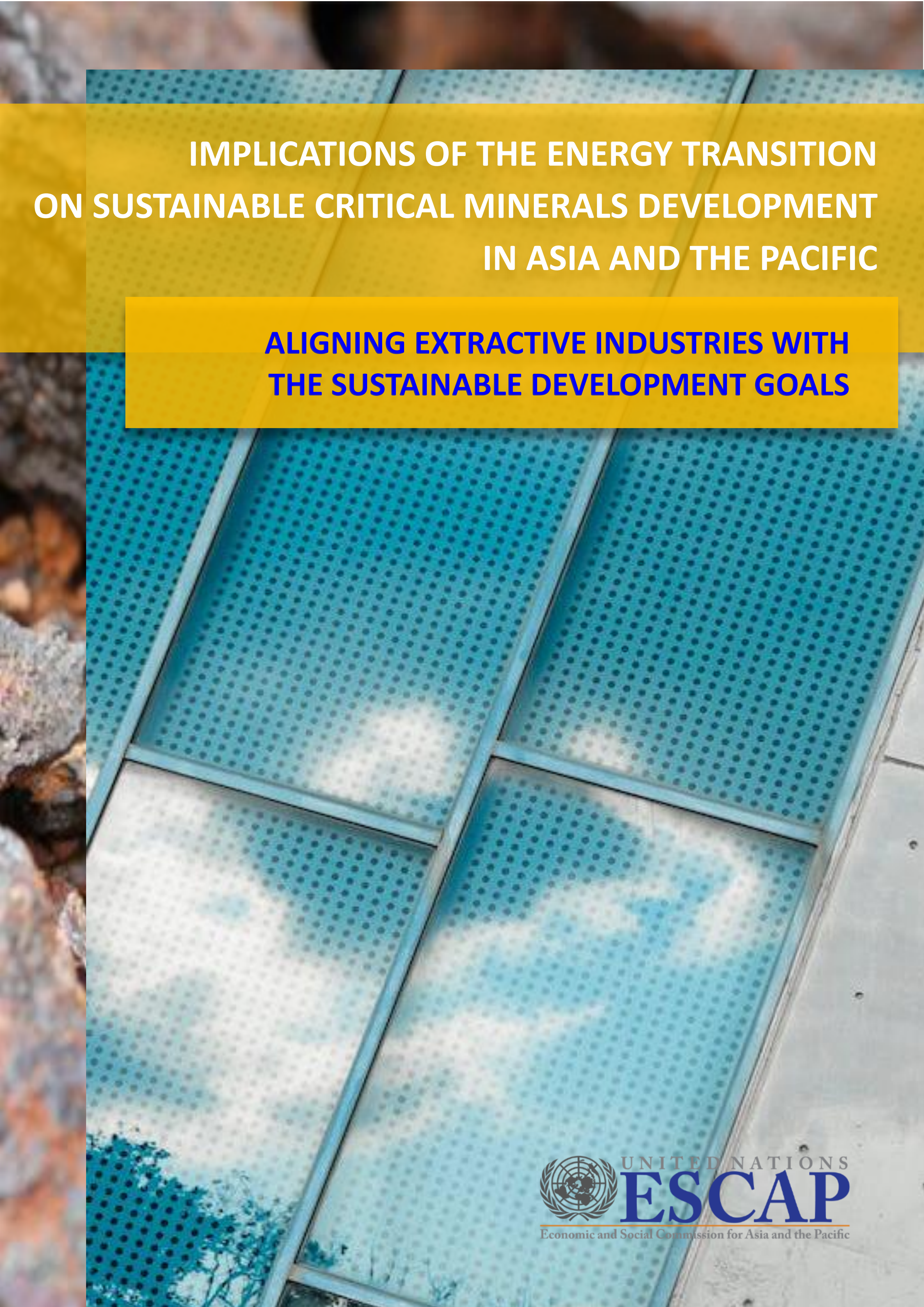

IMPLICATIONS OF THE ENERGY TRANSITION ON SUSTAINABLE CRITICAL MINERALS DEVELOPMENT IN ASIA AND THE PACIFIC

ALIGNING EXTRACTIVE INDUSTRIES WITH THE SUSTAINABLE DEVELOPMENT GOALS

UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific

The shaded areas of the map indicate ESCAP members and associate members. *

The Economic and Social Commission for Asia and the Pacific (ESCAP) serves as the United Nations' regional hub, promoting cooperation among countries to achieve inclusive and sustainable development.

The largest regional intergovernmental platform with 53 member States and 9 associate members, ESCAP has emerged as a strong regional think-tank offering countries sound analytical products that shed insight into the evolving economic, social and environmental dynamics of the region. The Commission's strategic focus is to deliver on the 2030 Agenda for Sustainable Development, which it does by reinforcing and deepening regional cooperation and integration to advance connectivity, financial cooperation and market integration. The research and analysis undertaken by ESCAP, coupled with its policy advisory services, capacity building and technical assistance to governments aims to support countries' sustainable and inclusive development ambitions.

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ABBREVIATIONS AND ACRONYMS

2DS	2-Degree Scenario
AEC	Aslan Energy Capital
AIDS	acquired immunodeficiency syndrome
AMS	Agri Maritim Sulteng
ASEAN	Association of Southeast Asian Nations
bcm	billion cubic metres
BP	British Petroleum
CIVICUS	Civil Society Rights and the Extractive Industries
COAG Energy Council	Council of Australian Governments Energy Council
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
CRM	critical raw material
CRMs	critical raw materials
CSIS	Center for Strategic and International Studies
CSP	concentrating solar power
CSR	corporate social responsibility
DMF	District Mineral Foundation
DOE	United States Department of Energy
DRC	Democratic Republic of Congo
DS	degree scenario
E2SG	economic, environmental, social and governance aspects
EBF	European Banking Federation
EFA	environmental financial assurance
EFFECT	Equitable Framework and Finance for Extractive-based Countries in Transition
EITI	Extractive Industries Transparency Initiative
ERGI	Energy Resource Governance Initiative
ESCAP	Economic and Social Commission for Asia and the Pacific
ESG	environmental, social and governance
ESIAs	environmental and social Impact assessments
ETS	Emissions Trading Scheme
EV	electric vehicle
EY	Ernst & Young
FCEVs	fuel cell electric vehicles
FFDI	Financing for Development in the Era of Covid-19 and Beyond Initiative

GBD MAPS	global burden of disease – major air pollution sources
GDP	gross domestic product
GHG	greenhouse gas
Government of PRC	Government of the People's Republic of China
GRI	Global Reporting Initiative
GW	gigawatt
GWP	global warming potential
HIV	Human Immunodeficiency Virus
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IGF	Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development
IGOs	intergovernmental organizations
ILO	International Labor Organization
IPCC	Intergovernmental Panel On Climate Change
IRENA	International Renewable Energy Agency
ISETS	International Society for Energy Transition Studies
ITC	International Trade Centre
JICA	Japan International Cooperation Agency
JOGMEC	Japan Oil, Gas and Metals National Corporation
JPY	Japanese Yen
Lao PDR	Lao People’s Democratic Republic
LCE	lithium carbonate equivalent
LNG	liquefied natural gas
MAC	Mining Association of Canada
MCA	Minerals Council of Australia
METI	Ministry of Economy, Trade, and Industry
MIIT	Ministry of Industry and Information Technology of the People's Republic China
MOC	Ministry of Commerce of the People's Republic of China
MPNR	Ministry of Petroleum and Natural Resources
MSP	Minerals Security Partnership
NCSD	National Council for Sustainable Development
NDC	nationally determined contribution
NDRC	National Development Reform Commission
NGOs	non-government organizations
NMP-1	National Mineral Policy
NRDC	Natural Resource Defense Council
NZE	net-zero emissions
OEC	Observatory of Economic Complexity
OECD	Organisation for Economic Co-operation and Development
Pakistan NMP-2	National Mineral Policy 2013
PRI	principles for responsible investment
RE	renewable energy

RECs	Renewable Energy Certificates
REEs	rare earth elements
RMF	Responsible Mining Foundation
RMI	Responsible Mining Index
RTS	reference technology scenario
SDF	Skills Development Fund
SDG	Sustainable Development Goal
SDS	Sustainable Development Scenario
SDSN	Sustainable Development Solutions Network
SLO	social licence to operate
solar PV	solar photovoltaic
STEPS	Stated Policies Scenario
SWF	Sovereign Wealth Fund
UN	United Nations
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WEO	World Energy Outlook
WTO	World Trade Organization

References to dollars ($) are to United States dollars, unless otherwise stated.

EXECUTIVE SUMMARY

Transitioning towards a clean energy future is a mainstay of the global efforts to achieve the Paris Agreement’s climate goals. The energy transition implies a shift from a fuel-intensive system to a material-intensive energy system, and will create significant demand for critical raw materials (CRMs), including critical minerals, because the technologies underpinning low-carbon energy systems, such as wind, solar PV and batteries, are more minerals-intensive than fossil fuel-based technologies. There is no single definition for which minerals and other materials qualify as CRMs, but broadly speaking they include any raw materials considered to have a high-level of economic importance and the potential for supply risks. While developing CRMs creates significant economic opportunities, their extraction and processing – as for other extractive industry products – may lead to additional environmental, social and governance challenges. Therefore, there is an urgent need to explore challenges and opportunities in the extractive industries that provide critical support to the energy transition.

The issues faced by the critical mineral development during the energy transition are significant for the Asia-Pacific region -- defined in this context as the ESCAP member States as a whole. Understanding the implications, impact and magnitude of the energy transition are prerequisites for the Asia-Pacific region to align the development of its CRM resources with sustainable development, as articulated in the form of the Sustainable Development Goals (SDGs).

As the guardian of the SDGs and key coordinator of global climate efforts, the United Nations actively promotes the sustainable development of critical minerals. Following on from the discussion and findings of expert roundtables organized in 2021 and 2022, ESCAP is continuing to investigate the potential implications of the energy transition for the Asia and the Pacific mineral extractive industry, and the broader social-economic context of CRM extraction.

This report examines the implications of the energy transition on SDGs for countries that currently or could potentially extract and export critical minerals. After the Introduction, Chapter 2 presents the potential implications of the energy transition on critical mineral development. Replacing fossil fuels with clean energy sources by extension increases dependence on mineral resources. As the transition towards a clean energy future deepens, a fundamental change in the demand for extractive products, away from fossil fuel and towards mineral resources, will take place. Chapter 3 discusses the opportunities and challenges that the sustainable development of CRMs will face during the energy transition. Chapter 4 examines the energy transition and critical mineral development in Asia-Pacific countries. Chapter 5 summarizes CRM development in selected Asia-Pacific countries, followed by a summary of the global best practice that can contribute to achieving sustainable CRM development. The remaining gaps that need to be filled for the purpose of promoting sustainable critical mineral development are summarized in Chapter 7, which also lays the foundation for policy recommendations in chapter 8.

Most of the chapters, i.e., 3, 6 and 7, adopt the E2SG framework – analyse from the economic, environmental, social and governance aspects. Chapter 3 presents opportunities and challenges from those four aspects. Chapter 6 draws on lessons and experience in the areas of sustainable economic development, environmental management, social management, and the role of Governments. Chapter 7 further elaborates on gaps left for achieving sustainable CRM development from the four areas. While the extractive industries have enormous potential to boost economic growth and reduce poverty, their production also raises economic, environmental, social and governance concerns; thus further studies are required to prepare extractive industries for the energy transition towards a sustainable future and transform them into an engine for sustainable development.

Some key findings are:

1. Replacing fossil fuels with clean energy sources, by extension, increases dependence on mineral resources. Demand for many critical minerals is expected to grow multifold by the mid of the century. These critical minerals, however, are more concentrated on production and processing, and have less transparent markets than fossil fuels; thus they incur many supply security concerns.

2. Increased demand for CRMs has also intensified competition for mineral resources in the world's major developed countries. As a result, many countries have designated certain minerals as "critical" as part of their development strategies, suggesting that their economic security is highly dependent on the continuous and stable supply of critical minerals.

3. This change in CRM demand will have profound and far-reaching implications, not only confined to the extractive industries but also extending into the socio-economic, environmental and governance realms of resource-rich countries, posing both challenges and opportunities for their sustainable development. At the core of the complexity are the opportunities and challenges that are raised by the development of extraction industries, which are closely related to almost all SDGs due to their wide-ranging connections to other industries as well as to societies and economies more generally.

4. The Asia-Pacific region will play an important role in the future supply of critical minerals, due not only to their resource abundance compared with countries in other regions, but also because of the growing demand within the region. However, the presence of significant fossil fuel resources, current dominance of fossil fuels in their energy systems and the energy transition present challenges to sustainable development as advancing phase-down of fossil fuel might come into conflict with broader efforts to achieve the SDGs (Appendix). The presence of CRM potential and the demand for critical minerals, on the other hand, also require robust institutions to minimize social and environmental costs and transfer mining revenue into sustainable development.

5. Asia-Pacific countries have formulated different sustainable development strategies, such as strengthening domestic mineral exploration and exploitation, securing overseas resources, restricting exports and production, and enforcing legal regulation. Environmental protection is on the agenda of every CRM--producing country. For CRM-poor countries, there have been some attempts to diversify imports and increase their indigenous supply despite of cost-ineffectiveness. For those that have no CRM resources, their strategies include investing overseas, recycling and developing alternative materials. Both CRM-rich and CRM-poor groups value international cooperation, innovation and circular economy as key means to ensure the security of supply. However, they have differences in priority, with CRM--rich countries focusing on environmental protection and processing of CRMs, while CRM-poor counties focus on innovation for new supply or alternative products. The two groups have great potential for cooperating on investment, information sharing and technical support. More broadly, there are many existing cooperation initiatives that involve ESCAP member States.

