ASSOCHAM Minerals and Mining Conclave 2025

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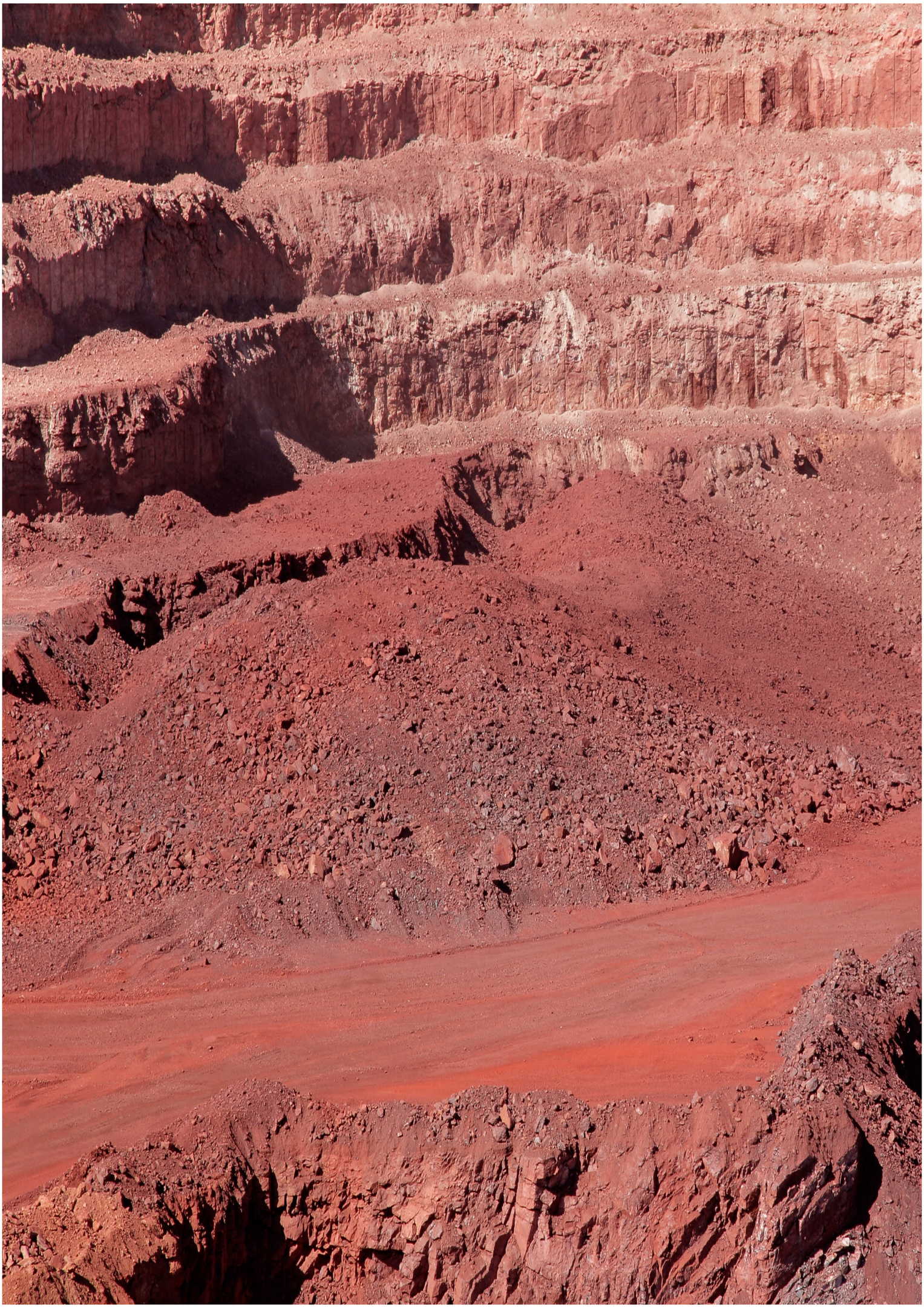
India's Mineral Economy: Driving Growth Through Reform, Innovation, and Resilience



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Foreword

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As a resource-rich nation, India produces 95 minerals, encompassing bulk commodities like coal and iron ore, critical inputs such as bauxite and chromite, and increasingly significant strategic resources like lithium, rare earths, and other critical minerals. These natural endowments not only power infrastructure, energy, and manufacturing sectors but also position India to play a pivotal role in global mineral supply chains, especially in the context of the energy transition and decarbonisation.

The last decade has witnessed a gradual transformation of the sector, enabled by landmark reforms including the MMDR Act amendments, mineral auction regime, commercial coal mining, and the broadening of end-use norms. These policy shifts have improved transparency, enhanced investor confidence, and accelerated domestic production. Yet, the sector continues to face persistent structural bottlenecks that hinder timely project execution and full value realisation.

India's ambitions to reduce import dependence, especially for thermal coal, coking coal, and fertilisers, are reflected in the Government's targeted interventions in coal gasification and coal block auctions. Meanwhile, the rising emphasis on critical minerals—underscored by global partnerships like the India-Australia Critical Minerals Partnership—signals a strategic pivot towards building secure and resilient supply chains for clean energy technologies.

Eastern India, with its concentration of mineral resources, continues to drive production volumes, while western and southern regions are emerging as new frontiers for investment, logistics development, and value-added processing. Foreign Direct Investment has begun to gain momentum in key segments like exploration, coal-to-chemicals, and mineral beneficiation, backed by 100% FDI via the automatic route in many areas.

This report encapsulates the evolving dynamics of India's mining sector, drawing insights from global benchmarks, state-wise comparisons, sectoral reforms, and future opportunities. As India pursues self-reliance in mineral resources and aligns its mining ecosystem with global sustainability goals, the sector offers vast potential—not just as an economic growth engine but also as a strategic lever for industrial and technological advancement.

Foreword

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India's mining sector is poised for a structural transformation, driven by a confluence of strategic imperatives: energy security, infrastructure-led growth, global demand for critical minerals, and the push for sustainable industrialisation. As one of the world's largest producers of coal, iron ore, bauxite, and other key minerals, India holds a central position in the global resource economy. However, its mining sector has long underperformed relative to its potential, due to complex regulatory processes, limited exploration intensity, infrastructure bottlenecks, and underinvestment in downstream value addition.

Over the past decade, decisive policy reforms have begun to shift this trajectory. Legislative amendments to the MMDR Act, introduction of commercial coal mining, streamlined mineral auctions, and the easing of FDI norms have enhanced transparency, attracted private capital, and injected greater competition into the sector. States like Odisha, Chhattisgarh, and Jharkhand have emerged as mineral powerhouses, while others are ramping up exploration to unlock untapped reserves. Despite this progress, the sector still contends with delays in clearances, challenges in land acquisition, and logistical gaps that continue to hamper project execution and output scaling.

The future growth of India's mining industry will be shaped by its ability to adapt to emerging demands. The rise of electric vehicles, renewables, and energy storage has amplified the strategic importance of critical minerals such as lithium, cobalt, rare earths, and graphite. India has begun to map, auction, and secure access to these minerals, both domestically and through global partnerships. At the same time, coal remains an indispensable component of India's energy mix. While thermal coal demand from the power sector is expected to remain robust in the near term, the Government is simultaneously expanding domestic coking coal production and promoting coal gasification to reduce import dependence and foster coal-to-chemical applications.

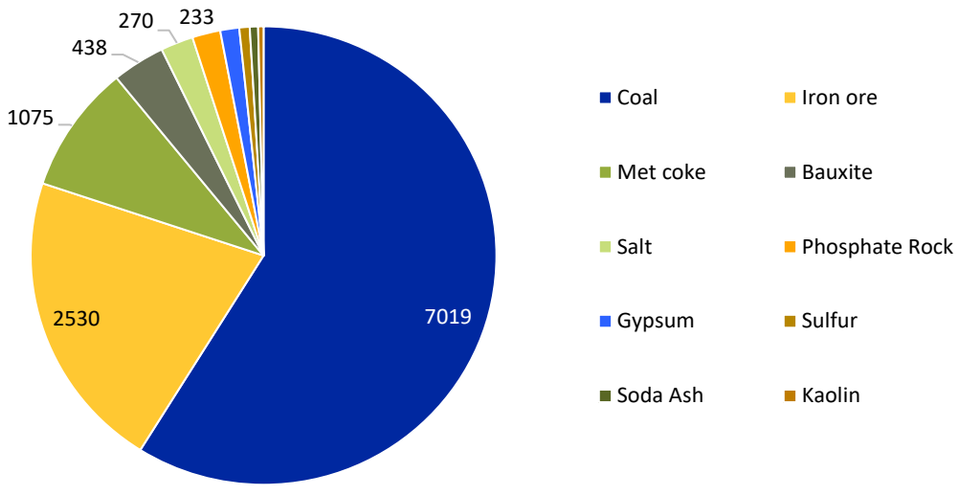
Sustainability is now a defining pillar of the sector. Leading mining companies are increasingly adopting environmentally conscious practices—ranging from zero liquid discharge and renewable-powered operations to electric vehicles and circular economy models. These efforts are complemented by policy tools such as the Star Rating system, ESG disclosures, and bio-reclamation mandates, reinforcing the transition toward responsible mining.

As India navigates this complex and opportunity-rich terrain, the mining sector is not only expected to meet the material demands of a growing economy but also play a pivotal role in enabling a resilient, resource-secure, and sustainable industrial future. Unlocking this potential will require continued regulatory innovation, public-private collaboration, infrastructure upgrades, and a sharper focus on value addition, exploration, and technology adoption across the mining value chain.

The Global Mining Industry: A cornerstone of the global economic and energy transition landscape

The global mining industry occupies a central and evolving role in the contemporary world economy, serving as the essential supply source for materials that fuel modern societies—construction aggregates, metals for infrastructure, and minerals integral to clean energy technologies. The mining sector underpins critical industries ranging from steel and cement manufacturing to advanced technologies and electrification efforts. Global production has expanded markedly in recent decades, mirroring urbanisation, population growth, and increased demand for minerals. In 2021, global mining output was approximately 17.9 billion tonnes—more than twice the volume recorded in 1985. Bulk commodities such as coal and iron ore dominate the landscape, with coal alone accounting for roughly 40% of mined tonnage in 2023, primarily supporting energy and steel production. Iron ore remains the second most-produced material, with over two billion tonnes mined annually, driven by robust steel demand in Asia. Meanwhile, phosphate rock—critical for fertilizer production—exhibited explosive growth, tripling in output between 2021 and 2022 as global agricultural demand rose.

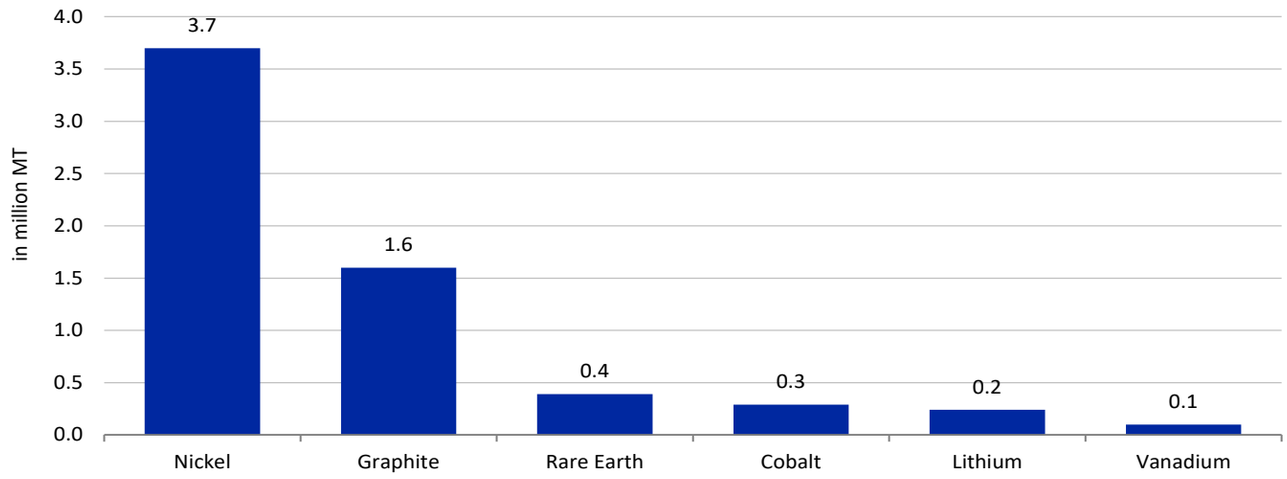
Exhibit 1: Global production of major minerals in CY2023 (data in million metric tonne)



Source: US Geological Survey, ICRA Research

While traditional bulk minerals generate high-volume outputs, the past decade has seen a strategic shift toward so-called transition or critical minerals, vital for renewable energy systems and high-tech applications. These include lithium, cobalt, nickel, rare earths, vanadium, and graphite. Though currently comprising only about 3.2% of mined volumes in 2022, the annualised growth in demand for these materials is projected to be several times greater than that for bulk commodities, driven by electric vehicle, battery storage, and renewable energy infrastructure deployment. The International Energy Agency warns that unless mining for critical minerals scales rapidly, energy transition goals may be compromised.

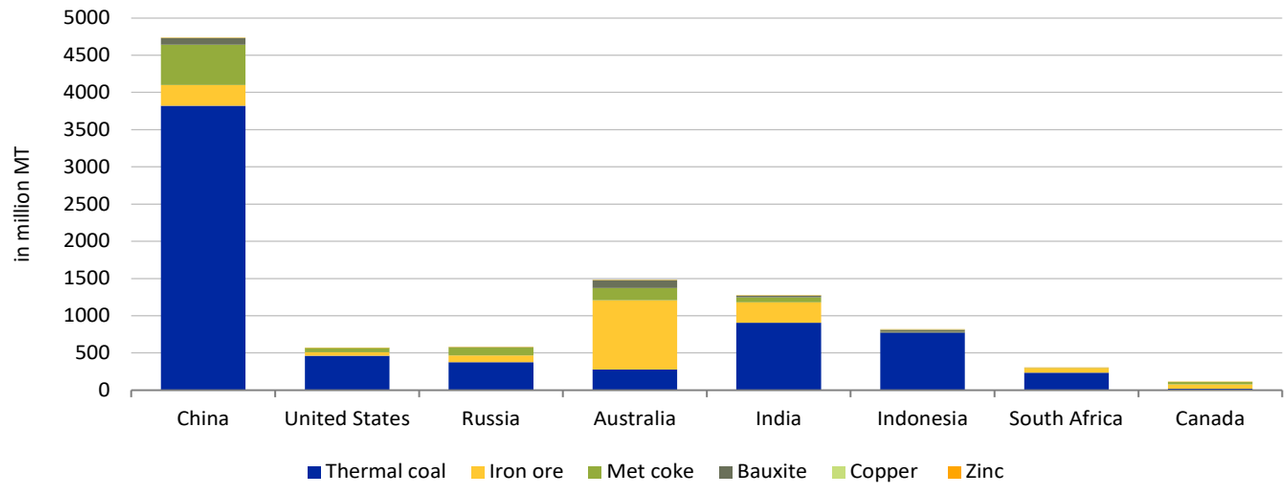
Exhibit 2: Global production of critical minerals in CY2024 (data in million metric tonne)



Source: US Geological Survey, ICRA Research

Regionally, mining activity is heavily concentrated in Asia, which accounted for over 60% of global mineral production in 2021. China leads this effort, not only as the world's largest extractor of mineral commodities—including coal, rare earths, and graphite—but also as the dominant force in mineral processing and refining. India, Indonesia, and Russia also play major roles in the region's production portfolio. North America and Oceania follow, with the United States, Canada, and Australia being prominent producers of a wide range of commodities, from gold and copper to bauxite and nickel. South America, notably Chile, Peru, Brazil, and Argentina, holds substantial reserves and production capabilities, particularly for lithium, copper, and silver. Africa, despite its rich geological potential, contributes less in volume but is immensely significant in terms of critical minerals. The Democratic Republic of Congo (DRC), for example, supplies over 70% of global cobalt, while South Africa leads in platinum group metals.

Exhibit 3: Country-wise major mineral production in CY2023 (data in million metric tonne)



Source: US Geological Survey, ICRA Research

Looking ahead, global mined tonnage is expected to grow ~3-5% annually, driven by ongoing infrastructure development and the rapid scaling of clean energy systems. Countries like India have clear opportunities: not just by increasing bulk commodity output but also by ramping up exploration and processing of critical minerals, investing in downstream facilities, and improving governance frameworks to attract investment and ensure sustainable benefits.

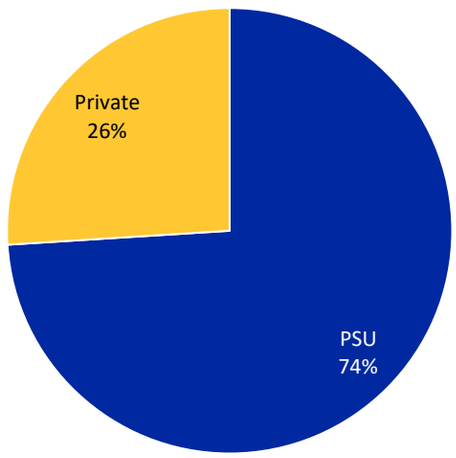
In summary, mining remains indispensable to both classic industrial development and the emerging low-carbon economy. Its global significance is underscored by the scale of production, the strategic value of critical minerals, and the geopolitical and social complexities involved in its expansion. As resource priorities shift, nations with diversified mineral portfolios, agile regulatory regimes, and sustainable practices—India included—will be best positioned to harness the evolving landscape of global mineral supply and demand.

Domestic Mining Industry: Structural profile and production dynamics

The Indian mining sector is a critical component of the country's industrial framework, providing essential raw materials for infrastructure, energy, manufacturing, and economic development. Extracted minerals support the backbone of core sectors such as power, steel, cement, fertilisers, and chemicals, thereby making mining indispensable to both upstream and downstream value chains. In addition to its traditional role in supplying bulk commodities like coal and iron ore, the mining sector is gaining strategic prominence in the context of the global energy transition, where critical minerals such as bauxite, zinc, rare earth elements, and lithium are becoming increasingly vital for green technologies.

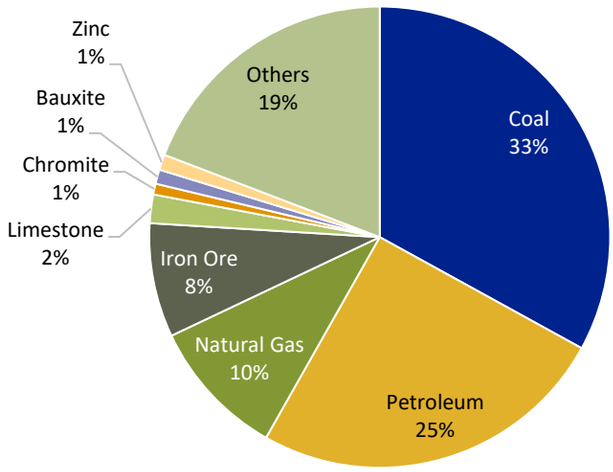
Structurally, the Indian mining industry has long been dominated by large public sector undertakings (PSUs), which account for approximately 70–74% of the total value of mineral production, according to Ministry of Mines. This dominance is especially prevalent in bulk commodities like coal, where central PSUs such as Coal India Limited (CIL) maintain near-monopoly status. In contrast, the private sector's presence in mineral extraction remains fragmented and largely composed of small- and medium-scale enterprises. These private miners operate primarily in non-coal minerals and industrial ores and face numerous challenges, including constrained access to capital, regulatory complexity, and underdeveloped logistics infrastructure. However, captive mining is shaping up and will add significantly to the coal segment, going forward. Regulatory oversight for the mining sector is shared between the Central and the state governments, often leading to jurisdictional overlaps and prolonged project execution timelines.

Exhibit 4: Value of Mineral production- PSUs Versus Private



Source: ICRA Research

Exhibit 5: Mineral wise value of production



Source: Ministry of Mines, ICRA Research; figures for FY2022

Mineral-wise, coal holds the lion's share of India's mining output by value, accounting for over 33% of the mineral basket (excluding petroleum and natural gas), followed by iron ore (8%). Together, four minerals—coal, iron ore, limestone, and lignite—make up nearly 55% of India's total mineral production by volume. India ranks second globally in coal production and fourth in iron ore. The country is the third-largest producer of zinc, fourth in chromite, fifth in bauxite, and seventh in copper. These rankings position India as a significant global player in bulk and base minerals, although it remains largely absent from global production charts for high-value energy transition minerals such as lithium, cobalt, and rare earth elements. India remains heavily dependent on imports for most of its critical mineral requirements, creating potential vulnerabilities for its green energy ambitions.

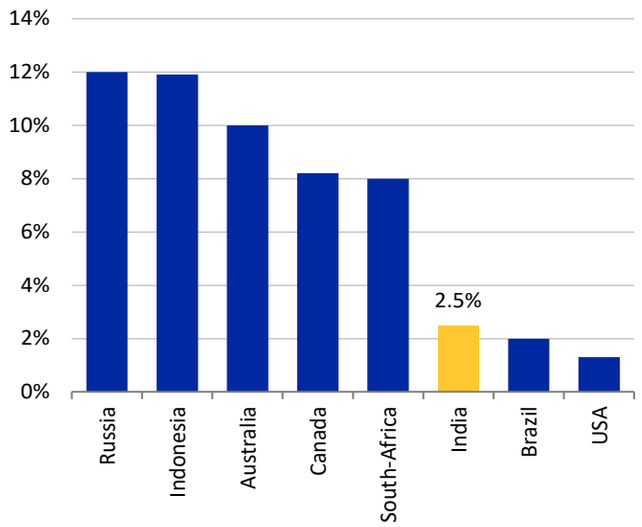
Exhibit 6: Contribution and rank of India in world production of major minerals

	Contribution of world production (%)- 2022	India's Rank in World 2022	Order of self-sufficiency- 2024
Bauxite	5.94%	5th	85.0%
Zinc	7.06%	3rd	96.0%
Iron ore	10.27%	4th	100.0%
Copper	0.12%	7th	36.0%
Coal	11.14%	2nd	84.0%
Chromite	9.39%	4th	95.0%

Source: Ministry of Mines, ICRA Research

The contribution of India's mining and quarrying sector to the national GDP remains modest at approximately 2.2% to 2.5% as of FY2022–23, significantly lower than in other major mining economies. In contrast, mining accounts for 12% of GDP in Russia, 10% in Australia, 12% in Indonesia, and over 8% in countries like South Africa and Canada. Even Brazil, with comparable resource diversity, maintains a mining share of around 2%. The United States, despite a far more diversified economic base, reports a mining contribution of about 1.3% excluding oil and gas, rising to over 3% when these are included. This stark contrast highlights the relative underperformance of India's mining sector, both in its economic footprint and in its integration with global resource value chains.

