LATIN AMERICA'S ENVIRONMENTAL POLICIES IN GLOBAL PERSPECTIVE

*This series explores the international dimensions of Latin America's environmental challenges and the role of environmental issues in shaping the region's most important diplomatic and economic relationships.*

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# Mining Our Way Out of the Climate Change Conundrum? The Power of a Social Justice Perspective

By Jewellord Nem Singh

*"Today's mineral supply and investment plans fall short of what is needed to transform the energy sector, raising the risk of delayed or more expensive energy transitions."*

International Energy Agency (2021)[1]

On February 24, 2021, President Joe Biden signed the Executive Order on America's Supply Chain, which sought a broad review of the United States' increasing dependency in securing critical raw materials to sustain both its clean energy transition and strategic techno-military industrial complexes.[2] Biden's executive order came at the juncture of growing US-China tensions commencing from the trade war with China under the Donald Trump administration, the overwhelming demand from global civil society to respond to the climate crisis, and crucially, the disruption of major supply chains as a result of the COVID-19 pandemic. In 2017, former President Trump signaled the vulnerability of the US economy and national security toward foreign suppliers. He issued Executive Order 13817, which outlines the degree to which the United States has been heavily

Photo credit: Aerial view of enormous copper mine in Phalaborwa, South Africa: Mark Schwettmann, Shutterstock

Wilson Center | Latin American Program | Brazil Institute | Environmental Change and Security Program | Global Europe Program | China Environment Forum

**TABLE 1: EU LIST OF CRITICAL RAW MATERIALS, 2020**

| | | | |
|---|---|---|---|
| Antimony | Fluorspar | Magnesium | Silicon Metal |
| Baryte | Gallium | Natural Graphite | Strontium |
| Bauxite | Germanium | Natural Rubber | Tantalum |
| Beryllium | Hafnium | Niobium | Titanium |
| Bismuth | Heavy REEs | PGMs | Tungsten |
| Borates | Indium | Phosphate rock | Vanadium |
| Cobalt | Light REEs | Phosphorus | |
| Coking Coal | Lithium | Scandium | |

Source: European Commission [8]

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reliant on imports of various critical minerals, thereby perceiving limited access as a weakness in promoting security and long-term industrial competitiveness of US industries.[3] To be clear, the issue of secured access to critical raw materials was raised earlier, in 2010, when China began to tighten its grip on world supply through exports restriction policy and consolidation of rare metals production around a few major companies.[4, 5] In 2011, the European Union (EU) commenced a series of technical studies aimed at identifying the criticality of raw materials and potential strategies to mitigate the impacts of China's export quota policy.[6] Similarly, the US Geological Survey (2017)[7] examined 23 mineral commodity groups identified as critical for the United States. The transatlantic economic powerhouses share a common vulnerability—that China's monopoly over critical raw materials might pose a threat to not only the United States' and European Union's long-term economic viability but also their ability to effectively secure the minerals necessary for a worldwide transition from fossil fuels toward low-carbon, renewable energy technologies. Against this backdrop, this paper offers a global perspective on the green transition and an opportunity to move beyond the narrow geopolitical lenses often applied to the study of rare metals.

Today, media attention and policy debates focus on the trade disputes and strategic competition between the United States and China. Previous studies have also emphasized the challenge of making renewable energy—notably wind and solar power—a plausible strategy for addressing climate change and energy poverty in the advanced industrialized world and subsequently in China and other emerging market economies.[9, 10, 11, 12] While these studies enrich our understanding of the complexity of energy transition, questions about social equity and ecological compensation in relation to the green transition are largely ignored.

A social justice perspective is urgently required if we are to succeed in tackling climate change. To begin with, climate justice perspectives can shine a light on a huge blind spot among global leaders and national policymakers—that the costs of the green transition are highly uneven, wherein significant amounts of raw materials for renewable energy and clean technology will need to be outsourced from a few developing countries. Second, if we accept the premise of Latin America and the Global South more broadly playing a critical role in the renewable energy transition, a social justice perspective compels us to recognize the limits of existing supply-driven policy solutions and to find new answers to the green growth question. If mining has historically been a laggard in contributing to growth, and yet more mineral extraction is expected to take place in extractive frontiers, decision-makers across multiple levels of governance must incorporate intergenerational, interregional equity issues alongside the need to effectively roll out the transition to adopt clean technologies. For example, this might entail policy elites in the West to rethink their existing prejudice against industrial policy in order to allow developing countries to design public policies aimed at improving domestic competitiveness and sectoral promotion. These policies include an array of options, such as supporting the domestication of mineral processing, embracing local content requirements to facilitate technology transfer, and/or identifying linkages between the resource and productive sectors for export diversification and value addition in economic activities. It might also mean revisiting debates on decentralization and taxation reforms in order to compensate for the mining communities at the extractive frontiers, who disproportionately feel the negative socio-environmental and health impacts of resource extraction.

This paper offers a global viewpoint that incorporates a critical political economy perspective and locates Latin America within the global energy transition debates. In so doing, the paper builds toward recommendations for centering a social justice perspective in decisions supporting the transition to clean energy.