6. Critical mineral development needs to address broader social-economic, environmental, and governance challenges and gaps, including: sufficient investment, economic diversification and mining revenue sharing; a life-cycle environmental management approach and circular economy; inclusive decision-making and implementation processes and gender equality; good national governance; and close international cooperation.

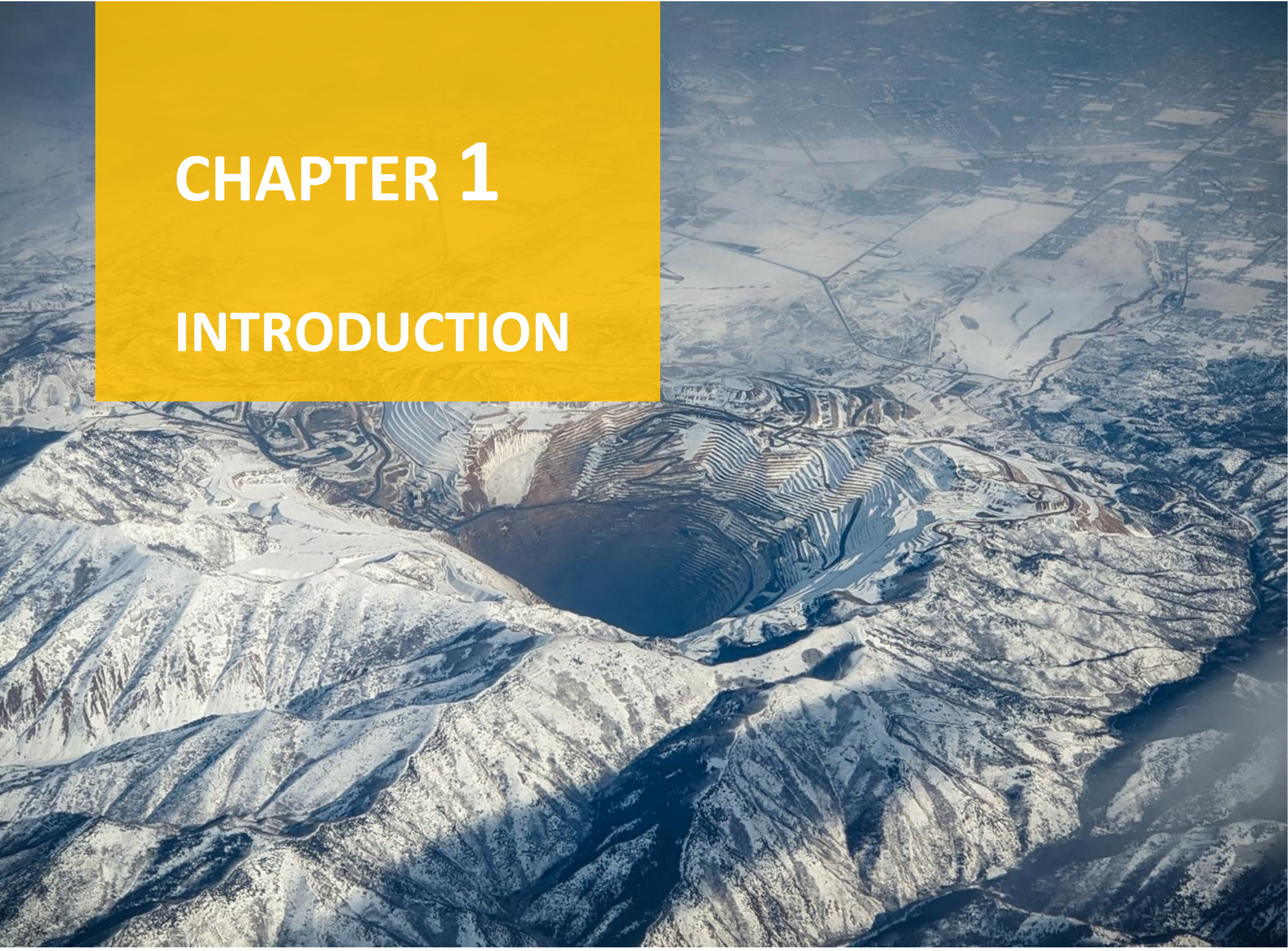
Based on the analyses, several challenges and gaps to further advancing sustainable critical mineral development have been identified, including, but not necessarily limited to: insufficient investment, supply chain vulnerability and weak core technologies; unmitigated emission, insufficient recycling, and inappropriate e-waste disposal; social acceptance of mining, women's participation, artisanal and small-scale mining; weak institutions, and insufficient coordination nationally and internationally.

Aligning Asia-Pacific's extractive industries sector with the SDGs and Paris Agreement requires adoption of a holistic and life-cycle approach underpinned by four priorities: supply sufficiency and affordability, fair revenue sharing, a people-centred and just process, and environmental integrity. This will further lead to policy measures in areas including investment, research and development, lower emission mining, recycling and circular economy, revenue management, governance, workforce upskilling, and data and transparency. Three immediate priority actions for the CRM industry, CRM-rich and CRM-poor Governments, and the international communities, respectively, are suggested: prioritizing work to establish common operational rules for markets, green finance and standards; sharing knowledge and experiences among regions and countries; and, creating regional and international coordination institutions.

The United Nations is well-positioned to coordinate countries at the global, regional and even subregional levels. As the Asia-Pacific regional commission for the United Nations, ESCAP can support member State efforts to promote sustainable critical mineral development by creating and sharing knowledge, assisting in building national strategies and capacity development, studying and highlighting case studies and best practices, and coordinating regional efforts.

CHAPTER 1

INTRODUCTION



Climate change and sustainable development are two major challenges facing our world. Mitigating climate change requires that countries transition away from fossil fuel-dominant energy systems to low-carbon and renewable energy systems. Energy transition (box 1) is not only a technology change from fossil fuels to clean energy, but also a paradigm shift that concerns the entire energy system built around energy production, transportation and consumption (McMeekin and others, 2019). This is a complex, multi-dimensional process prompted by a mix of at times conflicting considerations, including, for example: the enormity of the climate change challenge and debates about the role of renewable energy and other clean energy sources in mitigating CO_2 emissions; technological innovations in clean energy; the desire to promote economic growth; and the cogency of the economic growth-electricity demand nexus narrative, particularly in the developing world (Hribar and others, 2021, Mejía-Montero and others, 2020, and Z. Wang and others, 2017).

The energy transition will lead to a substantial reduction in fossil fuel demand (Betz and others, 2015; Shi, 2013a). The Glasgow Climate Pact is the first COP Statement to call on countries to "accelerate measures towards the phase-down of unabated coal power", and to "phase out and rationalize inefficient fossil fuel subsidies". Later in 2022, the Sharm el-Sheikh Implementation Plan of COP27 re-affirmed the need to "accelerate efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies" (UNFCCC, 2022). The net-zero emissions (NZE) scenario analysed in the IEA's report "Net Zero by 2050" sees a massive decline in the use of fossil fuels, from almost four-fifths of the total energy supply in 2020, to slightly over one-fifth by 2050. All remaining emissions in 2050 will be offset by negative emissions elsewhere (IEA, 2021c). Similar results are also found in the recent IPCC report, where all pathways that are likely to limit global warming to 2°C and below show substantial reductions in fossil fuel (Shukla and others, 2022).

Box 1. Energy transitions

What differentiates the current transition from the previous ones is that the transition currently in progress will see fossil fuels being gradually replaced by low-carbon energy sources. In a broad sense, the energy transition can be considered as "the change in the composition (structure) of primary energy supply, the gradual shift from a specific pattern of energy provision to a new state of an energy system" (Smil, 2010). The current energy transition – from fossil fuels to clean energy sources – is not the first transition the world has experienced. There were four major transitions before the current one: the first (early-to-mid 18th century) was the shift from traditional biofuels (primarily wood) to coal; the second involved a rapid diffusion of electrical appliances, starting in 1882 with Edison's pioneering electricity-generating plants; the third (the 1950s to 1970s) involved the development and adoption of refined oil products; and the fourth (1980s to more recent years) involved an increased reliance on gas (Smil, 2019).

The previous transitions, in contrast, could more precisely be characterized as 'energy additions', through which new energy sources and associated infrastructure were added to the global energy system to satisfy the rising demand for energy (York and Bell, 2019). Furthermore, the current transition needs to occur in the next three decades to achieve rapid and deep decarbonization of the energy sector in line with levels necessary for mitigating the worst impacts of climate change (IEA, 2021c).

The energy transition has global momentum. More than 136 countries worldwide have committed to carbon neutrality, representing 80% of the world's population, 83% of emissions and 91% of GDP (Net Zero Tracker, 2022). To meet the targets laid out under the Paris Agreement, the list of countries planning or legislating to phase out coal for power generation is growing, albeit mainly in Europe (Andrijevic and others, 2020). The share of renewable energy in electricity generation had risen significantly to 28% by 2020, reflecting the rising importance and reliance on renewable energy worldwide (IEA, 2021d).

The transition has profound implications for economies in general, and extractive industries in particular. As the transition towards a clean energy future deepens, the demand for mineral resources will likely increase dramatically. Increased deployment of modern renewable energy and energy-efficient technologies means an increased demand for rare earth elements and other mined inputs, which boost their extraction. The transition to low carbon energy that is critical to meeting the Paris Agreement goal of limiting temperature rise to well below 2 degrees Celsius (2°C) leads to increasing demand for critical minerals, the extraction of which could cause serious challenges to sustainable development. New patterns of interactions could emerge in response to the rising demand for mineral resources driven by a rapid deployment of clean energy technologies (IPCC, 2018).

The development of critical raw minerals (CRMs) (box 2) to support the energy transition, while generating positive economic outcomes, can also lead to challenges to sustainable development. In recent years, increasing attention has been paid to the implications of the energy transition, and, in particular, the rapid uptake of low-carbon energy technologies, on commodity demand and mineral resources (IEA, 2021d; World Bank, 2017 and 2020b). The energy sector is transitioning from a fossil-intensive to a more mineral-intensive sector as the process of energy decarbonization deepens (Gielen, 2021). Clean energy technologies generally require considerably more mineral inputs than their fossil fuel counterparts, and thus minerals emerge as a critical topic in the energy transition (IEA, 2021d). On average, the level of mineral intensity of new power generation has increased by 50% since 2010 due to the increased share of renewables (IEA, 2021d). Moreover, material intensity is expected to continue to increase with the level of decarbonization (World Bank, 2020b). Some minerals (especially metallic minerals) are required in large quantities to produce clean energy technologies (in particular, electric vehicles, solar panels and wind turbines) and battery storage are known as critical minerals (Gielen, 2021).

Box 2. Definition of critical minerals

Critical minerals are broadly defined as those that are vital for various industrial sectors, including energy, transportation, and aerospace, where they are used in advanced manufacturing applications (IEA, 2021e). However, the 'criticality' of a mineral is context-specific, varying across countries and regions (Glöser and others, 2015). A country often labels certain minerals as 'critical' based on its own resource endowment, industry needs, and the capacity for mineral substitution (i.e., using more abundant minerals to replace scarce ones) and recycling (Gielen, 2021; IEA, 2021d; Institute for Sustainable Futures, 2019; World Bank, 2020b). The United States, European Union and Japan identify 35, 27 and 31 critical minerals, respectively (Department of Industry Innovation and Science, 2019). In 2022, the United States further expanded its list to 50 minerals, by splitting the rare earth elements and platinum group elements into individual entries and adding two new minerals, i.e., nickel and zinc (United States Geological Survey, 2022).

In the context of this report, 'critical minerals' refers to those minerals widely used in clean energy technologies, as most of the future mineral demand will come from the accelerated deployment of these technologies in an effort to mitigate the worst impacts of climate change. They are also often called 'energy transition minerals'. They include, for example, aluminium (bauxite), cobalt, copper, lithium, manganese, nickel and rare earth metals (mainly neodymium and dysprosium) (IEA, 2021d; IRENA, 2021; World Bank, 2017). Our scope of critical minerals is relatively small.

The development of critical minerals does not always contribute to sustainable development, as commonly defined by the SDGs. In terms of activities, mining for critical minerals has many of the same potential economic, social and environmental consequences as has been seen in fossil fuel extraction and other extractive industries.[1] In terms of revenue, the potential for high and increasing revenue from critical mineral development poses challenges to countries with weak governance and revenue management capabilities. To prepare extractive industries for the energy transition towards a sustainable future, and transform them into an engine for sustainable development, there is an urgent need to explore challenges and opportunities in the extractive industries.

The issues faced by the critical mineral development during the energy transition are significant for Asia-Pacific region – defined in this context as ESCAP member States as a whole. Given the significant development potential, the Asia-Pacific countries will face many of the same challenges in managing the impacts of mining activities and revenue as other resource rich countries have done. Many countries in the region with already well-developed extractives industries will benefit, but some countries will develop a significant extractives industry for the first time. New resource development countries need effective regulatory and governance environments to transform these resources into a source of prosperity for all, as a significant increase in CRM extraction is expected to generate additional stress for economic, environmental, social and governance systems. Understanding the implications, impact and magnitude of the energy transition are prerequisites for the Asia-Pacific region to align the development of its CRM resources with sustainable development, as articulated in the form of the SDGs.