Exhibit 7: Contribution of the mining industry to the GDP of various countries



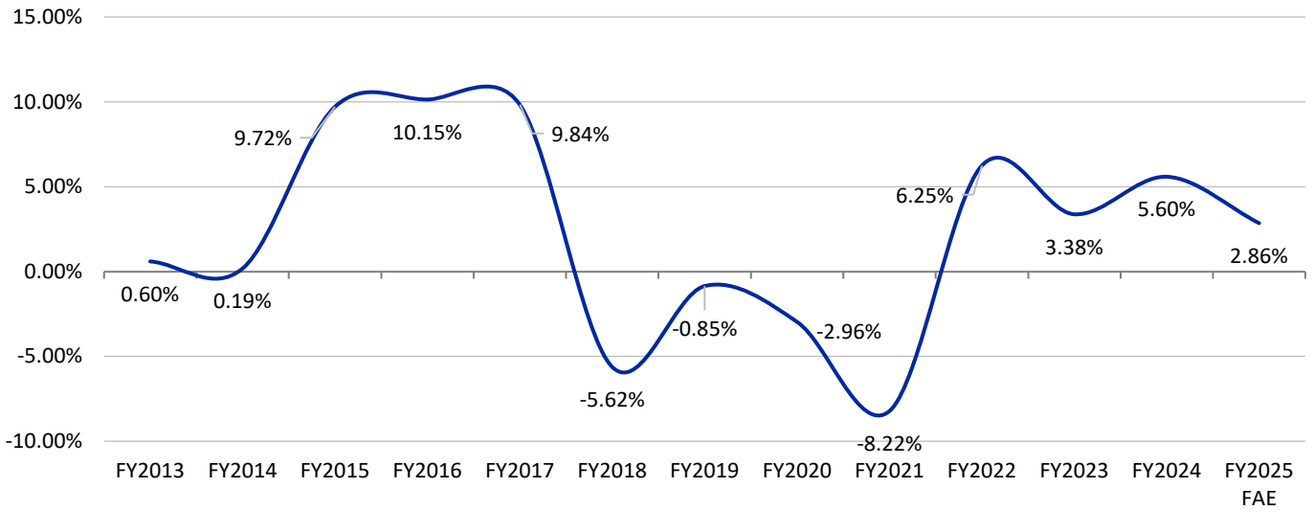
Source: ICRA Research; India's data is for FY2023; other country's data indicates latest available year

Several factors explain India's lower mining-to-GDP ratio. India's exploration intensity remains inadequate—accounting for less than 0.3% of global exploration budgets—leading to suboptimal resource discovery and reserve conversion. Moreover, the dominance of the public sector in core segments like coal restricts competitive dynamism and technological modernisation, especially when compared to Australia or Canada, where private capital and innovation play central roles. Supportive Government policies and a favourable investment climate would be important enablers for India's mining sector to contribute a greater share of the GDP and create more employment opportunities.

Mining sector's GVA growth

In recent years, the sector's contribution to the Gross Value Added (GVA) and overall economic output has experienced substantial volatility. Historical data reveals that India's mining sector had a strong growth trajectory between FY2015 to FY2017, registering almost double-digit year-on-year GVA growth rates of ~10%. This momentum, however, began to dissipate in the following years, wherein the growth witnessed contraction during FY2018 and FY2019, reflecting a combination of macroeconomic headwinds, stagnating investments, regulatory challenges, and subdued commodity prices.

Exhibit 8: Trend in India's mining sector YoY GVA growth



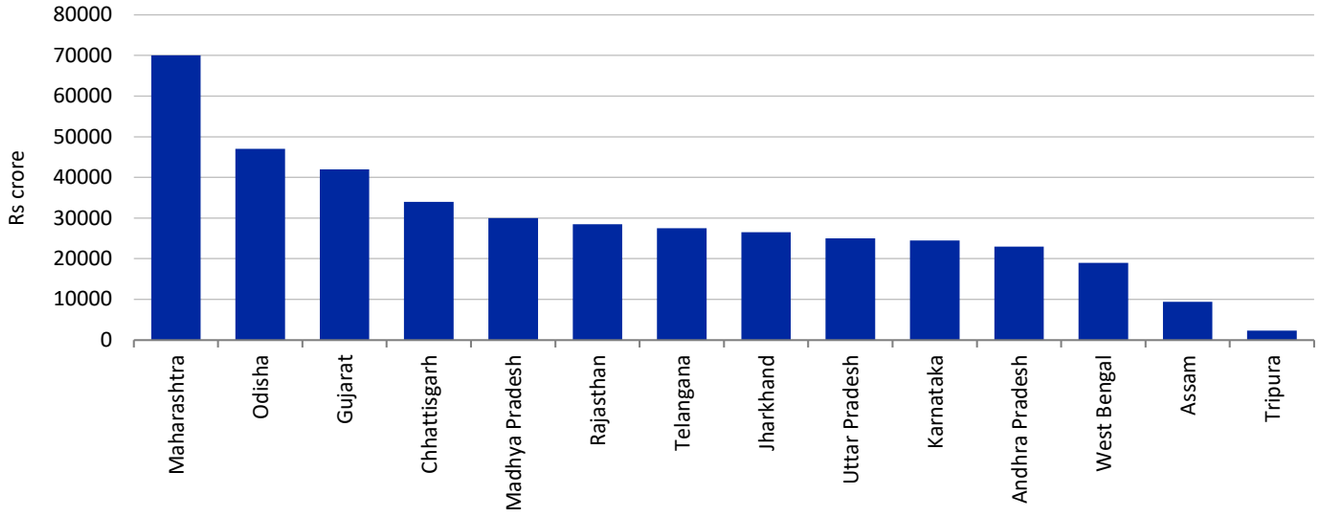
Source: Ministry of Statistics and Program Implementation; ICRA Research; FAE: First Advance Estimate

In response to the sector's declining trajectory, the Government of India introduced the National Mineral Policy (NMP), 2019. One of the cornerstone goals of this policy was to enhance the value and volume of domestic mineral production by 200% over a seven-year period, targeting FY2026 as a milestone. Implicit in this target was a projected compound annual growth rate (CAGR) of 10.4% for mining GVA, a significant increase compared to historical trends. Unfortunately, the sector did not achieve the desired turnaround. The Covid-19 outbreak further disrupted operations, supply chains, and project execution, leading to back-to-back contractions in FY2020 and FY2021. Although there was a recovery in FY2022, the same again decelerated in the following years.

State-Wise Mining Sector Performance in India: GVA Trends, Auctions, and Economic Contribution

The performance of India's mining sector is deeply intertwined with the initiatives and governance capacity of individual states, given that mineral resources fall under the dual control of both the central and state governments. The decentralised governance structure means that state-specific reforms, administrative efficiency, and mineral resource potential have a direct bearing on the growth of mining output, its contribution to regional economies, and the pace at which mineral assets are monetised. An analysis of the mining and quarrying Gross Value Added (GVA) across key mineral-rich states in FY2023 highlights not only the uneven distribution of mining activity but also the disparity in institutional capacity to generate value from natural resources.

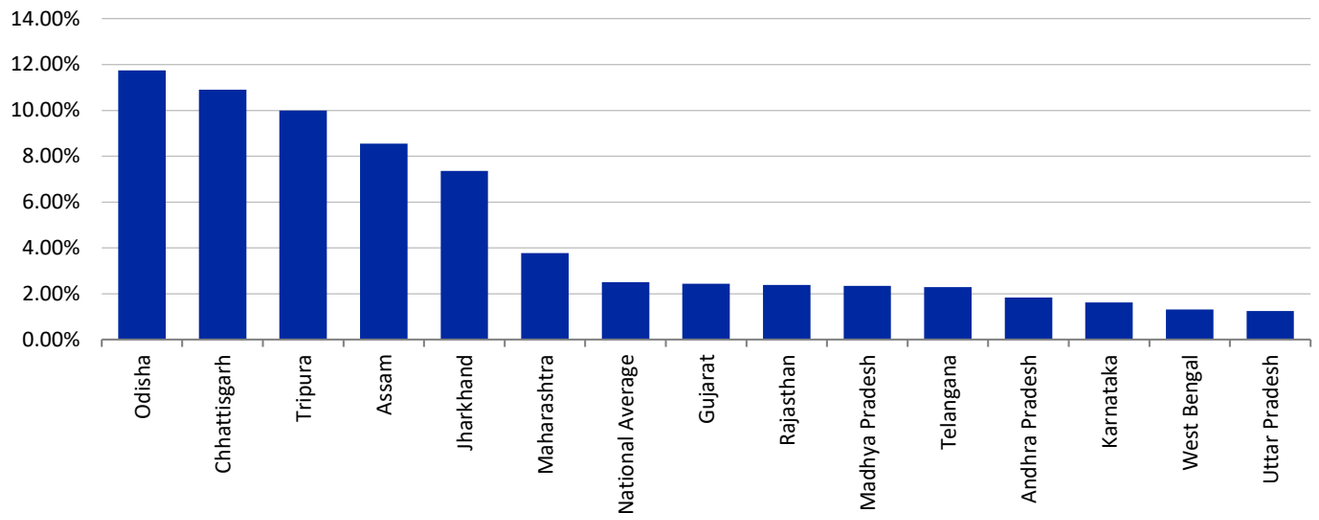
Exhibit 9: Gross value added (GVA) from mining & quarrying in key mineral rich states in FY2023 (current price)



Source: Ministry of Statistics and Program Implementation; ICRA Research

In absolute terms, Maharashtra emerged as the largest contributor to India's mining sector GVA in FY2023, accounting for approximately 13.7% of the national mining output. This was followed by Odisha (9.2%), Gujarat (8.2%), Telangana (5.4%), and Chhattisgarh (6.7%). Together, these five states were responsible for over 44% of the country's mining GVA, underscoring their strategic importance. When extended to the top ten contributing states, the cumulative share increased to approximately 70.0%. This concentration of mining activity reflects both the geological endowment and the administrative drive to push through auctions, clearances, and operationalisation of leases.

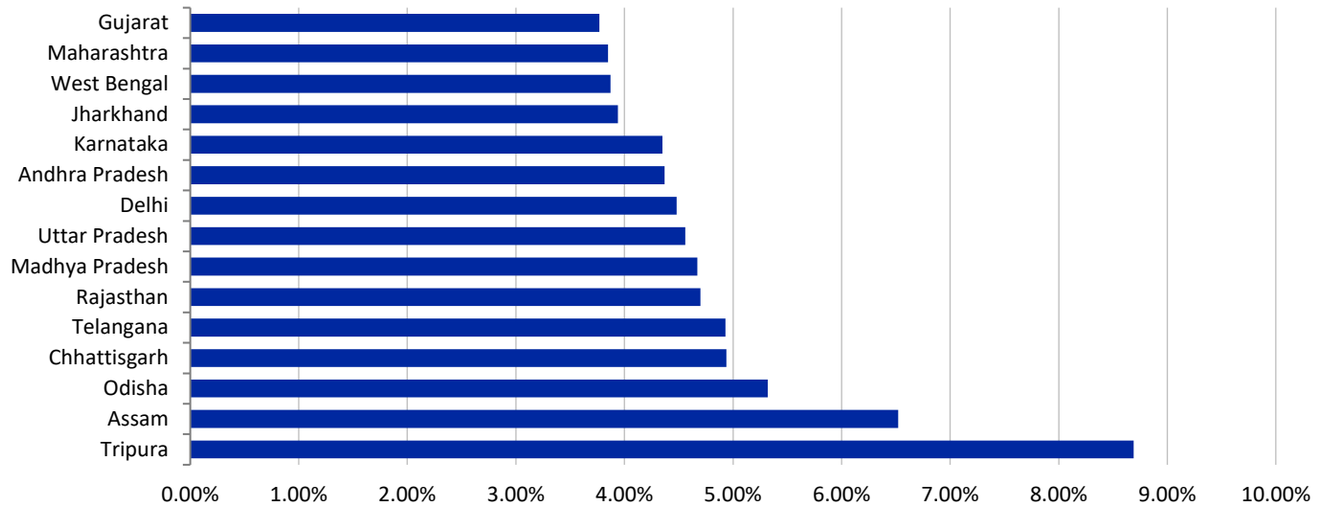
Exhibit 10: Contribution of the mining sector to the state GDP of key mineral rich states in FY2023



Source: Ministry of Statistics and Program Implementation; ICRA Research

However, the size of the mining economy at the state level does not necessarily translate into a high proportional contribution to the state's GDP. For instance, while Maharashtra and Gujarat have large mining sectors in absolute terms, their contribution to the state GDP stands at a modest 3.8% and 2.4%, respectively. In contrast, eastern and northeastern states such as Odisha, Chhattisgarh, Tripura, Assam, and Jharkhand show a far more integrated relationship between mining and their local economies. In FY2023, mining contributed 11.8% and 10.9% of Odisha's and Chhattisgarh's GSDP, respectively, with Tripura (10.0%), Assam (8.6%), and Jharkhand (7.4%) also among the top contributors. This demonstrates the economic dependence of certain states on mining activity and highlights where supportive policies can yield the highest developmental impact.

Exhibit 11: CAGR of mining sector GVA (current price) between FY 2013 to FY2023 for key mineral rich states

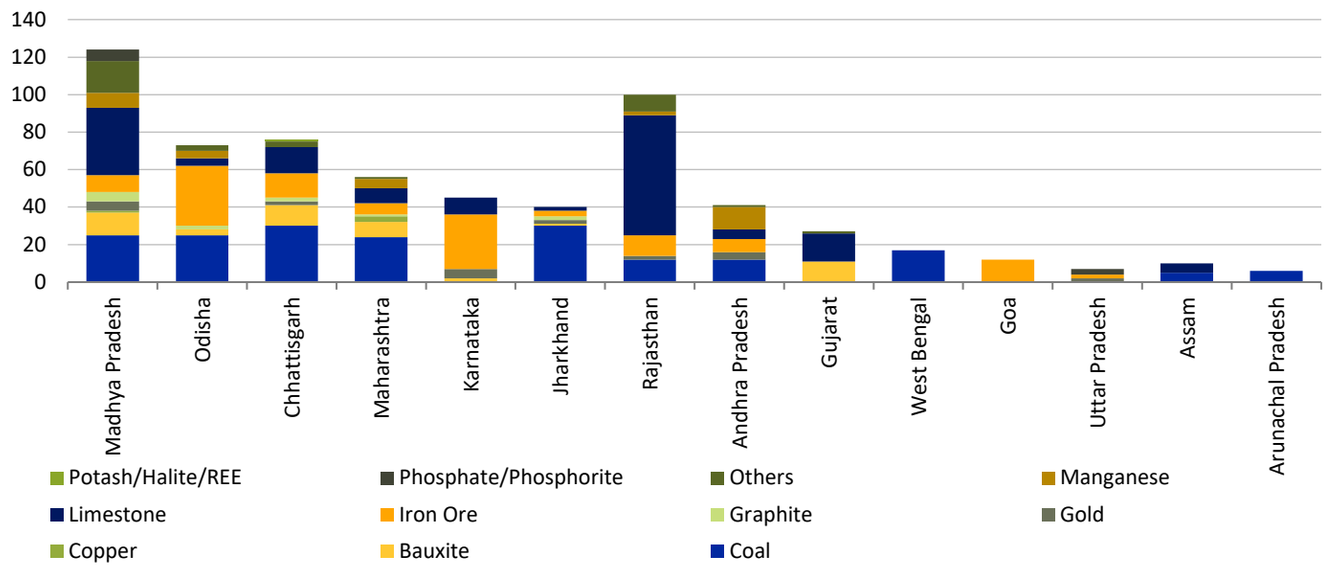


Source: Ministry of Statistics and Program Implementation; ICRA Research

The disparity in growth trends is further evident when reviewing the compound annual growth rate (CAGR) of the mining sector between FY2013 and FY2023. While India's mining sector witnessed subdued growth, some states significantly outperformed the national average. Tripura led the pack with a CAGR of 8.7%, followed by Assam at 6.5%, Odisha at 5.3%, and Chhattisgarh at 4.9%. These states not only implemented consistent policy measures but also successfully attracted private sector participation and expedited project execution. On the contrary, some traditionally mineral-rich states lagged. Jharkhand, for example, recorded a near-stagnant CAGR of just 3.9%.

The number of mines auctioned by states is another key indicator of the pace of resource monetisation and the success of post-MMDR reforms. As per Exhibit 31, Odisha and Madhya Pradesh lead the country in terms of cumulative mines auctioned, with 124 and 73 blocks awarded respectively. They are followed by Chhattisgarh (76), Maharashtra (56), and Karnataka (45). The relatively high auction volumes in these states are indicative of the implementation of the proactive mineral policy and stronger administrative machinery.

Exhibit 12: State wise number of mines auctioned till date



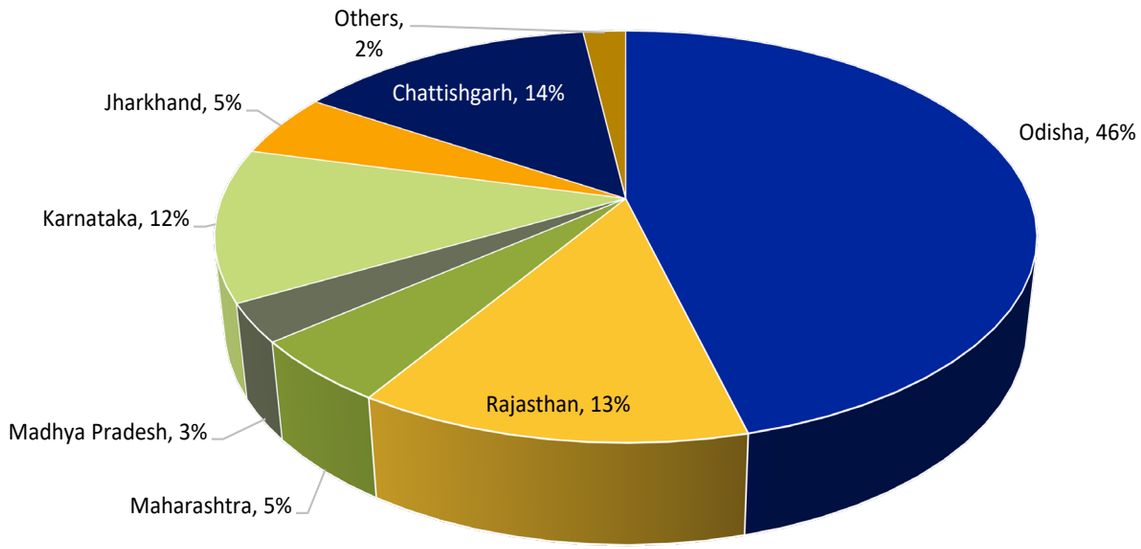
Source: Ministry of mines and Ministry of coal; ICRA Research

Moreover, the type of minerals auctioned also varies significantly across states. Odisha's auctions are skewed towards iron ore and manganese, reflecting its dominance in ferrous metallurgy. Rajasthan and Andhra Pradesh have shown greater emphasis on limestone, marble, and industrial minerals, supporting cement and ceramics industries. Maharashtra and Chhattisgarh have a more diversified portfolio including coal, iron ore, and bauxite, which aligns with their integrated metallurgical and power generation ecosystems.

Mining Landscape of Eastern and North-Eastern India

As discussed, above, while the sharp regional divergence has been witnessed in mineral production in India, Eastern India emerges as the dominant mining powerhouse. Odisha, Jharkhand, Chhattisgarh, and West Bengal have played pivotal roles in shaping this trend, while the Northeastern states like Assam and Arunachal Pradesh are gradually stepping into focus. These regions together form the mineral-rich eastern belt of India, responsible for a lion's share of the country's coal, iron ore, bauxite, and chromite output.

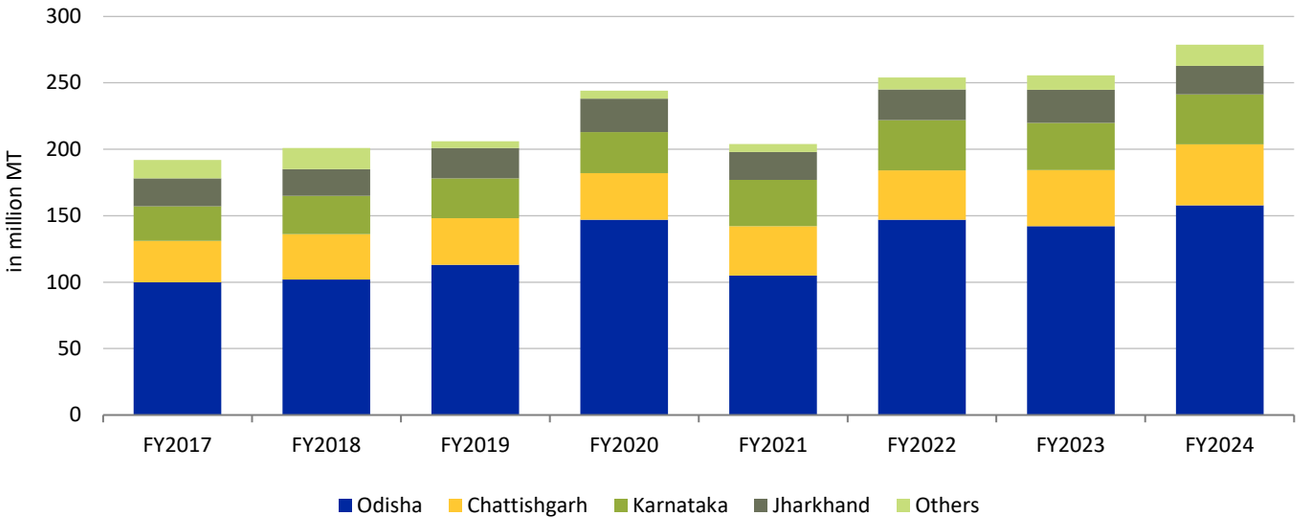
Exhibit 13: State-wise share of value of mineral production in FY2024 (excluding atomic minerals and hydrocarbons)



Source: Indian Bureau of Mines (IBM), Ministry of Coal, ICRA Research

As per the Odisha Department of Steel & Mines, Odisha alone contributed over 46% of the national mineral production value in FY2024 (excluding hydrocarbons and atomic minerals). This is followed by Chhattisgarh (12%) and Rajasthan (13%). Jharkhand contributes ~5% of total value. Notably, Odisha has consistently maintained leadership due to its rich deposits of iron ore, bauxite, chromite, and coal. Jharkhand, meanwhile, holds significant coal reserves and ranks among the top iron ore producers, while Chhattisgarh is known for both coal and iron ore. These three states have not only shown consistency in output but also experienced accelerated production growth over the last few years, supported by proactive mineral policy reforms and faster auctioning of mineral blocks.

