Southeast Asia Tech Stack Sovereignty

Paper 2: Critical Minerals

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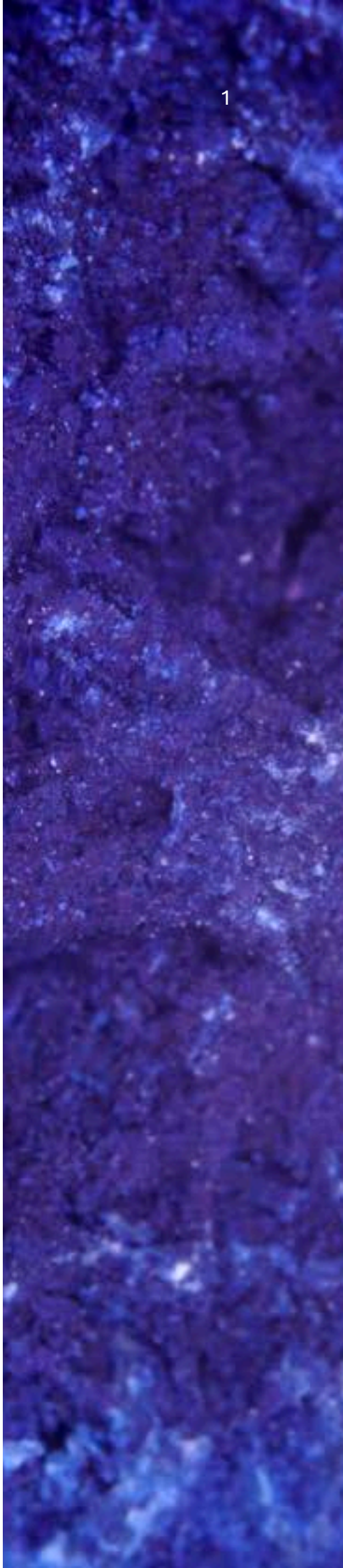
Introduction

Critical minerals have emerged as among the most strategic commodities of the 21st century amid an increasingly uncertain geopolitical landscape. They sit at the foundation of technologies enabling digitization and the global energy transition. These non-fuel minerals, including nickel, cobalt, tin, and rare earth elements (REEs), particularly neodymium, praseodymium, dysprosium, and terbium are essential inputs for emerging technologies, ranging from the batteries in electric vehicles to semiconductors used in data centers, as well as key components in wind turbines and power grids. Control over critical minerals has therefore become closely linked to national competitiveness and national security. This dynamic has triggered a global race to secure reliable access to these resources, as countries seek to sustain their technological and economic positions in the decade ahead.

Southeast Asia stands at the center of this scramble as both a major source and an emerging consumer of critical minerals. The region's ability to harness these resources will determine its "tech stack" sovereignty – autonomy across the various layers of the technology value chain. An economy cannot credibly claim resilience if it remains structurally dependent on unstable or politicized upstream inputs. In this sense, critical mineral sovereignty represents the first layer that Southeast Asia must secure to achieve any degree of tech stack sovereignty.



Critical minerals are therefore central to Southeast Asia's long-term strategic ambitions, including scaling electric vehicle and battery ecosystems, expanding semiconductor packaging and testing capabilities, building resilient power grids, and supporting the data infrastructure required for artificial intelligence and the digital economy. Ensuring access to critical minerals is a prerequisite for developing a resilient, high-tech economy that can withstand external shocks and strategic pressures.

This paper examines how critical minerals will shape Southeast Asia's geopolitical and economic future, assesses the gaps that constrain the region's ability to achieve degrees of sovereignty, and proposes pathways for navigating tech sovereignty forward-looking policy frameworks and regional collaboration.

1 What is critical mineral sovereignty and why does it matter?

Before assessing sovereignty, it is necessary to clarify what constitutes a critical mineral, as definitions differ across countries and institutions depending on their contexts.

1.1 Scope of the term 'critical minerals'

The term "critical minerals" has been increasingly used with regard to natural resources, but it is inherently context-specific and depends on national circumstances, regional dynamics, and the level of analysis applied.

In broad—though not universally standardized—terms, critical minerals generally refer to mineral resources that serve as essential inputs in the manufacturing of green, digital, and advanced technologies[1].

According to the ASEAN-IGF Minerals Cooperation report[2], the definition of critical minerals is based on two key considerations.

1. Minerals and metals may be considered 'critical' when they are essential to industrial activities but are not available domestically, resulting in high import dependence. This reliance exposes countries to supply chain vulnerabilities and increases the risk of disruption due to geopolitical, economic, or logistical factors.

2. Minerals may be deemed critical when they play a strategic role in enhancing a country's position and competitive advantage within global value chains, particularly through the development of domestic industrial capacity. In this sense, minerals are considered critical because of the value they enable within existing and emerging supply chains.

Both contexts are relevant for Southeast Asia. Some but not all countries possess reserves of these resources. However, given they are important for so many strategic sectors, and many lack substitutes, their value is greater than other raw materials. Based on this framing, this report defines critical minerals as mineral resources that are essential for advanced industrial production in Southeast Asia, including nickel, tin, bismuth, tungsten, manganese, bauxite, copper, and rare earth elements.

1.2 Working definition of critical mineral sovereignty

To assess critical mineral sovereignty in Southeast Asia, this paper adopts the framework set out in our foundational paper **"SEA Tech Stack Sovereignty: An Analytical Framework for Understanding Technology Sovereignty."** Under this framework, sovereignty is evaluated across three core criteria applied to the functional domains of the modern technology stack: access sovereignty, capability sovereignty, and governance sovereignty.

Each sector, including the critical minerals industry, exhibits its own configuration of sovereignty across these three domains. While the overarching structure of the framework remains consistent, the specific interpretation of each domain varies depending on sectoral context. For critical mineral sovereignty, the three domains are defined as follows:

Access sovereignty refers to a nation's control over the physical availability of critical minerals, including who owns and extracts the resources, where they are sold, and under what terms. In the context of critical minerals, sovereignty is not defined solely by the presence of geological reserves within national territory, but by the effective capacity to lawfully explore, extract, and manage those resources under legitimate bodies or organizations. Mineral deposits that exist but cannot be developed due to technical dependence, foreign dominance, or weak regulatory enforcement do not translate into meaningful access sovereignty.

Authorities should also possess the ability to shape how critical minerals are utilized domestically, including whether to prioritize export, stockpiling, or downstream industrial development. Equally important is commercial autonomy. A country with access sovereignty must retain the ability to determine its buyers, diversify trade partners, and reallocate supply without structural constraints.

Capability sovereignty refers to the ability to process and utilize critical minerals domestically, encompassing the technological and industrial capacity to transform raw materials into higher-value products and capture economic value from them. This capacity extends beyond machinery and infrastructure; it includes human capital, technical expertise, engineering capabilities, research and development, and the institutional knowledge required to operate, upgrade, and innovate across the value chain.

Capability sovereignty refers to the extent to which domestic processing and refining capacity is sufficient to manage critical minerals from upstream activities without continued reliance on foreign actors, and whether domestic players hold a dominant role along the domestic value chain. Moreover, meaningful capability sovereignty requires the ability to generate higher-value outputs, such as battery-grade materials or advanced components, that strengthen integration into global supply chains rather than remaining confined to low-value intermediate stages.

Governance sovereignty refers to the ability to set, implement, and enforce rules, standards, and policies that shape the critical minerals sector within national borders without undue external intervention. It is not defined merely by the existence of laws or policy documents, but by the credibility, consistency, and effectiveness of their implementation. Meaningful governance sovereignty requires that regulatory frameworks are applied uniformly, monitored rigorously, and enforced across all relevant stakeholders, including mining operators, processing facilities, investors, and linked downstream industries such as batteries, electronics, and renewable energy manufacturing.

Strong governance sovereignty also implies coherence across the broader supply chain, ensuring that all policies, rules and standards align from extraction through end-use production. Beyond domestic enforcement, sovereignty is reinforced when national standards are recognized by external partners and can be translated into structured international cooperation. However, trade measures aimed solely at securing supply do not, in themselves, constitute governance sovereignty, as they do not create sovereignty within national borders.

For each domain of sovereignty, this study establishes a set of criteria to distinguish varying degrees of sovereignty. These criteria are used to assess each Southeast Asian country and translate qualitative differences into a standardized score from 1 to 5. A higher score reflects a greater level of sovereignty in that domain. The detailed criteria corresponding to each score level are presented in the table below.