As the key global coordinator to achieving the 2030 SDGs and the Paris Agreement, the United Nations faces significant challenges in coordinating the two goals during the energy transition, and urgent action is required. The United Nations also actively promotes the sustainable development of critical minerals.

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[1] Extractive industries, in the context of this report, are referred to as the process of extracting raw materials from the earth, including fossil fuels (in particular, coal, gas and oil), minerals (including rare earth minerals, bauxite, and gold) and aggregates (such as sand, gravel, and clay).

In February 2021, ESCAP organized an expert roundtable that brought together high-level representatives from Governments, intergovernmental institutions, the private sector, non-profit organizations, and academia to examine the future of the extractive industries sector in the context of meeting the SDGs (ESCAP, 2021a). This was one of five roundtables organized by the United Nations Regional Commissions to address this topic. In May 2021, a high-level global roundtable was organized where messages from roundtables organized by the five United Nations Regional Commissions – including ESCAP – were highlighted (United Nations, 2021a). Following on from the discussion and findings of these roundtables, ESCAP is continuing to investigate the potential implications of the energy transition for Asia and the Pacific CRM extractive industries in the future. While much has been written about this topic, relatively limited studies have looked at the impact of the energy transitions on the critical minerals from the perspective of sustainable development.

The overall objective of this report is to develop and provide a comprehensive policy study focused on the Asia-Pacific region that analyses the implications of the energy transition on the extractive industries sector from the perspective of SDGs. This report addresses the following questions:

- What are the implications of the energy transition for countries that currently, or could potentially, extract and export critical minerals?
- What are the relationships between energy transition, critical mineral development and SDGs?
- What best practice policies and regulations can be implemented to reduce the environmental impact and improve the governance of the extractive industries sector?
- What is the role of sub-regional, regional (including ESCAP), and global entities in enabling the just, equitable and sustainable development of the extractive industry in the Asia-Pacific region?

CHAPTER 2

ENERGY TRANSITION AND CRITICAL MINERAL DEVELOPMENT

Replacing fossil fuels with clean energy sources by extension increases dependence on mineral resources. Demand for many critical minerals is therefore expected to grow multifold by the middle of this century. These critical minerals, however, are more concentrated in their production and processing and have less transparent markets than fossil fuels, and thus incur many supply security concerns.

2.1. CRITICAL MINERAL AND CLEAN ENERGY TECHNOLOGIES

Large amounts of mineral resources will be required to support the global transition toward a low-carbon energy future. Many clean energy technologies are mineral-intensive. A typical electric vehicle, for example, requires six times as much as the input of selected minerals compared with a conventional vehicle. An onshore wind turbine requires nine times more of selected mineral inputs than a gas power plant with the same capacity (IEA, 2021d). PV and wind power per unit generation require up to 40 times more copper and 14 times more iron than fossil fuel generation on a life-cycle basis (Hertwich and others, 2015).

Wind energy, solar cells, batteries and fuel cells are highly dependent on metals such as platinum, cobalt, lithium and Rare Earth Elements (REEs), which are mined and/or processed in relatively few countries (see Table 2 later in this report). Energy storage technologies are also mineral-intensive, and though battery chemistries can vary, the battery types in high demand for energy transition related uses require relatively large amounts of graphite, lithium and cobalt. Copper, chromium, and molybdenum are cross-cutting minerals that are widely used in a variety of clean energy and storage technologies. Up to 75% of future demand for critical minerals will come from investments in electricity networks, battery storage (in particular, for use in electric vehicles), and renewable electricity generating capacity (Ali and others, 2017). Renewable power generation, grid expansion, batteries and electric motors are the main drivers of critical materials demand (IRENA, 2021). About 87% of the demand for aluminium would come from solar PV, while 98% of the demand for zinc would come from wind turbine, 64% of the demand for titanium would come from geothermal technology. Approximately 75% of the demand for copper would come from solar PV and wind turbines, according to a World Bank (2020b) report.

Some of the critical minerals (e.g., chromium, copper, molybdenum and nickel) are used across a wide variety of clean energy and storage technologies (World Bank, 2020b). Others are predominantly used in one or two types of clean energy and storage technologies, such as lithium and cobalt for batteries, neodymium and dysprosium for permanent magnets used in electric motors and wind turbines, and silver for solar PV modules (Gielen, 2021; IEA, 2021d; World Bank, 2020b). Many rare earth metals, for example, are critical inputs into clean technology applications such as batteries, solar panels and wind turbines, and demand for these and other raw materials is projected to significantly increase as the energy transition moves forward (World Bank, 2020b). Four elements – neodymium, dysprosium, praseodymium, and terbium – are of particular importance to the clean energy sector. Other minerals that are indispensable to clean energy technologies include uranium for nuclear power, and silver for photovoltaics (Vikström, 2020). Non-metallic minerals also have an essential role in the clean energy transition. For example, silicon is the most crucial critical mineral in solar PV, while graphite, a non-metallic mineral, has an irreplaceable position in producing electric vehicles and their batteries.

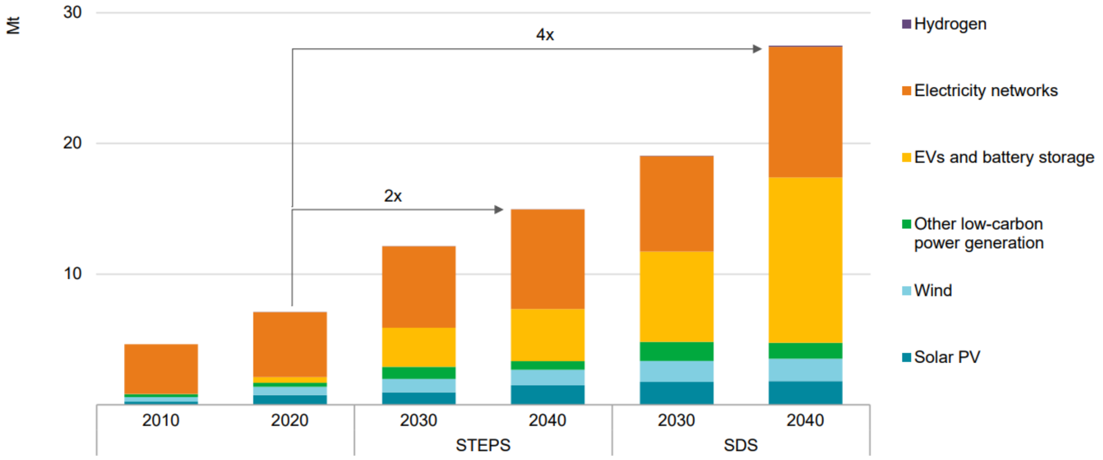
2.2 FUTURE DEMAND FOR CRITICAL MINERALS

Since critical minerals will be indispensable for global development in the coming decades, the demand for critical minerals will be significantly increased for renewable energy generation, electric vehicles, and energy storage. This section summarizes projected outlooks for critical minerals by some well-regarded institutions.

2.2.1 *International Energy Agency projection*

In 2021, the IEA published a bottom-up assessment of mineral demand for 2040 under various scenarios (figure 1). It found that, compared to today, total mineral demand (excluding steel, aluminium, uranium and others) from clean energy technologies will double by 2040 under the 2020 World Energy Outlook (WEO) Stated Policies Scenario (STEPS), which assumes the implementation of current and planned policies, and quadruple under the Sustainable Development Scenario (SDS), which assumes that countries meet the 2 degrees Celsius (2°C) Paris Agreement goals (climate stabilization at "well below 2 degrees Celsius (2°C) global temperature rise"). To achieve net-zero emissions by 2050, the IEA projects that the mineral demand will increase by six times (IEA, 2021d).

FIGURE 1. Total mineral demand for clean energy technologies by scenarios



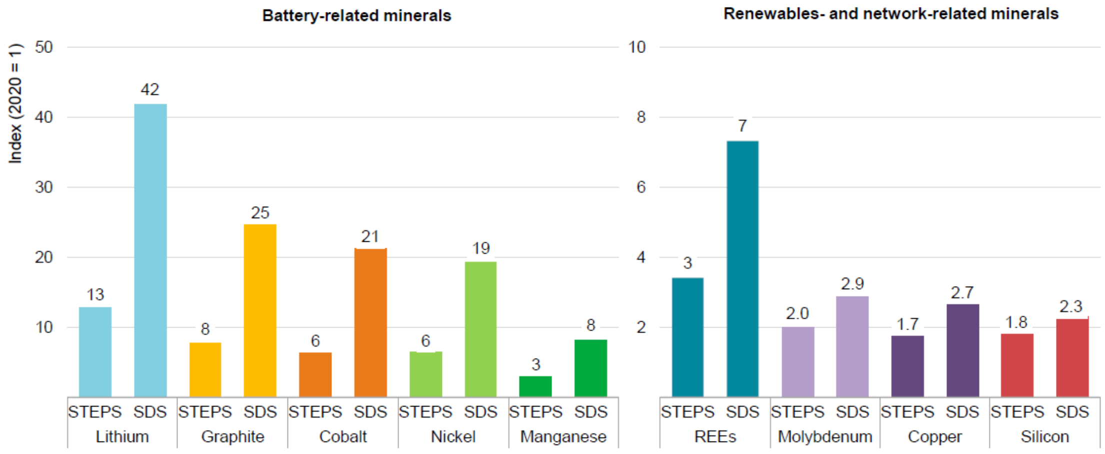
Source: IEA, 2021d.

Under the IEA's SDS from the 2020 WEO, the primary driver for increased demand will be electric vehicles (EVs) and battery storage, which will account for about half of the mineral demand growth from clean energy technologies by 2040. Mineral demand for EVs and battery storage will grow nearly tenfold under STEPS and by around 30 times under the SDS.

Also, under the SDS, copper demand by the power sector will double, while mineral demand will triple. The IEA, however, explicitly states that its projections are subject to large technology and policy uncertainties (IEA, 2021d).

Lithium will experience the fastest growth in demand (more than 40 times in the SDS by 2040) arising from clean energy technologies, followed by graphite, cobalt and nickel (around 20 to 25 times) (figure 2). Nickel and zirconium for electrolysers, and platinum-group metals for fuel cell electric vehicles (FCEVs) will also experience major growth in demand due to the fast development of hydrogen. The demand for REEs – mainly used for EV motors and wind turbines – will grow threefold under STEPS and around sevenfold under the SDS (IEA, 2021d).

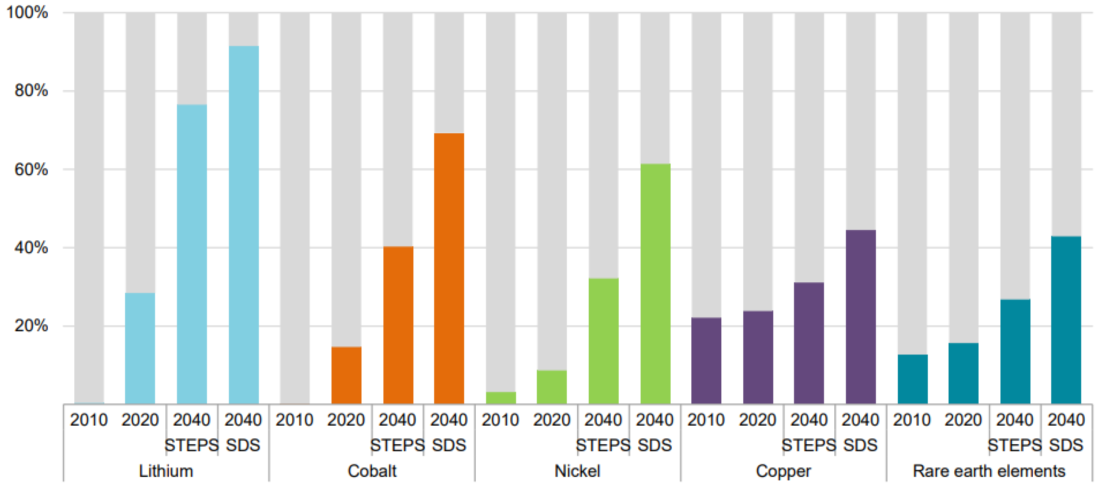
FIGURE 2. Growth in demand for selected minerals from clean energy technologies in 2040 relative to 2020 levels



Source: IEA, 2021d.

To put these outlooks into perspective, under the SDS scenarios, by 2040 the share of energy transition-related demand out of total demand for these minerals will rise from relatively marginal levels today to more than 40% for copper and rare earth elements, 60% to 70% for nickel and cobalt, and almost 90% for lithium (figure 3). The current largest consumer of lithium – EVs and battery storage – will become the largest consumer of nickel by 2040 (IEA, 2021d). By weight, mineral demand in 2040 will be dominated by copper, graphite and nickel (excluding steel, aluminium and cement, among others) (IEA, 2021d).

FIGURE 3. Share of clean energy technologies in total demand for selected minerals



Source: IEA, 2021d.