## THE GREEN TRANSITION'S SUPPLY AND DEMAND FOR RARE METALS: THE GLOBAL NORTH AND CHINA

I adopt a broad category of rare metals to include "technology'" or "minor metals," which are a set of critical raw materials produced in low quantities per day, and are often utilized as intermediate inputs in advanced manufacturing sectors, notably in digital, renewable, and energy technologies. Because of their distinctive industrial competences and technological niches, the US and EU governments have undertaken separate studies to identify their respective lists of critical raw materials. The United States' list consists of 35 critical minerals, based on how essential they are to US economic and national security interests and wider supply chain vulnerabilities.[13] The EU Commission report identifies 30 critical raw materials, found in Table 1.[14, 15]

Among the minerals listed in Table 1, the most significant and critical—due to their strategic importance and limited secured access—is a group of metals called rare earth elements (REEs). Table 2 summarizes these 17 chemically similar metals and their applications across various industries. These metals have a wide variety of industrial applications, including as intermediate outputs as alloys and components, which are then assembled into higher

Photo credit: Miner inside an underground gold and copper mine in the Maule region of Chile: Jose Luis Stephens, Shutterstock

**TABLE 2: REES AND SELECTED INDUSTRIAL APPLICATIONS**

| Name | Symbol | Atomic No. | Applications and products |
|---|---|---|---|
| Scandium | Sc | 21 | Aerospace materials, consumer electronics, lasers, lighting, magnets, sporting goods |
| Yttrium | Y | 39 | Ceramics, communications systems, frequency meters, fuel additives, jet engine turbines, lighting, microwave communications, satellites, televisions, vehicle oxygen sensors |
| Lanthanum | La | 57 | Catalyst in petroleum refining, energy storage, fuel cells, night-vision instruments, rechargeable batteries, televisions |
| Cerium | Ce | 58 | Catalyst in petroleum refining, catalytic converters, diesel fuel additives, glass, polishing agents, pollution control systems |
| Praseodymium | Pr | 59 | Aircraft engine alloys, airport signal lenses, catalyst, ceramics, coloring pigment, electric vehicles, fiber-optic cables, lighter flints, magnets, photographic filters, welder's glasses, wind turbines |
| Neodymium | Nd | 60 | Air bags, antiglare glass, antilock brakes, cell phones, computers, electric vehicles, lasers, magnetic resonance imaging (MRI) machines, magnets, wind turbines |
| Promethium | Pm | 61 | Beta source for thickness gauges, lasers for submarines, nuclear powered batteries |
| Samarium | Sm | 62 | Aircraft electrical systems, electric vehicles, electronic countermeasure equipment, flight control surfaces, missile and radar systems, optical glass, permanent magnets, precision-guided munitions, stealth technology, wind turbines |
| Europium | Eu | 63 | Compact fluorescent lights (CFLs), lasers, tag complexes for the medical field, televisions |
| Gadolinium | Gd | 64 | Computer data technology, magneto-optic recording technology, microwave applications, MRI machines, power plant radiation leak detectors |
| Terbium | Tb | 65 | CFLs, electric vehicles, fuel cells, optic data recording, permanent magnets, televisions, wind turbines |
| Dysprosium | Dy | 66 | Electric vehicles, home electronics, lasers, permanent magnets, wind turbines |
| Holmium | Ho | 67 | Color glass, microwave equipment, |
| Erbium | Er | 68 | Color glass, fiber optic data transmission, lasers |
| Thulium | Tm | 69 | X-ray phosphors |
| Ytterbium | Yb | 70 | Improving stainless steel properties, stress gauges |
| Lutetium | Lu | 71 | Catalysts, positron emission tomography (PET) detectors |

Source: Navarro and Zhao (2014) [20]

value-added industrial goods such as electric motors and drones.[16] Rare metals are essential inputs for clean technologies, notably in the mass production of wind turbines, photovoltaic panels, and hybrid and electric vehicles.[17, 18] Though these minerals are used in high-tech sectors beyond renewable energy, in this paper, I will confine the discussion to industries relevant to the green transition.

REEs are mined in small quantities and have historically been part of a stable supply chain. However, tensions between the United States and China, as well as the supply disruptions caused by COVID-19, brought the issue of criticality to the forefront of policy debate and media discussions. As the world experiences a continuing shortage of semiconductors, governments and industry experts are facing a growing awareness that the production of microchips, processors, and other smart technologies will face further supply constraints as the number of electric cars on the roads increase, directly competing with existing technologies like mobile phones and computers that already have a high demand for semiconductors.[19]

Table 3 lists the known REE reserves and current mine production quantities. The world faces a potentially difficult situation in securing access to these critical resources. REEs are currently concentrated in China, which has an estimated 90 to 95 percent of the global supply and approximately 60 percent of global reserves. The technology for processing heavy REEs—critical to the production of permanent magnets—is focused in China, further strengthening the trade position of Chinese companies in the REE sector. The ability of China to control the majority of both REE supply and reserves can be explained by two key factors—(1) the willingness of China to absorb the environmental externalities and adverse social or ecological impacts brought forth by mineral

**TABLE 3: WORLD MINE PRODUCTION AND RESERVES**

| Country | Mine Production (estimated in metric tons) | | Reserves (in metric tons) |
|---|---|---|---|
| | 2018 | 2019 | |
| United States | 18,000 | 26,000 | 1,400,000 |
| Australia | 21,000 | 21,000 | 3,300,000 |
| Brazil | 1,100 | 1,000 | 22,000,000 |
| Burma (Myanmar) | 19,000 | 22,000 | NA |
| Burundi | 630 | 600 | NA |
| China | 120,000+ | 132,000+ | 44,000,000 |
| Greenland | - | - | 1,500,000 |
| India | 2,900 | 3,000 | 6,900,000 |
| Russia | 2,700 | 2,700 | 12,000,000 |
| South Africa | - | - | 790,000 |
| Tanzania | - | - | 890,000 |
| Thailand | 1,000 | 1,800 | NA |
| Vietnam | 920 | 900 | 22,000,000 |
| Others | 60 | - | 310,000 |
| WORLD TOTAL (Estimates) | 190,000 | 210,000 | 120,000,000 |
| Notes:<br>+ Production quota. Does not include undocumented/illegal REE production. | | | |