Criteria for critical mineral sovereignty

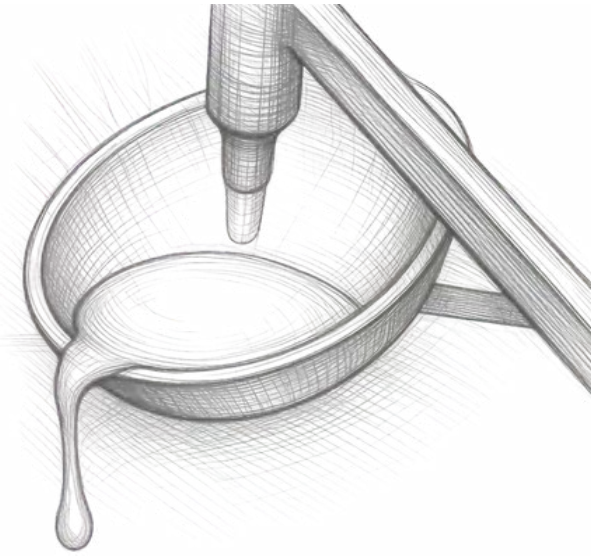
Score	Access Sovereignty	Capability Sovereignty	Governance Sovereignty
1	Negligible reserves; almost entirely import-dependent for critical minerals	No domestic processing or refining capability; exports raw minerals	No effective policy or regulatory control over critical minerals
2	Limited or modest reserves; small-scale production with minimal market influence	Basic or low-value processing capability; limited scale and technological depth	General mining policies exist but lack critical-mineral specificity
3	Significant reserves and production; meaningful domestic supply but limited regional or global influence	Advanced processing capacity present but dominated by foreign firms or technology	Dedicated domestic policies and regulations for critical minerals
4	Abundant reserves in selected critical minerals; leading producer at regional or global level	Domestic firms possess and operate advanced processing, refining and relevant technologies	Comprehensive domestic governance with engagement at international level
5	Abundant reserves with active control over access, exports, or allocation of selected critical minerals	Domestic technology leadership with large-scale, globally competitive processing capacity	Ability to shape or set regional or global standards for critical minerals governance

After assigning scores for each domain of sovereignty, the results are aggregated and averaged to generate an overall score. This composite score is used to indicate the relative level of critical mineral sovereignty for each country in Section 5.

2 About the critical mineral sovereignty stack

While they serve as essential inputs for end-use industries, the critical mineral sector is also an industry in its own right. Its supply chain spans an integrated value chain composed of multiple interconnected stages, from upstream extraction to midstream processing and downstream manufacturing[3].

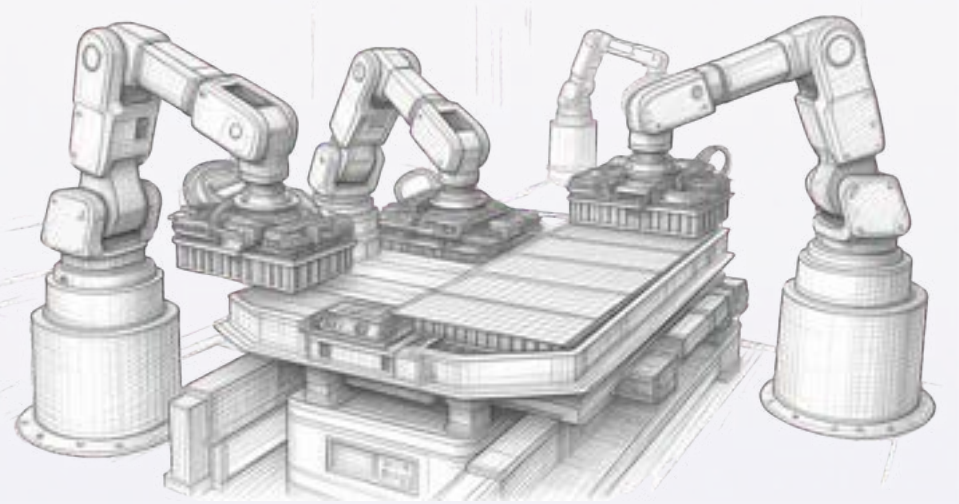
Mining and extraction mark the entry point of this chain, where geological resources are converted into mineral output. This stage involves exploration, licensing, mine development, and physical extraction. At this stage, raw ores and mineral concentrates such as nickel ore, tin concentrates, rare earth clay concentrates, or tungsten concentrates are extracted. It is asset-intensive and location-dependent. However, despite their foundational importance, outputs at this stage typically capture limited economic value relative to subsequent stages. In other words, extraction alone does not translate into sustained strategic advantage. Countries that upgrade these minerals into refined forms required by downstream industries are able to capture greater value.



Processing and refining represent the stage at which mineral sovereignty becomes materially more meaningful. Here, ores and concentrates are transformed into refined metals or chemical products through smelting, leaching, separation, purification, and other conversion processes. Typical outputs include refined metals and high-specification intermediates such as nickel pig iron, ferronickel, battery-grade nickel sulfate and cobalt sulfate, refined tin, tungsten intermediates and powders, and separated rare earth oxides and metals.

This segment of the supply chain is both technology- and infrastructure-intensive. It requires substantial capital investment, reliable energy and water supply, effective waste management systems, and specialized technical expertise. It also determines material quality for end-use industries.

For example, electric vehicle battery production requires Class I nickel with a purity level exceeding 99.8 percent, which differs significantly from conventional industrial-grade nickel[4]. Accordingly, sovereignty at this stage is not merely about the presence of processing facilities, but about ownership of technological know-how and the ability to sustain and upgrade these capabilities over time.

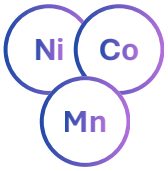
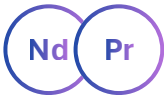
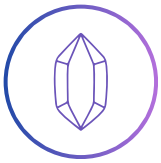


Component manufacturing represents the downstream stage where refined minerals are converted into specialized materials and components for end-use applications. At this stage, the focus shifts from volume to precision and technological sophistication.

Production requires skilled labor, strict process control, advanced quality assurance systems, proprietary knowledge, and often lengthy qualification procedures with end-use manufacturers. For this reason, component manufacturing tends to capture the highest value added within the supply chain. Typical outputs include battery cathode active materials and precursors, lithium-ion battery cells, permanent magnets derived from rare earth alloys, tungsten components and tooling, semiconductor-grade materials, and high-performance compounds used in power electronics.

Following these stages, refined mineral products and components are integrated into downstream industries and finished technologies such as electric vehicles, solar panels, wind turbines, consumer electronics, and defense systems. Illustrative examples of technology stacks for selected end-use industries are presented below.

Example of Tech Stack: From mineral to finished products

Industry	Mining and Extraction	Processing and Refining	Component Manufacturing
EV Industry	 Nickel, Cobalt, Manganese	 Nickel sulfate, Cobalt sulfate, Manganese sulfate	 Lithium-ion battery cathode active material
Clean Energy	 Rare earth minerals such as neodymium and praseodymium	 Rare earth oxides/metals	 Wind turbine permanent magnet
Data center	 Quartz, Silica	 Polysilicon Electronic-grade silicon	 Semiconductor chip
Defense industry	 Bauxite	 Polysilicon Gallium compounds	 Radar power amplifier semiconductor

3 Viewing sovereignty from regional position

Southeast Asia plays an important role in the global supply of critical minerals. Many countries in the region are major producers and refiners of a wide range of metals and minerals, positioning Southeast Asia as a key supplier of several strategically important resources.

At the same time, Southeast Asian economies serve as important manufacturing hubs for advanced industries, all of which rely heavily on critical minerals as essential inputs for end-use production. As a result, the region occupies a strategic position on both the supply and demand sides of the global critical mineral value chain.

However, due to differing resource endowments, industrial structures, and levels of economic development, countries across Southeast Asia vary considerably in their capacities. This variation places them at different levels across the three sovereignty domains outlined in Section 1. Nevertheless, certain regional patterns remain visible. As a whole, Southeast Asia tends to be strong in upstream resource endowment, but comparatively less advanced in higher-value stages of the supply chain. The following section analyzes the region's position across the three sovereignty domains at the aggregate level.

3.1 Access sovereignty

As part of access sovereignty, the availability of critical mineral resources is the first factor indicating whether a country has the ability to leverage these assets and exercise control over them. In this regard, Southeast Asia holds a strong position. The region has emerged as a significant global player in the critical minerals sector, performing a disproportionately large role as a supplier relative to its overall economic size. Although exploration spending in the region over the past decade accounted for only around 2.4% of global exploration expenditure, Southeast Asia has attracted substantial investment commitments across integrated supply chains. These investments have supported a gradual shift from upstream extraction and export toward downstream processing and manufacturing, driven in particular by corporations from China and other East Asian economies[5].

The region is a global leader in the production of several critical minerals and holds substantial reserves of others, including nickel, tin, tungsten, and rare earth elements. Indonesia stands out as the region's dominant powerhouse, leading global nickel production. Other countries, such as the Philippines, Myanmar, and Vietnam, also occupy globally significant positions in specific mineral categories.

Taken together, Southeast Asian countries account for up to approximately 65% of global nickel production and around 37% of global tin production. Rare earth elements represent about 15% of global output, with production increasing sharply by nearly 90% between 2019 and 2023. Production levels for many other critical minerals have also increased steadily across the region in recent years.

Selected Raw Mineral Production

Mineral	ASEAN Production in metr. t (2023)	Global Production in metr. t 2023)	ASEAN Share as % of World (2023)	% Growth in Production (2019-2023)	Key Producers
Nickel	2,425,000	3,689,247	65.73%	36.90%	
Tin	106,285	288,806	36.80%	-1.88%	
Bismuth	1,148	10,110	11.36%	11.92%	
Bauxite	14,541,481	390,902,596	3.72%	7.48%	
Tungsten	7,962	83,785	9.50%	-5.71%	
Manganese	535,290	20,226,171	2.65%	-4.44%	
Copper	1,056,710	22,458,973	4.71%	8.85%	
Rare earths	58,250	385,321	15.12%	89.19%	

Source: World Data Mining

As part of access sovereignty, the availability of critical mineral resources is the primary factor in determining whether a country has the capacity to leverage and exercise control over them. In this respect, Southeast Asia holds a strong position.

