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Policy Brief | February 2022

Critical Minerals for India

Assessing their Criticality and Projecting their Needs for Green Technologies*

Rajesh Chadha and Ganesh Sivamani

*This policy brief is extracted from the CSEP Working Paper 19 – Critical Minerals for India: Assessing their Criticality and Projecting their Needs for Green Technologies.

Key Takeaways

- India needs critical minerals to meet its climate change mitigation objectives
- Domestic mining alone is not currently enough to meet the green technology manufacturing requirements
- Further work must be done to better utilise the available minerals within the country for its longer-term needs
- The country must focus on securing supply chains for critical minerals and acquiring foreign mineral assets to ensure their continuous supply

While India would need to rely on imports for green technologies over the next two decades, further work must be done to better utilise the available minerals within the country for its longer-term needs. India can be better prepared by laying the groundwork for exploring and mining. There are some minerals of which India has no known resources and for these the country must focus on securing supply chains for these minerals and acquiring foreign mineral assets to ensure their continuous supply.

Backdrop

India has been taking various steps for climate change mitigation (Ministry of Environment, Forest and Climate Change, 2021). The Prime Minister's Council on Climate Change announced the National Action Plan on Climate Change (NAPCC) in 2008 to achieve sustainable development in line with its economic and environmental objectives. In addition, it announced its Nationally Determined Contributions (NDC) in 2015 (Government of India, 2015), which aim to reduce, from the 2005 levels, the emission intensity of its GDP by 33-35% in 2030. Critical minerals will play an important role in achieving these goals.

Critical minerals refer to mineral resources, both primary and processed, which are essential inputs in the production process of an economy, and whose supplies are likely to be disrupted on account of non-availability or risks of unaffordable price spikes. These minerals lack substitutability and recycling processes. The global concentration of extraction and processing activities, the governance regimes, and environmental footprints in resource-abundant countries adversely impact availability risks. While some of these minerals are inputs for traditional industries, many are crucial for the high-tech products required for clean energy, national defence, informational technology, aviation, and space research (Chadha, 2020).

A recent CSEP Working Paper assesses the criticality level of 23 select minerals for India's manufacturing sector and projects their needs for green technologies needed for climate change mitigation.

Assessing the Criticality of Non-Fuel Minerals in India

A Planning Commission report in 2011 (Planning Commission, 2011) highlighted the need for the assured availability of minerals resources for the country's industrial growth, with a clear focus on the well-planned exploration and management of already discovered resources. The report analysed 11 minerals under four broad categories: metallic, non-metallic, precious stones and metals, and strategic minerals. The Ministry of Mines sponsored study titled "Rare Earths and Energy Critical Minerals: A Roadmap and Strategy for India" (CSTEP & C-Tempo, 2012) reviewed India's production, consumption, and reserves and suggested policy initiatives and government interventions to propel the growth of the mining sector. The minerals' supply chain broadly consists of exploration, mining, processing, and manufacturing. However, initiatives need to be taken in refining, metal/alloy production, and manufacturing components for end-use.

A study sponsored by the Department of Science and Technology and the Council on Energy, Environment and Water (DST-CEEW) highlighted the paucity of research in India related to ensuring mineral resource security for the manufacturing sector. The study made a pioneering attempt at computing a criticality index for 49 non-fuel minerals, including rare earth minerals (Gupta, Biswas, & Ganesan, 2016). The study identified 13 minerals that would become most critical by 2030, of which six were critical even in the reference year 2011.

Methodology

The CSEP Working Paper assesses the criticality level of 23 select minerals for India's manufacturing sector. These include bauxite, copper, chromium, cobalt, graphite, indium, iron ore, lead, limestone, lithium, manganese, molybdenum, neodymium, nickel, niobium, heavy rare earth elements (yttrium and scandium), light rare earth elements (cerium), silicon, silver, strontium, titanium, vanadium, and zinc. In addition, various indicators quantify the criticality along economic importance and supply risk dimensions. The CSEP study used a modified version of the EU methodology 2017 (European Commission, 2017) for its critical minerals assessment.

