The minerals that will power tomorrow must be mined differently today

As demand for critical minerals surges with the clean energy transition, mining must adopt sustainable, technology-led practices to balance growth, environmental responsibility, community expectations

Representative Picture

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The mining industry stands at a defining moment. The global shift to clean energy, electrified mobility and climate resilient infrastructure is changing not only which minerals matter but how those minerals must be produced. Every solar panel, wind turbine, electric vehicle, semiconductor and transmission line depends on mining. Yet the success of the world's transition will be determined by the responsibility with which we extract the minerals that enable it. Sustainability can no longer sit on the periphery of mining. It must become the integral operating system that guides the sector's future.

A Structural Shift in Global Demand

According to the International Energy Agency (IEA), demand for key transition minerals such as lithium, cobalt, nickel, graphite and rare earths is poised to rise two-fold by 2040 even with a conservative stated policy. Copper requirements are projected to almost double as electrification becomes central to modern economies. Silver, aluminium and zinc are witnessing persistent demand due to their pivotal roles in solar technologies, electric vehicles and galvanised steel that supports renewable infrastructure.

Mining is no longer supplying the traditional industrial age. It is enabling a new energy system built around low-carbon technologies. At the same time, expectations around environmental responsibility, community development and transparent governance have intensified. Mining expansion will only be sustainable if matched with high standards of environmental and social impact - including the proactive design of mines for climate resilience, addressing risks such as extreme weather events, water scarcity, and long-term climate variability.

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Three global forces are reshaping the trajectory of mining. The first is investor behaviour. International capital now evaluates miners on decarbonisation pathways, water management, biodiversity protection and inclusion metrics as rigorously as financial performance. Increasingly, lower sustainability performance is leading to higher capital costs and weaker long-term competitiveness.

The second force is regulation. From Europe's Carbon Border Adjustment Mechanism (CBAM) to evolving sourcing rules across North America and Asia, low emission raw materials are becoming necessary across major value chains. Environmental permitting rules, mine closure standards and disclosure requirements are tightening across jurisdictions.

The third force reshaping mining is society itself. Mining communities today expect cleaner operations, fairer distribution of benefits, and stronger commitments to environmental protection. Globally, the mindset has shifted from merely limiting harm to actively restoring ecosystems — a shift reflected in the growing influence of international sustainability frameworks.

Among these, the International Council on Mining and Metals (ICMM) has emerged as one of the most rigorous standard setters for responsible mining, shaping expectations across climate action, tailings safety, biodiversity protection, and community engagement. This evolution is now moving towards greater coherence and accountability, with ICMM progressing towards a Consolidated Mining Standard that brings these expectations together under a unified framework.

In this context, India's recent milestone, marked by Hindustan Zinc becoming the first Indian company to join the ICMM, underscores how global sustainability principles are beginning to take root domestically. It reflects a growing convergence between international expectations and India's mining ambitions, where growth, responsibility, and global alignment are increasingly viewed as inseparable.

India's Opportunity in a Reconfigured Mineral Economy

India holds a large, underexplored geological potential across non-ferrous metals and critical minerals. As global supply chains diversify to build resilience, India is positioned to play a meaningful role in supplying minerals essential for the energy transition. This opportunity is defined by rising domestic demand, favourable policy direction and the rapid evolution of technology.

India's drive toward renewable energy, electric mobility, grid modernization, and green hydrogen will hinge on access to considerable quantities of transition metals. The pursuit of a resilient and sustainable mineral base will shape the country's industrial competitiveness and energy independence. Recent policy action reinforces this trajectory: critical mineral auctions, deep-exploration initiatives, and sustainability linked norms reflect a new vision for the sector: future mining growth must advance in alignment with climate and nature goals.

Delivering on this new vision will increasingly depend on how effectively technology is harnessed across the mining value chain. Artificial intelligence enabled exploration, advanced ore body imaging, automated drilling, electrified mine transport, digital monitoring and low carbon processing technologies point to a mining model that is safer, more efficient and less intrusive. India has an opportunity to embed these practices from the outset rather than retrofit older systems.

What a Sustainable Mining Model Requires

The mining industry of the future will operate fundamentally differently from the one we see today. Decarbonised operations powered by renewable energy, electrified equipment, and enhanced energy efficiency will be central to reducing lifecycle emissions. Equally critical is water stewardship. Closed-loop water systems, minimal freshwater withdrawal, and advanced tailings reprocessing will become essential in an increasingly water-constrained world.

Digitalisation will be a key enabler of this transition. Advanced analytics, artificial intelligence, automation, and autonomous technologies will support precision mining, reducing waste, minimising land disturbance, and

significantly improving worker safety. These tools will allow operators to optimise extraction, predict asset behaviour, and deliver stronger environmental and operational outcomes.

Technology alone cannot secure the future of sustainable mining. Equal emphasis must be placed on developing digital talent and human capability. Investing in upskilling from AI and automation to advanced maintenance through structured training programs for employees and local communities will build stronger partnerships and create more resilient regional ecosystems.

Social impact and biodiversity restoration must therefore be embedded into long-term strategy. Progressive land reclamation, ecosystem restoration, community partnerships, and transparent engagement will increasingly shape the next generation of mining licences and define trust between industry, communities, and regulators.

A Decisive Decade Ahead

The decade ahead will reshape mining more fundamentally than the past fifty years. The world cannot achieve its climate ambitions without minerals. Yet the world also cannot afford minerals produced in ways that undermine climate goals or degrade ecosystems. The mining industry must embrace a new mandate to extract responsibly, innovate continuously, restore natural ecosystems and deliver meaningful societal value.

If countries and companies align their geological potential with sustainability leadership and engage with global frameworks that strengthen accountability, the sector can evolve into a regenerative and innovation driven pillar of the clean energy transition. Mining should not be viewed as an industry tied to the past. With a sustainability centred vision, it will power the future.

[***Priya Agarwal Hebbar is the chairperson of Hindustan Zinc Limited, the world's largest integrated zinc producer and the first Indian company to become a member of the International Council on Mining and Metals (ICMM).***]