The data presented above indicates that Southeast Asian countries not only possess abundant critical mineral reserves, but also maintain substantial extraction capacity, enabling them to convert ore into raw materials for subsequent industrial processes.

However, resource endowment and production capacity alone are insufficient to ensure access sovereignty. Effective control requires that minerals be managed under legitimate legal process. This condition does not fully apply in certain cases, such as Myanmar, where rare earth extraction has been conducted by ethnic armed organizations, limiting the central government's effective control over these resources.

Another important consideration is the extent to which critical minerals are domestically utilized and strategically directed. Although several Southeast Asian countries lead in mining output, they do not fully control route and destination of critical minerals. In some cases, external partners that dominate key segments of the global value chain exert significant influence. This dynamic has prompted certain governments to introduce export restrictions in an effort to strengthen domestic control and enhance bargaining power.

3.2. Capability sovereignty

Beyond mineral extraction, Southeast Asia has emerged as an important player in the refining and processing of several locally sourced critical minerals. A number of countries in the region rank among the top five globally in specific mineral processing activities, including Indonesia and Philippines for nickel, Malaysia for rare earth elements, and Vietnam for tungsten. As value addition has become increasingly important to the development of the sector, Southeast Asia's share of global processing and refining capacity for key critical minerals has continued to rise[6].

However, this progress does not necessarily translate into strong capability sovereignty. Capability sovereignty is not defined solely by the existence of processing facilities, but by the ability to transform raw materials into higher-value outputs and to retain technological and industrial control. In practice, the region's current position in refining and processing remains concentrated in lower-value segments of the value chain. For example, although the Philippines processes a significant share of global nickel supply, its facilities primarily produce intermediate mixed sulfide products that must be exported for further refining.

As a result, Southeast Asia continues to export large volumes of unprocessed or semi-processed minerals while importing finished technology products. A substantial proportion of the region's critical mineral output, measured by value, is exported in minimally processed form, with higher-value refining and manufacturing activities largely carried out by external partners. For instance, more than 95% of nickel exports from Indonesia and the Philippines are directed to China, while nearly all exports of manganese, rare earth elements, and tin ores are also sent to China[7]. This pattern of trade leaves the region exposed to intensifying great power competition, which increasingly shapes global critical mineral markets.

Capability sovereignty is further constrained by reliance on foreign technology and ownership. In many Southeast Asian countries, refining capacity has expanded significantly, yet the underlying technology, capital, and operational control are often foreign. Indonesia's nickel smelting sector illustrates this dynamic. Although the country has achieved substantial scale, a large share of its smelting capacity is controlled by Chinese firms, leaving Indonesia dependent on foreign technology and investment. A similar situation can be observed in Malaysia, where a large-scale rare earth separation facility was developed using Australian technology, limiting the extent of domestic technological capability.

With the partial exception of Singapore, which has consistently invested in advanced processing technologies and higher-value segments, most countries in the region remain constrained by limited technological depth, lower value-added production, and continued foreign dependence. These structural factors limit the region's ability to achieve a more robust level of capability sovereignty within the critical mineral value chain.

3.3. Governance sovereignty

Governance sovereignty at the regional level depends on coordinated and collaborative action among countries. While many Southeast Asian states have established national laws, standards, and policy frameworks to regulate or promote their critical mineral sectors, efforts to institutionalize governance at the regional level remain limited.

Regional cooperation on critical minerals in Southeast Asia is primarily structured around the ASEAN Minerals Cooperation Action Plan (AMCAP), which serves as the central framework for aligning mineral sector policies among the ten ASEAN member states (excluding Timor-Leste)[8]. The plan has evolved through several iterations, reflecting the region's efforts to move beyond a fragmented raw material exporter toward becoming a more strategically coordinated and sustainable participant in global mineral supply chains. The core programs under (AMCAP-IV) 2026-2030 focus on trade and investment in minerals, sustainable mineral development, minerals information and databases, and capacity building in materials. However, despite these initiatives, the region still lacks a comprehensive and unified framework, including harmonized standards for sustainable mineral management.

Beyond this regional action plan, ASEAN also engages with external dialogue partners to strengthen technical capacity and diversify mineral supply chains[9]. One key platform is the ASEAN Plus Three (APT) Minerals Cooperation Work Plan (2022–2025), under which China, Japan, and South Korea collaborate with ASEAN on mineral exploration, technical expertise sharing, and the promotion of sustainable mining practices.

At the national level, policy approaches vary considerably depending on each country's resource endowment, industrial ecosystem, and development strategy. Some countries have adopted more assertive resource-nationalist measures, while others prioritize downstream development or technology capability building. Although not all countries have developed comprehensive frameworks covering the full value chain, there has been a visible increase in regulatory and policy attention to strengthening domestic supply chains. Moreover, growing international scrutiny, particularly related to environmental, social, and governance requirements in Western markets, has compelled governments to place greater emphasis on standards addressing issues such as deforestation, pollution, and community impacts.

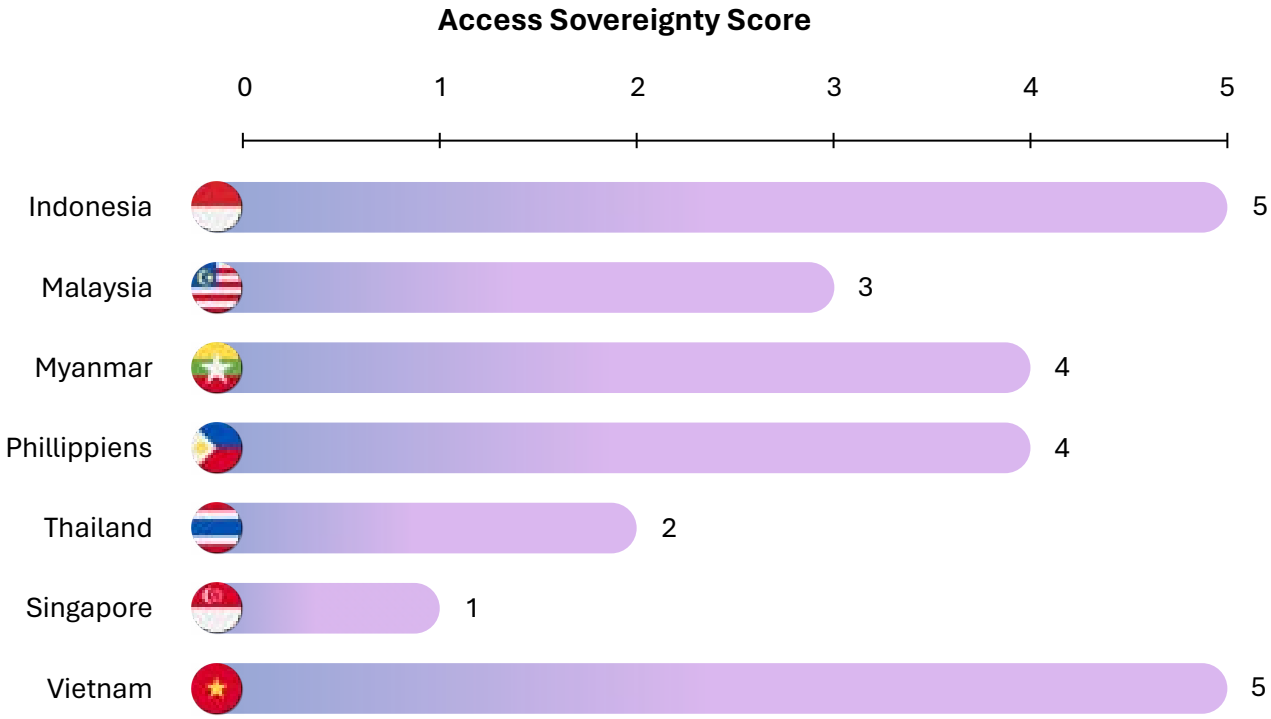
Overall, Southeast Asian countries have not yet achieved a high level of governance sovereignty at either the national or regional level. Nevertheless, incremental progress is evident, with many governments expanding policy instruments, regulatory oversight, and standards in an effort to create a more stable, credible, and competitive environment across the critical mineral value chain.

4 Sovereignty scorecard

Each country in Southeast Asia occupies a distinct and influential position within the regional critical minerals landscape, reflecting differences in resource endowments, strategic approaches, and levels of integration into global critical mineral supply chains. In this report, seven Southeast Asian countries are selected for detailed analysis.