Source: US Geological Survey (2020) [24]

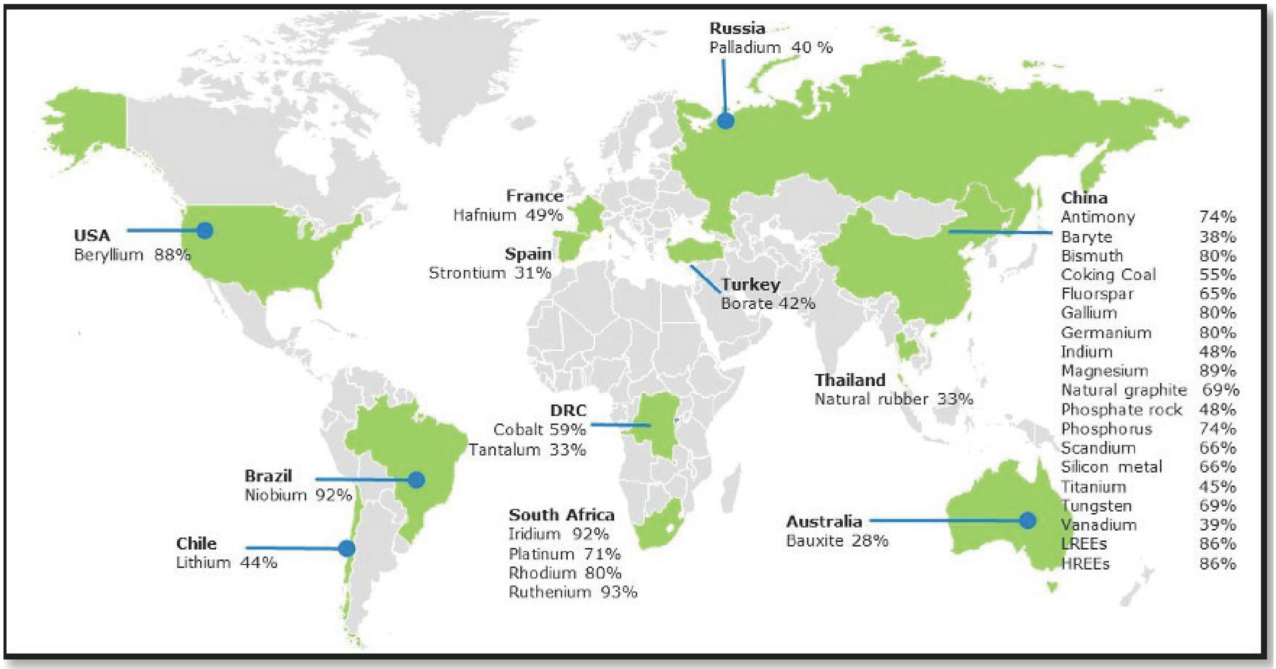
**“Based on the traditional geopolitical calculus, the United States and European Union face long-term strategic dilemmas in the absence of a secured primary supply chain.”**

extraction and processing; and (2) the capacity of Chinese firms to lower the price of REEs to outcompete other companies.[21, 22, 23] In contrast, the US and EU governments have moved away from opening mining sites for primary mineral production, instead opting for strategies aimed at recycling REEs from existing final goods like wind turbines, as well as developing technological solutions to allow for the substitution of some of these minerals. Despite these efforts, the projected increase in electric vehicles, wind turbines, and photovoltaic (PV) solar panels is unlikely to slow down the global demand for REEs.

The combined effects of control in supply and processing technology led to widespread awareness and concern among Western governments about the worldwide dependence and their own extreme vulnerability toward China’s export restriction policy. Beyond REEs, as Figure 1 illustrates, the European Union is heavily reliant on critical minerals from the rest of the world. Based on the traditional geopolitical calculus, the United States and European Union face long-term strategic dilemmas in the absence of a secured primary supply chain.

The vulnerability/risk perspective skews the global debate on the green transition. On one hand, Western governments have begun to promote clean technologies as the solution to the climate crisis. By shifting away from excessive reliance on fossil fuels for power generation, transport, and other critical economic activities, the assumption is that technology-driven solutions focused on the worldwide adoption of clean energy can effectively reduce carbon emissions. It also implies Western standards of living built on high energy consumption can be salvaged via adjustments in lifestyle choices alone. On the other hand, the Global South’s vantage points suggest a more complex policy dilemma, as the ultimate source of the raw materials for energy transition is

**FIGURE 1: PRIMARY SUPPLIERS OF CRITICAL RAW MATERIALS TO THE EUROPEAN UNION**




Source: European Commission (2020) [25]

likely to be mineral-rich developing countries.