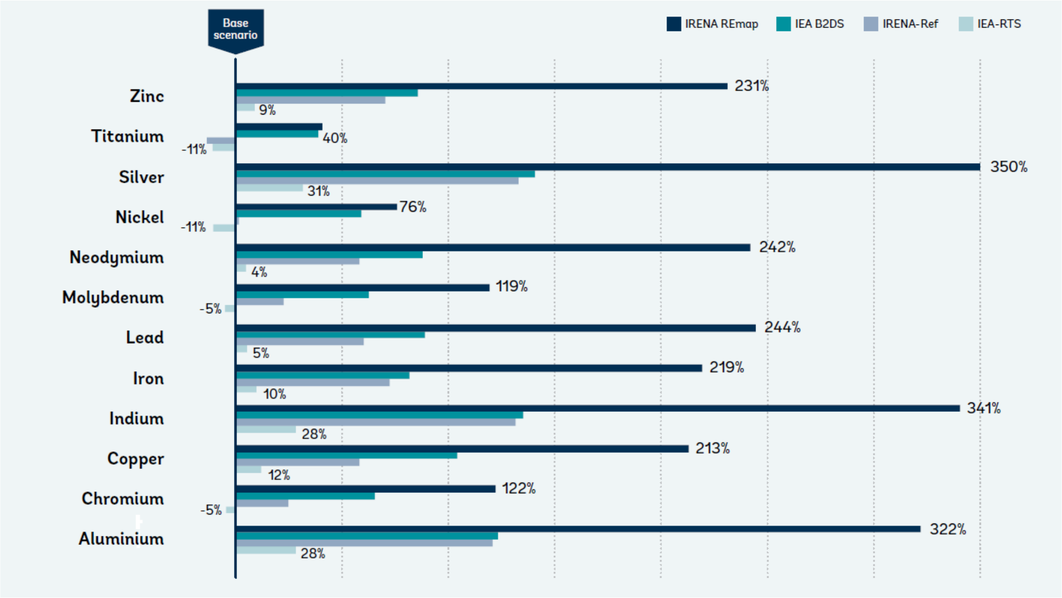
2.2.2 *World Bank projection*

In 2017, the World Bank published a set of commodities demand scenarios up to 2050. Notably, these scenarios were based, in turn, on the IEA's climate and technology scenarios (World Bank, 2017). The World Bank projections consider three technologies – wind, solar and batteries – under 2-, 4- and 6-degree global temperature increase scenarios (2,4, and 6 DS). It was found that renewable energy generation (including hydropower and biomass) in the energy mix would increase from 14% to a low of 18% under 6DS and a high of 44% under 2DS. Furthermore, the report found that low carbon technology requirements, and relevant metals demand, would increase rapidly between 4DS and 2DS. Batteries alone drive demand for aluminium, cobalt, iron, lead, lithium and manganese by more than 10 times under the 2DS compared to the 4DS (World Bank, 2017).

According to the World Bank (2020b), about 103 million tonnes of aluminium, 68 million tonnes of graphite, 60 million tonnes of nickel and 30 million tonnes of copper will be required during 2020-2050 to deploy clean energy and storage technologies required to put the global energy sector on a low-carbon pathway. More recently, the Under the 2DS, graphite, lithium and cobalt production would need to increase by more than 450% by 2050, relative to 2018 production levels, in order to meet demand from energy storage technologies (figure 4).

The projected demand for some base minerals is relatively small in percentage but large in absolute terms – for example, demand for aluminium and copper will be 103 million tonnes and 29 million tonnes by 2050, respectively (World Bank, 2020b).

FIGURE 4. **Relative change in demand for minerals from energy technologies (without storage) from 2013 to 2050 under different scenarios**

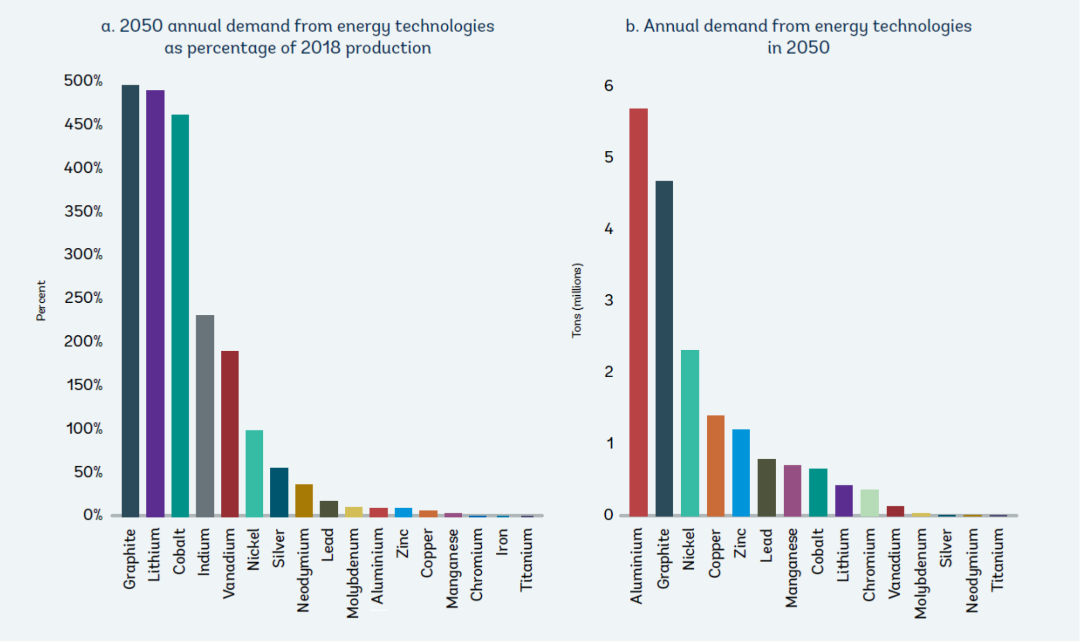


Source: World Bank, 2020b.
Note: Base scenario = 4-degree scenario from IEA (2016), B2DS = beyond 2-degree scenario, IEA = International Energy Agency, IRENA = International Renewable Energy Agency, Ref = reference scenario, REmap =renewable energy roadmap scenario, RTS = reference technology scenario.

The World Bank projected that, compared with 2018, demand for graphite, lithium and cobalt will increase by up to five times by 2050 due to battery production (Figure 5a). In terms of mass value, the increase is dominated by aluminium, graphite, and nickel, which have broad applications. Graphite demand is at the top in terms of both absolute and percentage increases due to its primary uses – for example, in anodes (commonly deployed in electric vehicles, grid-integrated and decentralized storage) (Figure 5b).

Moreover, many rare earth metals are critical in clean technology applications such as batteries, solar panels and wind turbines, and their demand is projected to significantly increase to support energy transition (World Bank, 2020b).

FIGURE 5. Projected annual mineral demand under 2DS from energy technologies, 2050 vs 2018 production levels



Note: 2DS = 2-degree scenario.

Source: World Bank, 2020b.

2.2.3 *International Renewable Energy Agency projection*

The third projection comes from the International Renewable Energy Agency (IRENA), which examines the potential demand for a few critical minerals in 2050 under a 1.5°C scenario (Table 1). The projection reveals the diversity in supply and demand among the critical minerals and differs significantly from, for example, the earlier World Bank estimates. By monetary value in 2050, copper has the highest share of about a third, followed by lithium and nickel (a quarter each), graphite (10%) and cobalt (7%) (IRENA, 2021).

Table 1. Current and projected demand in 2050 in a 1.5°C scenario, Mt/yr

	Current demand	2050 demand	Comment
Copper	30 (2020)	50-70	Energy uses are only part of total demand.
Nickel	2.54 (2019)	5-8	Currently mainly for stainless steel.
Lithium (LCE)	0.41 (2019)	2-4	Mainly for batteries.
Cobalt	0.14 (2020)	0.5-0.6	Mainly for batteries.
Neodymium	0.03	0.2-0.5	Mainly for permanent magnets.

Source: IRENA, 2021.

These three projections differ in terms of the scale of demand for the same critical minerals, but given that they have different starting points and different assumptions about the pace and scale of the energy transition, this is to be expected. The important point is they all show significant growth potential in demand due to the energy transition. They also reveal that there is significant heterogeneity across minerals, with inputs such as lithium, cobalt and neodymium – which are predominantly used for energy applications – logically more impacted by the energy transition than inputs with more general uses, such as copper and nickel. However, even in the case of these more generally utilized inputs, the energy sector becomes a significant driver of total demand. Therefore, the energy transition has sweeping implications for the entire extractives industry sector.

2.3 RESOURCE DISTRIBUTION AND SUPPLY SECURITY

As the energy transition progresses, energy security discussions are being increasingly focused on the availability and security of the supply of critical minerals. No country has domestic resources of all the required CRMs for the energy transition and countries occupy different positions in the clean energy supply chain, therefore trade is necessary. The urgency of the energy transition and implementation of the Paris climate agreement, coupled with the much-needed economic recovery from the COVID-19 pandemic, suggest new challenges and opportunities along the supply chains of critical minerals (Anna, 2021). There have been growing concerns that the supply chains of critical minerals are less transparent and more concentrated than those of fossil fuels (IEA, 2021d), and that they are therefore more vulnerable to disruption (Australian Government, 2022a).

Increasing dependence on critical minerals means in turn that CRM supply impacts a country's economic security with increasingly dependence on critical minerals. Access to large quantities of CRMs are essential to deploying low-carbon technologies. Assuring the supply of critical minerals and the resiliency of their supply chain may therefore be essential to a country's economic prosperity. However, CRMs are unevenly distributed worldwide, and their production is subject to a high degree of concentration (Table 2), raising concerns over supply security.

Table 2. Major producing countries in Asia-Pacific and their global share of critical minerals production in different energy transition elements

(Unit: Percentage)

Mineral [symbol] (Technologies)	Producing country	Production share (%)	Mineral [symbol] (Technologies)	Producing country	Production share (%)
Copper [Cu] (solar PV, Wind, hydropower, biomass, nuclear, evs, battery storage, hydrogen)	China	8.57	**Zinc [Zn]** (Solar PV, wind, hydropower, biomass)	China	32.31
	United States	5.71		Australia	10
	Australia	4.29		India	6.23
	Russian Federation	3.90		United States	5.69
	Indonesia	3.86		Russian Federation	2.15
Silicon [Si] (solar PV)	China	70.59	**Manganese [Mn]** (CSP, wind)	Australia	16.5
	Russian Federation	6.82		China	6.5
	United States	3.65		India	3
	France	1.41		Georgia	0.95
	Malaysia	0.9		France	0.81*
Chromium [Cr] (CSP, nuclear hydropower, geothermal)	Türkiye	17.07	**Nickel [Ni]** (geothermal, nuclear, EVs, hydropower)	Indonesia	37.04
	Kazakhstan	17.07		Philippines	13.70
	India	7.32		Russian Federation	9.26
	Russian Federation	1.35**		New Caledonia	7.04
	Iran, Islamic Republic of	0.37**		China	4.44
Molybdenum [Mo] (geothermal)	China	43.33	**Titanium [Ti]** (biomass, geothermal)	China	35.71
	United States	16		Australia	5.71
	Mongolia	0.97		Viet Nam	2.62
	Russian Federation	0.93		India	2.14
	Iran, Islamic Republic of	0.47		United States	1.19
Graphite (EVs, battery storage)	China	82	**Lithium [Li]** (battery storage)	Australia	55
	Russian Federation	2.70		China	14
	India	0.65			
	Viet Nam	0.54			
	Türkiye	0.27			

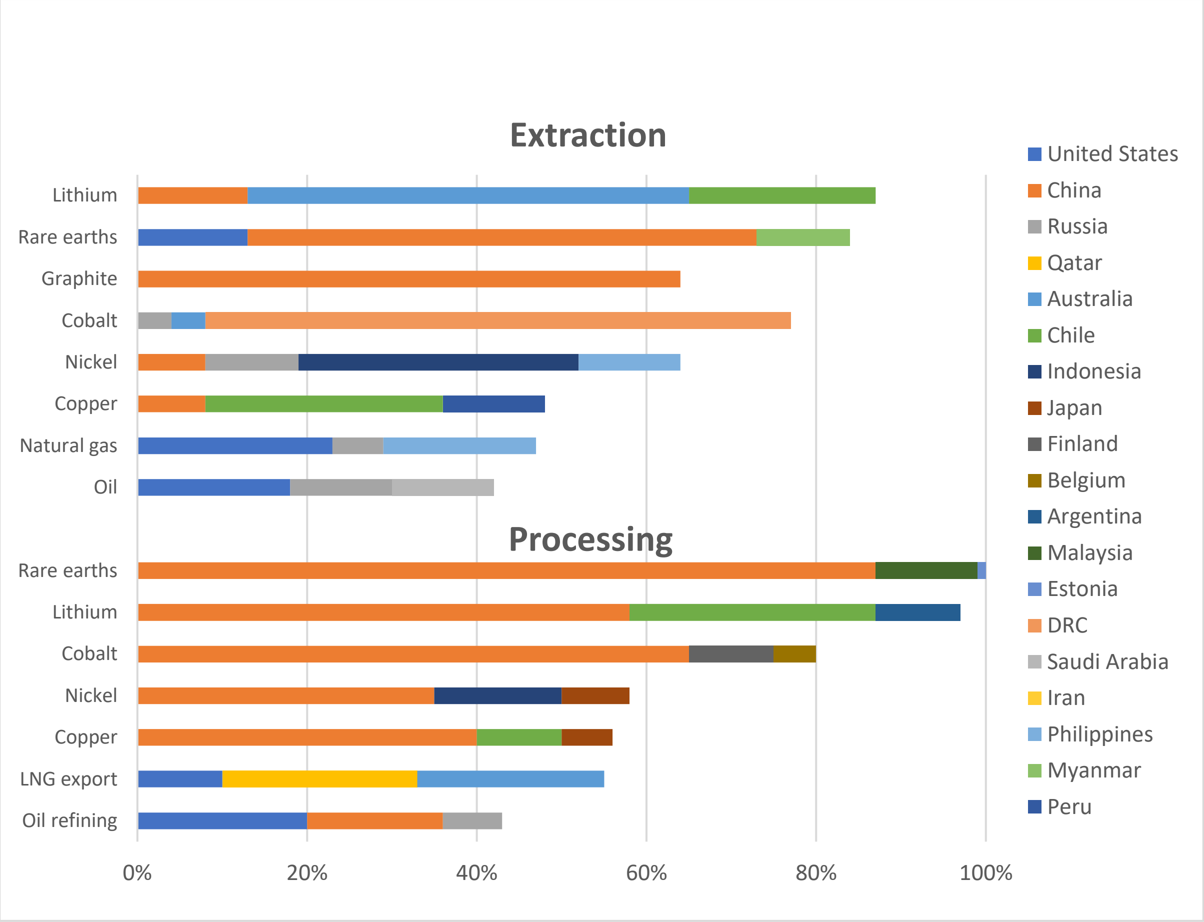
Sources: Production data are in percentages. Unless indicated below, all data are from the 2022 USGS mineral commodity summaries; * indicates from the 2019 minerals yearbook, and ** indicates from the 2020 minerals yearbook nited States.