Country	Key Critical Mineral	Refining Industry	Key End-use Industries	Policy and Cooperation
Indonesia 	Nickel	Extensive nickel smelting and refining	EV industry	• Ban nickel ore export • Investment incentives • Bilateral cooperation with UK, US, Australia
Malaysia 	Rare earth elements	Only large-scale rare earth separation facility outside China	EV industry, electronics and semiconductor	• National plan for mineral industry transformation • MoU with US on critical mineral cooperation
Myanmar 	Tin and rare earth elements	Very limited domestic refining	-	• Inconsistent policy and limited regulatory control due to political instability
Philippines 	Nickel	Limited domestic processing capacity	EV Industry	• Executive Order No. 130 lifting mining moratorium • Discussion on nickel export restrictions
Thailand 	Tin, tungsten, now depleted	Limited domestic processing capacity	EV Industry, electronics, renewable energy	• Downstream-focused industrial incentives • MoU with US on critical mineral supply chains
Singapore 	-	High-value processing technologies	Energy transition technology, data centers	• Policy to support supply chain resilience • Investment in advanced technologies
Vietnam 	Rare earth elements, tungsten	Advanced tungsten processing but limited rare earth separation	EV industry, electronics	• Ban export of unprocessed rare earth elements • Long-term mineral development strategy • Partnership with US

From an **access sovereignty** perspective, Indonesia and Vietnam dominate the region due to their abundance of critical mineral resources. These countries are not only leading reserve holders or producers of key strategic minerals—nickel in the case of Indonesia, and tungsten and selected rare earth elements in the case of Vietnam—but also possess relatively diversified portfolios of other critical minerals. More importantly, both countries exercise strong control over access to their resources through export restrictions, including Indonesia's ban on nickel ore exports and Vietnam's ban on unprocessed rare earth ores. These measures place both countries in a strong position in terms of access sovereignty.

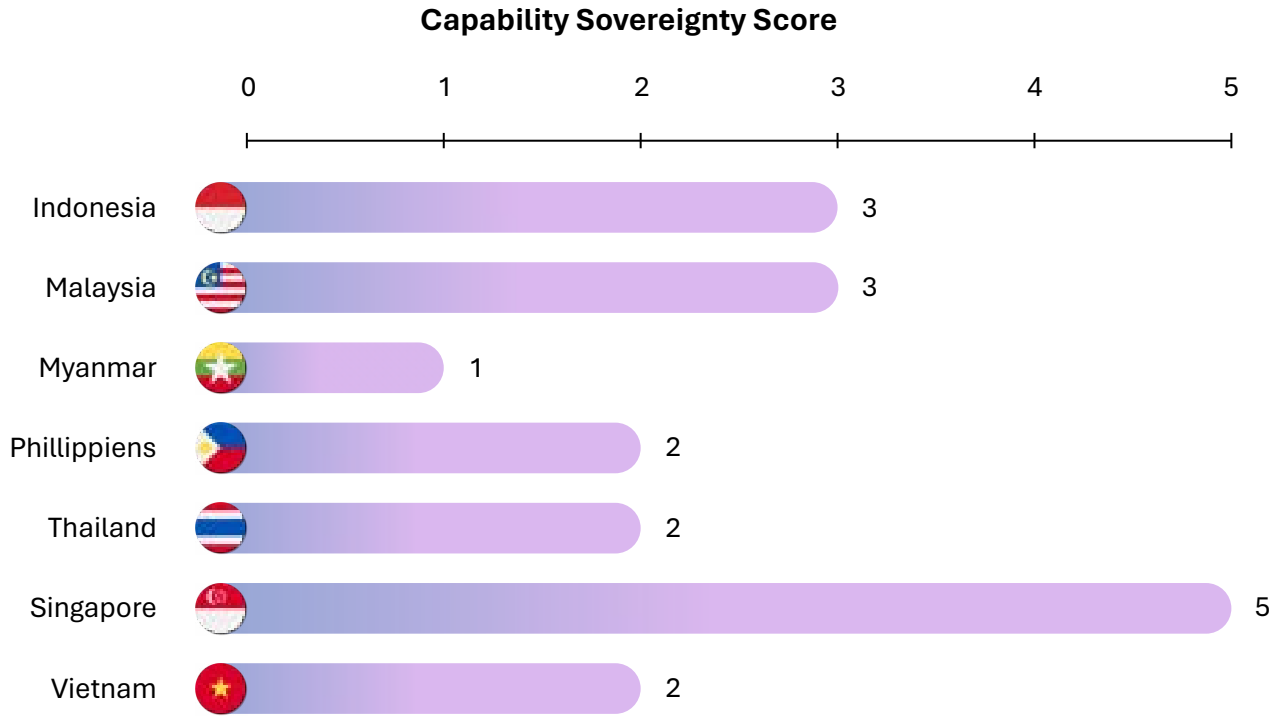


Despite the fact that a large share of its critical mineral production takes place outside effective central government control, Myanmar holds proven deposits of rare earth elements, making it a leading producer at the regional level and, in some cases, even at the global level in the current landscape. The Philippines is also a notable player, particularly as a major nickel producer, and it holds substantial reserves of several raw minerals. Although the Philippines has explored the possibility of imposing export restrictions on raw ores, strong domestic opposition has prevented effective implementation. As a result, its level of access sovereignty remains weaker than that of Indonesia.

Malaysia previously held a prominent position in global tin production, but this role has largely diminished as resources have become depleted. Nevertheless, the country still holds significant estimated rare earth deposits, which remain largely undeveloped. This resource potential provides Malaysia with continued relevance in the global critical minerals landscape and creates opportunities for the country to reposition itself as a regional leader in the future.

Thailand has similarly seen a decline from its former leadership in tin and tungsten production following extensive exploitation in the past. While some mining capacity remains, it is limited compared to that of neighboring countries. Singapore, due to its small geographic size, has no domestic reserves of critical minerals and is therefore highly dependent on imports, resulting in minimal access sovereignty in this domain.

In terms of **capability sovereignty**, Singapore stands at the forefront among Southeast Asian countries. While Singapore does not possess large-scale capacity in traditional mineral refining or processing, it has developed strengths in advanced and specialized technologies, including rare earth separation, lithium refining, and advanced materials purification. This positions Singapore as a technology provider within the critical minerals value chain, allowing it to retain a degree of sovereignty through control over high-value technological capabilities rather than through ownership of raw materials.



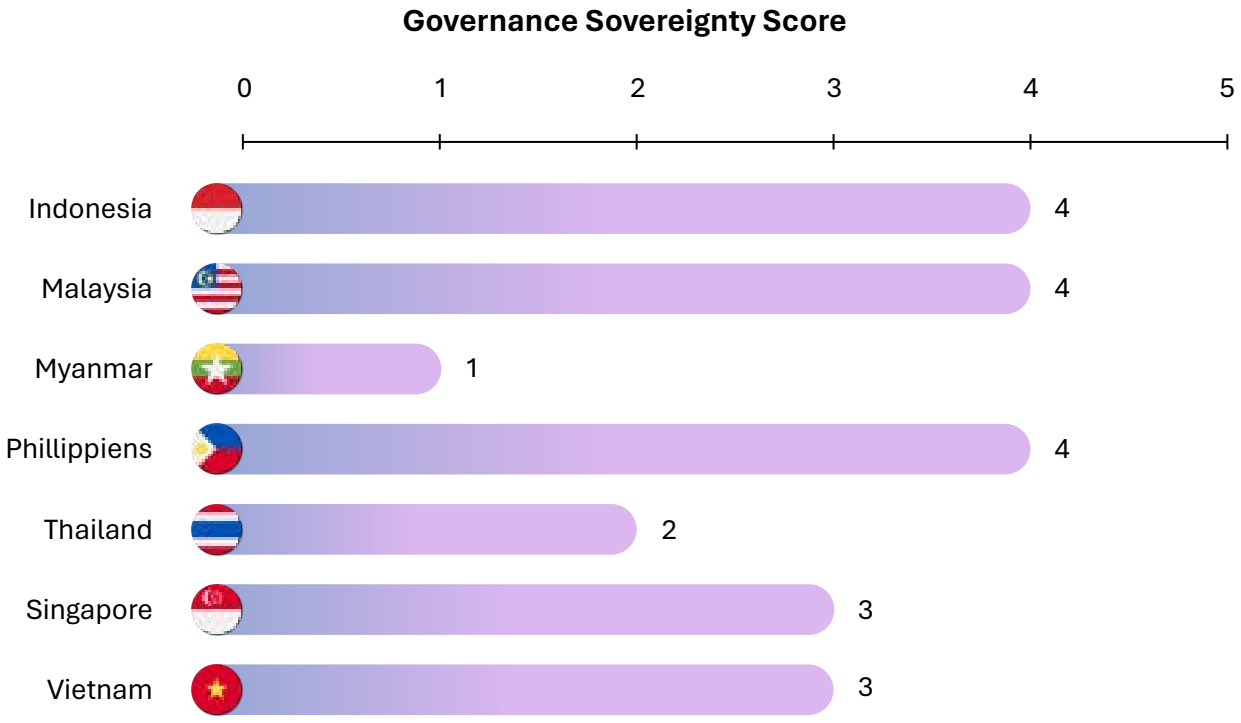
Malaysia and Indonesia exhibit similar characteristics in terms of refining and processing capacity, though at different scales. Indonesia leads the region by a wide margin, hosting around 50 nickel smelters, positioning the country as the world's largest producer of processed nickel products. Malaysia also plays a distinctive role through its rare earth separation facility, the largest such operation outside China, making it a critical node in efforts to diversify global supply chains. However, a key concern in both countries' models is their heavy reliance on foreign technology: Chinese technology and firms dominate Indonesia's nickel processing sector, while Australia-based technology underpins Malaysia's rare earth operations.