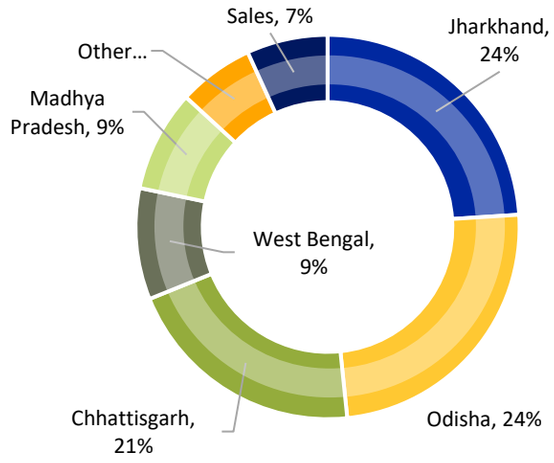
Exhibit 14: Trend in state-wise iron ore production in India (in million MT)



Source: Indian Bureau of Mines, ICRA Research

In **iron ore** production, Eastern India continues to dominate the national landscape. Odisha, Jharkhand, and Chhattisgarh collectively account for the majority of India's output, with Odisha alone contributing over 60% in FY2024, producing approximately 158 million tonnes. Jharkhand and Chhattisgarh also maintain strong output, supported by vast reserves in the Singhbhum and Bailadila regions, respectively. These states benefit from well-established rail corridors connecting mineral belts to industrial hubs and export ports, enabling efficient evacuation and logistics. Northeastern states, however, have limited iron ore resources and play a minimal role in this segment.

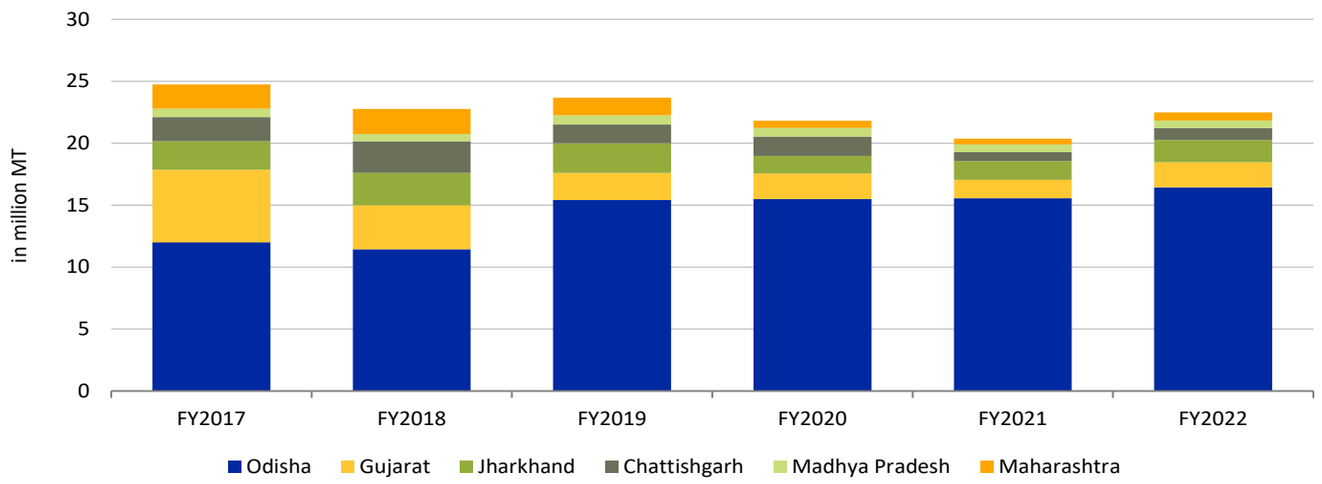
Exhibit 15: Share of leading states in India's coal resources



Source: IBM, ICRA Research; reserves as on Apr 1, 2022

In the case of **coal**, Eastern India again leads, with Jharkhand and Odisha occupying the top two positions nationally. In FY2023–24, Odisha produced around 237 million tonnes of coal—roughly 24% of the national output of 997 MT. Jharkhand and Chhattisgarh, another eastern states, closely follows with significant coalfields the regions and huge coal resources. Assam, representing the North East, has begun modest contributions to coal mining, with key reserves in Ledo and Margherita. However, coal production in the North East remains constrained by ecological concerns and infrastructural challenges.

Exhibit 16: Trend in state-wise bauxite production in India (in million MT)



Source: Odisha Department of Steel & Mines, ICRA Research

In **bauxite**, Odisha again leads the country, producing 17.5 million tonnes in FY2024, which accounts for nearly 73% of India's total bauxite output. However, other eastern states like Chhattisgarh also possess substantial bauxite reserves and have witnessed rising production in recent years. These deposits are critical for supporting India's aluminium industry. Northeastern states have limited bauxite resources and are not significant contributors to this mineral.

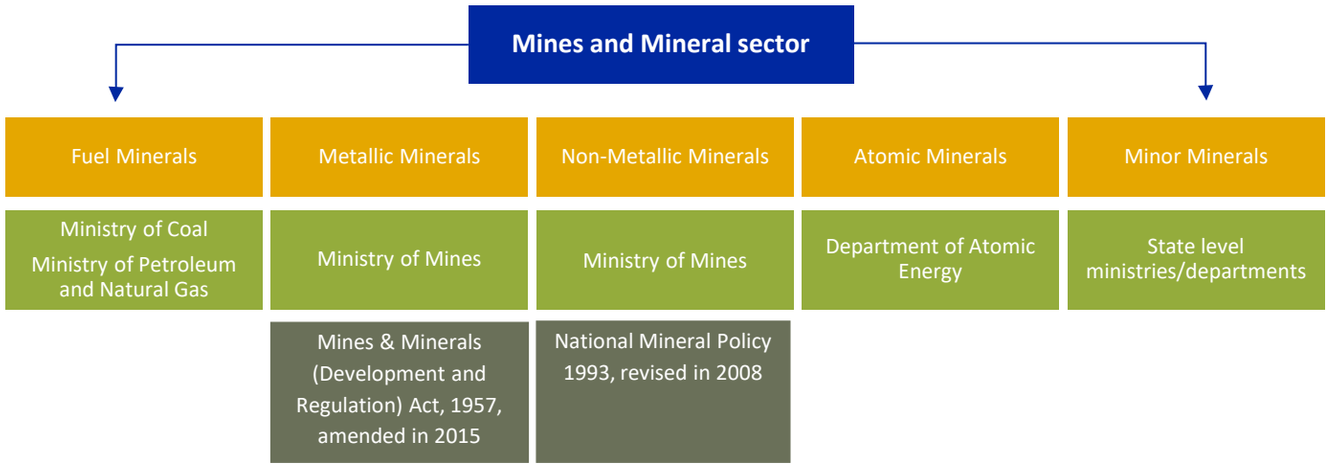
Regarding **chromite**, eastern India—specifically Odisha—dominates entirely, with the state holding 96% of India's chromite reserves and contributing 100% of its production. Most of this output comes from the Sukinda Valley, with production led by companies such as OMC and Tata Steel Mining. Chromite resources in other eastern states and the North East are negligible, making Odisha the single critical node for this strategic mineral.

In contrast, the mining output from western and southern India is relatively modest and skewed towards non-ferrous minerals. Karnataka, for instance, is a major iron ore producer but has stricter mining regulations due to environmental sensitivities and judicial restrictions. Gujarat and Maharashtra contribute primarily to lignite and bauxite production, while Rajasthan dominates in non-metallic minerals such as limestone, potash, and rock phosphate. Northern India, barring pockets of coal-bearing zones in Uttar Pradesh, plays a limited role in mineral production.

Regulatory framework for the mining industry

India's mining industry is governed by a complex regulatory ecosystem rooted in both the Central and state legislation. The foundational statute for the sector is the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act), which has been amended several times to accommodate evolving market needs, policy reforms, and judicial interventions. This legislation sets the legal and administrative foundation for mineral concessions, including reconnaissance permits, prospecting licences, mining leases, and composite licences for all minerals except petroleum and natural gas. The MMDR Act classifies minerals into four broad categories: coal and lignite, major minerals (such as iron ore, copper, zinc, bauxite, limestone), minor minerals (sand, building stones, clay, etc.), and atomic minerals (uranium, titanium, thorium, etc.). Their governance is divided across three primary authorities — the Ministry of Coal, the Ministry of Mines, and the Department of Atomic Energy — each of which oversees a specific subset of mineral groups. While major minerals and coal are primarily regulated at the Central level, the state governments regulate the minor minerals. However, even for major minerals, the role of the states remains significant in lease administration and revenue collection.

Exhibit 17: Administrative set-up for non-petroleum minerals



Source: Ministry of Mines,ICRA Research

Coal and lignite, which are critical to India's energy security, are governed by the Coal Mines (Special Provisions) Act, 2015, a legislation introduced following the Supreme Court's 2014 verdict that cancelled over 200 coal block allocations due to irregularities and lack of transparency. This Act laid down the framework for transparent auction-based allocation of coal mines to both public and private sector entities. The Ministry of Coal administers the allocation and management of coal blocks, and retains significant powers over block development timelines, clearances, and mine plan approvals.

For other major minerals, the MMDR Amendment Act of 2015 introduced sweeping reforms by mandating that all new mineral concessions—both mining leases

and composite licences—must be allocated through a competitive e-auction process. This was a significant shift from the earlier discretionary system, which was prone to opacity and rent-seeking behaviour. The amendment also introduced the concept of a Composite Licence (CL), combining prospecting and mining rights for blocks with insufficient exploration. A subsequent amendment in 2021 empowered the Central government to conduct auctions on behalf of states for certain minerals, especially where delays were hampering sectoral growth.

Regulatory compliance in mining is multifaceted and involves clearances and approvals from multiple departments. Mining operations must secure environmental and forest clearances, consents from pollution control boards, safety approvals from the Directorate General of Mines Safety (DGMS) and adhere to the Indian Bureau of Mines' (IBM) mining plans and monitoring frameworks. These layers of oversight, while necessary for environmental and social safeguards, often result in procedural bottlenecks and longer gestation periods for mine development.

The Indian judiciary has played a pivotal role in shaping the mining regulatory framework. Notably, the Supreme Court's verdicts in illegal mining cases in Karnataka, Odisha, and Goa led to stricter enforcement of penalty provisions and the creation of deterrence mechanisms. The same judgments led to the conceptualisation of frameworks such as the District Mineral Foundation (DMF) and National Mineral Exploration Trust (NMET), which mandate that lessees contribute a share of their earnings towards local area development and mineral exploration efforts, respectively.

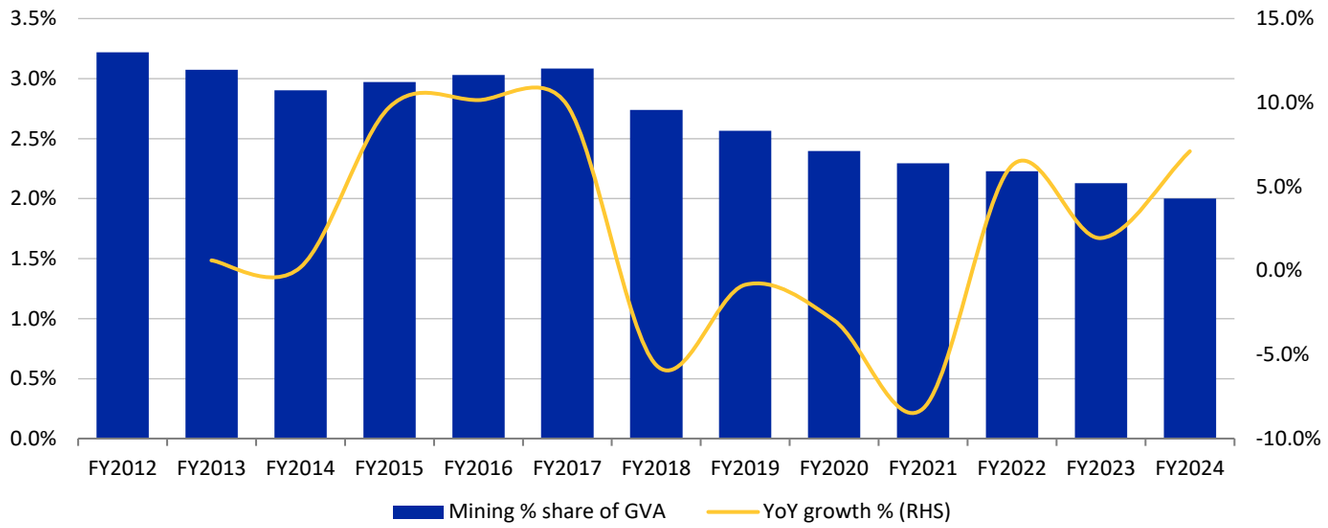
Another landmark development in this space is the Supreme Court judgment of May 2024, which reaffirmed that state governments have the legislative competence to impose taxes on mineral rights, even though royalty is exclusively under the Central jurisdiction. The court held that royalty, being a charge on the value of the mineral extracted, does not preclude the state's right to impose separate taxes under its sovereign powers. This ruling clarified the fiscal autonomy of states and is likely to have far-reaching implications on how states mobilise revenue from mineral exploitation, especially at a time when states are increasingly dependent on own-source revenues.

In conclusion, while India's mining regulatory architecture has evolved to become more transparent and structured, it remains a complex interplay of Central oversight and state-level execution. The reforms since 2015 have helped boost private sector participation, enhance mineral security, and improve governance. However, challenges such as approval delays, regulatory overlaps, and fiscal ambiguity between royalty and taxation continue to persist. Going forward, the effectiveness of the framework will depend on harmonising Central policies with state implementation capacity, balancing resource development with environmental concerns, and ensuring that the mineral wealth of the country leads to equitable and sustainable growth.

Investment Landscape and FDI trends in India's Mining Sector

India's mining sector has undergone substantial regulatory and structural reforms over the past decade, aimed at improving transparency, operational efficiency, and investor confidence. These reforms have included a shift to auction-based mineral allocation, amendments to the MMDR Act, and the introduction of policy instruments like the District Mineral Foundation (DMF) and National Mineral Exploration Trust (NMET). Despite these efforts and the vast geological endowment of the country, foreign direct investment (FDI) inflows into India's mining industry have remained tepid.

Exhibit 18: Trend in share of the mining sector to India's overall GVA

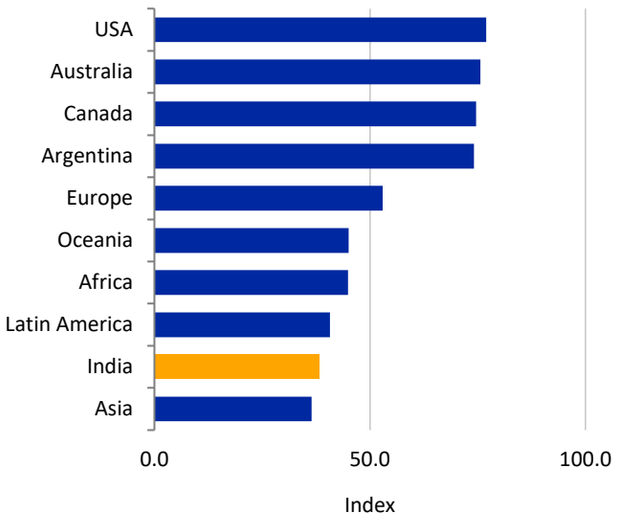


Source: MOSPI, ICRA Research

The sector's contribution to India's Gross Value Added (GVA) has been on a gradual decline. Between FY2012 and FY2018, it contributed about 3% to the overall GVA. This share dropped to around 2.3% post-FY2021, with the lowest level seen in FY2020 at just 2%, partly due to the COVID-19 pandemic's impact. Although FY2024 saw some recovery in production and sectoral growth, the contribution of mining to national output remains below potential.

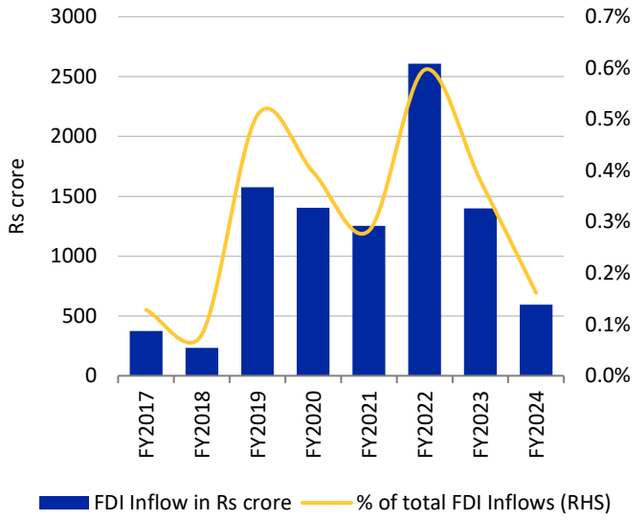
As of FY2023, India ranked 69th out of 86 countries on the Fraser Institute's Mining Investment Attractiveness Index, and a concerning 81st out of 86 on the Policy Perception Index. These rankings reflect persistent structural and regulatory impediments that deter global capital. Key concerns highlighted by global mining stakeholders include excessive regulatory complexity, legal uncertainties, overlapping jurisdictions, inconsistent policy enforcement, and delays in land acquisition and project approvals. According to the survey, 90% of the respondents cited legal risks as a barrier, while 83% pointed to inconsistent enforcement of laws, and 82% flagged issues with policy overlaps.

Exhibit 19: India's Rank in Mining Investment Attractiveness Index



Source: Fraser Institute Annual Survey of Mining Companies (FY2023), ICRA Research

Exhibit 20: Trend in FDI inflows to India's mining industry



Source: DIPP, ICRA Research

FDI data corroborates these perceptions. In FY2023, mining attracted less than 0.3% of India's total FDI inflows, highlighting the sector's low appeal to international investors compared to more open and predictable mining jurisdictions such as Australia, Canada, and Latin America. The volatility in India's mining FDI is further evident from trends over the last seven years. Although there were spikes in FDI during FY2021 and FY2022, inflows dropped sharply thereafter, reflecting waning investor confidence amidst regulatory rigidities and market risks. The mining sector's underwhelming share in India's FDI portfolio underscores its failure to convert geological potential into consistent capital attraction.

The reluctance of global investors to commit long-term capital in India's mining ecosystem stems from systemic challenges. These include prolonged permit timelines, inconsistent environmental and forest clearance norms, frequent judicial interventions, and unpredictability in fiscal regimes. Investors also cite inadequate infrastructure in mineral-rich areas, limited availability of geoscientific data, and ambiguity over revenue-sharing mechanisms as significant deterrents.

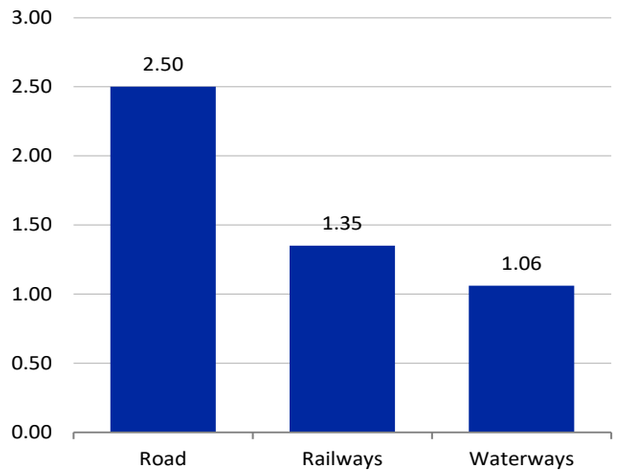
While India has made significant strides in reforming its mining governance, these have not yet translated into substantial foreign capital inflows. Without an improvement in regulatory certainty, institutional responsiveness, and policy predictability, the sector risks will remain undercapitalised despite the resource abundance. Targeted reforms aimed at enhancing the ease of doing mining business are critical for unlocking the FDI and sustaining long-term growth in the industry.