Note: Table 2 shows the production share of 10 critical minerals for selected critical mineral-rich countries, ranking the countries in descending order by their share of production.

While critical minerals are already indispensable, most countries are not self-sufficient. The IEA estimates that the expected supply from existing mines and projects under construction can meet only 50% of the projected lithium and cobalt requirements and 80% of copper needs by 2030 (IEA, 2021d). This projected supply shortage will delay energy transitions and push up their cost. This issue is exacerbated by the fact that the quality of ore has been declining for many commodities.

The gap in critical minerals is usually made up through global trade. Countries have different roles in the supply chain. Today's production and processing operations for many CRMs are highly concentrated in a small number of countries (figure 6).

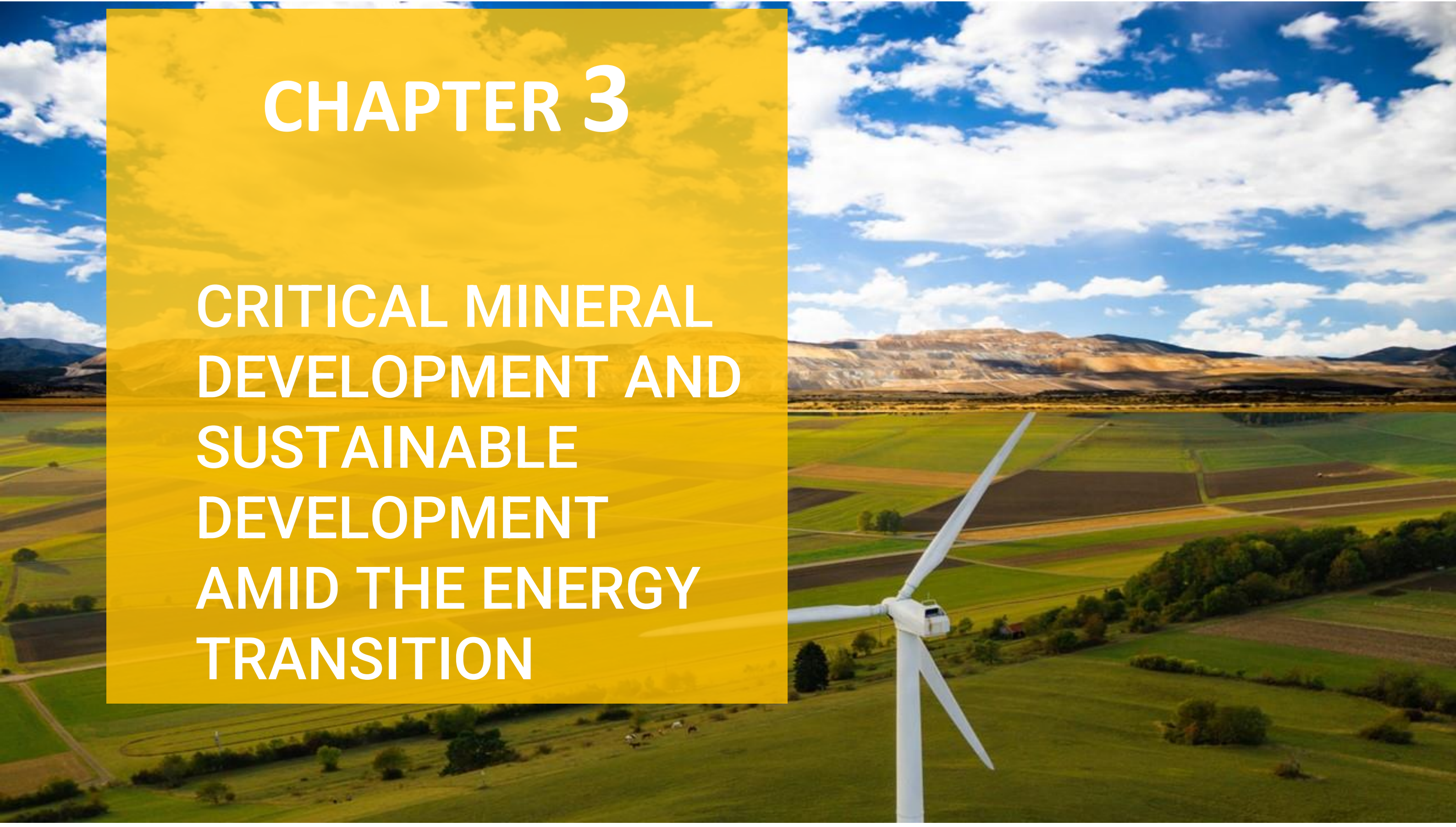
FIGURE 6. Share of top producing countries for selected minerals and fossil fuels, 2019



Source: IEA, 2021d.

These combined factors of high concentration and a lack of transparency make critical minerals more vulnerable than fossil fuels to physical disruption, trade restrictions or other developments in major producing countries (IEA, 2021d).

The challenges of trade and supply chains for critical minerals include many factors, such as economic and market issues, environmental matters, geopolitics and even the COVID-19 pandemic. All of them are relevant to critical minerals trade and supply chain security, and potential impacts of disruptions can be hard to predict. For example, the military coup in Myanmar caused a surge in the price of REEs (IEA, 2021d). The intensification of international competition will also create risks to the supply chain of critical minerals, especially rare earth elements, lithium and cobalt (Nakano, 2021). According to one research report, 84% of platinum resources and 70% of cobalt resources are located in high-risk contexts (Lèbre and others, 2020). In addition to accidents and labour strikes, natural disasters have also become the third most frequent cause of mineral supply disruption (Hatayama and Tahara, 2018).



CHAPTER 3

CRITICAL MINERAL DEVELOPMENT AND SUSTAINABLE DEVELOPMENT AMID THE ENERGY TRANSITION

The change in CRM demand will have profound and far-reaching implications, not only confined to the extractive industries, but also extending into the socio-economic, environmental and governance realms of resource-rich countries, thereby posing both challenges and opportunities for their sustainable development. At the core of the complexity are the opportunities and challenges that are raised by the development of extraction industries, which are closely related to almost all SDGs due to their wide-ranging connections to other industries as well as to societies and economies more generally. While the extractive industries have enormous potential to boost economic growth and reduce poverty, they also have economic, governance, social and environmental concerns. To prepare extractive industries for the energy transition towards a sustainable future and transform them into an engine for sustainable development, there is an urgent need to explore ways of managing the challenges and opportunities in the extractive industries. This chapter discusses the opportunities and challenges in the development of CRMs in the Asia-Pacific region on four important dimensions of sustainable development, i.e., economic, environmental, social and governance (collectively named the E2SG framework).

3.1. OVERVIEW OF CRITICAL MINERAL DEVELOPMENT AND SUSTAINABLE DEVELOPMENT

Increasingly, consumers and investors are seeking minerals that are produced sustainably and responsibly– that is, in a manner consistent with sustainable development. The popularity of sustainable development as a concept has an empirical background in the widespread recognition of the 'unsustainability' of the status quo in various domains, such as social (inequity, exclusion and poverty), economic (inflation, stagnation and unemployment), and environmental (ecological degradation, waste and climate change). This popularity has arguably contributed to a plethora of definitions of sustainable development and hence an increasing ambiguity as what the concept refers to in practice. Notwithstanding these ambiguities, there appears to be some agreement that achieving sustainable development requires transformative changes in current patterns of development to safeguard long-term ecological integrity, satisfy basic human needs, and promote intra- and inter-generational equity (Holden and others., 2014).

A useful framework for assessing progress towards this transformation are the SDGs adopted by all United Nations member States in 2015 as part of the 2030 Agenda for Sustainable Development. The SDGs comprise 17 interrelated and interdependent goals, supported by 169 specific targets that address various dimensions of sustainable development including, for example, economic growth, environmental integrity and social wellbeing. Minerals and the extraction thereof are intertwined with achieving the SDGs and SDGs' comprehensiveness. For example, increasing commodity prices and improvement in extraction technologies will boost the economic viability of minerals, and therefore serve as a driver of economic growth. At the same time, stringent social and environmental mechanisms and measures could make resource development more difficult (Ali and others, 2017b). SDGs, however, do not explicitly refer to minerals (Franks and others, 2022). Therefore, there is value in making the link between critical minerals extraction and SDGs more explicit.

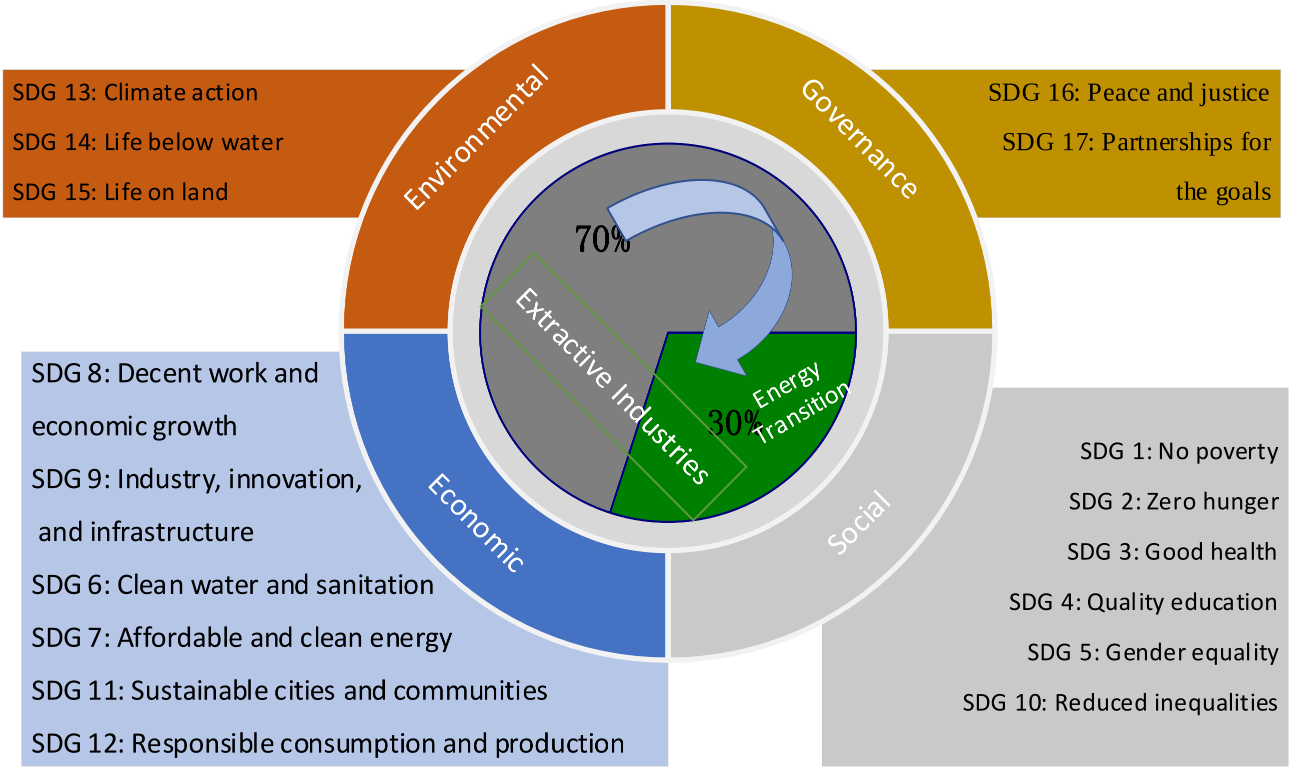
Broadly speaking, critical mineral extraction, processing, trade and recycling, (collectively named *critical mineral development*), have close but differential impacts on sustainable development. One issue of critical mineral development from the sustainable development perspective is extraction. Increased deployment of modern renewable energy and energy-efficient technologies means an increased demand for rare earth elements and other mined inputs (see Chapter 2 for further details). To meet this demand, the extraction of mineral resources needs to be ramped up, but large-scale mining could also lead to environmental degradation, including water competition, biodiversity, land use change, etc. This could have further negative impacts on health, poverty, inequality and demographic imbalances (Lèbre and others, 2020).