In Indonesia's case, the high degree of Chinese ownership over smelting capacity limits full capability sovereignty. Malaysia presents a somewhat different scenario, as although its flagship facility is owned by a foreign firm, it nonetheless demonstrates the feasibility of cultivating advanced processing capacity within the region under supportive policy and regulatory conditions.

For the Philippines, Thailand, and Vietnam, technological capabilities and midstream production capacity remain relatively modest. These countries possess limited domestic processing technologies for critical minerals and operate only a small number of facilities. Among them, Vietnam stands out for its long-term potential. Given its significant rare earth reserves, Vietnam has opportunities to develop strategic, specialized, and high-capacity processing projects in selected segments of the value chain.

Finally, Myanmar presents a clear gap in capability sovereignty. Despite being a leading producer of rare earth ores, the country lacks domestic processing capacity. As a result, rare earth materials are exported in raw or semi-processed forms, preventing Myanmar from capturing value through downstream processing and limiting its ability to build technological capability within the critical minerals sector.

Governance sovereignty plays a critical role in shaping a conducive environment for the development of the critical minerals sector and in determining how effectively value chains operate, particularly over the long term. At present, no country in Southeast Asia has fully established a comprehensive framework or unified standards for the sustainable management of critical minerals. Regional efforts are still evolving under the ASEAN Minerals Cooperation Action Plan 2026-2030, and as a result, Southeast Asian countries have not yet achieved a high degree of governance sovereignty in this domain.



Within the region, Indonesia and Malaysia are relatively more advanced in terms of governance sovereignty. Both countries have implemented clear domestic policies and regulatory frameworks to support the critical minerals sector, including strategic plans, targeted investment incentives for mineral processing and downstream industries, and active engagement at international level. These measures reflect a more deliberate effort to position themselves within global critical mineral supply chains and to exercise greater policy control over sector development.

The Philippines, Singapore, and Vietnam are in the midst of transitioning their policy frameworks to better align with changing global conditions. These countries have introduced dedicated domestic policies and regulations and are increasingly focusing on strengthening the broader supply chain, encompassing not only critical minerals but also research and development and end users industries. While some policies and regulatory measures remain under discussion, these efforts signal a clear intention to move forward.

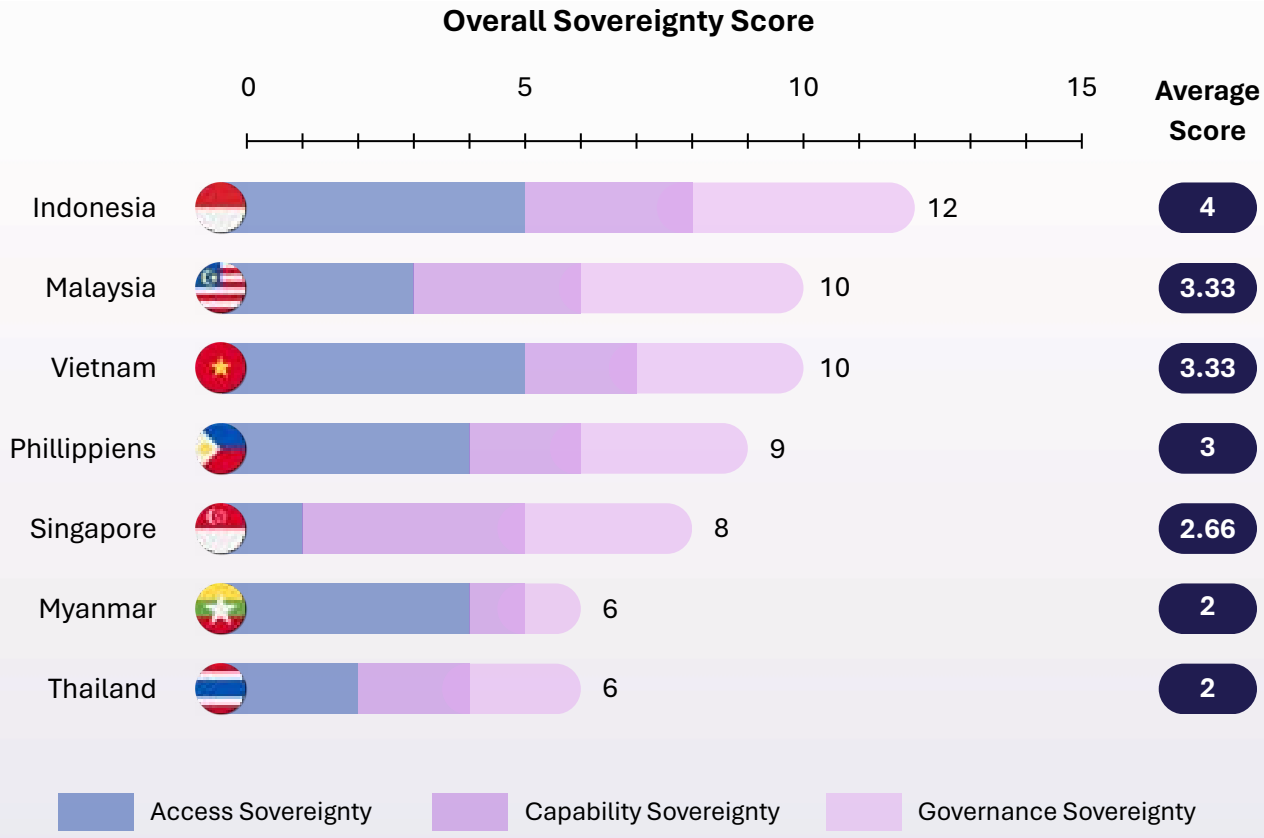
Thailand does not yet have a comprehensive policy framework directly targeting the critical minerals industry. Instead, Thailand's policy focus remains concentrated on downstream and end-use industries. This approach limits the country's engagement in mineral production and processing and, consequently, constrains its sovereignty in the critical minerals sector.

Myanmar illustrates how weak governance can undermine resource potential. Ongoing political instability and internal conflict have severely constrained the country's ability to control and regulate its abundant mineral resources. As a result, Myanmar has been unable to leverage its resource endowment to become a genuine and influential player in shaping or navigating global critical mineral supply chains.

When the scores across the three domains are considered together, the combined results provide an overall picture of critical mineral sovereignty among Southeast Asian countries. Indonesia emerges with the highest level of sovereignty in the region, supported by strong access to resources, competitive processing and manufacturing capabilities, and relatively advanced governance frameworks.

Malaysia and Vietnam follow Indonesia, reflecting their increasingly established positions across the value chain, particularly in processing capacity and policy development. Singapore, despite its limited access to domestic mineral resources, maintains a solid level of sovereignty through advanced technological capabilities and a proactive, forward-looking policy environment.

By contrast, Thailand and Myanmar lag behind other countries in the region. Strengthening their positions will require more focused efforts in specific domains, particularly in building processing capacity, strengthening governance, and improving integration into higher-value segments of the global critical mineral supply chain. Thailand, for example, although it may have missed the opportunity to build significant processing capacity, has instead developed a more advanced, downstream-oriented economy through targeted industrial policies, particularly in the automotive sector. This reflects the country's alternative effort to integrate itself into global supply chains.



However, it is important to note that a lower sovereignty score does not necessarily mean that a country cannot secure access to critical mineral supply chains or develop industries that rely on these materials as inputs. Countries may adopt alternative pathways to integrate into global value chains and maintain industrial competitiveness.

Singapore provides a useful example. Due to its limited natural resource base and geographic constraints, achieving full sovereignty across all dimensions of the critical mineral value chain is inherently challenging. Nevertheless, Singapore leverages trade openness, international partnerships, and strategic policy frameworks to ensure stable access to critical minerals required by its domestic industries. Through this approach, the country is able to remain competitive within global supply chains despite structural limitations in resource ownership or extraction capacity.

5 Driving factors and challenges for Southeast Asia

As major economies compete to secure stable access to strategic minerals, Southeast Asia increasingly finds itself at the center of intensifying geoeconomic competition. In this context, sovereignty reflects a country's ability to exercise control over its resources and industrial development pathways without being structurally constrained by external powers. Strengthening sovereignty therefore requires not only enhanced national capacity, but also deeper regional coordination, allowing Southeast Asia to act collectively rather than remaining fragmented within an increasingly competitive global landscape.