Navigating Obstacles: Key challenges in India's Mining sector

Logistics bottlenecks

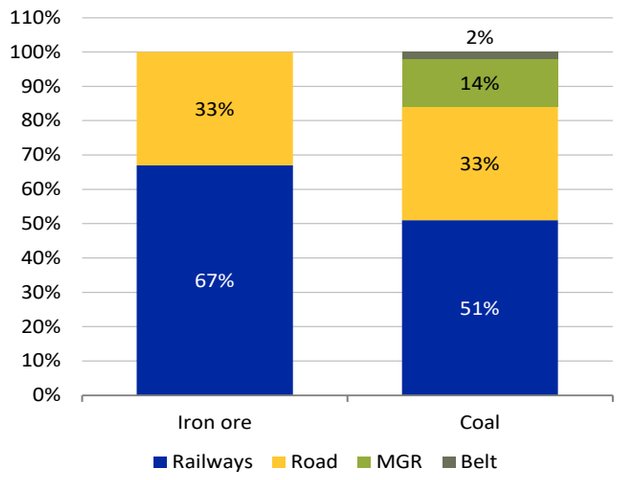
The mining sector in India continues to face deep-rooted structural challenges in its logistics and transportation ecosystem, which significantly impact cost efficiency and the competitiveness of downstream industries such as power generation, steel manufacturing, and cement production. Despite being a resource-rich country with a substantial base of bulk minerals like coal, iron ore, and bauxite, India struggles with the high cost and low efficiency of mineral evacuation, primarily due to an over-reliance on road transportation. In contrast to advanced economies such as the United States and China, which have extensively developed multimodal logistics frameworks integrating railways, inland waterways, and pipelines, India's mining logistics is predominantly road-centric.

Exhibit 21: Freight cost comparison through various modes (Rs/tonne KM)



Source: NITI Aayog; ICRA Research

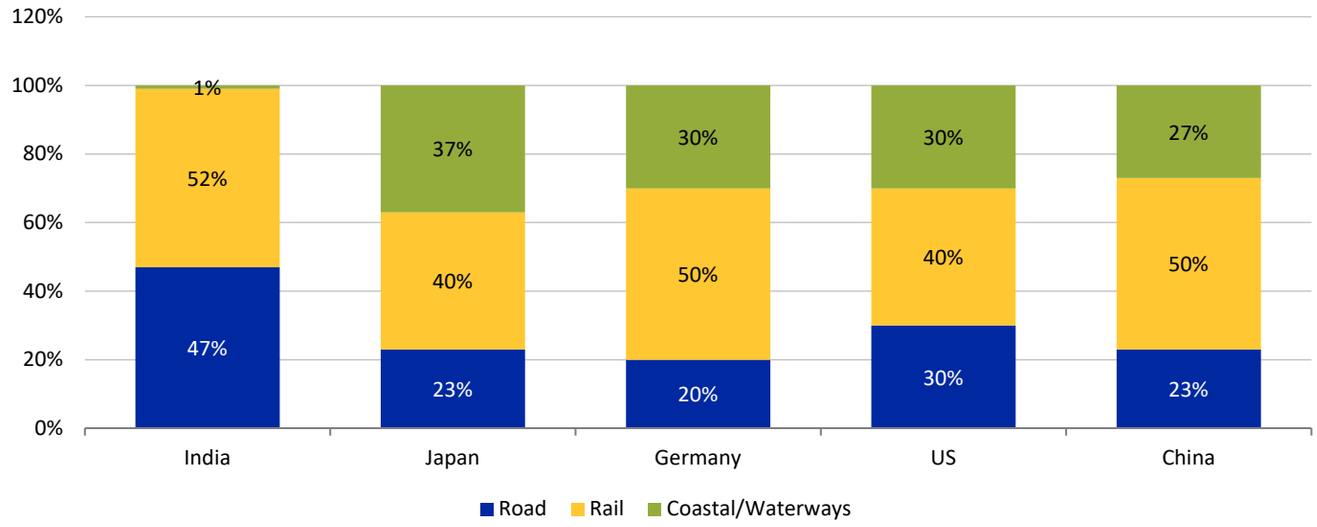
Exhibit 22: Mode of outward movement of coal and iron ore in India



Source: Ministry of Coal, Ministry of Railways, ICRA Research

Available data from NITI Aayog reveals that the cost of transporting minerals by road in India is around Rs 2.50 per tonne-kilometre, significantly higher than railways at Rs 1.35 and waterways at Rs 1.06 per tonne-kilometre. Despite this stark difference in unit costs, a large share of bulk minerals continues to be evacuated by road. In 2024, it was estimated that approximately 33% of both coal and iron ore production in India was transported by road. This excessive dependence on road freight results in higher landed costs for end-user industries, delays due to road congestion, and increased working capital requirements arising from supply chain unpredictability.

Exhibit 23: Mode of transportation for steel industry



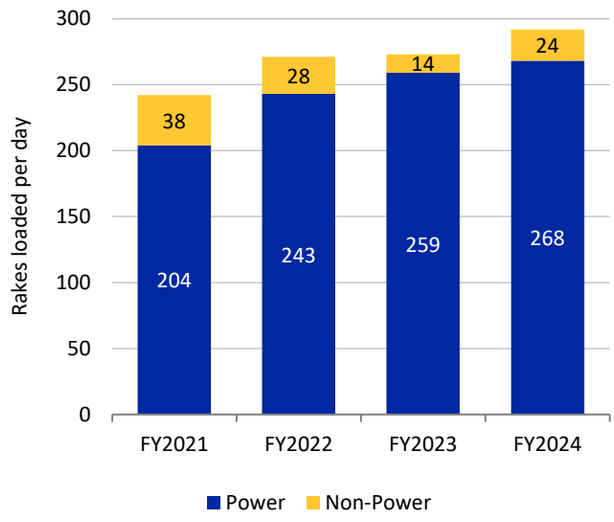
Source: Ministry of Steel, ICRA Research

This inefficiency becomes even more pronounced when benchmarked against international logistics practices, particularly in the steel industry. In India, nearly 47% of steel products are moved by road, while only 23% and 20% are transported this way in China and Germany, respectively. Developed economies have significantly invested in rail-based and coastal shipping networks, which have become the backbone of their bulk logistics systems. In countries such as Japan and Germany, railway and waterway transportation offer a cost and reliability advantage, enabling smoother industrial operations and lower input costs.

To enhance the cost competitiveness of the domestic mining and mineral industries, India must invest significantly in expanding its railway infrastructure. Shifting more bulk commodity transportation to railways could gradually reduce the dependence on costlier road transport, improve transit times, and optimise working capital cycles for industries. Additionally, investing in multimodal logistics solutions, including inland waterways, can further streamline supply chains, reduce congestion on roads, and promote a more efficient and sustainable logistics ecosystem.

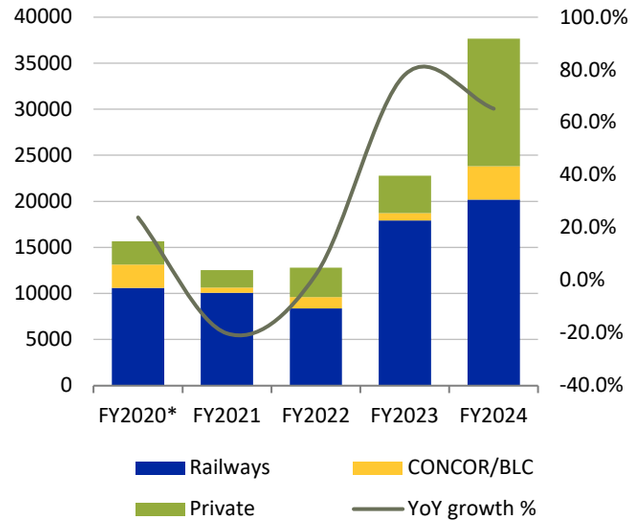
In addition, the persistent shortage of railway rakes remains one of the most critical logistical bottlenecks affecting India's mining sector, particularly during periods of peak demand such as the summer months from April to June. This bottleneck is most acutely felt by non-regulated sectors like cement, captive power, and steel, which depend on timely and predictable coal supplies. The limited allocation of rakes to these industries has resulted in chronic under-supply and frequent dispatch delays, thereby disrupting production cycles and adding to working capital pressures.

Exhibit 24: Rake availability for the coal sector



Source: Ministry of Coal, ICRA Research

Exhibit 25: Domestic production of railway wagons



*Source: Indian Railways, ICRA Research; *indicates 11M FY2020*

Data from the Ministry of Coal illustrates that the daily rake availability for non-power sectors declined sharply from 38 rakes per day in FY2021 to a low of 14–18 rakes in FY2022 and FY2023. While a partial recovery to 25 and 35 rakes was noted in FY2024 and FY2025, this level remains inadequate when compared to actual demand. For power sector customers, rake availability increased modestly from 204 in FY2021 to 280 rakes per day in FY2025. Overall, the compounded annual growth rate (CAGR) of rake availability between FY2021 and FY2024 stood at approximately 6.4 per cent, which has not kept pace with the coal sector's production growth of around 11–12 percent during the same period. This disparity underlines a widening demand-supply gap in rail-based mineral logistics, particularly affecting industries reliant on timely coal movement.

One of the key reasons behind this mismatch is the limited capacity of Indian Railways to augment its rolling stock infrastructure at the pace required to support rising mineral production. The production of railway wagons, although recovering in recent years, remains sensitive to both fiscal allocations and procurement delays. Exhibit 25 shows that wagon production increased significantly in FY2024, reaching levels above 35,000 units, supported by a rebound in private and public sector procurement. However, the momentum must be sustained consistently over the coming years to meet anticipated demand.

Exhibit 26: Estimated wagon procurement required by Indian Railways for coal traffic by 2030

	2022	2030	Additional
Rakes/day requirement for Coal Handling	465	956	491
5% Reduction in requirement due to various efficiency projects			467
Total No of Rakes assuming average Turnaround time of 3.9 Days per Rake			1821
Total No of wagons (58 wagons/Rake)			105,618

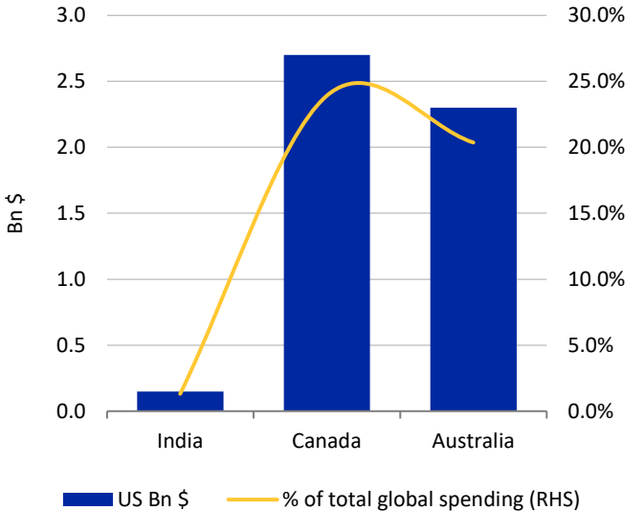
Source: Ministry of Coal, ICRA Research

Looking forward, the projected increase in coal evacuation requirements will necessitate a sharp scale-up in wagon availability. Estimates from the Ministry of Coal suggest that the daily requirement for coal handling rakes will nearly double from 465 in 2022 to 956 by 2030. Even after accounting for a 5 per cent reduction in requirement due to efficiency improvements (e.g., mechanised loading, improved turnaround), the system will still need approximately 467 additional rakes per day. Assuming an average turnaround time of 3.9 days per rake and 58 wagons per rake, the total additional requirement translates to about 105,618 wagons by 2030.

Limited investment in mineral exploration; private sector's presence negligible

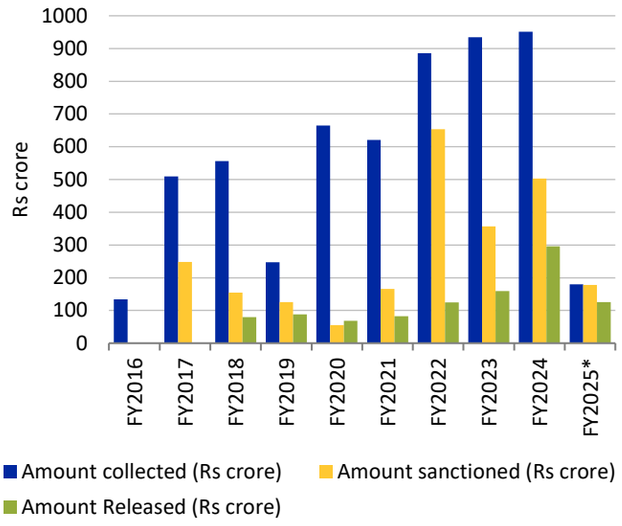
Mineral exploration serves as the foundational stage of the mining value chain and is inherently high-risk due to the substantial capital requirements, extended gestation periods, and low visibility on return. This challenge is particularly acute for deep-seated and high-value minerals such as copper, lead, zinc, gold, and diamonds, where exploration activities must penetrate deeper geological formations with considerable technical and financial complexity. In India, however, investment in this segment remains severely underdeveloped, limiting the country's ability to fully leverage its mineral endowment and reduce import dependence.

Exhibit 27: Exploration spending (US Bn$) and share of total expenditure



Source: Industry reports; ICRA Research

Exhibit 28: NMET's collection and amount released (Rs crore)

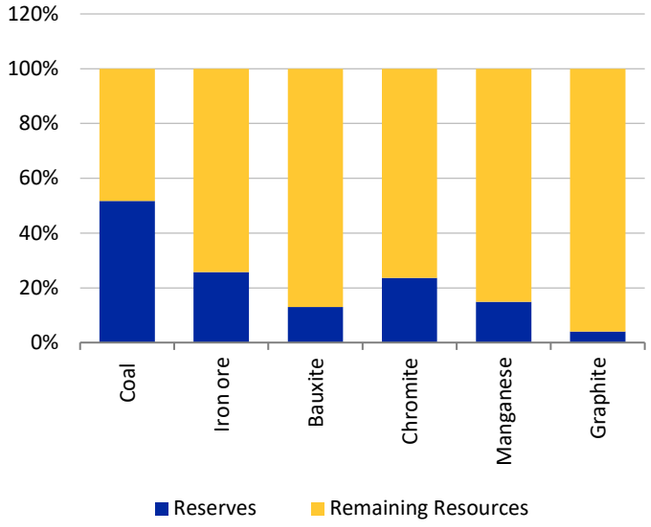


Source: Ministry of Mines, ICRA Research

India's share in global mineral exploration expenditure is a mere 1.3%, a stark contrast to exploration leaders such as Canada and Australia, which account for approximately 24% and 20% of global exploration spending, respectively. This disparity reflects a broader systemic underinvestment in exploration activities, stemming from a combination of regulatory uncertainty, lack of venture capital, and limited institutional frameworks that support risk-taking in early-stage mining ventures. India's mineral-rich potential, particularly in under-explored regions, remains largely untapped as a result of this exploration deficit.

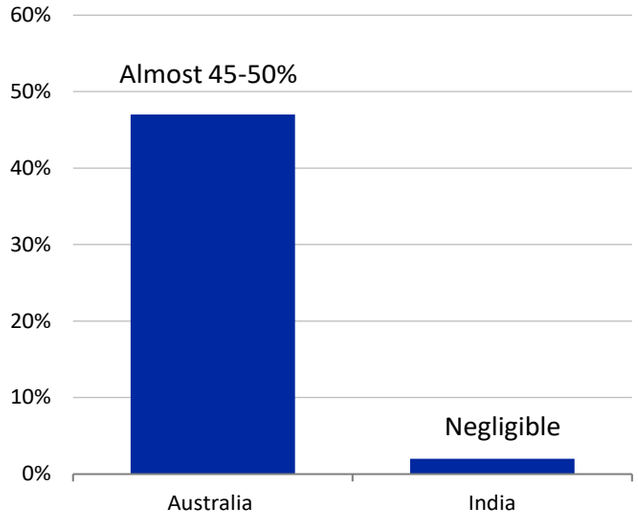
Compounding the problem is the inefficiency in utilisation of dedicated exploration funds such as the National Mineral Exploration Trust (NMET), which was established in 2015 with the objective of boosting mineral discovery through systematic survey and mapping. While NMET collections have risen consistently over the years, crossing Rs 7,000 crore in cumulative terms, the actual amount released or sanctioned for exploration work has been disproportionately low. This imbalance between collection and fund disbursal highlights issues in project identification, procedural delays, and bureaucratic bottlenecks that have prevented these funds from translating into actionable exploration on the ground.

Exhibit 29: Reserve to resources % for major minerals in India



Source: Ministry of Mines, ICRA Research

Exhibit 30: Exploration spending % by junior mining companies in India



Source: Ministry of Mines, ICRA Research

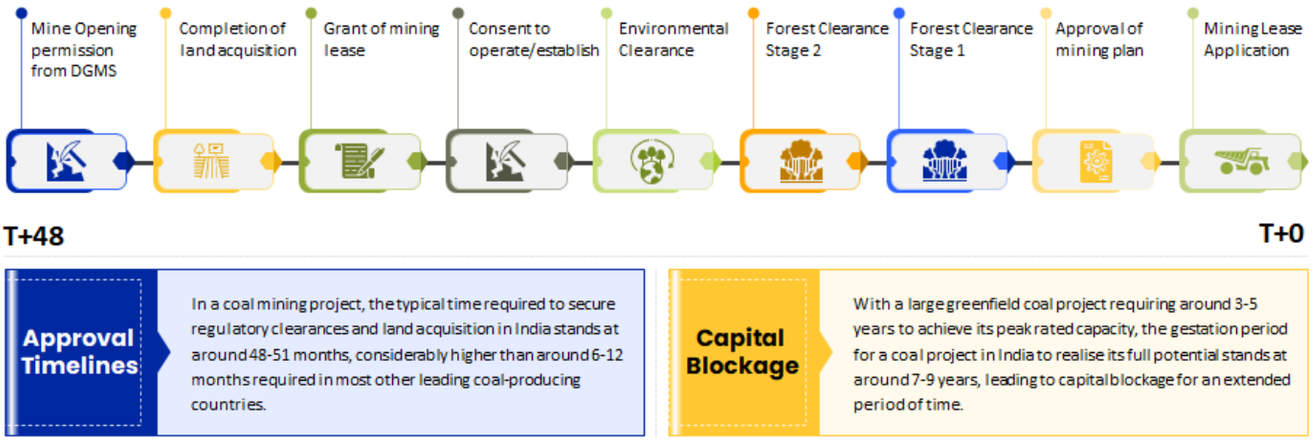
Another consequence of limited exploration investment is reflected in the resource-to-reserve conversion ratio across major minerals. According to data from the Ministry of Mines, for minerals like bauxite, manganese, chromite, and graphite, a significant share—often exceeding 80%—of total identified geological resources remain unclassified as proved reserves. This low conversion rate impedes commercial viability assessments, delays mining lease auctions, and constrains future production planning. Simply put, without the expansion of the reserve base through deeper and more widespread exploration, India's mining sector cannot build a reliable long-term production pipeline.

The problem is further compounded by the lack of meaningful private sector participation. Unlike global mining hubs such as Canada, Australia, and the United States, where junior mining companies play a crucial role in undertaking greenfield exploration, India's exploration landscape is overwhelmingly dominated by Government agencies. The Geological Survey of India (GSI), Mineral Exploration Corporation Limited (MECL), the Central Mine Planning and Design Institute (CMPDI), and state-level Departments of Geology and Mines are the primary actors, leaving very limited space for private players to innovate, experiment, or bring in modern exploration techniques. As reflected in the data, junior mining companies account for nearly 45–50% of exploration spending in countries like Australia, whereas their contribution is negligible in India.

Slow regulatory approvals

The mining industry in India continues to grapple with prolonged and complex regulatory approval timelines, which have emerged as one of the most formidable barriers to investment, particularly in greenfield coal and mineral projects. While policy-level reforms have aimed to improve the ease of doing business, the ground reality remains challenging. The process of securing approvals and clearances—ranging from reconnaissance permits and mining leases to land acquisition and environmental and forest clearances—is lengthy and cumbersome, involving multiple agencies and often resulting in significant project delays.

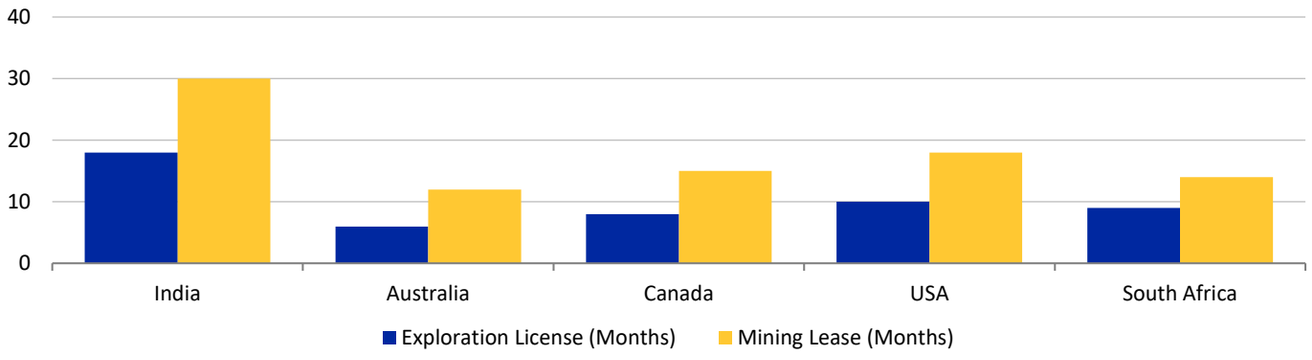
Exhibit 31: Stages of regulatory approvals before the start of the coal mining operations in India



Source: Discussion paper on Auction of Coal Mines For Sale of Coal, Ministry of Coal, ICRA Research

For coal mining projects in particular, data from the Ministry of Coal indicates that it typically takes around 48 to 51 months to secure all necessary regulatory clearances and complete land acquisition in India. This stands in stark contrast to leading mineral-producing jurisdictions such as Canada, Australia, and the United States, where similar approvals can be secured within a span of 6 to 12 months. For example, in Canada, most provinces and territories grant mining permits within six months, while in parts of the United States and Australia, the timeline is generally between 6 to 8 months. Sweden and other Nordic countries also exhibit a more investor-friendly timeline of under six months. These comparisons starkly highlight the extent of procedural delays faced by investors in India.