This paper also projected India's mineral needs for green technologies, including renewable electricity generation and electric vehicle manufacturing, in line with the country's various climate change mitigation objectives over the next two decades.

Economic Importance

The economic importance (EI) dimension broadly measures the impact on the manufacturing sector if a mineral is not available in the supply chain. Three indicators were used to compute the economic importance of each mineral. The first indicator is the average of the gross values added (GVAs) of the manufacturing sectors in which the mineral is consumed, weighted by the respective mineral consumption shares in these sectors relative to the

total mineral consumption. The second indicator is the substitutability index (SI), which measures the cost and performance of substitutes for the mineral, in case available, in each end-use application. The SI dampens a mineral's economic importance if similarly priced substitutes exist that perform well. The third indicator is the GVA multiplier coefficient, which measures a mineral's impact on the manufacturing GVA, computed using sectoral GVA multipliers. A higher GVA multiplier coefficient implies a greater impact on EI and vice versa.

Supply Risk

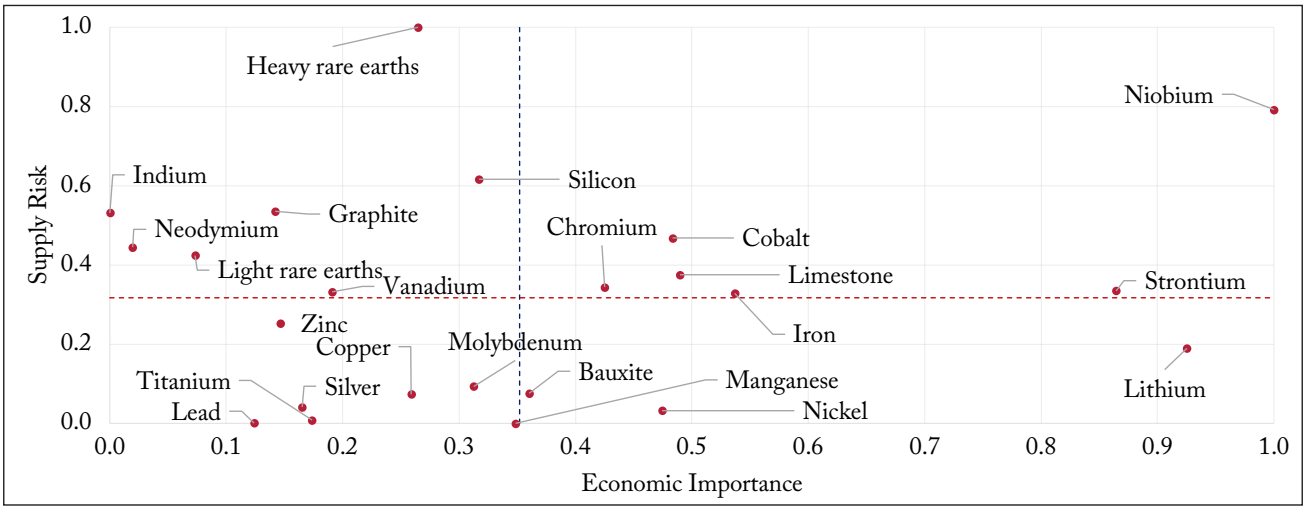
The supply risk (SI) dimension measures the vulnerability in global mineral supply chains due to the concentration of mineral extraction or processing in some countries and the quality of governance in these jurisdictions. The extracting countries and the countries from which India sources its raw material were considered. A higher concentration score for a mineral indicates that fewer countries extract or process this mineral, thus increasing its supply risk. The supply risk also rises if supplying countries have poor governance systems and vice versa. The governance and market concentration supply risks of a mineral are offset by three factors: India's import reliance on the mineral, the rate of end-of-life recycling in India, and the supply risk substitutability. In the case of a mineral with low import reliance, its global extraction or processing concentration becomes less relevant; for a mineral with a high recycling rate in India, the supply risk is lowered; and for a mineral with substitutes with lower supply risks, the mineral's supply risk is also reduced.