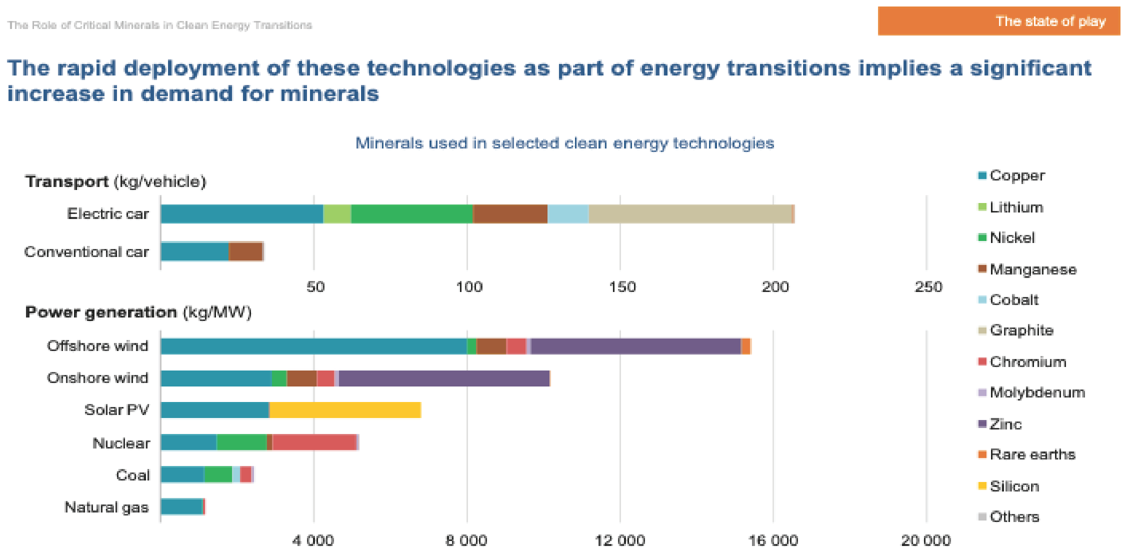
In their latest report, the International Energy Agency makes plain the costs of our worldwide demand for clean energy: To meet the Paris Agreement goals, the total demand for clean technologies by 2040 will require an increase of more than 40 percent for copper and REEs, 60 to 70 percent for nickel and cobalt, and almost 90 percent for lithium.[26] Some of these minerals are heavily concentrated in only a few countries, such as Chile, Bolivia, and Argentina for lithium; Brazil for niobium; Democratic Republic of Congo for cobalt; South Africa for platinum-group metals; and China for other REEs and minerals. In sum, the rapid deployment of clean energy technologies will accelerate extraction in the developing world, and in so doing, transfer the negative socio-environmental impacts of energy transition toward resource producers in the Global South.

Figure 2 compares the critical minerals needed for clean energy technologies. An electric vehicle requires more than 200 kilograms per vehicle of a wide swath of minerals for its assembly. Conventional cars depend on a quarter of that quantity per vehicle, and usually only copper and manganese. About 50 percent of the electricity produced within the European Union powers the 8 billion electric motors in use, which range from small-sized electronic products such as e-bikes to large motors for heavy transport.[27] Hybrid and electric vehicles require high-performing synchronous motors that are run by neodymium-iron-boron permanent magnets—nearly 95 percent of raw materials to produce magnets are found in China, while the processing of rare earth oxides into alloys for magnets and other products is largely controlled by firms in China and Japan.

In terms of power generation, the rapid expansion of wind power will change the course of electrification. Wind power just has recorded the best year in its history, with the installation of an additional 93 gigawatts during the COVID-19 pandemic.[29] However, wind turbines require several materials such as concrete, steel, iron, fiberglass, polymers, aluminum, copper, zinc, and REEs. Building taller and larger wind turbines will require lighter and more efficient permanent magnet synchronous generators. Turbines based on this type of generator require RREs (neodymium and dysprosium) that are concentrated in China.[30]

Unless an alternative supply of the REEs needed for wind power and other clean technologies can be consolidated outside of China, the REE market is likely to remain in the hands of the Chinese state. Amidst

**FIGURE 2: CRITICAL MINERALS FOR CLEAN TECHNOLOGIES**




Source: International Energy Agency (2021), "The Role of Critical Minerals in Clean Energy Transitions," All rights reserved; as modified by Jewellord Nem Singh.[28]


Photo credit: Protesters march at the "March for Climate Justice Through Racial Justice" in New York City: Ron Adar, Shutterstock, September 2020

growing tensions between China and the United States, a new primary supply chain outsourced in Australia and India through the informal Quadrilateral Security Dialogue (also known as the Quad Alliance), which includes the United States and Japan, seems like an appealing long-term strategy. However, consolidation of the REE market takes decades, so this solution is more visionary than an actual road map to secure access to critical minerals. In addition, there are mineral-specific characteristics that complicate the implementation of this strategy. First, mining projects have long gestation periods—an average of 16 years from discovery to first production. The Quad's members and REE companies would need to make substantial investments in resource-producing regions of Africa, Asia, and Latin America to make this a credible plan for the future. Second, price volatility and long periods of market tightness, which characterize the critical minerals sector, implies that profitability remains uncertain and risks of failure are high for private investors.[31] For the REE sector to become a strategic industry, governments must generate the right incentives for private firms to be willing to accept the investment risks. This includes governments encouraging industries to continue investing in exploitation activities and begin investing in the beneficiation and chemical separation stages that the Chinese experience demonstrates are environmentally damaging.[32] Third, the geographic locations of REE production and manufacturing processes complicate the geopolitical picture of a green transition. A few key aspects of this third point are explored in the rest of this paper.

## THE UNEVEN COSTS AND BURDENS OF THE GREEN TRANSITION ON THE GLOBAL SOUTH

The supply and demand dynamics of the REE sector thus suggest that the burdens of the green transition are likely to fall on the resource producers that are the sources of primary raw materials. While China's dominance in the REE market illustrates the possibility of successfully linking mineral production with domestic manufacturing, its particular historical and political contexts are unlikely to be replicated in other developing countries.