Exhibit 32: Comparative timelines for grant of approvals



Source: Fraser Institute Annual Survey of Mining Companies (2023); Ministry of Coal, Government of India; ICRA Research

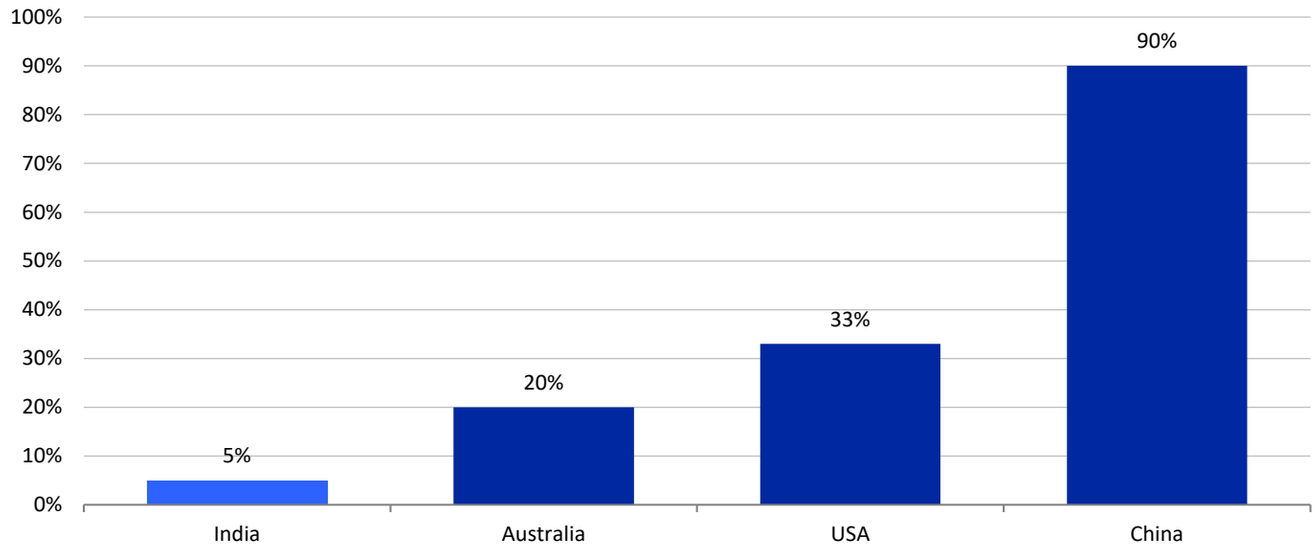
The extended approval timelines in India are further exacerbated for projects that intersect sensitive ecological zones, forested areas, or densely populated regions, or those that require alignment with overlapping infrastructure such as railway lines, highways, or transmission corridors. In such cases, the timeline to obtain clearances and commence operations can extend even further, leading to prolonged project gestation. For a typical large-scale greenfield coal mining project, the time taken to reach peak rated capacity in India is around 7 to 9 years, compared to 3 to 5 years in benchmark geographies.

To attract long-term investment and reduce the capital blockage risk, it is imperative for India to streamline its regulatory framework. The adoption of single-window clearance mechanisms with time-bound approvals, digitisation of licensing processes, and integration of state and Central regulatory systems could help eliminate redundant procedures

Sub optimal investment in technology

India's mining industry has made notable progress in extracting surface minerals such as iron ore, dolomite, and bauxite. However, the sector continues to underperform in the exploitation of deep-seated mineral resources that demand technologically advanced extraction techniques. This underutilisation of modern mining technology is particularly evident in the case of coal, where India has overwhelmingly favoured open-cast (OC) mining methods over underground (UG) operations, due to lower capital costs and faster commissioning timelines. As a result, underground mining accounts for a mere 5% of India's total coal output, a stark contrast to major coal-producing economies such as China (90%), the United States (33%), and Australia (20%), where underground extraction is significantly more common.

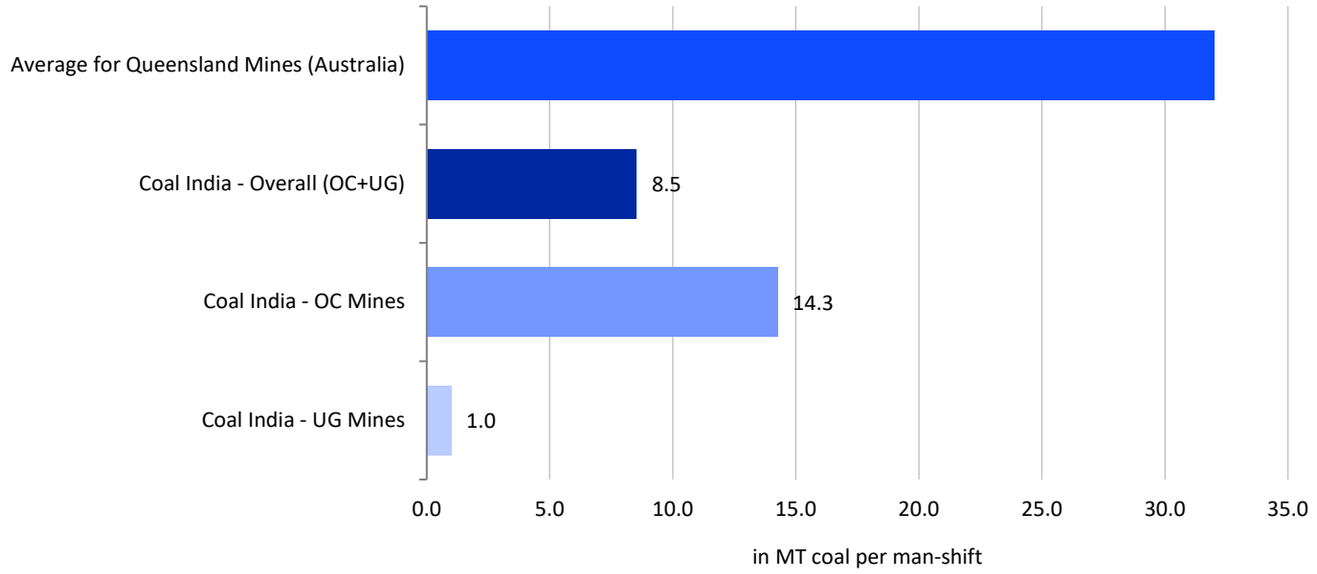
Exhibit 33: Share of production from underground coal mines



Source: Coal India, Planning Commission Twelfth Five Year Plan (2012–2017), ICRA Research

The low adoption of underground mining techniques in India can be attributed to several interlinked factors, including high upfront investment requirements, insufficient indigenous technological capabilities, and inadequate access to automated and mechanised mining systems. Technologies such as longwall mining, continuous miners, high-capacity surface miners, and real-time geospatial mapping tools have seen only limited deployment across Indian mines. In contrast, these technologies are well established in developed mining economies, which leverage them to boost safety, efficiency, and labour productivity.

Exhibit 34: Output per man shift (in tonnes) for Coal India and Australian miners



Source: Coal India, ICRA Research; OC: Opencast; UG: Underground

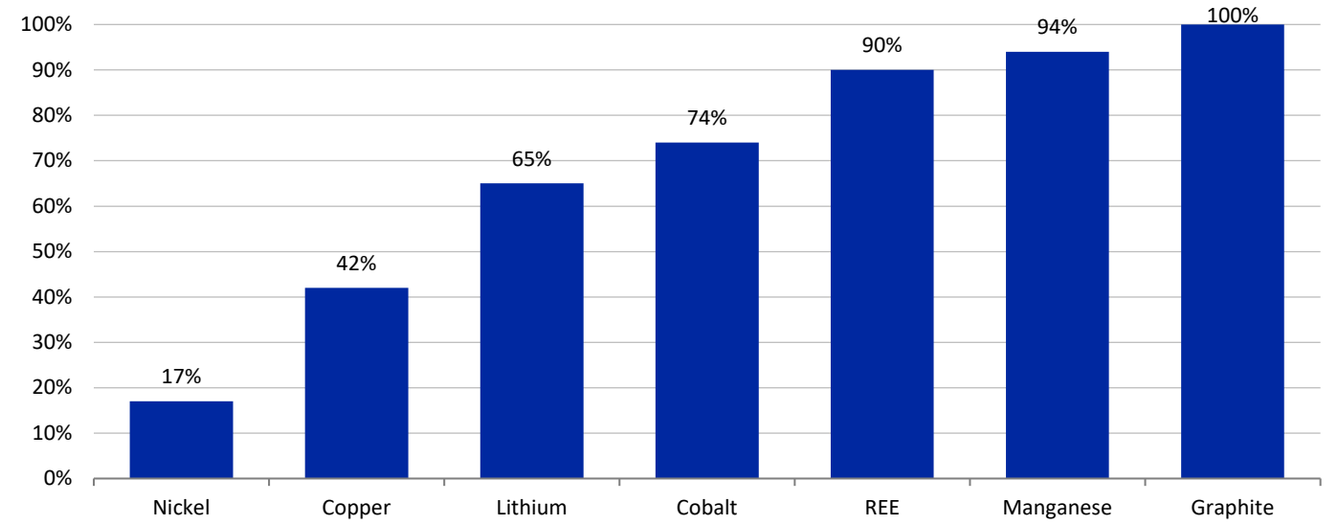
Exhibit 34 provides further insight into the productivity gap driven by technological disparity. Output per man-shift in Australia's Queensland coal mines is nearly four times higher than that of Coal India, reflecting the impact of automation, advanced equipment, and digital integration in mining operations. Within India, while open-cast mines achieve moderate output of about 14.3 tonnes per man-shift, underground mines lag significantly at around 1 tonne per man-shift—highlighting the severe underperformance of this segment and its inability to scale without urgent technological intervention.

In summary, sub-optimal investment in mining technology is a major structural barrier that curtails India's ability to deepen mineral exploration, improve recovery rates, and build globally competitive, sustainable mining operations. Reversing this trend will require concerted policy support for technology adoption and public-private partnerships to indigenise equipment manufacturing and training.

Geopolitical realignments and their implications for global mining policies

The global mining landscape is undergoing a structural transformation, driven by increasing geopolitical fragmentation and a push toward resource nationalism. The year 2023 marked a significant escalation in the impact of global conflicts and political realignments on mineral supply chains. The ongoing war in Ukraine, combined with growing strategic tensions between China and the western economies, has disrupted traditional trade relationships and exposed vulnerabilities in mineral procurement systems. These developments have led to an accelerated shift toward self-reliance among nations, with governments revisiting their mineral security strategies and prioritising domestic resource development.

Exhibit 35: Share of China in processing of critical minerals refining/processing



Source: IEA, Giani Metals, ICRA Research; REE – Rare Earth Elements

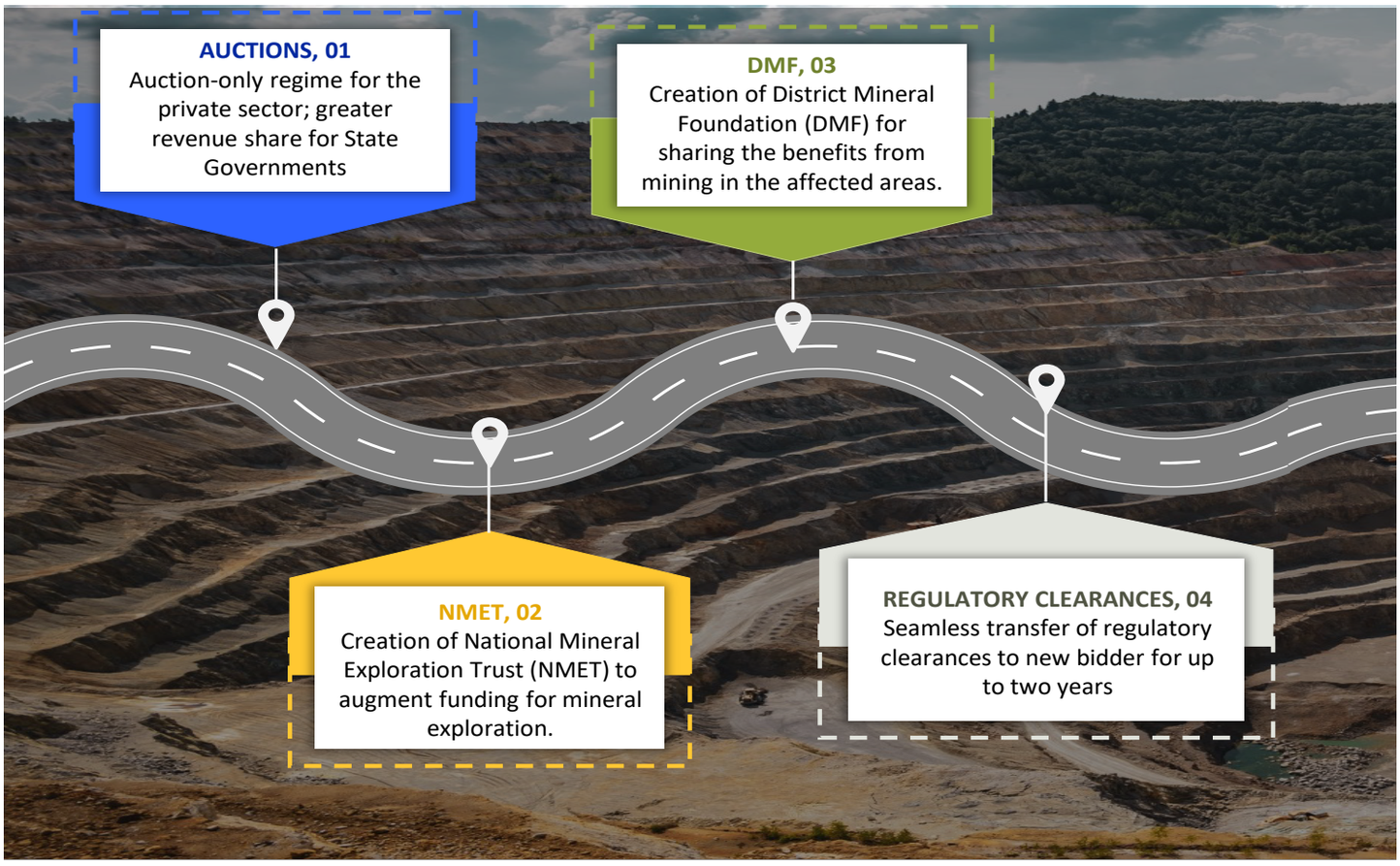
A key concern emerging from this shift is the growing dominance of China in the refining and processing of critical minerals essential for the global energy transition. China currently controls a disproportionately high share of global processing capacity—up to 90% or more for minerals such as rare earths, graphite, and manganese. This concentration of market power raises alarm over supply security for economies dependent on clean energy technologies, which are highly reliant on a steady flow of processed critical minerals.

The broader implication of this realignment is a fundamental shift in global mining policy—from efficiency-driven globalisation to risk-mitigated regionalism. Countries are now placing greater emphasis on safeguarding their mineral value chains through incentive-led investments, tighter export controls, and the establishment of domestic refining infrastructure. This trend is expected to intensify in the coming decades, as nations race to secure critical inputs for green technologies, including electric vehicles, battery storage, and renewable power systems.

Key policy shifts: Strategic reforms in India's Mining Landscape

In the past few years, the GoI has implemented multiple reforms for bringing in greater transparency, improving the ease of doing business, and enhancing the investment attractiveness for the domestic mining sector, while at the same time creating a mechanism for greater sharing of the benefits of mining activities with the respective state governments and the mining-affected areas. The Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) is the cornerstone of India's mining regulatory framework, governing the exploration, mining, and management of minerals other than petroleum and atomic minerals. Over the years, the Act has undergone several amendments aimed at improving transparency, increasing investments, and boosting efficiency in the mining sector. Below is a chronological overview of the key changes to the MMDR Act and their impact on the Indian mining industry.

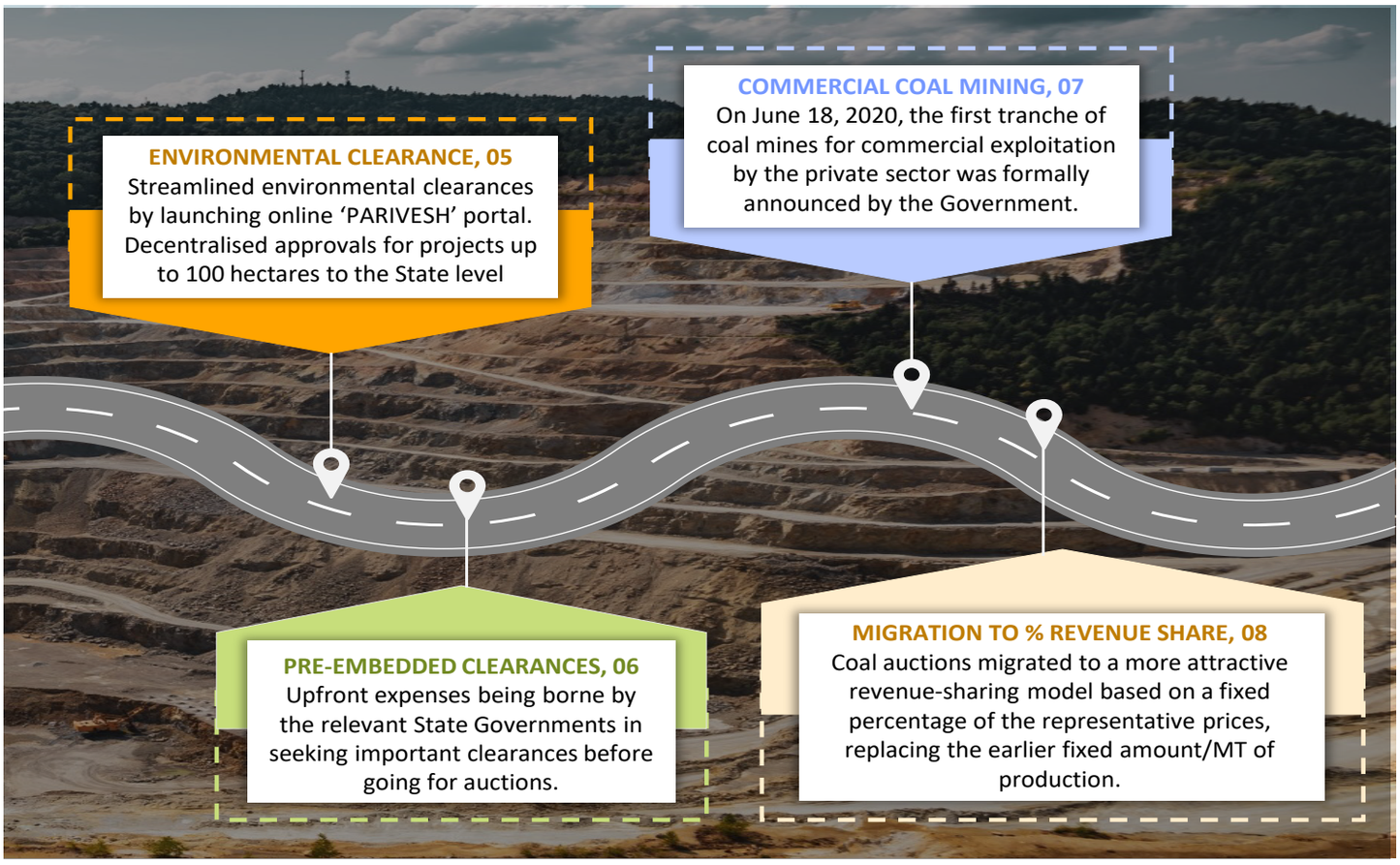
Exhibit 36: Key policy changes implemented in the mining sector since January 2015



Source: Ministry of Mines; MMDR Acts; ICRA Research

Migration to the auction-only route: In response to the Supreme Court's cancellation of 204 coal blocks in October 2014, the Government of India amended the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) on January 12, 2015. This amendment replaced the previous discretionary system of granting mining leases with a transparent auction-only approach for awarding mineral concessions to private entities. The shift to auctions not only enhanced transparency but also increased revenue-sharing with state governments. Since this policy adoption, India has auctioned 425 non-coal mineral blocks (such as iron ore, chromite, limestone, bauxite, and gold) and 163 coal blocks.

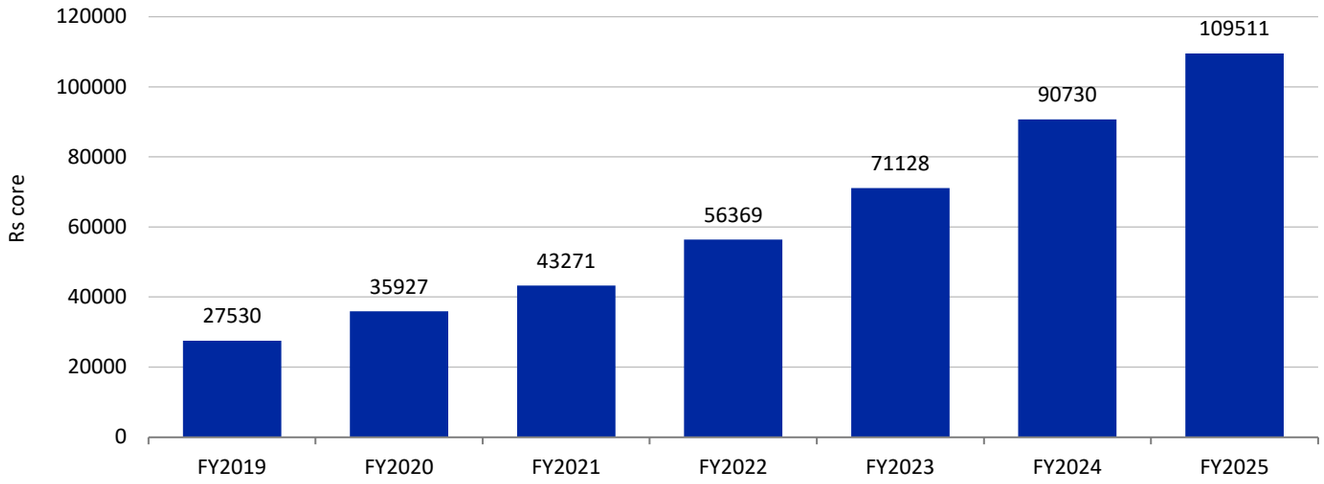
Increased funding and entry of private sector players in mineral exploration: The Mines and Minerals (Development and Regulation) Amendment Act, 2015 introduced a levy of 2% of mining royalties to fund the National Mineral Exploration Trust (NMET), aiming to boost investments in India's underfunded mineral exploration sector. The NMET was established to accelerate both regional and detailed exploration activities. In March 2021, the Government further liberalised exploration by removing the need for non-exclusive reconnaissance permits and allowing select private companies to conduct prospecting activities. These companies can also access the NMET funds to support their exploration efforts. So far, 14 accredited private exploration firms have been notified. Between FY2018 and FY2023, the NMET collections averaged Rs 635 crore annually, providing critical resources to advance exploration, which is essential for developing a robust mining ecosystem.