Results

The analysis suggests that niobium, lithium, and strontium have relatively high economic importance. Nine minerals have relatively low economic importance: titanium, graphite, silver, vanadium, zinc, lead, cerium, neodymium, and indium. Most minerals have some degree of substitutability, except for niobium and silver, for which there are no good substitutes.

The supply risk is relatively high for yttrium and scandium, followed by niobium and silicon. India does not have the recycling capacity for most minerals except copper and iron. While there are limited technological options for recycling some minerals, there is scope for increased end-of-life recycling, as demonstrated by higher recycling rates globally. Titanium, lead, and manganese face relatively low levels of supply risks.

Figure 1: Criticality of Minerals by Supply Risk and Economic Importance



Source: Authors' computations

Projecting India's Mineral Needs for Green Technologies

The recent meeting on climate change issues, COP26, was held in November 2021 in Glasgow to discuss accelerating action towards achieving the goals of the Paris Agreement (UNFCCC, 2021). Consequently, India has committed to increasing its non-fossil fuel energy capacity to 500 GW by 2030 (which is higher than the earlier 450 GW target which has been used in this study for mineral demands computations), reducing the carbon intensity of the economy by less than 45 per cent in 2030 compared to 2005 levels, and achieving the target of Net-Zero emissions by 2070 (Ministry of External Affairs, 2021).

One facet of India's critical mineral needs will depend on the types of clean energy technologies used in the transition and the share of domestic manufacturing versus import reliance on each technology. Thus, the discussion would differ across types of energies and their projections.

Solar power will play a major role in India's clean energy transition. Some of the key minerals for manufacturing photovoltaic cells include silicon, silver, indium, arsenic, gallium, germanium, and tellurium—none of which India produces.

Wind turbines will also play a role in India's clean energy transition. Some important minerals needed for their manufacture are chromium, manganese, molybdenum, nickel, and rare earth elements. India extracts some chromium, manganese, and rare earth elements (REEs), but the bulk of the REEs are currently mined and processed in China. India targets having 60 GW wind turbine capacity by 2022, up from 39.5 GW in August 2021 (United Nations, 2016).

Electric vehicles (EVs) are seeing a push in India under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme (Mint, 2021). The transition to electric vehicles would reduce vehicular emissions and dependency on fossil fuels. Key minerals needed to manufacture EV batteries include lithium, cobalt, and rare earth elements. However, India does not mine lithium or cobalt, though it has some resources and reserves of cobalt. NITI Aayog has set a 2030 target for EV sales to make up 70% of commercial car sales, 30% of private car sales, 40% of buses, and 80% of two-wheelers and three-wheelers (Narasimhan, 2020). Additionally, the country would need to develop its public-charging infrastructure.

There will be an increase in the demand for several critical minerals as India transitions towards renewable power generation and electric vehicles. The move to renewable energy will require increasing quantities of various minerals, including copper, manganese, zinc, and indium. Likewise, the move to electric vehicles will require increasing quantities of various minerals, including copper, lithium, cobalt, and rare earth elements. However, India does not have reserves of nickel, cobalt, molybdenum, rare earth elements, neodymium and indium, and the country's requirement of copper and silver are higher than its current reserves.

Tables 1 and 2 show data on the resources and reserves (i.e., the economically mineable section of a mineral resource) of minerals from the National Mineral Inventory (Indian Bureau of Mines, 2015) and contrast this with estimates of mineral requirements for clean energy technologies in the International Energy Agency's Stated Policies Scenarios (Table 1) and EVs in a Base Case Scenario (Table 2).