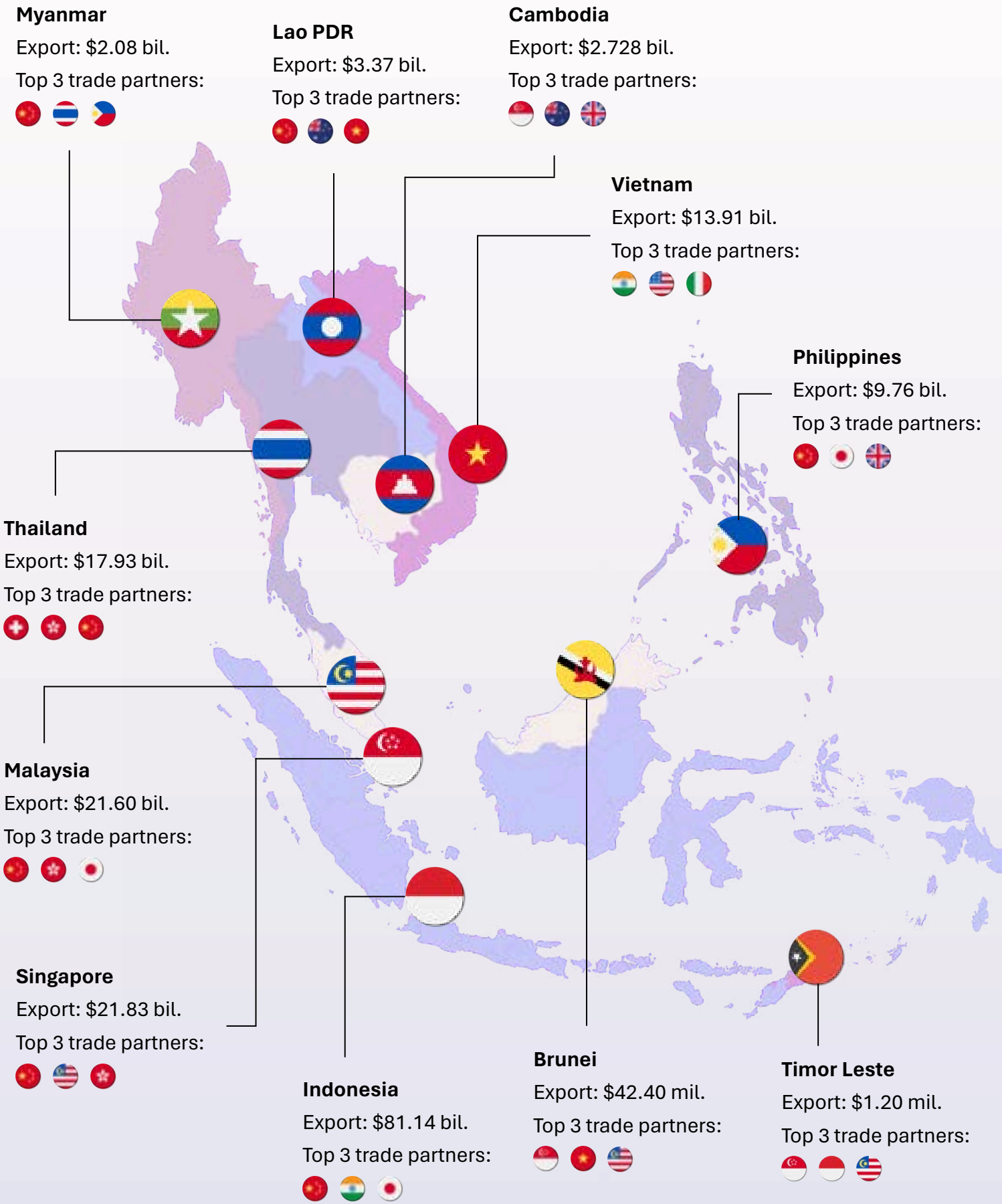
5.1 Driving factors for the critical mineral sector in Southeast Asia

As both a source of raw materials and a potential hub for processed mineral outputs, the region plays a distinctive role as a competitive supplier in the global market. It is widely recognized by the international business community as a key growth region and an attractive destination for supply chain diversification.

This role has become even more pronounced amid intensifying US–China trade tensions, which have created a more complex operating environment for countries heavily dependent on major powers. These geopolitical dynamics have accelerated the reconfiguration of global critical mineral supply chains, positioning Southeast Asia as a focal point for alternative and diversified sourcing strategies. In 2023, exports of critical minerals from Southeast Asian countries totaled approximately US$174.4 billion, accounting for around 6.9% of global exports[10]. Beyond intra-regional trade, the region's key trading partners include China, India, Japan, and Australia.

At the same time, structural shifts in the global economy are further increasing demand for critical minerals, reinforcing Southeast Asia's attractiveness as a key supplier within evolving global supply chains. As countries worldwide commit to climate targets, including achieving net-zero emissions by 2050[11], there is a rapid shift toward EVs, solar power, and wind energy. These industries require substantial quantities of nickel, cobalt, copper, and rare earth elements. With the global clean energy market projected to triple to more than US$ 2 trillion over the next decade[12], demand for critical minerals is expected to surge at an unprecedented pace.

Southeast Asia's Trade in Critical Minerals



Myanmar
Export: $2.08 bil.
Top 3 trade partners:

Lao PDR
Export: $3.37 bil.
Top 3 trade partners:

Cambodia
Export: $2.728 bil.
Top 3 trade partners:

Vietnam
Export: $13.91 bil.
Top 3 trade partners:

Philippines
Export: $9.76 bil.
Top 3 trade partners:

Thailand
Export: $17.93 bil.
Top 3 trade partners:

Malaysia
Export: $21.60 bil.
Top 3 trade partners:

Singapore
Export: $21.83 bil.
Top 3 trade partners:

Indonesia
Export: $81.14 bil.
Top 3 trade partners:

Brunei
Export: $42.40 mil.
Top 3 trade partners:

Timor Leste
Export: $1.20 mil.
Top 3 trade partners:

Another major factor underpinning demand for critical minerals is digital transformation. The expansion of digital technologies, particularly artificial intelligence and cloud computing, has increased the need for specialized infrastructure capable of continuous, high-intensity processing, most notably data centers. As these large-scale facilities require extensive systems for data storage, cooling, and power supply, critical minerals are essential throughout their construction and operation. In addition, data centers depend on robust and resilient power systems, which in turn rely on critical minerals for grid development and energy storage.

Southeast Asia has emerged as a key destination for hyperscale data center investment, driven not only by major technology firms such as Amazon, Google, Microsoft, and Meta, but also by growing participation from regional and domestic companies. With an estimated 330 data centers in January 2026[13] and further growth anticipated, the region faces growing pressure to strengthen its role in global critical mineral supply chains to ensure sufficient and reliable inputs for these industries.

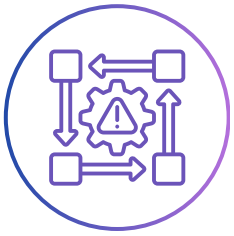
5.2 Key challenges shaping the regional critical mineral landscape

The opportunities facing Southeast Asia are accompanied by significant risks that could undermine the region's critical minerals trajectory. Environmental challenges represent one of the most pressing concerns, affecting both mineral extraction and processing. The expansion of critical mineral mining can be associated with deforestation, hazardous waste disposal, water contamination, and other long-term environmental and social impacts. These risks are further exacerbated in contexts characterized by regulatory uncertainty and weak governance.

Environmental issues

Myanmar illustrates these challenges clearly. Rare earth element mining in Kachin State, in northern Myanmar, has raised serious environmental concerns, as much of the activity is unregulated. In the absence of effective enforcement, mining operations have resulted in severe environmental and public health consequences, extending beyond local communities to neighboring countries such as Thailand, which has experienced toxic water spillovers originating from mining activities upstream[14]. As global demand for critical minerals increases, Southeast Asian producers will also face mounting pressure to comply with stricter ESG standards imposed by Western buyers, requiring substantial adjustments to meet internationally accepted benchmarks.

External dependence



Beyond environmental and governance risks, the region's critical minerals sector is also shaped by structural dependence on external actors. Despite Southeast Asia's position as a source of critical minerals, the region remains heavily dependent on external actors for processing and downstream activities. In Indonesia, for example, efforts to expand domestic refining capacity have attracted large-scale investment, yet much of this capacity remains controlled by Chinese firms, and a significant share of output is exported to China for further downstream processing. A similar pattern is evident in Myanmar, where rare earth production is largely oriented toward export with minimal domestic value addition.

5.3 Southeast Asia under Pathways to a Sustainable Critical Mineral Future

As critical minerals have become strategic inputs for future industries, they are increasingly important not only for Southeast Asia but also for major economies around the world. As demand continues to rise, the region is attracting growing attention from external powers seeking stable access to these resources. This trend risks reinforcing Southeast Asia's position as a focal point of strategic competition and geopolitical tension within the global critical minerals landscape.

Engagement from major powers has taken multiple forms. The United States has pursued trade agreements and cooperation initiatives to support the development of critical mineral industries in selected partner countries such as Malaysia, while China has expanded its presence primarily through investment and project financing, particularly in refining and processing industries such as those in Indonesia. These dynamics have enabled several Southeast Asian countries to develop meaningful refining and processing capacity. However, much of this expansion remains dependent on foreign technology, capital, and ownership structures.

These dynamics not only intensify geoeconomic pressure on the region, but also weaken Southeast Asia's capacity to influence pricing, enforce ESG standards, and pursue technological upgrading. In this context, countries in the region need to think carefully about how to position themselves within the global critical minerals landscape and how to respond to growing external competition without losing control over their long-term industrial development pathways.

Sovereignty is one important strategy in this regard. Greater control over resources and industrial development can help countries maintain competitiveness and reduce the risk of excessive dependence on external actors. However, pursuing sovereignty does not mean that countries should aim for complete self-sufficiency. Attempting to localize the entire value chain within national borders may not always be efficient or optimal, especially given the diversity of national resource endowments, industrial structures, and economic priorities across Southeast Asia.