Creation of the District Mineral Foundation (DMF) for mining-affected areas: The District Mineral Foundation (DMF), established under the 2015 Mines and Minerals Amendment Act, aims to share mining revenues with communities impacted by mining operations. Mining companies contribute 30% of royalties for older leases and 10% for newer ones, creating a substantial fund to improve healthcare, education, infrastructure, and livelihoods in mining regions.

DMF projects focus on building hospitals, schools, water facilities, and supporting skill development to promote economic resilience. Governance is led by district authorities with local representation to ensure that the funds meet community needs. Despite improvements in states like Odisha and Jharkhand, issues such as fund underutilisation and delays persist. Strengthening transparency, community involvement, and leveraging technology for monitoring can enhance DMF's impact, driving sustainable development in mining areas.

Exhibit 37: Trend in cumulative DMF collections (Rs crore)



Source: Ministry of mines; ICRA Research

Seamless transfer of clearances: The MMDR Act 2015 led to the expiry of several merchant mining leases on March 31, 2020. To address delays in obtaining fresh approvals by new bidders, the Government amended the Act in January 2020, allowing existing clearances to be transferred to the new lessee for a period of two years, providing a buffer to secure renewed approvals. However, due to persistent delays in this process, a further amendment was introduced on March 28, 2021, removing the two-year limit. This change ensured that statutory clearances could be seamlessly transferred to new lessees and remained valid for the entire lease term. This policy shift has enhanced certainty in the auction process, improved price discovery, and ensured a stable supply of raw materials for downstream industries.

Transitioning to a more balanced risk-reward framework on revenue-sharing with the states in mine auctions: Initially, coal mine auctions followed a revenue-sharing model where states received a fixed amount per metric tonne of production. This structure favoured state revenues, even during market downturns when falling prices squeezed miners' profit margins, thereby discouraging investor interest. To address this, in May 2020, the Government adopted a more balanced approach, linking revenue-sharing to a fixed percentage of representative prices. This change ensures that states share in both the upside and downside risks, aligning incentives and encouraging greater participation by investors, even during industry downturns.

Opening up the coal sector for commercial mining by private companies: India's coal sector was nationalised in 1973, but a shift toward privatisation began with the Coal Mines (Special Provisions) Ordinance, 2014, allowing for future commercial mining by private players. Despite this, end-use restrictions persisted for another five years, limiting private sector participation. Initial enthusiasm for captive coal block auctions faded due to unsustainable premiums, leading to a drop in interest by FY2018-FY2019.

To revive private investment, the Government introduced reforms between 2019 and 2020, such as allowing 25% open market sales from captive mines, enabling 100% FDI via the automatic route, and lifting end-use restrictions for certain mines. The sector was fully opened on June 18, 2020, with the announcement of the first tranche of coal blocks for commercial mining by private firms.

Removal of end-use restriction and distinction between captive and non-captive mines in auctions: On March 28, 2021, the GoI brought in amendments to the MMDR Act for removing the 'end-use' restrictions while auctioning minerals. Additionally, captive mines (other than atomic minerals), that had been already auctioned before March 28, 2021, were henceforth allowed to sell up to 50% of their annual production as merchant sales, subject to additional revenue share with the state government. This move to remove the end-use restrictions was intended to not only support better price discovery in future auctions, but also to incentivise mining companies, increase the domestic mineral availability to the end-use sectors, and reduce import dependence.

Streamlining processes for seeking environmental clearance: To promote transparency and real-time monitoring, the Ministry of Environment, Forest and Climate Change (MoEFCC) digitised the process of environmental clearance (EC) application through the online 'PARIVESH' web portal. Moreover, for a further de-bottlenecking of the decision-making for granting ECs, the MoEFCC, the procedure for the EC has been decentralised to the state level for lease areas measuring less than 100 hectares (increased from 50 hectares earlier). In addition, to fast-tracking EC approvals, in April 2015, the MoEFCC standardised the Term of Reference (ToR) and EC conditions, helping project sponsors simultaneously start preparing Environmental Impact Assessment Reports and Environmental Management Plans, even before applying for the ToR. At present, close to 20 major approvals are required before operationalising a coal mine.

Pre-embedded clearances in mineral auctions: To increase the ease of doing business in the mining sector, the Ministry of Mines issued guidelines on June 3, 2020, for the auction of mineral blocks with pre-embedded clearances. Though this would entail upfront expenses being borne by the relevant state governments in seeking important clearances before going for auctions, the mechanism can potentially lead to better price discovery, aided by greater policy clarity and reduced project gestation period. Such pre-embedded clearances would include: a) Approval of a mining plan by the Indian Bureau of Mines (IBM), with the winning bidder having the flexibility to enhance/reduce the mine capacity by 25%, b) Stage-1 forest clearance and EC from the MoEFCC, and c) Securing land acquisition for both Government and private land. The cost borne by the state government in getting these clearances would be recouped from the winning bidder.

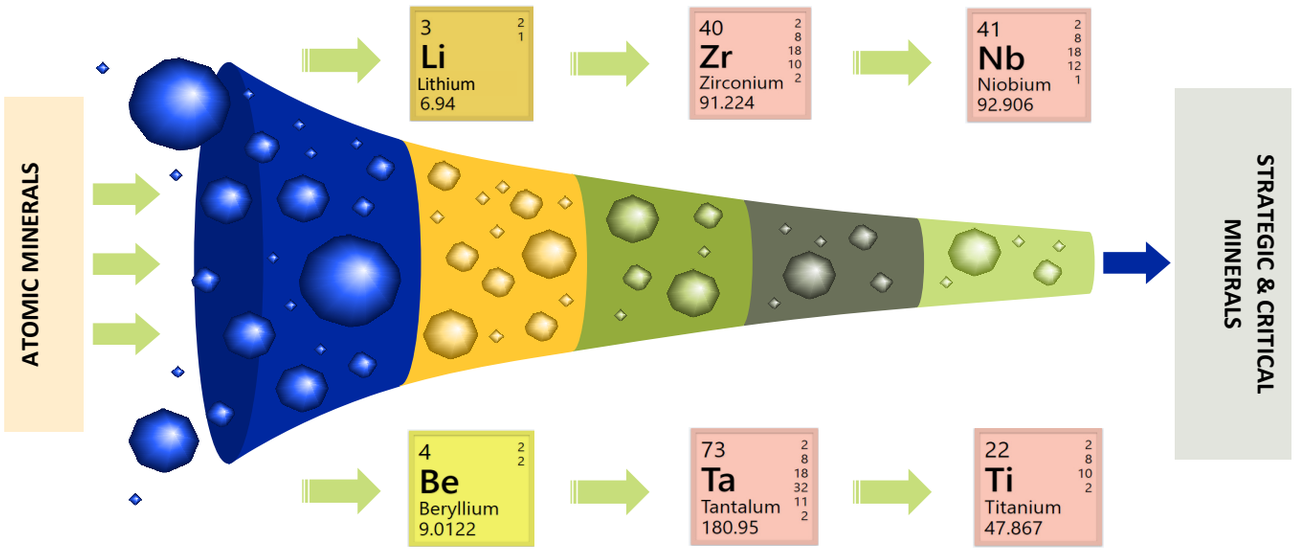
Exhibit 38: Impact of the MMDR Amendment Act 2021

Source: MMDR Amendment Act 2021, ICRA Research

The Mines and Minerals (Development and Regulation) Amendment Act, 2023 amended the Mines and Minerals (Development and Regulation) Act, 1957, with the aim of strengthening the exploration and extraction of critical minerals.

Regulatory change - Liberating lithium for private exploration

Exhibit 39: Reclassification of 6 atomic minerals to strategic & critical minerals as per MMDR Amendment Act, 2023

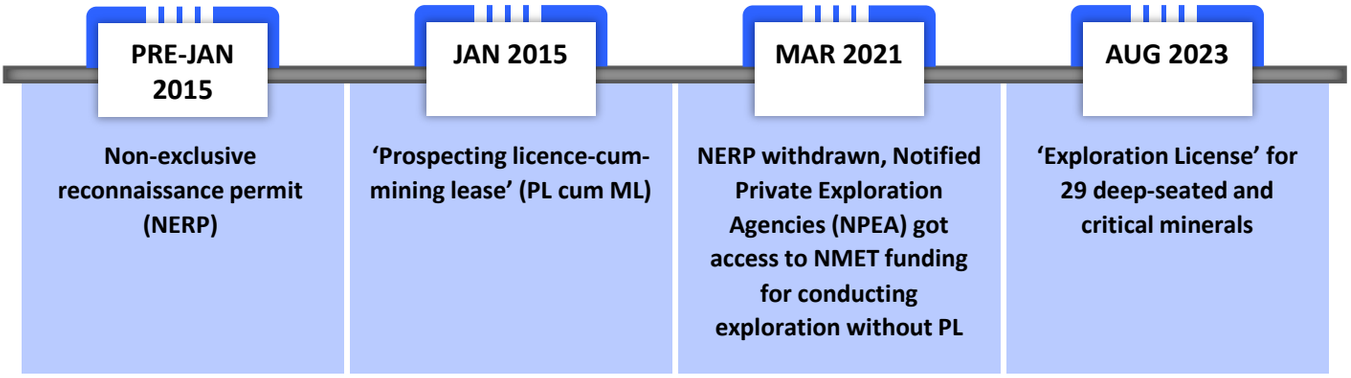


Source: ICRA Research

Lithium was previously classified as an atomic mineral due to its role as a primary source of tritium in thermonuclear reactions and its use in cooling systems of nuclear power plants. Under The Atomic Minerals Concession Rules, 2016, any lithium-bearing orebody with concentrations exceeding 5,000 parts per million (ppm) in hard rock/clay deposits, and 200 ppm in brine deposits, could only be mined by Government companies. Deposits with lower concentrations of lithium were available for private sector mining.

However, with the amendment to the MMDR Act in August 2023, lithium, along with five other minerals (including zirconium), was reclassified from an Atomic Mineral to a Critical & Strategic Mineral. This change opened the exploration and mining of lithium, across all ore grades, to private sector participation, significantly broadening the scope for exploration and development in the critical minerals space.

Exhibit 40: Transition of mineral exploration regime in India



Source: ICRA Research

Even though 100% FDI is allowed in the mining sector through the automatic route, India's earlier non-exclusive reconnaissance permit and PL-cum-ML regimes failed to attract global mining majors to the country. Subsequently, in March 2021, even as privately-owned Notified Private Exploration Agencies were allowed to undertake exploration without a PL and get access to funding from the National Mineral Exploration Trust (NMET), global mining majors/junior mining companies remained on the sidelines.

To fast track the production of critical & deep-seated minerals, the Mines and Minerals (Development and Regulation) Act was amended in August 2023 to empower the Central Government to conduct such auctions. Moreover, to enable a more attractive risk-return sharing for explored blocks, the Government introduced the auction of 'Exploration Licence' for 29 deep-seated and critical minerals, which would permit the licensee to undertake reconnaissance and prospecting activities. The preferred bidder for exploration licence would be selected through a reverse bidding process for a share of the auction premium paid by the mining lease holder. The bidder quoting the lowest percentage bid was likely to be the preferred one for exploration licence. This gives a higher upside to the exploration agency against the erstwhile NPEA regime.

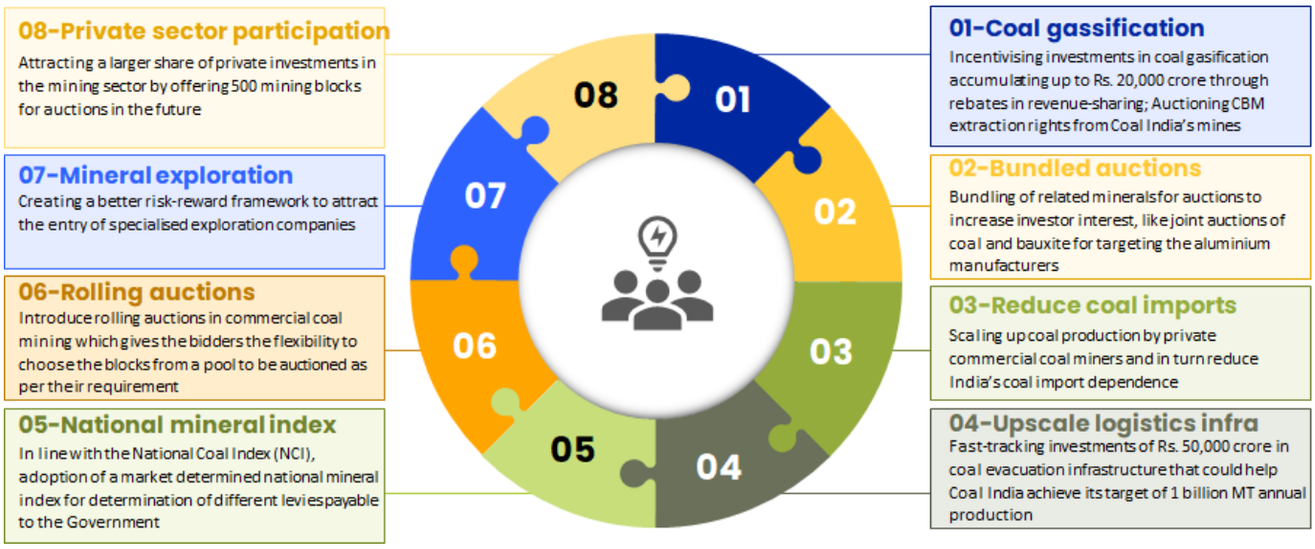
In March 2024, Karnataka (for gold, copper & lithium) and Rajasthan (for rare earths and potash) became the first states to launch 'Exploration Licences' in the country. Andhra Pradesh, Chhattisgarh, Madhya Pradesh, and Maharashtra are in line to launch the 'Exploration Licences'.

To encourage private exploration of critical and strategic minerals, the Ministry of Mines introduced a scheme offering partial reimbursement of exploration costs to licence holders. The Scheme for Partial Reimbursement of Exploration Expenses for Holders of Exploration Licenses (EL), launched on June 24, provides a 50% reimbursement on exploration expenses, with a maximum limit of Rs 20 crore.

Reforms under Atmanirbhar Bharat

On May 16, 2020, the GoI made a list of announcements under the Atmanirbhar Bharat scheme for enhancing investments in the mining sector and bringing in structural reforms. The focus of the scheme was to improve the ease of doing business, increase employment, reduce import dependence for minerals, and simultaneously establish India as an export hub for various commodities. The key focus areas of the scheme are highlighted in the exhibit below:

Exhibit 41: Key areas of the Atmanirbhar Bharat scheme for the mining sector



Source: Atmanirbhar Bharat presentation dated May 16, 2020, ICRA Research

Key takeaways from the Atmanirbhar Bharat scheme for the mining sector:

- Ramping up domestic coal production by private commercial miners and in turn reducing India's coal import dependence
- Establishing India as a major player in seaborne coal trade, incentivising investments in coal gasification accumulating up to Rs. 20,000 crore by CY2030 through rebates in revenue-sharing
- Auctioning coal-bed-methane (CBM) extraction rights from Coal India's mines
- Fast-tracking investments of Rs. 50,000 crore in coal evacuation infrastructure that could help Coal India achieve its aspirational target of 1 billion MT production
- Bundling of related minerals for auctions to increase investor interest, like joint auctions of coal and bauxite for targeting the aluminium manufacturers
- Attracting a larger share of private investments in the mining sector by offering 500 mining blocks for auctions in the future

Emerging trends shaping the future of mining

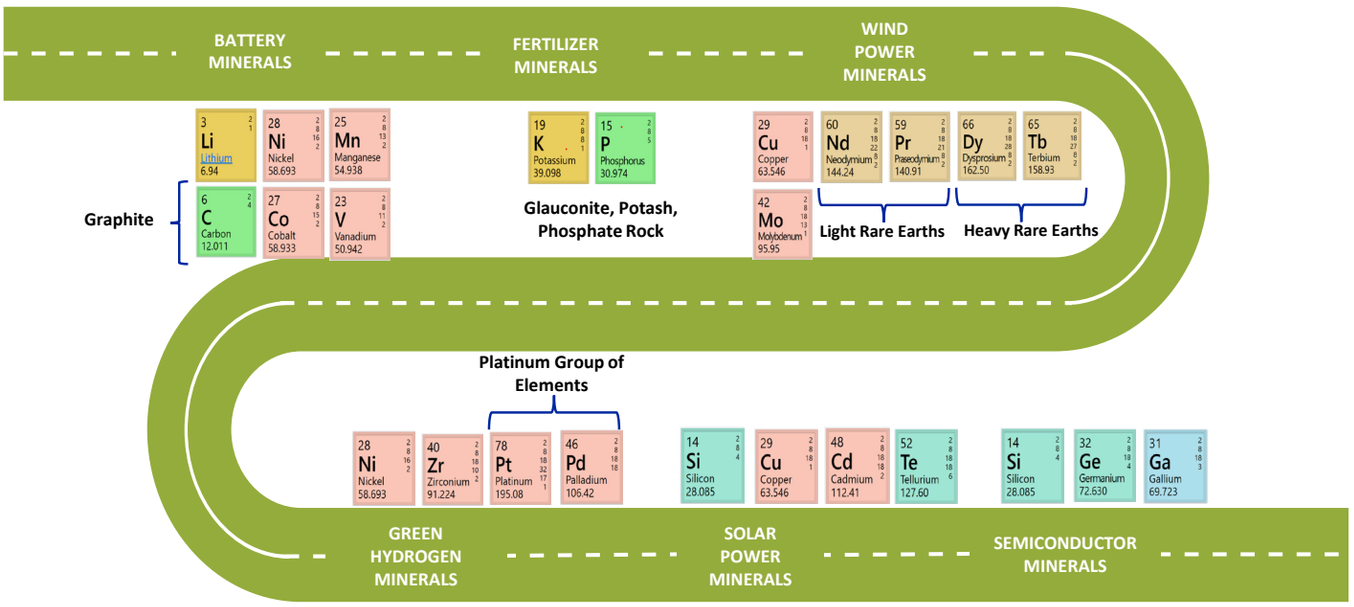
Mapping the key critical minerals behind breakthrough technologies

As the world moves toward decarbonisation, certain critical minerals have emerged as indispensable due to their unique properties that are crucial for enhancing efficiency, performance, and sustainability. **Lithium, cobalt, and nickel** stand out as the core materials behind battery technologies, particularly in electric vehicles (EVs) and energy storage systems.

Rare earth elements (REEs), including neodymium, praseodymium, dysprosium, and terbium, are essential for manufacturing permanent magnets, which are key components in electric motors, wind turbines, and other clean energy technologies. **Copper** is another critical mineral that underpins virtually all green technologies. Its superior electrical conductivity makes it indispensable for the wiring and circuitry in renewable energy installations such as solar panels and wind turbines. In addition to these well-known critical minerals, the **platinum group metals (PGMs)**—including platinum, palladium, and rhodium—play a primary role in hydrogen fuel cell technology.

As these breakthrough technologies continue to evolve, the demand for critical minerals will intensify, requiring a strategic approach to resource mapping and management. The interdependence between critical minerals and technology development makes it clear that sustainable access to these materials will be the linchpin of a successful global energy transition.

Exhibit 42: List of important minerals that are critical for India's mineral security and net-zero transition

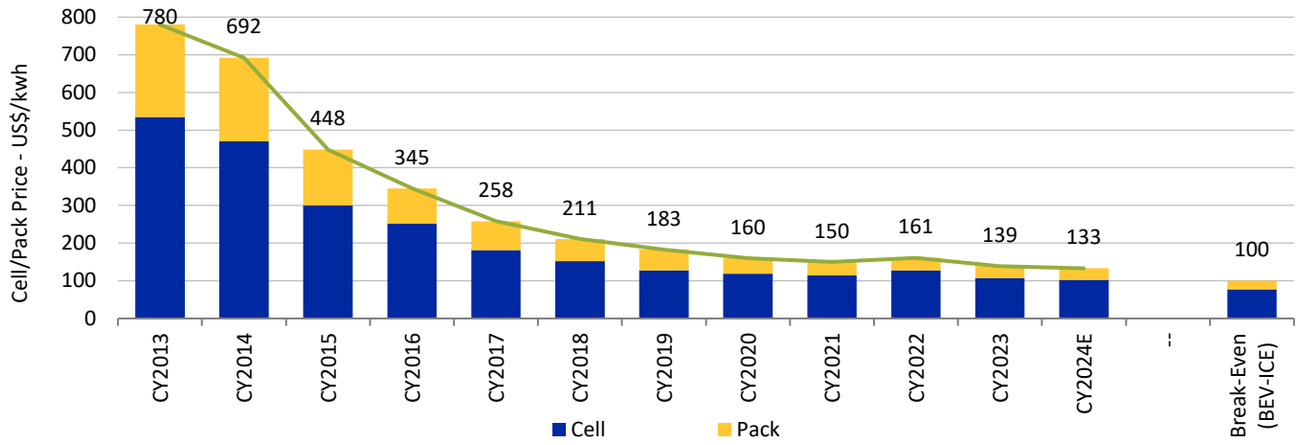


Source: ICRA Research

The Inflection Point: Demand for critical minerals to surge, going forward

Technological advancements and economies of scale have played a pivotal role in driving down the costs of green energy technologies. Over the past decade, the cost of lithium-ion batteries (LIBs) plummeted by more than 80%, decreasing from $780/kWh in 2013 to an estimated $133/kWh by 2024. This remarkable cost reduction, led predominantly by China's dominant role in battery manufacturing and supply chain optimisation, has been a critical factor in the rapid global adoption of renewable energy sources and electric vehicles (EVs).