Another nontrivial issue is the role of technology transfer and industrial policies that allow resource-producing countries to take advantage of their mineral endowments. Comparative and historical evidence on natural resources–based development suggests that few countries have been able to transform their mineral resources into engines of growth—a phenomenon known as the "resource curse." Manufacturing paved the way for industrialization in the 19th and 20th centuries, which led to the concentration of technology and value-added production in the core economies of North America, Western Europe, and Japan. Through export-oriented manufacturing based on industrial policy, South Korea, Taiwan, Singapore, and (to a limited extent) other nations in Southeast Asia successfully caught up with the industrial powerhouses.[33, 34, 35] With limited natural resources, these countries focused on labor and capital-intensive sectors as their motor of industrialization. With the exception of the Gulf States and a few others, resource-endowed states have barely benefitted from economic growth strategies centered on raw materials, in part due to negative effects of resource specialization and a lack of robust institutions in the developing world to mitigate excessive rent-seeking in mining.[36, 37, 38, 39] The high prices of resource booms benefit mining and oil and gas firms, yet simultaneously appreciate currency, which often incentivizes labor and capital to move away from agriculture and manufacturing toward the resource export sector. When the resource boom ends and commodity prices fall, resource specialization makes it difficult for workers and capital to return to the productive sectors. In some cases, the process may cause permanent deindustrialization.[40, 41]

As we envision an exponential growth of investments in critical minerals in response to the new gold rush toward clean energy technologies, political elites have an incentive to push for more extraction at a faster pace. In Latin America, resource booms became a key source of political conflicts, despite the attempts of governments to use resources for broad-based, inclusive growth. High demand for minerals, petroleum, and export agriculture in Bolivia, Ecuador, Peru, and Colombia have led to political conflicts between social movements and mining communities on one hand, and conflicts between their governments on the other hand, irrespective of their political orientations.[42, 43] In Argentina, most emblematically, increasing export taxes of soya led to a protracted conflict between former President Cristina Kirschner's government and the agribusiness elites in the countryside.[44, 45] Beyond policy choices about mining-based development, mineral states wishing to take advantage of the rising demand for critical minerals to create a comparative advantage must also reckon with the looming opposition to mining projects. Advocates in social movements and mining communities expect Latin American governments to craft a social contract with those who will likely be impacted by further extraction through policies that, for example, redistribute wealth and ensure mineral extraction can yield substantial economic gains for the country.

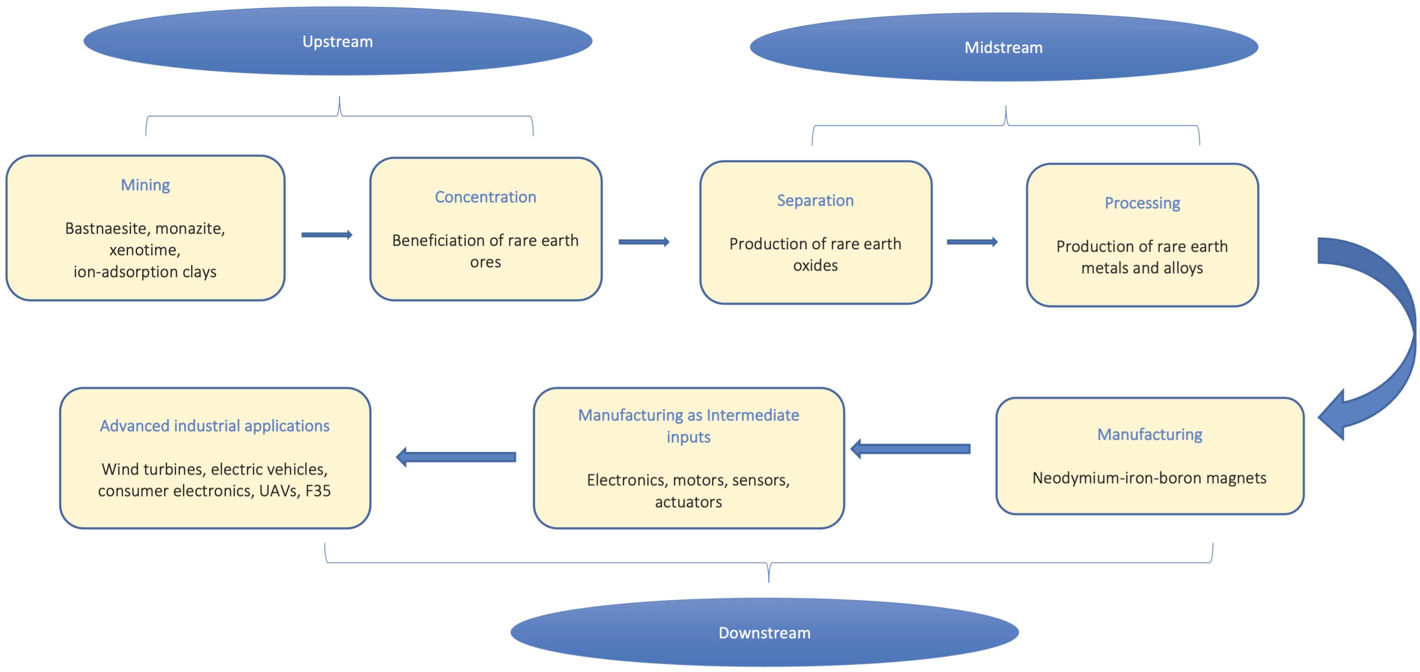
To make mining-based development strategies more effective, we need creative policies that can traverse traditional prescriptions about industrial policy and export diversification. One concrete approach, inspired by Albert Hirschman (2013),[46] draws from building sectoral linkages between the resource sector and the productive economy. Put simply, governments must support technologies related to their natural resources and design public policies that can create spillover effects between connected firms and sectors. Historically, this is part of how the oil and gas sector has been economically successful. Oil exporters invested in petrochemicals to add value to crude oil, thereby enabling governments to increase profits by selling refined oil derivatives to world markets (so-called forward linkages). Countries with more sophisticated manufacturing capabilities, such as Norway and Brazil, supported their state-owned enterprises in building a domestic supply chain of goods and services to support oil extraction (so-called backward linkages). In Brazil, the state played a central role in building both backward and forward linkages, reinforcing the vision of creating a diversified and highly internationalized oil value chain. Indigenous technological development became possible through the state-owned company Petrobras's decades-long initiative to establish research centers with ties to universities for developing ultra–deep sea water engineering technology. Consequently, this investment enabled Brazil's offshore drilling capacities, leading to the discovery of oil reserves 2,000 meters below sea level.[47, 48]