However, given the wide differences among Southeast Asian countries, regional coordination can play an important role in strengthening positions at the regional level. By working together, Southeast Asian countries can build greater collective negotiating power when engaging with major powers and respond more effectively to external pressures. At the same time, regional coordination can strengthen Southeast Asia's overall position by allowing countries to leverage one another's strengths and pursue a more complementary and resilient approach to critical mineral development.

6 Policy recommendations

Critical minerals are increasingly important not only because of the value created along their own supply chains, but also because they serve as foundational inputs for the broader technology stack. For Southeast Asia, the development of the critical mineral sector is not only a matter of resource management, but also a strategic issue tied to the region's long-term position in industrial advancement.

At the regional level, through ASEAN, or bilateral or multilateral partnerships, Southeast Asia can consider the following to build greater sovereignty and control over future industrial pathways:

1. **Elevate critical minerals as a regional priority and strengthen coordinated action**
   Southeast Asian countries should place critical minerals more prominently on the regional agenda. The ASEAN Minerals Cooperation Action Plan 2026–2030 can serve as a key foundation, but its implementation should place greater emphasis on critical mineral development across the value chain. Rather than pursuing uniform approaches, ASEAN should allow flexibility for countries to develop based on their respective strengths, while establishing coordination mechanisms that align national strategies and reinforce the region's collective position in global supply chains. Strengthening regional connectivity across the critical mineral value chain should also be prioritized by reducing barriers to cross-border flows of investment, finance, inputs, and mineral products. Policies such as the G7 Critical Minerals Action Plan, which highlights the importance of building a 'standards-based market', can be used as a reference to strengthen coordination mechanisms. In this context, ASEAN can play a convening and coordinating role to help member states leverage their complementary advantages, whether in resource endowment, processing capacity, technology, or market demand.

2. **Adopt standards and a regional traceability system**
   Rather than developing entirely new standards from scratch, Southeast Asia should align its critical mineral governance framework with internationally recognized standards and due diligence approaches. This could include drawing on relevant frameworks such as ISO/TC 298 for rare earths mining, ISO/TC 333 for lithium mining, the OECD Due Diligence Guidance for Responsible Mineral Supply Chains, and other recognized assurance mechanisms for responsible mining.

Referencing such standards would help ensure that critical minerals produced and processed in the region are more readily accepted in global markets, particularly those with stringent compliance requirements. In parallel, Southeast Asia should strengthen efforts to establish a regional traceability system to track critical minerals across the value chain. The steps outlined in The Role of Traceability in Critical Mineral Supply Chains, developed by the IEA and OECD, can serve as a useful reference for ASEAN in setting up a framework that improves transparency, supports responsible sourcing, and builds greater trust with international partners. At the same time, standards alone will not be sufficient without stronger oversight and enforcement. ASEAN member states therefore need to enhance monitoring systems, improve regulatory oversight, and ensure more consistent implementation at the national level.

3 **Invest in critical mineral technologies**

Advancing capability sovereignty requires the development of homegrown expertise and technological capacity. Southeast Asian governments should place greater emphasis on midstream and downstream development through technological innovation, to complement extraction. Strategic partnerships with technologically advanced economies such as Australia, Japan, South Korea, the European Union, and the United States can support this effort. These partners are actively seeking diversified critical mineral supply chains and are investing in resilience across the value chain. However, such cooperation should be structured around mutual benefit rather than dependency, ensuring that Southeast Asian countries remain in the driver's seat as co-developers, rather than technology adopters. In parallel, Southeast Asian countries could jointly establish a regional institute for critical mineral research and development. This institution could focus on addressing key technical challenges, including environmentally sustainable nickel refining, advanced rare earth separation techniques, and recycling technologies for battery metals. Models such as the U.S. Critical Materials Innovation Hub, the Australian Critical Minerals Research and Development Hub, and Canada's Critical Minerals Centre of Excellence can be examined and adapted to fit the regional context. For ASEAN, Singapore could play a leading role in this initiative, given its strengths in research, innovation policy, and advanced technological development.

Bringing these efforts together, Southeast Asian countries can move beyond fragmented national approaches toward a more coherent and resilient regional strategy, enabling the region to exercise greater control over its critical mineral resources and strengthen its position within the global technology and supply chain landscape.

Appendix: Key country snapshots

Indonesia

Indonesia is the powerhouse of critical minerals in Southeast Asia, based on vast resource endowments and an assertive strategy to move up the value chain. The country holds the world's largest nickel reserves, estimated at around 55 million tons[15] and is also the largest global producer, accounting for approximately 55% of global nickel output[16]. Beyond nickel, Indonesia possesses significant deposits of cobalt, bauxite, tin, copper, and gold.

In addition to its resource abundance, Indonesia has aggressively expanded its processing and refining capacity, particularly in the nickel sector. A large number of nickel smelters producing nickel pig iron, ferronickel, and battery-grade nickel matte have been developed across the country. By 2025, Indonesia hosted nearly 50 nickel smelters nationwide[17], many of which are financed and operated in partnership with Chinese firms. It is estimated that around US$65 billion in investment from China has flowed into Indonesia over the past decade[18], with approximately 75% of the country's nickel smelting capacity controlled by Chinese companies[19]. Indonesia is now among the few countries capable of producing battery-grade nickel sulfate and nickel matte domestically. More than one million tons of nickel products are exported annually, with over 90% destined for China. The dominant positions of Indonesia and China in the nickel market have led some observers to describe them collectively as the "OPEC of nickel[20]."

The Indonesian government has actively pursued resource nationalist policies to convert mineral wealth into broader industrial development. In the nickel sector, a ban on raw nickel ore exports was imposed in 2020[21] to compel domestic smelting and downstream processing. This policy has played a central role in attracting billions of dollars in investment in domestic nickel processing facilities. These efforts are part of Indonesia's broader strategy to establish an integrated electric vehicle (EV) battery supply chain, spanning mining, refining, and cell manufacturing. As a result, much of the nickel and associated minerals such as cobalt refined in Indonesia is directed toward battery cathode materials, serving both domestic EV production and export markets[22]. In addition to export restrictions, the government has introduced supporting measures, including tax holidays, reduced royalty rates, and streamlined permitting processes for mineral processing projects and downstream industries, to advance its ambition of building a comprehensive domestic supply chain.

Beyond its close investment ties with China, Indonesia has also sought to diversify international partnerships in the critical minerals sector. The country has signed strategic cooperation agreements with the United Kingdom[23], Australia (Northern Territory)[24], and the United States[25]. These partnerships aim to strengthen Indonesia's critical minerals ecosystem through cooperation on investment in mining activities, trade arrangements, skills development, and the promotion of sustainable practices across the mineral value chain.

Malaysia

Malaysia plays a specialized role in the critical minerals sector as a former major producer and an emerging refining and processing hub. Historically, Malaysia was a leading global tin producer and gained international prominence during the 20th century. Although domestic tin output has declined as deposits have been depleted, the country remains among the world's top producers, ranking approximately 11th globally[26]. Other remaining mineral resources include bauxite, as well as smaller deposits of gold, copper, and iron.

Nowadays, Malaysia's most distinctive role lies in rare earth processing. The country is estimated to hold around 16 million tons of rare earth deposits[27]. More importantly, Malaysia hosts the only large-scale rare earth separation facility outside China, operated by Lynas Corporation. This facility processes approximately 12-15% of global rare earth output[28], positioning Malaysia as a critical value-added processor and trading hub rather than a major exporter of raw ore. Through this role, Malaysia acts as a key link between resource-rich countries and downstream manufacturers of advanced products.

Malaysia has continued to strengthen its position within the critical minerals supply chain through targeted investment and international cooperation. In late 2025, Lynas Rare Earths and JS Link signed an agreement to develop a RM 600 million (approximately US$142 million) rare earth magnet manufacturing facility in Pahang, the largest state in Peninsular Malaysia. This project aims to expand domestic processing capacity and further reinforce Malaysia's role in the rare earth value chain[29]. In addition, Malaysia is currently in discussions with the Japan International Cooperation Agency (JICA) regarding an assistance program for rare earth mining and refining. Once agreed upon, this collaboration is expected to provide Malaysia with technical expertise and technology transfer, while Japan would receive priority access to rare earth shipments from Malaysia[30].

Downstream end-use industries in Malaysia are also relatively well-developed. The country has a strong electronics and semiconductor manufacturing base that relies on advanced materials processing.

In parallel, Malaysia has promoted EV assembly, EV battery manufacturing, and renewable energy development through targeted investment incentives. These industries generate sustained demand for critical minerals and contribute to the formation of a more complete domestic critical mineral supply chain.

National policy has played an important role in shaping Malaysia's critical minerals strategy. The National Mineral Industry Transformation Plan 2021-2030 identifies rare earth elements and metallic minerals as priority growth areas. Malaysia has also actively expanded international partnerships. In late 2025, Malaysia and the United States deepened cooperation through two agreements: the Agreement on Reciprocal Trade (ART) and a Memorandum of Understanding on Critical Minerals Cooperation, the latter aimed at promoting trade and investment across the full spectrum of critical mineral activities[31].

Myanmar

Myanmar is a vital source of critical minerals, but political turmoil has weakened centralized governance, resulting in fragmented control over resource extraction. The country is particularly rich in tin and heavy rare earth elements. Myanmar ranks as the third-largest tin producer, following China and Indonesia, supplying more than 14% of global tin output in 2023[32]. Over the past decade, it has also emerged as the world's second-largest source of rare earth ores, accounting for approximately 14% of global production in 2023[33], second only to China. In addition, Myanmar hosts significant deposits of antimony, nickel, and copper.