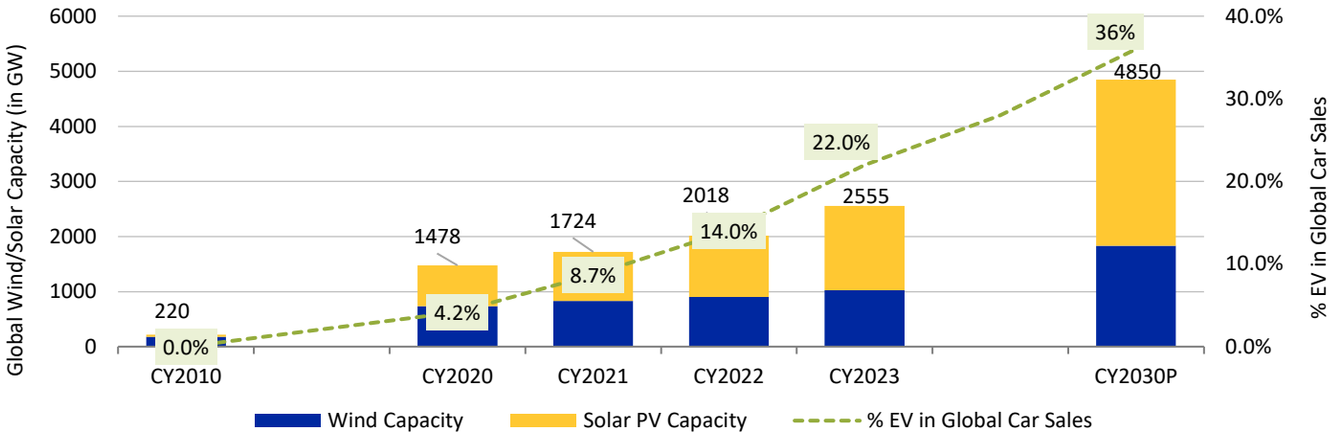
Exhibit 43: Trend in prices of lithium ion batteries



Source: Bloomberg New Energy Finance, ICRA Research; $100/kwh LIB price is widely considered the sweet spot when EVs are expected to reach cost-parity with ICE vehicles

The scale of this transformation is evident in the latest forecasts by the International Energy Agency (IEA), which projects that by 2030, the global installed capacity for renewable energy (including wind and solar) will reach 2.4 times its 2022 levels. Simultaneously, EV penetration in the global automotive market has grown significantly, reaching a market share of 14% in 2022, with further expansion projected to 36% by 2030.

Exhibit 44: Trend in adoption of renewable energy and EVs (IEA forecasts)

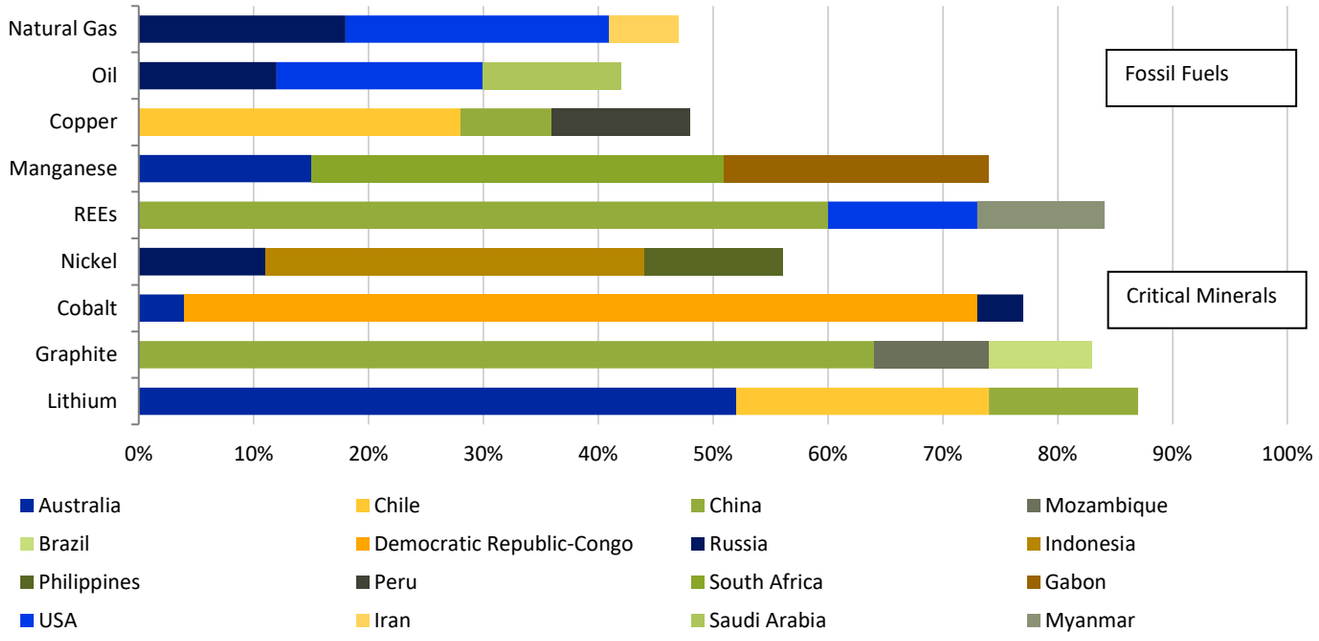


Source: IEA, ICRA Research

This shift towards green technologies is creating an unprecedented demand surge for critical minerals. As the energy transition accelerates, key minerals such as lithium, cobalt, nickel, copper, and rare earth elements will see a sharp increase in consumption, driven by their essential roles in battery production, renewable energy infrastructure, and other low-carbon technologies. Estimates suggest that demand for some of these critical minerals could multiply several times over the current levels, placing immense pressure on supply chains and amplifying the strategic importance of securing reliable, diversified sources of these materials.

However, the production of key energy transition minerals exhibits a higher level of concentration compared to oil and natural gas. For lithium, cobalt, and rare earth elements, more than three-quarters of the global output is controlled by the top three producing nations, with some minerals seeing a single country contributing nearly half of the global supply. In 2019, the Democratic Republic of the Congo (DRC) accounted for approximately 70% of global cobalt production, while China was responsible for 60% of the rare earth element output.

Exhibit 45: Share of top producing countries in extraction of selected minerals and fossil fuels, 2019



Source: IEA, ICRA Research

The high degree of concentration, coupled with complex and interdependent supply chains, heightens the risk of disruptions due to geopolitical tensions, trade restrictions, or regulatory changes in major producing regions. As the global energy transition accelerates, securing diversified and resilient supply chains will be critical in mitigating these risks and ensuring stable access to the minerals will become essential for sustainable energy technologies.

India's Critical Minerals Scenario: Navigating the Present

India's demand for critical minerals is witnessing a sharp rise, driven by its ambitious targets for renewable energy expansion, electric vehicle (EV) adoption, and the overall growth of high-tech industries. However, India is heavily import-dependent for the majority of its critical minerals. Despite having some reserves of graphite, bauxite, and rare earth elements, the country relies on imports for key minerals like lithium, cobalt, and nickel, which are essential for battery production and clean energy technologies.

Most of India's lithium and cobalt imports come from Australia, Latin America, and Africa, while China dominates the supply of processed rare earth elements and graphite. This high dependency on imports exposes India to supply chain vulnerabilities and price volatility in global markets, particularly as demand for these minerals intensifies worldwide.

As India scales up its clean energy ambitions, securing a stable supply of critical minerals through strategic partnerships, domestic exploration, and investment in mineral processing infrastructure will be vital to meeting future demand and reducing import dependency.

Exhibit 46: India's import dependence of key critical minerals

Sl. No.	Critical Mineral	Percentage (2020)	Major Import Sources (2020)
1	Lithium	100%	Chile, Russia, China, Ireland, Belgium
2	Cobalt	100%	China, Belgium, Netherlands, US, Japan
3	Nickel	100%	Sweden, China, Indonesia, Japan, Philippines
4	Vanadium	100%	Kuwait, Germany, S. Africa, Brazil, Thailand
5	Niobium	100%	Brazil, Australia, Canada, S. Africa, Indonesia
6	Germanium	100%	China, S. Africa, Australia, France, US
7	Rhenium	100%	Russia, UK, Netherlands, S. Africa, China
8	Beryllium	100%	Russia, UK, Netherlands, S. Africa, China
9	Tantalum	100%	S. Africa, Australia, Indonesia, Malaysia, US
10	Strontium	100%	China, US, Russia, Estonia, Slovenia
11	Zirconium	80%	S. Africa, Australia, Indonesia, Malaysia, US
12	Graphite	60%	China, Madagascar, Mozambique, Vietnam, Tanzania
13	Manganese	50%	S. Africa, Gabon, Australia, Brazil, China
14	Chromium	2.50%	S. Africa, Mozambique, Oman, Switzerland, Turkey
15	Silicon	<1%	China, Malaysia, Norway, Bhutan, Netherlands

Source: Ministry of Mines, ICRA Research

India's critical mineral future is also deeply tied to global partnerships. Given the country's limited domestic reserves of key minerals like lithium and cobalt, securing long-term Mineral Supply Agreements (MSAs) with resource-rich countries is crucial. India has already made significant strides in establishing partnerships with nations like Australia, Argentina, and Chile for lithium and cobalt supplies.

These collaborations not only ensure access to essential minerals but also provide opportunities for technological cooperation and joint ventures in mining and processing. As the competition for critical minerals intensifies globally, India's ability to navigate and strengthen these international alliances will be crucial for securing its place in the global supply chain.

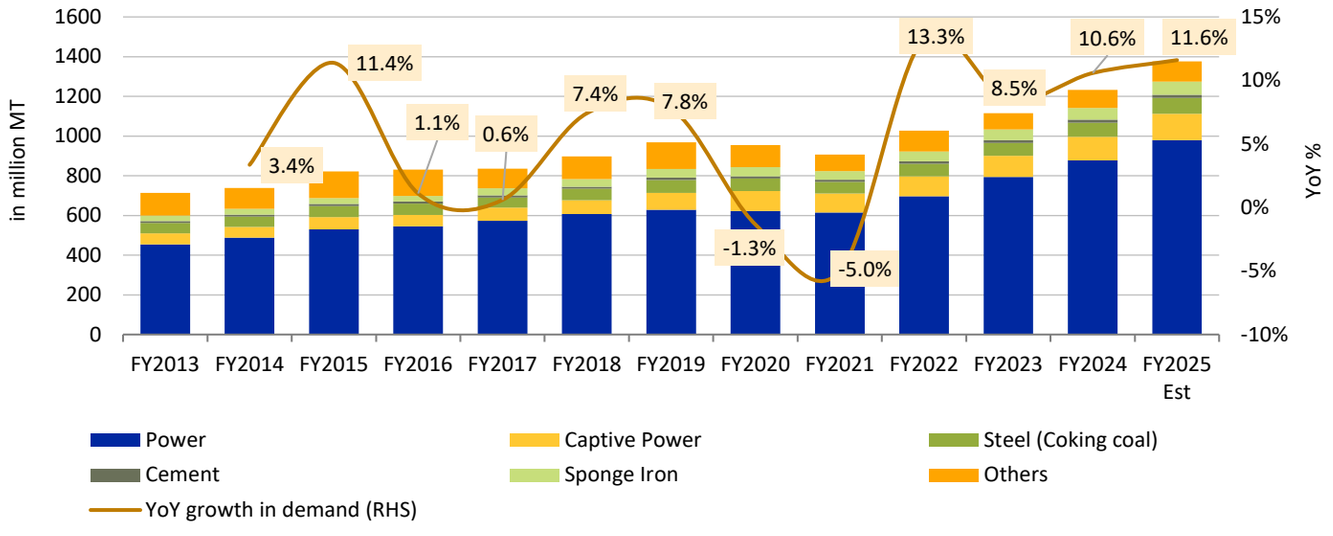
Coal in Command: Sectoral Demand Surges Amid Energy Security Priorities

Despite the intensifying global discourse around phasing out fossil fuels and transitioning to cleaner energy alternatives, India's reliance on coal continues to deepen, driven by the dual imperatives of energy security and economic expansion. The thermal power sector, which remains the bedrock of India's electricity generation framework, continues to dominate domestic coal consumption, accounting for over 71% of the total coal consumption. As of FY2025, dispatches to the power sector from Coal India Limited (CIL) and Singareni Collieries Company Limited (SCCL) exceeded 890 million tonnes, reflecting the sustained demand pressures amid record electricity consumption, summer peaks, and limited baseload alternatives.

Domestic coal demand has witnessed robust growth in recent years. After registering a steep 13.4% rise in FY2022 and a further 8.5% in FY2023, demand growth continued to remain robust to around 10.6% in FY2024 and 11.6% in FY2025 (estimated). Consequently, the structural demand drivers remain intact, particularly for the industrial and captive segments. Production of coal from captive and commercial miners surged by 28% year-on-year in FY2025, reaching almost the 200 million tonnes mark for the first time, a trend, which is expected in the coming future as well. This growth reflects the increasing contribution of merchant and industrial users in meeting their own energy requirements, thereby diversifying supply beyond the two dominant public sector miners.

Non-power sectors also continued to reflect steady demand. The cement, sponge iron, and steel sectors (including coking coal) collectively consumed approximately 150-160 million tonnes annually over the past two years. These sectors, which rely heavily on coal either for direct combustion or as a reducing agent in manufacturing processes, showed resilience despite input cost volatility. Sponge iron manufacturers, in particular, have sustained their reliance on domestic coal in the absence of cost-effective gas-based alternatives. The 'others' category, including brick kilns, paper, ceramics, and other small-scale industries, accounted for roughly 100 million tonnes of demand in FY2025 and is expected to remain at similar levels in FY2026, largely supported by growing construction and infrastructure activity across states.

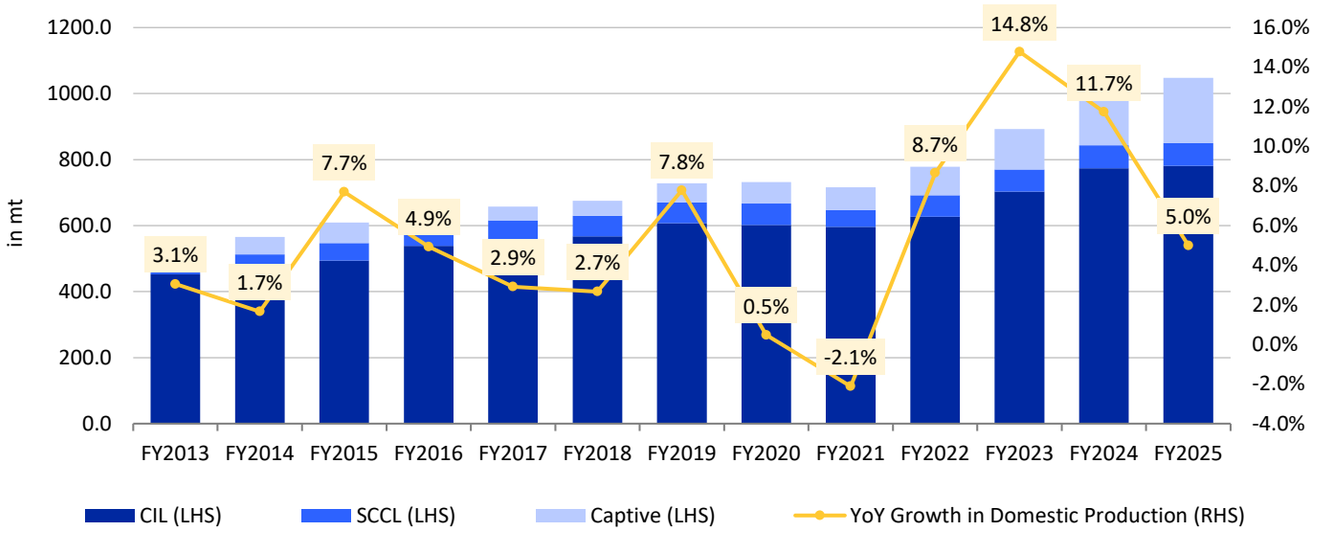
Exhibit 47: Trend in sectoral break-up of domestic coal demand



Source: Ministry of Coal; ICRA Research

From a supply perspective, domestic coal production recorded the fastest growth in decades. The all-India coal production in the FY 2024-25 stood at 1048 MT (provisional) in comparison to 998 MT in the FY 2023-24 with a growth of about 5.00%. While Coal India continues to maintain a dominant position, the relative share of captive and commercial mining has increased considerably, supported by policy reforms and faster project clearances. This shift not only helps meet growing demand but also supports the Government's broader objective of reducing import dependency, particularly for thermal coal used in domestic power generation.

Exhibit 48: Trend in domestic coal production

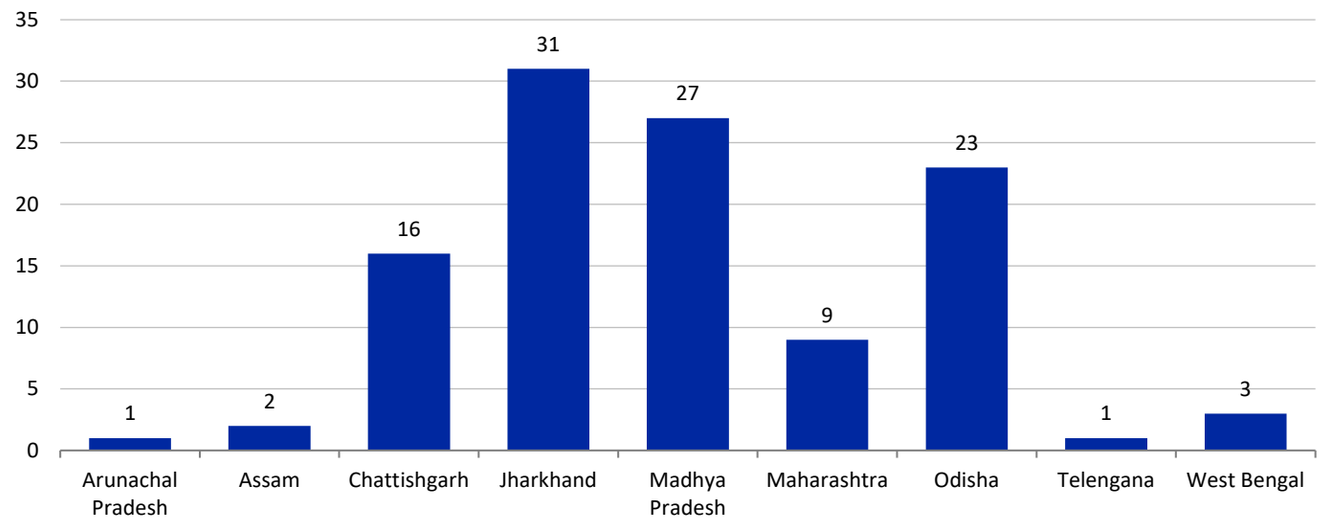


Source: Ministry of Coal, ICRA Research

The commercial coal mining framework in India represents a significant departure from the erstwhile regime, which was characterised by restrictive end-use conditions, sectoral limitations, and regulated pricing. Under the current policy landscape, these constraints have been fully removed, paving the way for a market-driven, investor-friendly ecosystem. The reforms have introduced several enabling provisions, including a reduced upfront payment requirement, the option to offset upfront payments against future royalty obligations, and the adoption of liberal efficiency norms to promote operational flexibility. A fully transparent and competitive bidding mechanism has been instituted, further supported by the allowance of 100% foreign direct investment (FDI) through the automatic route. Financial terms under the new regime are structured around a revenue-sharing model linked to the National Coal Index, ensuring alignment with market dynamics.

Since the launch of this liberalised framework, a total of 113 coal blocks have been successfully auctioned across multiple states, including Arunachal Pradesh, Assam, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Telangana, and West Bengal, reflecting growing investor interest and state-level participation in the sector's transformation.

Exhibit 49: State wise auction of commercial coal mines



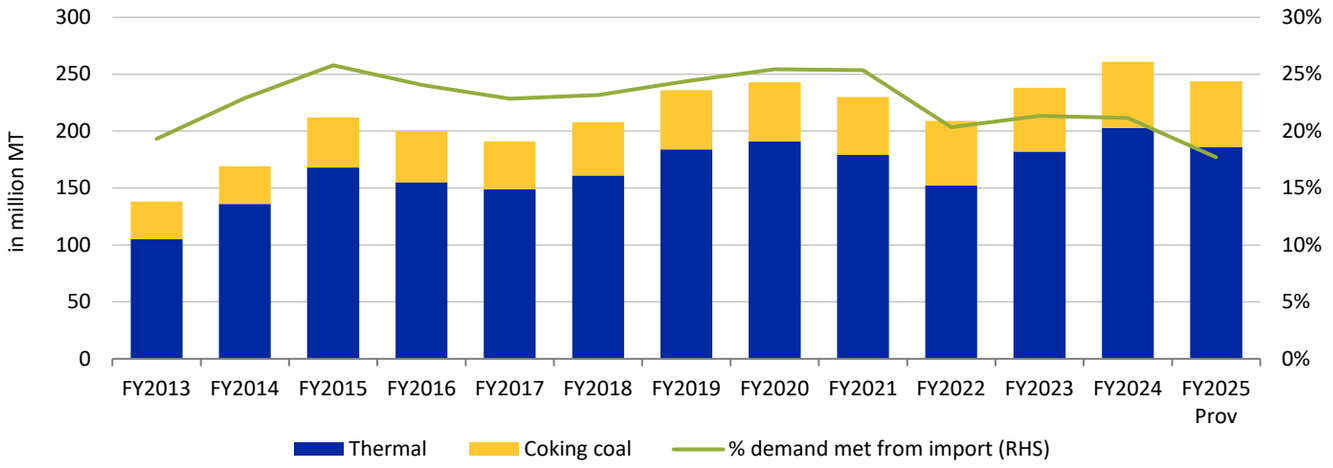
Source: Ministry of Coal; ICRA Research

Looking ahead, the demand for coal is expected to remain on an upward trajectory. In ICRA's baseline scenario, domestic coal demand is projected to grow at a compounded annual growth rate of 3.5–4.0% between FY2026 and FY2032. While the long-term policy direction envisions a gradual pivot to cleaner fuels like green hydrogen and solar-wind hybrid systems, coal is likely to retain a central role in India's energy mix at least until 2040. In fact, the structural underpinnings of India's coal demand – including rising baseload requirements, industrial energy needs, and the challenges of energy storage and intermittency in renewables – make an immediate or steep decline in coal use highly unlikely.