For critical raw materials, the supply chain is highly complex. Figure 3 illustrates the REE supply chain for neodymium-iron-boron magnets. Similar to oil and gas, REE downstream manufacturing processes have several points in the supply chain at which resource producers could design policies to support value-added activities that would capture value and maximize rents. Typically, the advanced stages of manufacturing are occupied by firms from the European Union, the United States, and Japan, which have maintained their competitive advantage by moving low-value manufacturing to China but retaining the engineering and R&D-intensive activities in their home countries. The government of China sought to consolidate its control of the sector by enabling domestic companies to expand their activities across the different segments of the supply chain. Specifically, companies were able to move from mining and concentration extraction (upstream segments) toward chemical separation and processing (midstream) stages in the production of rare earth oxides, and subsequently to the production of alloys and magnets (downstream segments). By participating across the processing stages, REE-producing countries might be able to break the cycle of their participation in low value-added activities. Policies supporting the research and development of specific technologies for processing heavy REEs (for participation in the manufacturing chain of neodymium-iron-boron magnets) will be critical for future REE producers to participate in the other segments of the value chain.

## THE WINNERS AND LOSERS: WHERE DOES LATIN AMERICA STAND?

In the 2000s, oil, minerals, and export agriculture experienced soaring commodity prices that enabled commodity-based growth to take place in Latin America and other resource-rich, poor regions. In Latin America, the commodity boom coincided with the election of political parties both left and center in the political spectrum, leading to a golden age of poverty-reduction policies. Driven by Chinese demands for natural resources, Latin American elites, social movements, and the public converged toward what Arsel et al. (2016)[50] aptly labeled the "extractive imperative."[51, 52, 53] Natural resource extraction has

**FIGURE 3: TRACING THE CLEAN TECHNOLOGY VALUE CHAIN FROM MINING TO HIGH-TECH MANUFACTURING**




Source: U.S. Department of Energy (adapted) (2020).[49]

been (re)imagined as central to Latin America's economic prosperity and is likely to remain the region's central model for economic growth. Despite varying policy orientations across the continent, the majority of elites and social forces consider future economic growth to be based on the extraction of mineral resources, although some social movements have advocated for a radical rethinking of the growth model.[54, 55]

In this context, it should not come as a surprise that Latin America is likely to remain a producer of the raw materials for commodities. As the world moves toward a clean technology-based future, Latin America's commodities will be highly sought-after by the Global North and the emerging economies of Asia, which are increasingly dominating the sector's world trade, finance, and investment. A quick glance at the EU Commission report, in Figure 4, shows this possibility. When comparing the producers of raw materials, China, Latin America, and Africa are the main sources of critical minerals for the green transition. However, the assembly of inputs for high-technology sectors is predominantly occupied by China, the European Union, the United States, and the rest of Asia.

**"Despite varying policy orientations across the continent, the majority of elites and social forces consider future economic growth to be based on the extraction of mineral resources, although some social movements have advocated for a radical rethinking of the growth model."**

**FIGURE 4: REGIONAL SHARES IN RAW MATERIALS STAGES IN HIGH-TECHNOLOGY SECTORS**

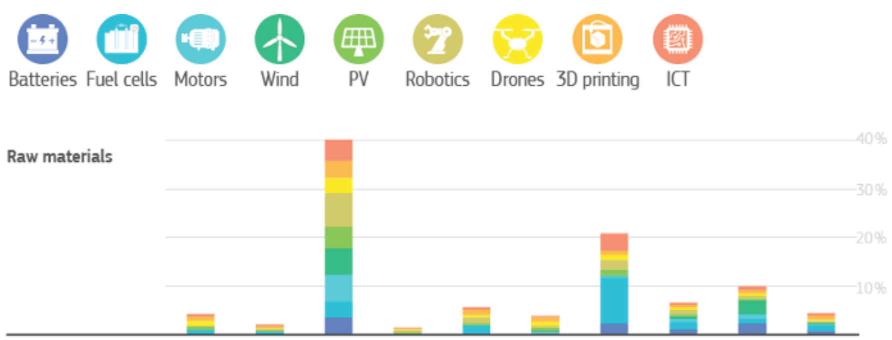
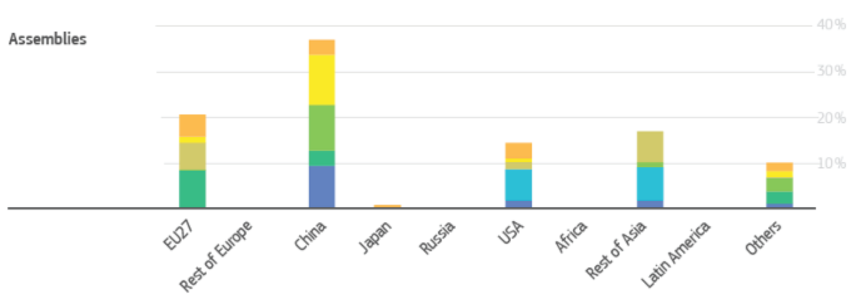