Critical mineral development also has strong implications for trade because no country has all the required metals for the energy transition, such as manufacturing electric vehicle batteries. At the same time, increased and more effective recycling of mineral-based products could help to reduce the need for extraction and trade of mineral resources.

The extractive industries are closely related to almost all SDGs due to their wide-ranging connections to other industries and to societies and economies more generally (See figure 7 for an illustrative relationship). In some cases, the relationship is a potentially positive one. Extractive activities could, for example, foster economic and social development by generating jobs and revenue (SDG 8), helping reduce poverty (SDG 1), and contributing to better provision of health care (SDG 3), education (SDG 4), energy (SDG 7) and water (SDG 6) (ESCAP, 2021b; Hund and others, 2020). At the same time, however, extractive activities could also negatively impact or impede sustainable development as it relates to land (SDG 15), water (SDG 14) and climate change (SDG 13) (Lèbre and others, 2020) and may also adversely have an impact on society's cultural and other aspects, such as population displacement, inequality (SDG 10) and armed conflicts (UNDP and others, 2017).

In addition, the production, transportation and consumption of fossil fuels are the main contributors to climate change (SDG 13). More responsible production and consumption of mineral resources (SDG 12) could help to manage these impacts.[2]

FIGURE 7. An SDG- and E2SG-based perspective on the changing energy-extractives nexus



Source: ESCAP.

The following sections will examine the relationship between critical minerals and the SDGs through the four dimensions of the E2SG framework.

3.2. ECONOMIC DIMENSION

The economic dimension of CRM development is closely related to economic growth (SDG 8), inequality (SDG 10), and responsible production and consumption (SDG 12). Critical mineral development could also generate fiscal revenue for the

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[2] `This report presents a framework for quantitatively analysing the trade-off and synergy between extractive industries' developments and SDGs in the Appendix. The analysis can also be extended to investigate the impacts of critical mineral when data are available.

Governments and thus enhance their capacity to improve the provision of basic services, such as food (SDG 2), health care (SDG 3), education (SDG 4), clean water (SDG 6) and energy (SDG 7). Economic losses related to reduced demand for fossil fuels could put pressure on the social contexts in which they are experienced, exacerbating existing tensions and contradictions, such as widespread poverty (SDG 1) and a rural-urban divide (SDG 10).

3.2.1. Economic growth

The critical mineral sector appears to have brought significant economic benefits, as indicated by high economic output, value-added, employment and personal income multipliers. For example, Kim and others (2020) found that, in the Republic of Korea, every United States dollar invested in the mining sector (including, coal, crude oil, natural gas, metal ores and non-metallic mineral) would lead to an increase of $0.85 in value-added and a rise of $0.33 in personal income. In a similar study, it was found that every US dollar invested in China's mining sector could lead to an increase of between $0.27 and $0.33 in value-added and between $0.11 and $0.13 in personal income (Zhang and others,2022).

Mineral industries contribute to economic development in many ways. The most direct contribution is through revenue. In many countries, this revenue source can be significant (IEA, 2021). In several developing countries, the extractive industries sector accounts for a significant share of GDP (Qian and others, 2021). It can also provide raw materials for various industries promoting the economic development of a country or region.

As the energy transition proceeds, increased mineral extraction to meet the demand for mineral resources (as discussed in 0) presents opportunities for fostering economic growth, facilitating job creation (SDG 8), and promoting infrastructure development and the creation of downstream industries (SDG 9). Extractive industries often benefit remote communities due to the development of substantial infrastructure development that is required to support extraction and transport of products to market. Revenue from increased mineral extraction could also create opportunities for countries to invest in a sustainable future and thus contribute to SDG 1 (no poverty), SDG 2 (zero hunger), SDG 3 (good health), SDG 4 (quality education), SDG 6 (clean water and sanitation) and SDG 7 (affordable and clean energy), by improving the socio-economic conditions of the mining communities and wider society.

The economic rents arising from the extraction and production of energy and mineral resources have, however, not always translated into positive impacts on sustainable socio-economic development – a phenomenon known as the resource curse (Auty, 1993). Abundant natural resources are a 'double-edged sword' for resource-based countries or regions. Mineral wealth can, if exploited responsibly, contribute to public revenue and provide economic livelihoods for many persons. However, if poorly managed, mineral development can lead to a myriad of economic challenges (IEA, 2021). For example, Bhattacharyya and Resosudarmo (2015) found that the growth of the mining sector from 1977-2010 had no statistically significant impact on GDP per capita across 26 Indonesian provinces,. Similar results have also been found for other Asia-Pacific resource-exporting countries, such as Azerbaijan (Zotin, 2017a), the Islamic Republic of Iran (Zotin, 2017b), Papua New Guinea (Fox and Schroder, 2017, Howes and others, 2019), the Russian Federation (Ahrend, 2005) and Timor-Leste (John and others, 2020).

The reasons behind the resource curse are diverse and complicated. One is 'Dutch disease', where the development of the resources sector results in a decline in other economic sectors and hence affects overall economic development. The basic argument is that resource exports may generate large balance of payment surpluses, appreciating the real exchange rate and increasing relative prices for non-tradeable inputs. These, together with rising demand from a mining boom, the argument continues, tend to make other trade-exposed sectors (e.g., the manufacturing sector) less competitive, thereby being gradually crowded out of the market (Corden, 1984). Other often-cited reasons include weak institutions, poor rule of law, not credible regulation, inadequate financial management and a lack of capital control mechanisms (Auty, 1993; Badeeb and others, 2017).

3.2.2. *Employment*

Mining and other investments also have a high potential to create both direct and indirect jobs, and employment opportunities. Improved infrastructure access and services enables businesses and households to increase their output and productivity, and thus create further job growth potential. Moreover, it contributes to indirect employment more positively than direct employment (UNEP, 2020). A survey of 25 top mineral-dependent countries showed that the mining contribution to direct employment ranges from 0.1% to 4.5% of total employment. It is estimated that a $1 billion expenditure on road construction in the United States can generate about 6,000 direct jobs, 7,790 indirect jobs and 14,000 induced jobs (Mancini and Sala, 2018).

Therefore, job losses caused by mine closure in fossil-dependent regions as well as the loss of indirect jobs in other interconnected sectors could have a significant impact on labour markets, economies and livelihoods of local communities and countries as a whole; this is especially so due to the agglomeration effects of fossil extraction that often lead to the creation of fossil-related industrial clusters in pursuit of scale economies (ILO, 2022a). For example, in India 2.5 million people are dependent on the coal economy, while more than 13 million are employed in related sectors such as transport, power, steel, sponge iron and others. Further inclusion of the indirect and informal workforce (such as third-party vendors and warehousing staff) could increase this number to 20 million (Dsouza and Singhal, 2022). All these jobs are under threat of being transformed or as the energy transition reduces demand for coal. Therefore, the impact of the clean energy shift on well-established fossil fuel industries is potentially profound.

Some studies are less concerning about job loss, based on the argument that less than 5% of total employment is directly involved in the extraction and production of energy and mineral resources in the region (table 3). Others suggest that these job losses can be somewhat or entirely offset by new jobs created in low-carbon technology industries (Pai and others, 2020). For example, IRENA (2020) estimates that jobs created by the renewable industry, including manufacturing, installing, operating, and maintaining renewable energy systems, could reach 42 million worldwide by 2050 – more than sufficient to offset jobs lost in the fossil fuel industries. Similar results are also found in a report initiated by the Natural Resource Defense Council (NRDC), as part of the China Coal Consumption Cap Plan and Policy Research Project, which analysed the potential employment impact of reduced coal consumption across the country. It suggests that the implementation of the coal consumption cap policy in China will increase unemployment by 720,000 in the coal mining and washing sector, while at the same time, more than 740,000 new jobs will be created in the renewable energy and energy efficiency industries (NRDC, 2015).

Even though parts of the mining sector may benefit from the energy transition and the total number of jobs and net revenues may not be reduced, the change in the distribution of the employment impact across sectors on stakeholders and nations is a key challenge that must be addressed. Reduced fossil fuel extraction would disproportionately affect fossil fuel-dependent regions and communities, posing challenges to enhancing social equality and inclusion (SDG 10) (Johnstone and Hielscher, 2017). Even within a single country, while energy transition may not necessarily lead to fewer jobs nationwide, the regional distribution (SDG 10) of jobs affects whether such transitions are justifiably sustainable (Fankhauser and others, 2008). Indeed, coal-mining regions may not have a clear advantage over other regions when it comes to contributing to the clean energy economy. In practice, low-carbon technology industries are more likely to create jobs in close proximity to energy demand centres, where most activities related to the installation, operation and maintenance of renewable facilities occur, rather than in the coal mining regions that are often far away from energy demand centres.

Table 3. Employment by sector in major Asia-Pacific countries, 2019

	Share of total employment (%)						Total ('000)
	A	E	M	U	C	S	
Australia	3	2	7	1	9	78	12,628
Azerbaijan	36	1	5	1	7	49	4,834
Brunei Darussalam	1	5	4	1	5	83	197
China	25	0.3	20	1	7	46	766,617
India	42	0.4	12	1	12	32	467,793
Indonesia	29	1	15	0.4	6	49	128,460
Iran, Islamic Republic of	18	1	16	1	12	51	24,727
Kazakhstan	16	3	6	3	8	64	8,655

Malaysia	10	1	17	1	9	63	15,152
Mongolia	27	4	8	2	6	53	1,252
Myanmar	49	1	10	0.3	4	35	24,301
New Zealand	6	0.2	9	1	9	75	2,580
Pakistan	37	0.2	16	1	8	38	70,651
Papua New Guinea	58	2	1	0.4	3	35	2,606
Philippines	23	1	9	0.4	10	57	43,852
Russian Federation	6	2	14	3	7	68	70,402
Türkiye	18	1	18	1	7	55	28,867
Turkmenistan	20	1	34	2	6	38	2,549
Uzbekistan	24	1	14	2	13	47	14,374

Source: Developed by the authors, based on information obtained from the World Labour Organization database.
Note: A = Agriculture; E = Extractive; M = Manufacturing; U = Utilities; C = Construction; S = Services.

In addition, the skills and knowledge required by the low-carbon technology industries are quite different compared with the coal mining industry, so it may not be easy for displaced workers to transition to clean energy jobs (Johnstone and Hielscher, 2017). Some extractive industries typically create a limited number of jobs as they are highly technology-intensive and generally dominated by foreign multinationals (United Nations, 2021b). These multinationals or new resource companies increasingly tend to employ a skilled workforce, experienced foreigners and immigrants from other regions, rather than retained local workers (Norcliffe, 2019). Most of the workers involved in the coal mining and washing sectors are not well-educated and, therefore, may find it difficult to find employment in other sectors (Duan, 2016). Furthermore, the reliance on informal labour for mining activities in some countries (e.g., some parts of India) also suggests that declining demand for fossil fuels, if not managed properly, would disproportionately affect the most vulnerable in a society (ILO, 2022a).

3.2.3. *Industrial development*

The energy transition will lead to the phasing-down of the fossil fuels sector and the growth in the use of critical minerals, both of which will face challenges during the transition process. Reduced fossil fuel extraction driven by the transition towards a clean energy future could incur substantial economic losses in terms of, for example, fewer jobs, reduced export revenue and less investment (SDGs 8 and 9). These losses are not only limited to local communities where extractive activities take place. They could also spread to the whole national economy through the demand-side linkages between fossil-related industrial clusters and other economic sectors.

Energy transition has already led to the withdrawal of some major financial institutions from the fossil fuel industries. With shareholders becoming more sensitive to the issues of climate change in recent years, large fossil fuel companies have started to cut back on their investments in the expansion of production capacity. This process needs to be accompanied by the sufficient uptake of the replacements for fossil fuels and a reconfiguration of the whole energy system to accommodate the changing energy mix (P.Wang and others, 2021). If this is not done, the security of the energy supply (SDG 7) could be affected, resulting in the unreliable provision of energy services (in particular electricity), frequent outages and increased price volatility. These would, in turn, pose challenges to economic growth that is related to several SDGs, such as SDG 1 (poverty reduction), SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation, and infrastructure). This impact may be more pronounced in energy-importing countries, especially considering their reliance on international markets for satisfying their energy needs.

The decline in mineral quality is another challenge to future CRM mining projects. As high-quality deposits tend to be exploited earlier, ore quality declines across commodities. For example, as IEA reported in 2021, the average copper ore grade in Chile has decreased by 30% during the past 15 years (IEA, 2021). Extracting lower-quality ores requires more energy and produces more waste and tailings. The outcomes could be higher production costs and more emissions.

Developing critical minerals projects, as argued by the Government of Australia (2022), is complex and technically challenging. Long project lead times exacerbate the risk of a mismatch in timing between demand and the industry's ability to bring on new projects. A study of major mine openings between 2010 and 2019 revealed that the average time between discovery to the first production is 16.5 years (IEA, 2021a). In addition, making the most of clean energy also requires a vital infrastructure, but this will also be a challenge in some countries during the energy transition.

3.3. ENVIRONMENTAL CHALLENGES AND OPPORTUNITIES

The application of critical minerals in clean technologies helps to fight pollution and climate change in the long term, but their development poses significant environmental challenges. Apart from the traditional impact of mining, anticipated demand growth and possible high prices for critical minerals could incentivize mining investments in more environmentally and socially sensitive areas.