Breaking the Import Habit: India's Pursuit of Thermal Coal Self-Reliance

India's coal import dependency, particularly for thermal coal, remains a critical dimension of its energy supply chain. Despite record levels of domestic production in FY2024 and FY2025, import substitution efforts have not fully offset the structural shortfall in supply, especially in the non-regulated sector and for specific industrial applications. As of FY2025, India imported around 244 million tonnes (MT) of coal, of which nearly 186 MT was thermal and the rest coking coal, used mainly in the steel industry. While coking coal imports are harder to replace due to India's limited reserves and lack of washing infrastructure, thermal coal imports continue to offer a viable substitution opportunity, particularly for domestic power generation and captive users.

Exhibit 50: Trend in India's coal import



Source: Ministry of Coal; ICRA Research

Domestic thermal coal production grew at a robust pace in FY2025, yet imports continued to account for 18% of total coal demand, down from 21% the previous year, according to official estimates. In FY2025, with domestic production crossing 1,048 MT, the government aimed to cap thermal coal imports through expanded dispatches by Coal India Limited (CIL), accelerated coal block operationalisation, and easing logistics. Yet, total thermal coal imports still remained significant at around 180-190 MT, with Indonesia continuing to account for nearly 60% of that volume, primarily due to its logistical advantage and lower-grade coal that blends easily with domestic varieties.

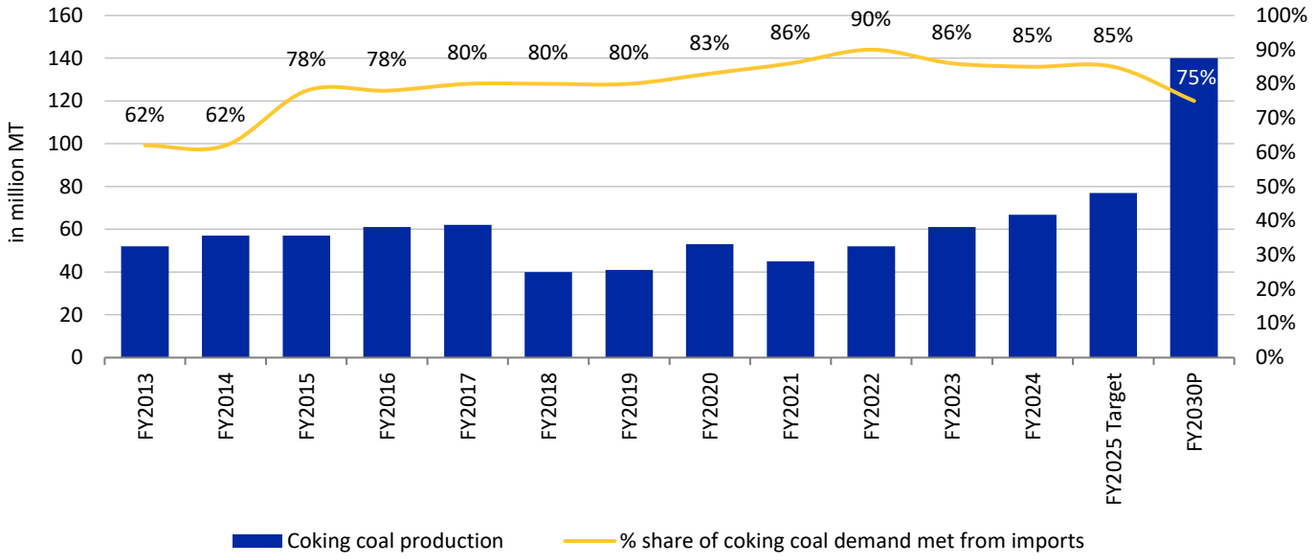
A detailed breakdown of thermal coal imports in FY2024 and FY2025 shows that around 110 MT was imported from Indonesia, used largely by domestic power plants, including captive power users. This category of coal is of lower calorific value and is favoured for blending purposes. Captive and merchant generators, especially in the metals and mineral processing sectors, continue to rely on this stream given its cost and design compatibility. Imports from other countries such as Australia, South Africa, the US, and Russia—totalling around 76 MT—mainly comprise high-grade coal, which is typically used by non-regulated sectors such as cement and sponge iron. These higher calorific coal grades are difficult to replace immediately due to the absence of adequate domestic substitutes, a challenge compounded by quality gaps and a lack of sufficient coal washing infrastructure in India.

Going forward, the policy emphasis is clearly on reducing import reliance, especially for thermal coal used in domestic power generation. While imports for blending and niche industrial needs may continue in the medium term, India's growing domestic production capacity, supported by both public and private sector miners, positions it to significantly reduce its thermal coal import bill over the next five years. If supported by infrastructure upgrades, beneficiation investments, and pricing reforms, this shift could mark a pivotal moment in India's journey toward coal self-sufficiency.

Mission Coking Coal: India's Push to Cut Steelmaking Import Dependency

India's steel sector, particularly through the Blast Furnace–Basic Oxygen Furnace (BF–BOF) route, continues to be heavily reliant on imported coking coal, a critical reductant used in the coke-making process. With the BF–BOF route accounting for nearly 45% of India's steel production, the country's demand for metallurgical coal is structurally high. Domestic coking coal production has remained relatively stagnant over the last decade, fluctuating in a narrow range of 40-60 million tonnes per annum, largely sourced from Jharkhand. The persistent challenge lies in the high ash content of domestic coal, often ranging from 18% to 49%, which necessitates extensive washing to bring it down to usable levels below 18%. As of FY2024, domestic coking coal output was approximately 67 million tonnes, and the ash adjustment gap continues to limit its broader industrial applicability.

Exhibit 51: Trend in domestic coking coal production



Source: Ministry of Coal; ICRA Research

Consequently, India's dependence on seaborne coking coal imports has steadily increased, rising from ~62% in FY2013 to as high as ~85% in recent years, making the steel sector vulnerable to international price volatility. Imports are primarily sourced from Australia, followed by the US, Canada, and Mozambique. In FY2025, India is estimated to have imported ~58 million tonnes of coking coal, driven by robust steel production and a lack of sufficient domestic washing capacity.

Recognizing this strategic vulnerability, the Government of India launched the 'Mission Coking Coal' initiative in August 2021, aiming to more than double domestic coking coal production to 140 million tonnes by FY2030. The initiative is also intended to reduce import dependency from the prevailing 85–90% to around 75%. ICRA's analysis suggests that to meet this target, India will not only need to raise raw coal production but also expand coal washing capacity significantly—from the current estimated 23 million tonnes per annum (mtpa) to nearly 78 mtpa. This would enable improved blending potential of domestic coal with imported high-grade coking coal, reducing both cost and import volumes over time.

Coal to Chemicals: India's Strategic Pivot Towards a Gasification-Led Future

As part of its long-term energy diversification and industrial self-reliance agenda, the Government of India has placed a sharp focus on coal gasification as a transformative pathway to value-added coal utilization. With an ambitious target to gasify 100 million tonnes of coal annually by FY2030, the Ministry of Coal has launched the National Coal Gasification Mission, which is expected to unlock an investment potential exceeding Rs 4 lakh crore across coal-bearing states. The mission is being implemented in three phases, with the final phase (FY2026–2030) targeting 90–100 MT of coal gasification per year. Financial incentives such as a 50% rebate in revenue share for coal blocks used for gasification—conditional upon using at least 10% of mined coal for gasification—are being extended to catalyze investment.

The technology centers around the generation of syngas—a mixture of carbon monoxide and hydrogen—which can be processed further to produce a variety of chemical and petrochemical products currently imported in significant volumes. These include synthetic natural gas (SNG), methanol, ethanol, synthetic diesel, ammonia, and ammonium nitrate, among others. Coal gasification is also emerging as a critical bridge technology for substituting imported LNG in industrial sectors, and as a stepping stone towards green hydrogen adoption for cleaner steelmaking.

Exhibit 52: Planned domestic coal gasification projects

	Talcher Fertilizer	Coal India (ECL)	Coal India (MCL)	Coal India (SECL)	Coal India (WCL)	Neyveli Lignite	Jindal Steel & Power	New Era Cleantech Solution
Technology Partner	Wuhan Engineering Company	GAIL	BHEL	IOCL	-	Air Products, USA and EIL	Midrex Technologies, USA	-
Product	Urea	Synthetic Natural Gas	Ammonium Nitrate	Di-methyl ether	Ammonium Nitrate	Methanol	DRI	Methanol/ Urea
Capacity	1.27 mtpa	633.6 mio. m^3	0.66 mtpa	0.72 mtpa	0.66 mtpa	0.396 mtpa	1.8 mtpa	-
Coal/Lignite Gasified	2.5 mtpa	1.4 mtpa	1.3 mtpa	1.35 mtpa	0.8 mtpa	2.26 mtpa	2.4 mtpa	5 mtpa
Project Cost	Rs. 13,277 crore	Rs. 13,053 crore	Rs. 11,782 crore	-	-	Rs. 4,383 crore	-	~Rs. 20,000 crore (US$ 2.5 billion)

Source: Company Annual Reports, Ministry of Coal, PIB, ICRA Research; GAIL: GAIL (India) Ltd, IOCL: Indian Oil Corporation Ltd, EIL: Engineers India Ltd, BHEL: Bharat Heavy Electricals Ltd

As of FY2025, several gasification projects are either under construction or in advanced planning stages. Among the most prominent is the Talcher Fertilizer Project in Odisha, a joint venture between CIL, GAIL, RCF, and FCIL, which will be India's largest coal gasification-based urea complex with a capacity of 1.27 million tonnes per annum (mtpa). The project is expected to be commissioned by the end of FY2025. Jindal Steel & Power has already operationalized a coal gasification-based sponge iron plant at Angul, Odisha, while Neyveli Lignite Corporation and Coal India have signed MoUs for five additional coal-to-chemical projects, including one focused on lignite gasification.

In addition to surface projects, underground coal gasification (UCG) has also gained policy traction, with pilot sites identified in Deocha Pachami (West Bengal) and Telangana. Furthermore, indigenous R&D is being supported through pilot-scale projects such as the 500 TPD coal-to-hydrogen demonstration unit, mandated by the government and led by BHEL.

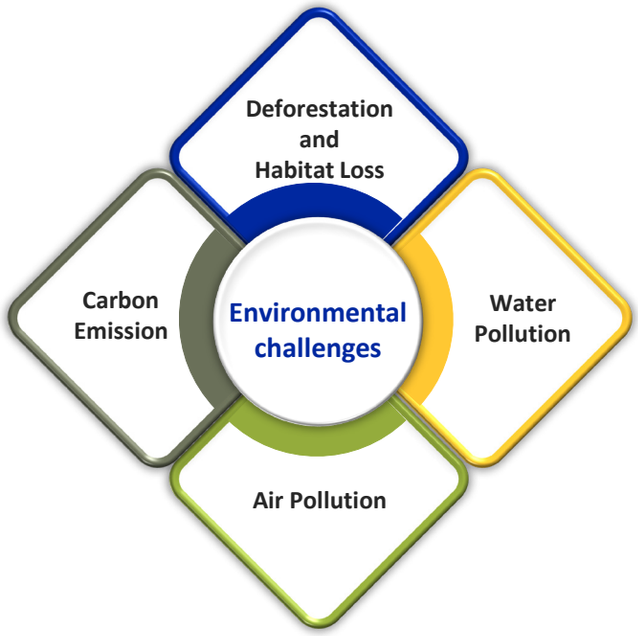
Looking ahead, coal gasification is poised to play a strategic role in India's efforts to reduce import dependency on chemicals and natural gas, monetise high-ash domestic coal, and decarbonise hard-to-abate industrial sectors. However, timely execution, infrastructure for syngas handling, and the development of downstream market linkages will be essential for realising the full economic and environmental potential of these investments. If the Government's targets are met, coal gasification could emerge as the backbone of India's transition from thermal combustion to a coal-to-chemicals economy, signalling a paradigm shift in how coal is valued and utilised.

Sustainability in Mining: Balancing Growth with Environmental Stewardship

The mining industry in India is pivotal to the country's economic growth, supplying the raw materials essential for infrastructure, manufacturing, and energy sectors. However, mining activities also pose significant environmental and social challenges, such as habitat destruction, water pollution, air quality degradation, and community displacement. Recognising the need to balance economic benefits with environmental stewardship and social responsibility, Indian mining companies are increasingly adopting sustainable practices.

The focus is now on reducing the environmental footprint, enhancing resource efficiency, and improving community relations to ensure the long-term sustainability of the industry. Rule 35 (2) of the Mineral Conservation and Development Rules, 2017 mandatorily provides for 'Star Rating' of non-coal/lignite mining leases in the country based on sustainable mining practices. In June 2023, the Ministry of Coal announced the introduction of the 'Star Rating' system for domestic coal mines as well.

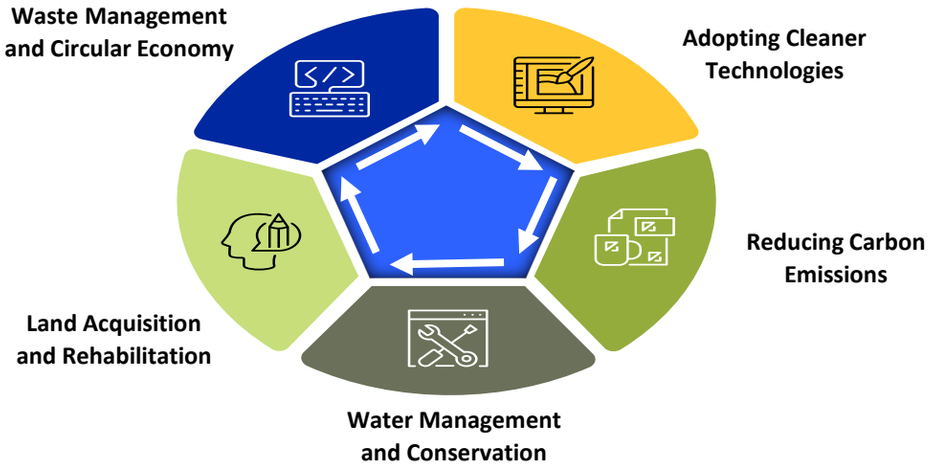
Exhibit 53: Key environmental challenges in Indian mining



Source: ICRA Research

To reduce the environmental impact of mining activity, Indian mining companies are increasingly adopting sustainable practices as outlined in the following key pillars:

Exhibit 54: Five Pillars of Sustainable Mining



Source: Industry reports, ICRA Research

Cleaner Technology

Mining technology has evolved over the years and today multiple options are available for companies to adopt mining techniques that reduce the extent of environmental impact. Indian mining companies are increasingly adopting advanced technologies to enhance operational efficiency and minimise the environmental impact.

Advanced Mining Technologies:

- **Surface Miners:** These machines enable precise cutting of minerals, reducing the need for drilling and blasting, which in turn minimises dust and noise pollution. For instance, the National Aluminium Company Limited (NALCO) employs surface miners in its bauxite mines to enhance efficiency and reduce environmental disturbances.
- **Continuous Miners and Longwall Mining Systems:** These technologies are pivotal in underground coal mining, allowing for continuous extraction and helping reduce the environmental footprint.

Electric and Hybrid Machinery

- Battery Electric Vehicles (BEVs): Hindustan Zinc Limited has pioneered the use of BEVs in its underground operations. In January 2023, the company introduced the Normet Agitator SmartDrive EV into its underground mining operations, marking a significant step toward reducing carbon emissions and promoting sustainable mining practices.
- Hybrid Excavators: Tata Steel has incorporated hybrid hydraulic excavators in its mining operations. These machines combine diesel and electric power, leading to lower fuel consumption and reduced greenhouse gas emissions.

Automation and Remote Operations

- Automated Drilling Systems: Hindustan Zinc Limited (HZL) has implemented automated drilling in its zinc mines, enhancing precision and safety while reducing energy consumption.
- Remote Monitoring and Control: JSW Steel utilises remote monitoring systems in its iron ore mines, allowing for real-time data analysis and operational adjustments. These steps significantly improve efficiency and reduce environmental impact.
- Hindustan Zinc is leveraging IoT and automation technologies to optimise energy use in its underground mining operations.

Water Management and Conservation

Leading Indian mining companies like Vedanta and Tata Steel have implemented Zero Liquid Discharge (ZLD) systems, ensuring that all wastewater generated during their operations is treated, recycled, and reused on-site, thereby preventing any discharge into local water bodies and protecting surrounding ecosystems.

For instance, Vedanta's Lanjigarh alumina refinery and Tata Steel's Jamshedpur plants have successfully integrated ZLD systems, significantly reducing their impact on local water sources. These companies have also embraced rainwater harvesting and efficient water recycling systems to minimise their dependence on freshwater sources.

Waste Management and Circular Economy

Indian mining and metals companies are increasingly focusing on waste management and circular economy initiatives to reduce environmental impact and optimise resource utilisation.

- Tata Steel has been reusing slag generated from its steel production for road construction and as an additive in cement manufacturing, turning what was once considered waste into valuable inputs for infrastructure projects.
- Similarly, Vedanta has launched various waste-to-wealth initiatives, converting by-products from its aluminium and zinc operations into commercially useful materials. Vedanta's red mud and fly ash recycling projects not only reduce waste but also supply materials for cement and brick production. By adopting these practices, companies are not only reducing landfill waste but also contributing to a more sustainable circular economy.

Land Acquisition and Rehabilitation

Mining activity and its associated degradation of soils, biomass, and local ecosystems make the land unsuitable for alternate use until initiatives for bio-reclamation of mined areas and reforestation are undertaken. In this regard, to promote mine tourism, Coal India and SAIL have developed eco-parks and biodiversity parks on reclaimed land.

Internationally, mining companies like Alcoa have gone a step ahead by implementing not only large-scale reforestation but also by restoring local species present at a mine site before mining operations began.

Conclusion

India's mining sector stands at the cusp of transformative growth, buoyed by an ambitious national vision, strong global mineral demand, and a wave of regulatory reforms. Recent amendments to the Mines and Minerals (Development and Regulation) Act and liberalisation across key mining segments have enhanced transparency and investor confidence, while also streamlining the allocation of mineral resources. These policy interventions are poised to catalyse private investment, accelerate exploration, and firmly position India as a globally significant mining player.

However, several structural bottlenecks continue to impede the sector's full potential. Delays in obtaining environmental clearances, complex regulatory procedures, and land acquisition challenges have constrained the timely operationalisation of mining projects. Addressing these hurdles is imperative to sustaining momentum. This will require targeted policy simplification, faster project approvals, and improved coordination across Central and state authorities. In parallel, strengthening logistics infrastructure—particularly rail linkages, slurry pipelines, and coastal shipping—will be critical to enhancing the cost-efficiency of mineral transportation.

The emphasis on sustainability is no longer optional—it is essential for the sector's long-term viability. Progressive Indian mining companies are already adopting cleaner technologies, zero liquid discharge systems, circular economy practices, and responsible mine closures. Leaders like Hindustan Zinc, JSW Steel, Tata Steel, and Vedanta are pioneering initiatives in energy efficiency, digital mining solutions, and low-carbon operations, setting benchmarks aligned with global sustainability standards.

A stronger focus on social inclusion will also be vital. Mining firms must prioritise inclusive development through local employment, fair rehabilitation, and meaningful CSR engagement. Ensuring that mining benefits percolate to host communities will not only create a social licence to operate but will also foster equitable growth in mineral-rich regions.

Looking ahead, India's mining industry holds immense promise to contribute significantly to GDP, employment generation, and infrastructure-led development. By continuing to advance reforms, attract capital, expand sustainable practices, and unlock the potential of critical minerals such as lithium, rare earths, and cobalt, India can fully realise its mineral wealth in a manner that is not only economically vibrant but also socially responsible and environmentally resilient. The future prospects for critical minerals in India are vast and strategically important. The country is at a pivotal moment, where domestic investments, technological innovations, and regulatory reforms can collectively transform India into a key player in the global critical minerals market. However, for this vision to be realised, India must continue to build a sustainable supply chain, foster international collaborations, and develop a regulatory framework that encourages innovation and investment. As the world's demand for critical minerals surges, India's ability to scale-up its critical mineral capacity will define its strategic standing in the global market and secure its industrial and technological future.

Notes

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About ASSOCHAM

ASSOCHAM initiated its endeavor of value creation for Indian industry in 1920. It brings in actionable insights to strengthen the Indian ecosystem, leveraging its network of more than 4,50,000 members, of which MSMEs represent a large segment. With a strong presence in states, and key cities globally, ASSOCHAM also has more than 400 associations, federations and regional chambers in its fold.

Aligned with the vision of creating a New India, ASSOCHAM works as a conduit between the industry and the Government. The Chamber is an agile and forward-looking institution, leading various initiatives to enhance the global competitiveness of the Indian industry, while strengthening the domestic ecosystem. With more than 100 national and regional sector councils, ASSOCHAM is an impactful representative of the Indian industry. These Councils are led by wellknown industry leaders, academicians, economists and independent professionals. The Chamber focuses on aligning critical needs and interests of the industry with the growth aspirations of the nation.

ASSOCHAM is working hand in hand with the government, regulators and national and international think tanks to contribute to the policy making process and share vital feedback on implementation of decisions of far-reaching consequences. In line with its focus on being future-ready, the Chamber is building a strong network of knowledge architects. Thus, ASSOCHAM is all set to redefine the dynamics of growth and development in the technology-driven 'Knowledge-Based Economy. The Chamber aims to empower stakeholders in the Indian economy by inculcating knowledge that will be the catalyst of growth in the dynamic global environment.

Vision

Be the knowledge architect for the Indian economy, with a focus on strengthening India's domestic ecosystem and enhancing global competitiveness.

Mission

Its mission is to impact the policy and legislative environment so as to foster balanced economic, industrial and social development.

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