Since the military coup in February 2021, Myanmar has faced international sanctions, civil conflict, and the withdrawal of many Western companies, exacerbating a governance vacuum in parts of the mining sector. Key rare earth and tin mining areas, particularly in Kachin State and Shan State, lie outside effective control of the central government and are administered by ethnic armed organizations[34]. As a result, critical minerals in these regions are often informally produced and traded through cross-border channels, with China serving as the primary destination. Despite Myanmar's unstable political environment, the volume of critical minerals originating from the country continues to exert a significant influence on global supply conditions and price dynamics, particularly for tin and rare earth elements.

Beyond mining and extraction, Myanmar has very limited domestic refining capacity. In the tin sector, DS Myanmar Company Limited operates a tin smelter southeast of Yangon, producing refined tin at 99.99% purity[35]. Wa State, the country's largest tin-producing area, near the Chinese border, remains outside central government control.

As there are no smelting facilities in Wa State, nearly all mined tin is transported across borders for processing in China, Thailand, or Malaysia[36]. A similar pattern applies to rare earth elements, as Myanmar lacks domestic separation facilities; all mined clay concentrates are exported to China for processing.

Myanmar's domestic industrial base remains underdeveloped, resulting in minimal internal demand for critical minerals. Prolonged political instability and ongoing conflict have also limited the government's ability to implement and enforce mineral sector policies across much of the country. As a result, effective regulation and formalization of the critical minerals sector remain highly constrained, with meaningful progress dependent on the restoration of peace and legitimate governance.

Philippines

The Philippines is a resource-rich player in the critical minerals sector. It is a major global source of nickel, ranking second only to Indonesia in terms of production. The country holds an estimated 4.8 million tons of nickel reserves and produced approximately 340,000 metric tons of nickel in 2023[37], accounting for around 10% of global output. Following Indonesia's ban on nickel ore exports, the Philippines became the world's largest exporter of nickel ore. In addition to nickel, the country is a significant supplier of cobalt as a by-product of nickel mining and possesses substantial reserves of copper, gold, and chromite, reinforcing its position as an export-oriented producer of raw minerals.

Despite this strong resource base, the Philippines has limited domestic processing capacity for critical minerals. Currently, the country hosts two major high-pressure acid leach (HPAL) facilities, operated by Coral Bay Nickel Corp. and Taganito HPAL Nickel, both of which are partially owned by Nickel Asia Corporation[38]. These facilities do not produce refined nickel metal domestically; instead, they produce intermediate mixed sulfide products of nickel and cobalt that are shipped overseas for final refining. In the copper sector, the Philippines has only one copper smelter and refinery, operated by Philippine Associated Smelting and Refining Corporation (PASAR), located in Leyte, Eastern Visayas region[39].

The Philippines remains a critical link in global supply chains due to the sheer volume of nickel and other critical minerals it exports to major industrial economies such as China and Japan. However, the country has so far captured limited domestic development benefits from this position. Constraints are evident not only in processing and refining capacity but also in downstream industries, including electric vehicles, defense, and semiconductors, where manufacturing activity and market size remain limited. In the absence of strong domestic demand, most critical minerals continue to be exported to countries with more advanced industrial ecosystems.

In an effort to promote value-added industrialization, Philippine policymakers have begun exploring strategies to move up the value chain. In 2021, President Rodrigo Duterte signed Executive Order No. 130, lifting the moratorium on new mining agreements and allowing the approval of new projects to expand the production of nickel, copper, and other minerals[40]. The government has also considered policy options similar to Indonesia's approach, including the introduction of higher taxes or potential bans on raw ore exports, particularly for nickel[41]. Although a Senate bill proposing a ban on nickel ore exports by 2027 initially gained traction, it faced strong opposition from mining industry groups. This ongoing policy debate has contributed to uncertainty surrounding the future direction of the Philippines' critical minerals sector.

Thailand

Thailand's role in the critical minerals sector is relatively limited in terms of production. Historically, the country was a leading global exporter of tin and tungsten during the late 19th century, with key mining areas concentrated in the northern region for tungsten and the southern peninsula for tin. Despite its strong position during that period, most minerals were exported in the form of raw ore or concentrates due to the absence of sufficient domestic processing facilities to produce intermediate products. Following the closure of most mines and smelters after the mid-1980s, Thailand's engagement in the production and export of critical minerals has declined significantly[42].

However, Thailand's ambition to position itself as a manufacturing hub in Southeast Asia, particularly for EVs, electronics, and renewable energy technologies, has increased its demand for critical minerals and pushed the country to integrate into global supply chains primarily as an end user. Rare earth elements are among Thailand's key strategic interests. Nonetheless, there is no commercial rare earth mining in the country, and existing reserves are limited and insufficient to meet domestic demand. Thailand also lacks commercial-scale midstream processing facilities, resulting in heavy reliance on imports of intermediate mineral products for use by downstream industries[43].

Imported rare earth intermediate products are used in the production of metals and magnets, which are either consumed domestically or re-exported. While key sectors, such as the EV industry, continue to depend heavily on imported critical components, including battery cells, battery materials, and rare earth magnets, Thailand has begun to play a more significant role in downstream activities by expanding domestic value-added processing[44].

Notably, in late 2025 Thailand signed a memorandum of understanding on critical mineral supply chains with the United States, aimed at strengthening trade and investment in critical mineral-related activities. The cooperation framework focuses on the development of processing technologies and the assessment of Thailand's potential as a source of rare earth elements, reflecting the country's ambition to enhance its position within regional and global supply chains[45]. Beyond this bilateral initiative, Thailand's broader policy framework does not directly target critical minerals development but instead supports downstream demand through incentives for EV manufacturing, renewable energy investment, and data center development.

Singapore

While Singapore has no domestic mineral reserves, it plays an important role in the regional critical minerals value chain due to its strengths as a financial center, logistics hub, and high-technology research and development base. Singapore serves as a vital hub for the trading, refining, and distribution of precious and base metals that are essential for electronics, renewable energy technologies, and EV batteries. It also provides key supporting services, including transit storage, quality testing, and trade financing, which are critical to mineral flows across Southeast Asia.

In addition, Singapore plays a strategic role in the processing of high-technology materials used in batteries and electronics. Rather than acting as a raw material exporter, the country contributes to the value chain through high-value technological capabilities. This includes the export of specialized equipment and technologies used in rare earth separation, lithium refining, and advanced materials purification[46].

As Singapore accelerates its push toward advanced industries, particularly in support of the energy transition and its ambition to strengthen its position as a semiconductor manufacturing hub, demand for critical minerals is expected to rise significantly. Given its heavy reliance on imported minerals, supply chain security has become a strategic priority. Beyond engaging with mineral-rich countries to secure stable and reliable access to critical minerals, Singapore has placed strong emphasis on research and development. By investing in materials science, recycling technologies, and alternative materials, Singapore aims to enhance supply chain resilience and reduce its exposure to global supply disruptions[47].

Vietnam

Vietnam is emerging as an important player in the critical minerals landscape, supported by significant resource endowments and a growing industrial base. The country possesses a diverse portfolio of critical minerals, most notably rare earth elements (REEs) and tungsten. Within Southeast Asia, Vietnam holds some of the region's largest rare earth deposits, with estimated reserves of approximately 3.5 million tons of rare earth oxide (REOs)[48]. At the same time, it is the world's second-largest tungsten producer after China, accounting for around 9% of global output in 2023[49]. In addition, Vietnam produces manganese and titanium and has more limited deposits of nickel and copper.

Vietnam's tungsten refining capacity is relatively advanced compared to other segments of its critical mineral sector. Masan High-Tech Materials operates the Nui Phao mine and owns advanced downstream processing facilities following its acquisition of H.C. Starck. These facilities enable the conversion of raw ore into approximately 13,300 tons of high-value tungsten products annually[50]. In contrast, rare earth processing capacity remains limited. Vietnam is currently able to produce mixed REE concentrates but lacks the separation facilities required to achieve the 95% purity standards needed for individual rare earth oxides used in advanced applications[51].

The development of Vietnam's critical mineral sector is closely linked to the needs of its electronics manufacturing base and its emerging electric vehicle industry. However, several critical minerals essential to these industries, including nickel, cobalt, and lithium, are not yet produced domestically. In addition, key downstream components such as rare earth magnets, tin solder, and tungsten-based components are largely imported, as domestic mineral resources are still primarily exported or utilized in raw or semi-processed form.

To prioritize domestic value addition, the government has issued the Geological, Mineral, and Mining Industry Development Strategy to 2030, with a vision extending to 2045. Vietnam has also strengthened its policy framework through legal reforms. The 2024 Law on Geology and Minerals reinforces state control over mineral resources as public assets and prohibits the export of unprocessed rare earth ores[52]. This measure signals Vietnam's intent to retain more value domestically while attracting investment in downstream processing. At the international level, Vietnam has expanded cooperation through initiatives such as the US-Vietnam Comprehensive Strategic Partnership, which includes technical cooperation to assess and quantify Vietnam's supply of strategically important minerals, particularly rare earth elements[53].

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