**FIGURE 5: REGIONAL SHARES IN ASSEMBLIES STAGES OF HIGH-TECH MANUFACTURING**




Source: European Commission (adapted) (2020).[56]

Within the region, Chile and Brazil stand out as potential winners in a race to secure critical minerals for broad-based development, due in large part to their policy initiatives in recent years.[57]

*Chile*

In Chile, amidst growing public dissatisfaction with the neoliberal policy regime imposed by the dictator Augusto Pinochet (1973–1989), President Michelle Bachelet, a member of the Socialist Party, sought a review of the lithium policy by creating a National Lithium Commission. The commission launched an extensive consultation process throughout the second half of 2014, which highlighted several issues related to the need for Chile to benefit more from lithium extraction, including:

(1) the recognition of the environmental fragility of the salt flats where lithium is extracted;

(2) the maintenance of lithium as a non-concessionable metal that would retain the power of the Chilean Nuclear Energy Commission to carefully regulate and control the exploitation, commercialization, and trade of lithium and its derivatives;

(3) strong institutional oversight in managing the salt flats;

(4) a state-owned enterprise to exploit these reserves consistent with the strong role of the Chilean Nuclear Energy Commission in lithium management; and

(5) the creation and strengthening of a sectoral lithium cluster, which would expand the participation of Chilean firms from upstream to midstream and downstream segments of the value chain.

In January 2016, Bachelet accepted the commission's main recommendations and used the findings to formulate a national lithium strategy. The state agency CORFO sued the biggest lithium producer, SQM, for breach of contract to expand the company's refining facilities. A taxation-related controversy also came to light in this process. Producers of high-grade lithium carbonates at the largest Chilean salt flat, Salar de Atacama, were paying less than other sites (US $3 per kilogram, while other deposits cost between US $4 and US $4.7 per kilogram), but the companies were not paying all of the taxes required on their high profit margins.[58] In the context of growing public demand for state regulation in the sector, the state-owned copper enterprise Codelco also formed a subsidiary in the lithium sector in early 2017 to develop and extract new lithium production facilities. Codelco entered joint ventures with private firms to operate in several salt flats.

These are positive steps for Chile in extending control of the downstream segments of lithium production. These downstream efforts complement attempts to extend state control in the upstream segment of the supply chain, i.e., into the processes that add value to lithium manufacturing and create sectoral linkages.[59, 60] These regulatory changes are vital steps toward improving the material conditions of those impacted by lithium extraction and enhancing the share of national income for Chileans as they participate in the value chain of clean technology. Still, more is needed to fully embrace a social justice perspective in terms of the development possibilities of rare metals exploitation and commercialization.

*Brazil*

At the subnational level in Brazil, there are nascent discussions about linking critical minerals and the offshore wind turbine sector. Brazil holds at least 89 percent of the world's niobium reserves, mostly located in the state of Minas Gerais. Once it is mixed with other materials, niobium is used for electric and hybrid vehicles, as well as for infrastructure. Brazil also holds the world's second-largest known reserves of REEs, although production levels are low (see Table 3). With the advancement of renewable energy, in particular wind turbines, REE markets might provide new sources of economic dynamism to reinvigorate Brazil's economy. The world's top five

Photo credit: Wind turbines at a wind power plant in Galinhos, Brazil: Caio Pederneiras, Shutterstock, April 2017

**"The tide is shifting away from fossil fuel dependency in favor of clean technologies. However, an uncritical embrace of clean technology may also lead to greater inequalities and uneven development."**

markets for wind-power installations in 2020 were China, the United States, Brazil, the Netherlands, and Germany.[61] Further, no significant slowdown has been reported in project construction in Brazil during the COVID-19 pandemic. New installations in 2020 were developed through private Power Purchase Agreements, which are rapidly growing in Brazil due to wind power's competitive prices.

Historically, Brazilian growth strategies have been managed through a developmentalist model, whereby combinations of state involvement and market incentives were initiated to pursue ambitious development plans.[62, 63, 64] It remains to be seen whether the Brazilian federal government can promote sectoral linkages between REEs and wind power (or whether the unpopularity of President Jair Bolsonaro will lead to a change in government in favor of the Workers' Party in the upcoming elections). Currently, neither a national industrial strategy nor state-led financing has been utilized under the Bolsonaro government.

## CONCLUSIONS: MOVING FORWARD WITH A SOCIALLY JUST ENERGY TRANSITION

The tide is shifting away from fossil fuel dependency in favor of clean technologies. However, an uncritical embrace of clean technology may also lead to greater inequalities and uneven development. Latin America and Africa will be the new battlefield for resource extraction between China and the West. But these regions can also become a source of new political ideas about how to strike a balance between our insatiable demands for critical minerals and the need for social justice perspectives to be at the center of a new resource governance model.

