeria.

Figure V Main recommendations made at the tenth Nigeria Energy Forum



Source: Nigeria Energy Forum, 2025.

5.2. Institutional capacity and monitoring frameworks

In relation to critical minerals, improved institutional capacity and monitoring frameworks could further enhance reporting by government agencies in Nigeria, including the Nigeria Extractive Industries Transparency Initiative, the Mining Cadastre Office, the Mines Inspectorate and the Federal Ministry of Solid Minerals Development.

In 2024, the African Minerals Development Centre published training modules on the Pan-African Resource Reporting Code, for the capacity-building, knowledge development and accreditation of professionals in the mining sector (African Minerals Development Centre, 2024b). In Nigeria, a national focal point could be appointed or a national centre of excellence could be established to foster the adoption of the United Nations Resource Management System and the Pan-African Resource Reporting Code in existing annual auditing processes pertaining to the solid minerals industry, which is typically coordinated by the Nigeria Extractive Industries Transparency Initiative.

6. Recommendations

Critical minerals must be extracted and managed responsibly and efficiently, so that shared and equitable benefits can be fostered in all producer and consumer countries. Such responsibility and efficiency will prevent negative consequences for communities, development and the environment.

In the light of the present study, the following recommendations are made to stakeholders throughout the sector:

- To adopt and localize integrated resource management policies and strategies that are aligned with the United Nations Resource Management System for the sustainable production of critical minerals to ensure that critical minerals are reused, recycled or recovered, to the extent possible, throughout the sector
- To establish a national reporting system for lithium projects that complies with the United Nations Resource Management System and the Pan-African Resource Reporting Code
- To implement principle 12 (continuous strengthening of core competencies and capabilities) of the United Nations Resource Management System and pillar II (develop people and technological capability) of Africa's Green Minerals Strategy, by embedding continuous capacity-building agreements into engineering and procurement contracts at all stages of critical minerals value chains
- To attract investments in high-fidelity mineral exploration and geological data mapping, with a view to quantifying resource and reserve estimates and optimally locating critical minerals
- To demonstrate circular economy strategies for enhancing the sustainability of projects for the processing of critical minerals in Nigeria, and elsewhere in Africa, in line with principle 6 (comprehensive resource recovery), principle 7 (value addition) and principle 8 (circularity) of the United Nations Resource Management System and with pillar III (building key value chains) of Africa's Green Minerals Strategy
- To promote capacity-building and fund mineral exploration activities from royalties, tax revenue, private sector investment or international partnerships for the sustainable production of critical minerals, in accordance with the principles of the United Nations Resource Management System and the pillars of Africa's Green Minerals Strategy
- To strengthen innovation in relation to clean energy sources, to the circular economy and to youth-led and community-led action for critical mineral production

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