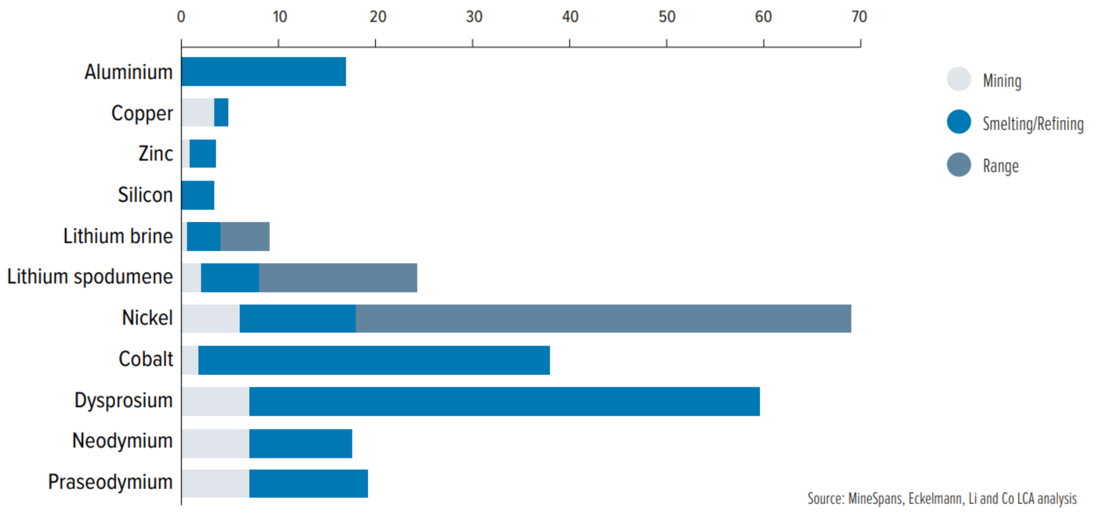
3.3.1. Emissions and climate risks

The extractive industries are energy-intensive and produce large amounts of greenhouse gas (GHG) emissions (SDG 13), both from the direct use of fossil fuels as well as from deforestation associated with the mining process. The extraction and processing of natural resources account for approximately half of global greenhouse gas emissions, including approximately 20% from the mining of metals and non-metal minerals (UNEP, 2019). The extraction of fossil fuels is also a main source of methane emissions – a potent and fast-acting greenhouse gas (IEA, 2021b). Methane's global warming potential – the ability of a GHG to absorb heat in the atmosphere – is 28 to 36 times greater than CO_2 when considering its impact over a 100-year timeframe (Vallero, 2019). This means that one tonnes of methane is equivalent to 28 to 36 tonnes of CO_2. The climate impact of mineral extraction is more pronounced in Asia and the Pacific, where most of the extractive activities take place (UNEP, 2019).

The extraction of some critical minerals has a higher emissions intensity relative to other commodities due to their lower concentration in ore (figure 8). For example, compared with steel production, the extraction of lithium carbonate and Class 1 nickel could generate three and ten times more emissions, respectively (IEA, 2021). All other things being equal, growth in mineral demand, coupled with falling mineral ore grade, would increase the mining activities' energy demand (i.e., exploration, extraction, beneficiation and processing, and refining), and therefore potentially increase the carbon footprint of mineral extraction (Igogo and others, 2021; Norgate and Haque, 2010), depending on the energy sources used in the mining process, and their associated emissions.

In addition, climate risks pose challenges to ensuring reliable and sustainable supplies of critical minerals. Several major CRM-producing countries and regions are also subject to various forms of climate risk, including extreme heat or flooding. Flooding, for example, can cause extensive environmental damage through spills of hazardous waste from mine sites or waste storage and tailings dam failure (German Environment Agency, 2019).

FIGURE 8. **GWP primary metal production, split into mining and metal-making steps (tonne CO_2/tonne metal, for lithium tonne CO_2/tonne LCE)**



Source: MineSpans, Eckelmann, Li and Co LCA analysis

Lithium and nickel range depends on the end-product (carbonate/hydroxide for lithium, class 1/class 2 for nickel)

Source: (Gregoir and Van, 2022).

3.3.2. Other environmental impacts

The extractive industries are also associated with other environmental problems, such as deforestation, pollution, conflict, depletion of non-renewable resources and disruption of ecosystems. These problems could affect the health and safety of workers and the overall wellbeing of local communities.

Mineral development affects the environment at different levels (local, regional and global) and across different segments (land, air and water). Mining is currently associated with a range of serious environmental problems, such as air pollution, water and soil contamination, and deforestation (Askarova and Mussagaliyeva, 2014; Main and others, 2015; Rauner and others, 2020; M. Zhou and others, 2020). According to Lèbre and others (2020), potential externalities from the extraction of critical minerals include the waste that has an impact on the downstream ecosystems, hydro-morphological changes and transformation of water catchments and water competitions, biodiversity, land-use changes, community impacts, social impacts (including poverty, inequalities and demographic imbalance), and adequacy and effectiveness of national political and regulatory institutions. For example, nickel mining activities cause the degradation of freshwater and marine ecosystems in Indonesia (Agusdinata and others, 2022), and lithium mining activities threaten the habitat of flamingos in the Lithium Triangle (Agusdinata and others, 2018). These problems put the survival of many species at risk (SDGs 14 and 15) and pose significant risks to public health, especially in communities in proximity of extractive activities (SDGs 3 and 11) (GBD MAPS Working Group, 2018; Hendryx, 2015; Tang and others, 2017).

All stages of mining can produce particles and dust, and thus deterioration of air quality, which further adversely affects human health and ecosystems, such as polluted food (SDG 2), polluted water (SDG 6) and a loss of other ecosystem services (UNEP, 2020). Mining consumes, and may contaminate, large volumes of water as well as produce other types of pollution such as mine drainage, wastewater or tailings (IEA, 2021d). Increasing waste generated by critical mining includes overburden, waste rock and tailings. The water demand creates competition for water between mining and other industries, especially agriculture, and thus affects food security (SDG 2) (Bontje and Duval, 2022).

Mining can cause major changes in land cover, which is closely associated with a range of negative impacts, including fragmentation and degradation of ecosystems and biodiversity loss. In Brazil, the expansion of mining activities led to 11,670 km^2 of deforestation in the Amazon Forest during 2005-2015 (Sonter and others, 2017). A more recent survey showed that mining activities around the world occupy 57,277 km^2 (less than 0.05% of total land area), and that more than 50% of these land areas are concentrated in only five countries – China, Australia, the United States, Russian Federation and Chile (Maus and others, 2020). A study also found that producing 1,000 tonnes of copper ore will need two to about 20 hectares of built-up land (Murakami and others, 2020). Furthermore, mining activities can have spillover effects in nearby regions, such as increased urbanization and deforestation (Ranjan, 2019; Siqueira-Gay and others, 2020). Land use by mining development often causes the displacement of communities, and the loss of habitats for endangered species (IEA, 2021d). Moreover, land competition can endanger the well-being of the local population and lead to impoverishment (Mancini and Sala, 2018).

Tailings disposal is another environmental challenge. The development of critical minerals creates large amounts of waste rock movement and removal per unit of usable metal, which both consumes energy and produces radioactive waste materials. Waste from mining and milling activities often contains low concentrations of radioactive materials. Indonesia, for example, is considering replacing the prevailing land-based tailings storage facilities with deep-sea tailings placement due to the country's unique geographical conditions (e.g., high precipitation and frequent seismic activities) and lower cost (IEA, 2021), which could result in severe marine environmental issues.

In addition, the extraction of some mineral resources, such as copper and lithium, is water-intensive, and some of this extraction (more than half in the cases of copper and lithium) is produced in areas with high water stress levels, such as Northern Chile or Australia, and this percentage is expected to increase (Tomás, 2022). A recent survey found that 65% of copper ore bodies that have not been mined are in areas with high water risk. That is, too little water means miners compete for it among other local water users, and too much means waste can be difficult to contain (Kemp and others, 2021). Major Asia-Pacific mineral producers, such as Australia and China, are also exposed to extreme heat or flooding risks (IEA, 2021).

Environmental impacts also vary substantially across mineral resources, depending on the energy intensity, energy sources, water requirements, land use and processing routes associated with their extraction and processing. For example, producing lithium from brine-based recovery is much less emissions-intensive (three times less) than production from hard rock. Similarly the production of nickel from laterite resources consumes more energy than other methods and, hence, leads to more carbon emissions if fossil fuels are used (IEA, 2021).

It worth noting, however, that the potential contribution of mineral production to GHG emissions and pollution does not negate the environmental benefits associated with clean energy technologies, when considered alongside the full life-cycle environmental footprint of fossil-based technologies. Total lifecycle GHG emissions of EVs are, on average, around 50% lower than internal combustion engine cars, with the potential for a further 25% reduction when combined with low-carbon electricity, according to the IEA (2021). Similar results are also found by World Bank (2020), where clean energy technologies (e.g., renewable energy and energy storage) are found to have a smaller life cycle GHG footprint (16 $GtCO_{2\text{-}e}$) than coal (160 $GtCO_{2\text{-}e}$) and gas (96 $GtCO_{2\text{-}e}$), when compared over the years up to 2050.

3.3.3. Environmental opportunities

Mitigation or elimination of the negative environmental impacts of CRM mining also presents an environmental opportunity. Reduced fossil fuel extraction during the energy transition would have a positive impact on environmental and human health. The environmental restoration of former extraction areas could provide employment opportunities, mitigating the economic impacts of the phase-out of fossil fuel extraction (Haggerty and others, 2018). These opportunities primarily arise from investment in the restoration of the environment and natural landscapes damaged by mining activities. Such environmental restoration will employ a workforce, equipment and capital similar to that displaced by the end of extractive and consumptive activities (Hibbard and Lurie, 2013; Kelly and Bliss, 2009; Taylor and others, 2017). Additional opportunities come from environmental amenities, including scenery and access to recreational opportunities that can contribute to regional growth and employment (SDG 8) (Deller and others, 2001; McGranahan, 2008; Winkler and others, 2007).

3.4. SOCIAL DIMENSION

The growth of critical minerals supply not only plays a vital role in enabling clean energy transitions, but also holds great promise to lift some of the world's poorest people out of poverty (SDG 1). At the same time, however, with regard to social equality and justice (SDGs 10 and 16), the impact of extraction may also result in, for example, contestation over water rights and land use (Connor and others, 2008), excessive environmental and health burdens imposed on local communities by fossil fuel extraction (Morrice and Colagiuri, 2013), and the failure of authorities to address local communities' health and environmental concerns (Higginbotham and others, 2010). Extraction activities may also affect the cultural and other aspects of local communities through, for example, mining-induced displacement, relocation and resettlement (Owen and Kemp, 2015), and project development on sites with historical and cultural significance (Gilberthorpe and Hilson, 2016). Therefore, the extraction of CRMs has potentially both positive and negative social impacts.

3.4.1. Mining community

Extractive industries are often the primary or sole source of employment and income for mining communities, which means these communities are highly impacted by diminished revenue or secondary services from the mining operations. For example, many cities in China were created due to mining activities (Wang and others, 2019). However, a high economic dependency on the mining industry could make the whole regional economy more vulnerable to commodity price fluctuations, and negative effects of boom-bust cycles can occur (Mancini and Sala, 2018). For economies as a whole, specialization in extractive industries can become a barrier to economic diversification in non-resource industries, as articulated by Dutch Disease theory.

Fossil fuel-producing communities and countries are among the most vulnerable in energy transition, and face challenges on how to sustain their mining communities and even their national economies. A United Kingdom case study found that rapid closure of coal mines has caused long-lasting structural problems for coal communities, such as high unemployment levels (SDG 8) (Johnstone and Hielscher, 2017). In remote resource-based cities, problems such as unreasonable industrial structure, the low added value of products, and small employment scale have emerged, an issue that is compounded by the fact that those cities have fewer opportunities for economic diversification (Langton and Mazel, 2008; Mancini and Sala, 2018). How to effectively address the socio-economic and environmental impacts of mine closures has been a key issue for policymakers and natural resource scholarship in the energy and resource space (Newell and Mulvaney, 2013).

Ensuring that local communities benefit from mineral wealth will be essential, but also a long-lasting challenge, particularly in countries with a significant amount of informal mining activities (World Bank, 2017). Given potentially adverse social impacts, existing mining communities may not necessarily welcome the energy transition. A survey of fossil fuel-based mining communities in the United States in 2016 revealed that such communities strongly reject renewable energy development (Olson-Hazboun, 2018). Even when broad public support for a green economy exists, local resistance to renewable energy projects in coal regions in the United States is often strong and delays the development of solar projects (Crowe and Li, 2020).

The fossil fuel extraction industry also favours agglomeration that creates economies of scale for related industries using fossil fuels as an input, such as coal for the steel industry and crude oil for petrochemical industry (Kalhoro and others, 2021; Kalkuhl and others, 2019). This agglomeration often leads to the development of fossil-related industrial clusters that generate employment (SDG 8), spur infrastructure development (SDG 9), and help to reduce poverty (SDG 1), especially in local communities in close proximity to where fossil extraction activities take place. Undesirably, this agglomeration creates resource-dependent regions that have frequently appeared in the literature due to their greater challenges in economic restructuring, energy transitions and emission reduction (Li and others, 2019; Wang and others, 2019). Ensuring that everyone benefits from the production of critical minerals may be challenging in some countries, and assistance from other countries may be necessary to fill these gaps.