To deal with the complex challenges associated with the transition to green technology, growing demands for critical minerals, and unequal burdens placed on the developing world, we need to incorporate a social justice perspective. To some, blame goes to the industrialized world, which owes an ecological debt, thereby justifying carbon-based growth in middle- and low-income countries. Other radical calls seek for degrowth, a reversal of humanity's pursuit of unfettered consumption and production.[65, 66] A nuanced position demands common but differentiated responsibilities. The basic principle is that because industrialized countries had decades of development with unrestrained carbon emissions, they are now obligated to reduce emissions and contribute more financial assistance to developing nations to support their energy growth and transition to clean technologies.[67]

## "Are industrialized countries now more willing to accept the costs of climate change and do more on behalf of the developing world?"

These debates about how to deal with the uneven costs and burdens of the green transition pose difficult but fundamental questions. Are industrialized countries now more willing to accept the costs of climate change and do more on behalf of the developing world? To what extent can the rapid deployment of clean technologies achieve global targets, given how China's economic development model is based on high energy consumption, much of it with coal?[68] If China does move toward a renewable energy strategy, will the country merely shift the costs and externalities of the transition from the national government and urban China to rural China, Latin America, and other resource-rich regions, making them even more vulnerable to the negative effects of mineral extraction?

A social justice perspective on the green transition enables our global leaders to transcend the hard security and geopolitical perspectives dominant in policy debates. The perspective allows new policy ideas about equity and ecological compensation to be incorporated into the economic growth question; it gives voices to mining communities and advocates of environmental justice about the importance of transparency and decentralization in mining governance; and it also opens up the debate to focus on technology transfer and new industrial policy instruments as a means of helping mineral states gain more from their mining industries. This last point is especially important given the increasing interest among the governments of developing countries in finding solutions to their position as primary raw materials producers for the industrialized world.

The following recommendations outline steps for more effectively centering a social justice perspective within policy decision-making for the transition to clean technologies:

(1) Conduct more robust studies on the social and ecological impacts of REE extraction and production to gauge more effectively who suffers from the burdens and risks of the renewable transition—both between countries and within the national territories of resource producers.

(2) In global and national policy debates on energy transition, discussions about solutions must bring together issues on both the supply and demand sides. To develop holistic, just, and sustainable solutions that benefit producers and consumers on both sides, more robust research is needed. On the supply side, mining firms should, in partnership with resource-producing nations, research more efficient, less environmentally hazardous extraction methods. The ability to address vulnerabilities and risks on the supply side would benefit from increased funding for research in materials engineering and environmental and geological sciences. In particular, research should focus on the efficacy and feasibility of recycling and substitution techniques to create a stable secondary supply chain and improve the sustainability of existing critical minerals in a circular economy. On the demand side, more research is needed to examine how governments can encourage citizens to make changes in their individual consumption lifestyles. Leaders should also develop policies aimed at supporting manufacturing firms involved in strategic sectors dependent on critical minerals to develop new business strategies to reduce current and future

resource use.

(3) Policy discussions on industrial policy and technology transfer are likely to become a source of friction between resource producers and consumers. High-tech manufacturing companies in downstream segments of the supply chain will seek to preserve their core technological advantage, and mineral producers will likely pursue trade and development policies seeking higher profits, technology transfer, and control over the sector. To avoid potential conflicts or incentives for corruption among industrial actors, governments must cooperate and incorporate the interests of resource producers. International dialogue should also promote better accommodation of developing countries' interests in economic diplomacy and bilateral or multilateral treaties by including the right to economic development.

(4) For resource producers, policymakers must find creative regulatory frameworks for mineral-based economic development, including but not limited to: sectoral linkages, taxation, export diversification, and sovereign wealth funds to manage natural resource rents. The sectoral linkages (both forward and backward linkages) that oil producing nations have developed to expand beyond their role as primary raw materials producers may provide a potentially useful framework for mining-based development. Given the dominance of foreign companies in the global value chain, domestic policymakers must weigh the balance of attracting foreign private capitalists and developing the capabilities of firms to nurture a competitive domestic mining sector. Discussions must focus on how to move from upstream production segments to the segments midstream and downstream in the value chains; the use of traditional policy tools such as local content requirements; support for research and development (including obligatory R&D payments of companies for sectoral development); and investments in human capital to develop technical expertise in the mining sector.

(5) For resource producers, national and community level discussions must tackle social inequity and the structural causes of poverty, especially given the trend of mining-affected communities often acceding to mineral extraction due to the absence of credible alternatives to their livelihoods. To support this, institutionalized channels that ensure the transparency and accountability of national governments and companies are vital to gain the trust of these communities. A subnational forum may provide a good starting point. Affected communities must be included as legitimate stakeholders, thereby redressing the power imbalance created when elites make decisions at the national levels on behalf of mining communities who are not involved in decision-making processes.

There are opportunities for mining-based development strategies to be implemented in resource-rich countries. The worldwide shift toward clean technology can offer a window of opportunity for more equitable growth. However, the challenges are undoubtedly formidable.

**Jewellord Nem Singh** is senior lecturer/assistant professor of international development at the International Institute of Social Studies, part of Erasmus University Rotterdam in the Netherlands. He is the principal investigator of a five-year research program entitled "Green Industrial Policy in the Age of Rare Metals: A Trans-regional Comparison of Growth Strategies in Rare Earth Mining (GRIP-ARM)," which this paper draws evidence from. This project has received funding from the European Research Council under the European Union Horizon 2020 Research and Innovation Programme under Grant Agreement No. 950056.

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