Table 1 Mineral Inventory and Select Mineral Needs for Clean Energy Manufacturing (2020–40)

Mineral	Reserves (KT)	Total Resources (KT)	Typical Share of Metal in Ore (%)	Mineral Needs (KT)	Ratio of Needs-to-Reserves (%)
Copper#	2,735	12,158	100	3244	118.6
Nickel	0	189	1.5	145	No reserves
Manganese	93,475	495,874	35	208	0.6
Cobalt	0	44,910	0.5	7	No reserves
Chromium	102,210	344,016	40	354	0.9
Molybdenum	0	19,372	0.5	42	No reserves
Zinc#	10,000	36,363	100	1400	14.0
Rare earths	0	25	100	19	No reserves
Silicon	17,283	183,963	100	2709	15.7
Bauxite	656,422	3,896,864	20	14827	11.3
Lead#	2,482	13,004	100	16	0.6
Titanium	14,420	413,626	6	3	0.3
Neodymium	None		N/A	N/A	No resources
Silver#	7	30	100	26	371.4
Indium	None		N/A	N/A	No resources

Note: #Mineral inventory includes reserves and resources of the metal content rather than the ore.

Table 2 Mineral Inventory and Select Mineral Needs for Electric Vehicle Manufacturing (2020-30)

Mineral	Reserves (KT)	Total Resources (KT)	Typical Share of Metal in Ore (%)	Mineral Needs (KT)	Ratio of Needs-to-Reserves (%)
Copper#	2,735	12,158	100	1,569	57.4
Lithium	None		N/A	262	No resources
Nickel	0	189	1.5	1,177	No reserves
Manganese	93,475	495,874	35	723	2.2
Cobalt	0	44,910	0.5	392	No reserves
Graphite	7,961	194,887	25	1,955	98.2
Zinc#	10,000	36,363	100	3	0.0
Rare earths	0	25	100	15	No reserves

Policy Implications: The Way Forward

The results of this projection exercise indicate that India is not equipped to meet its green technology requirements through domestic mining alone. Imports of minerals for domestic manufacturing or imports of the final product (embedded in these minerals) will be needed to meet its policy agenda on climate change mitigation.

While India would need to rely on imports for these technologies over the next two decades, further work must be done to better utilise the available minerals within the country for its longer-term needs. Newly installed renewable capacity today will require replacement after two to three decades. India can be better prepared for the next stage of green technology utilisation by laying the groundwork for exploring and mining. India has significant resources of nickel, cobalt, molybdenum, and heavy rare earth elements, but further exploration will be needed to evaluate the quantities of their reserves. In addition, heavy rare earth elements and cobalt face high-supply risks. While nickel currently has a lower supply risk than the other minerals in this study, it has high economic importance, and an assured domestic source would help lower the supply risk.

There are some minerals of which India has no known resources, such as lithium and indium, and for these the country must focus on securing supply chains for these minerals and acquiring foreign mineral assets to ensure their continuous supply.

The study results point to policy recommendations for ensuring uninterrupted supplies of critical minerals through enhanced domestic mineral exploration and extraction, along with assured sources elsewhere. Particular attention should be given to deep-seated minerals (Mathai, 2019). In addition, the import risks of critical minerals may be reduced by developing resilient supply chains, signing trade agreements, and acquiring mining assets abroad.

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About the authors

Rajesh Chadha is a Senior Fellow at CSEP. He was formerly a Professor & Research Director at NCAER. He has worked extensively on regional and multilateral issues pertaining to international trade. His other areas of interest include foreign direct investment and agricultural markets. He has provided research support to the Indian Government on multiple projects. He has also played a key role in the research projects sponsored by the Governments of India, Australia, and the UK, and various international organisations.

Ganesh Sivamani is a Research Analyst in the Natural Resources vertical, working with Professor Rajesh Chadha on the Non-Fuel Minerals and Mining in India (NFM&MIN) research project. He has worked on various issues pertaining to this sector, including the auctions process, critical minerals, international good practices, and economic linkages of the mining sector, through the construction of Input-Output Transactions Tables. He holds a Master of Engineering degree from the University of Cambridge, with a specialisation in Energy, Sustainability, and the Environment. His other research interests include climate change and its mitigation measures, and renewable energy, including nuclear power.

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