3.4.2. Social and gender equality

Social issues with mineral development are significant. For example, the world has 40 -million-plus artisanal and small-scale miners who live in poverty (World Bank, 2020a).

Mining projects often generate highly inequitable outcomes, and raise important ethical and social justice issues. The development of mining activities often increases economic inequalities between gender, between mine employees and non-mine employees, and between communities that do and do not receive benefits (IEA, 2021). For example, inflation and accommodation cost hikes can have an adverse effect on local populations (Mancini and Sala, 2018). More broadly, affected communities bear the burden of social and environmental costs, while economic benefits accrue largely to domestic and foreign metropolitan centres.

Gender inequality is one that is often highlighted as a challenge in the extractive industries for reasons such as unequal access to mining jobs, the loss of male support for household work, and extra efforts women must make to access safe water and food in a degraded environment (IEA, 2021).

While men often capture the majority of the benefits of extractive industry projects, social, economic, and environmental risks affect women disproportionately (World Bank, 2013). Women directly and indirectly contribute to extractive industries, but gender discrimination reduces their ability to claim economic and social benefits (UNEP, 2020). Evidence also shows that female mine workers not only face discrimination and poor working conditions, they are also victims of sexual harassment. They often receive lower wages for equal work to that carried out by men (UNEP, 2020). Women's rights are also affected if compensation and benefits associated with fossil fuel extraction are paid to men on behalf of their families, as this could potentially increase women's economic dependence on men (Macdonald and Rowland, 2002).

The wealth and rights inequality between women and men is often large in mineral resource-dependent countries than those in countries that are not resource-dependent (EITI, 2020). Moreover, the COVID-19 pandemic may have already deepened gender inequality in the extractive industries because women who engage in informal and lower-paying jobs are more vulnerable to movement restrictions and employment cuts (EITI, 2020; UNECE, 2020).

3.4.3. Health and safety

Extractive activities have the potential to create serious health and safety challenges in terms of occupational exposure as well as public health in general. The health and safety challenges due to mining activities are eventually closely related to environmental challenges due to contamination of water, air and soil (Coelho and others, 2011). These challenges could also arise from, for example, mine accidents.

3.4.4. Human rights

Extractive industries can lead to serious human rights violations, such as forced eviction or relocation (UNEP, 2020). Data from the Responsible Mining Index (RMI) Report 2020 show that the large mining companies assessed score on average a low 19 % on human rights-related issues (Responsible Mining Foundation (RMF), 2020). An estimated 1 million children are working as miners in Africa, Asia-Pacific, South and Central America and Europe. They are usually paid less than adult workers and have virtually no rights (World Vision, 2013). The mining industry is therefore an increasing target for calls to address the negative human rights consequences of climate change (BSR, 2021; Kirkpatrick, 2021).

3.5. GOVERNANCE DIMENSION

Many countries are expected to play a more important role in the future supply of critical minerals (Gillies and others, 2021), and further development of critical minerals raises numerous governance challenges, in particular for many developing countries. Governance challenges include a need to develop and implement environmental regulations, ensure effective revenue management (including addressing corruption) and enable broad and inclusive social development. Without effective policies and well-governed institutions in major producer countries, effective scale-up and stable supply of CRMs will be elusive.

3.5.1. Governance and sustainable development

The failure to translate resource wealth into broad-based socio-economic progress could become a major source of social conflicts, and perpetuate internal instabilities, e.g., ethnic and religious divisions, widespread poverty and a rural-urban divide (SDGs 10 and 16) (Le Billon, 2013; Ross, 2015). One factor responsible for the adverse impact of resource development, such as Dutch Disease, is weak institutions that tend to encourage rent-seeking and patronage behaviour, leading to higher levels of corruption and reduced economic efficiencies. These, in turn, cause poor allocation of resources, loss of government revenue, and increased income inequality (Angelopoulos and others, 2021; Larraín and Perelló, 2020; Mehlum and others, 2006).

The severity of the social and environmental impacts associated with mineral extraction could become even higher in jurisdictions where Governments are unable or unwilling to safeguard against severe environmental and social externalities in mineral extraction. Well-developed regulatory systems, strong enforcement and institutionalized transparency practices are key enablers of good environmental and social performance.

In addition, the resource curse phenomenon is often associated with increased geopolitical sensitivities, as these countries are more prone to external interference which exacerbates local and regional political crises and increases instability. This will create challenges to peace and justice (SDG 16), and test national governing capacity (SDG 17). As the history of oil and gas industry development shows, resource development has created tension between sovereign nations and mining companies. Resource-rich countries want to capture the benefits of the resources they hold, while in many cases the extractives industry is owned and/or managed by multinational companies, as for example in Indonesia (Tsafos, 2022). The extensive involvement of multinationals gives rise to complex tax issues, unique cost-sharing and financing arrangements, sensitivities over sharing the benefits from national resources, and cross-border supply chains.

3.5.2. Rent-seeking

Rent-seeking behaviour is often related to weak governability. Regarding the extractive sector, more specifically, high politicization and discretionary power in decision-making processes as well as inadequate governance arrangements leave room for favoritism, clientelism, political capture and interference, conflict of interest, bribery and other corrupt practices (OECD, 2016a). On the company side, gaps and discrepancies in internal corporate anti-corruption compliance and due diligence procedures contribute to weakening detection and prevention efforts. In particular undisclosed beneficial ownership could provide opportunities for corruption (OECD, 2016a).

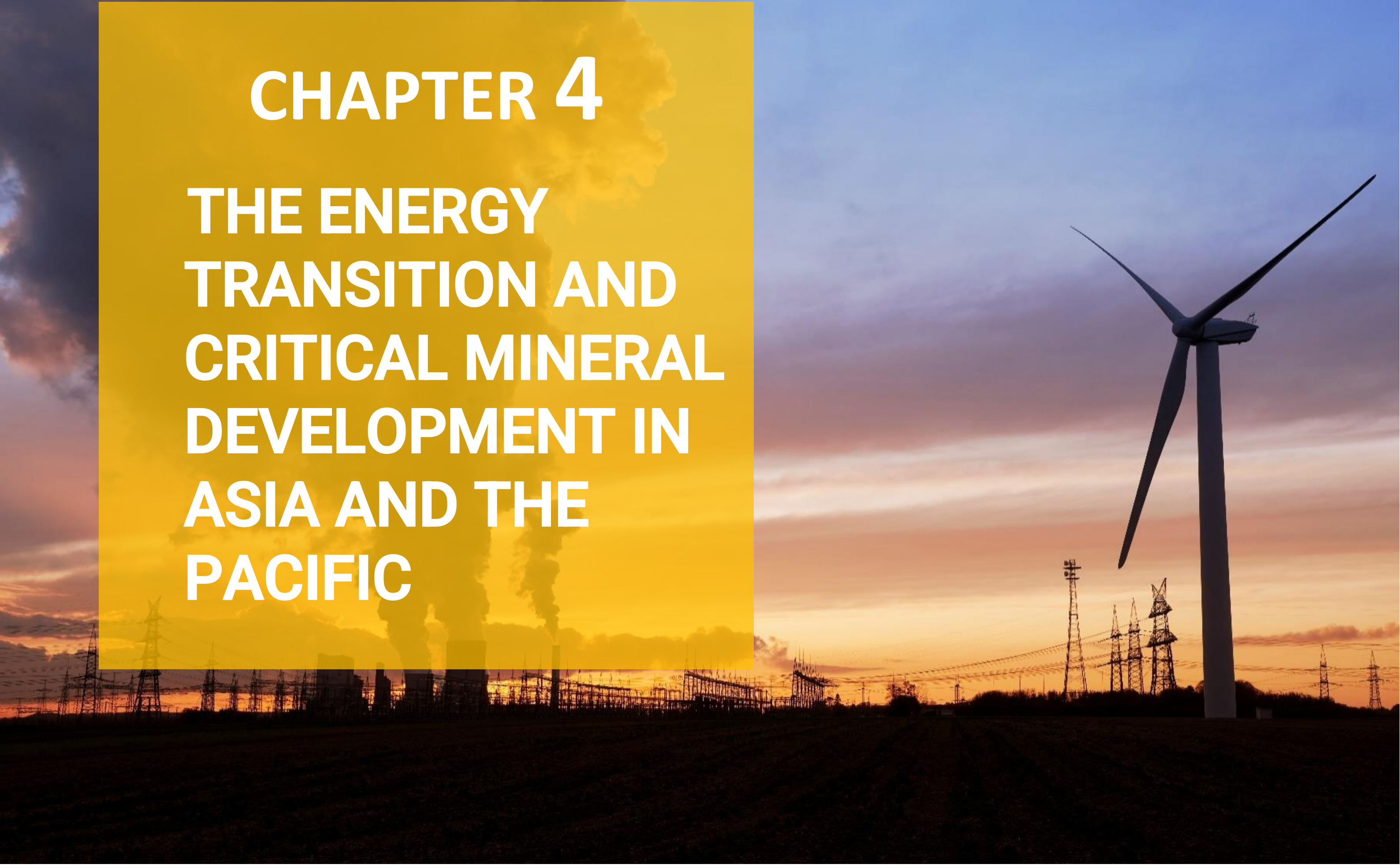
For critical minerals, the scale and pace of anticipated increased demand make the potential for corruption particularly problematic under the soaring demand for energy transition, as the sector is marked by immaturity of global markets, dominance of a small number of commercial players, and concentration of resources in countries with high corruption potential (Sebastian, 2022). For example, more than half of cobalt is located in the Democratic Republic of the Congo, which is considered very fragile and very corrupt (Manley and others, 2022). Furthermore, while most of the critical minerals are likely to be mined and extracted on an industrial scale, it could nonetheless drive a new boom or rush for licences by miners who may not be qualified to hold such licences. A survey has shown that Ghana allocates mining concessions on an open-door ‘first-come, first-served’ basis, which could further exacerbate corruption risks (Theophilus, 2022).

3.5.3. Governability

Even if the current legal and regulatory regime for critical minerals is largely adequate to address most of the prevailing issues in the industry, enforcement is a challenge. To strengthen strategic and economic management, many Governments seek greater control over critical mineral extraction. Such demands for State participation could exacerbate governance challenges. State-owned companies may seek to secure larger ownership stakes in mining projects and Governments may impose more stringent requirements related to domestic processing and local content. In Ghana, the Government has attempted to capture more value chain opportunities by creating dedicated State companies (Theophilus, 2022). Without adequate safeguards, however, State participation can become a strain on public finances and can be vulnerable to corruption. Large deals with commodity traders can also present governance risks and exacerbate sovereign debt in times of volatility if terms are not properly negotiated (Sebastian, 2022).

Surge demand for critical minerals and volatile prices could harm public finances and drive political instability. The mining sector has always experienced fluctuations in supply and demand. Mineral volatility could become more extreme during the global energy transition. Restrictive trade policies or conflicts could drive sudden price spikes.

At the same time, technological innovations, mineral substitutions and improved recycling rates could unexpectedly reduce demand for specific minerals. All this makes it hard for Governments to anticipate how much money they will earn from the sector, potentially undermining their ability to fund public services and fuelling political instability (Sebastian, 2022).



CHAPTER 4

THE ENERGY TRANSITION AND CRITICAL MINERAL DEVELOPMENT IN ASIA AND THE PACIFIC

The Asia-Pacific region will have an important role in the future supply of critical minerals, due not only to the region's relative resource abundance, but also because of the growing demand for critical minerals within the region. At the same time, the presence of significant fossil fuel resources and current dominance of fossil fuels in regional energy systems may create headwinds to the sustainable development of CRMs. Also, and somewhat counterintuitively, the energy transition itself presents challenges to sustainable development as advancing phase-down of fossil fuel might undermine achievement of SDGs (Appendix). Nevertheless, the presence of CRM potential and demand for critical minerals creates an opportunity for sustainable development of Asia and the Pacific. Successfully managing the transition requires robust institutions to minimize social and environmental costs and transfer mining revenue into sustainable development. This section first discusses some key features of this transition and then provides a panoramic overview of the potential impacts of the energy transition on the Asia-Pacific region.

4.1. FOSSIL FUELS IN ASIA AND THE PACIFIC

The Asia-Pacific region contains some of the world's top fossil fuel producers (table 1). For example, the BP Statistical Review of World Energy estimated that the world's total proven coal reserves were about 1.07 trillion tonnes, with five countries holding more than 75% of the deposits (BP, 2021). Four of these are located in Asia and the Pacific, i.e., Australia, China, India and the Russian Federation. Large crude oil and natural gas reserves are also found in the Asia-Pacific, especially in the Russian Federation, the Islamic Republic of Iran and some Central Asian countries (BP, 2021). Six of the world's 10 largest coal producers are located in Asia and the Pacific. China is the largest coal producer, producing 3,902 million tonnes (mt) of coal in 2020, accounting for about half of the world's total output This is followed by India (757 mt, 10%), Indonesia (563 mt, 7%), Australia (477 mt, 6%), the Russian Federation (400 mt, 5%) and Kazakhstan (113 mt, 1%).

The region also produces large amounts of gas, accounting for 44% of the world's total in 2020. Much of this production takes place in the Russia Federation – the world's second-largest gas producer, producing about 639 billion cubic metres (bcm) of gas accounting for 17% of total gas produced in 2020. Australia, China and the Islamic Republic of Iran are also among the world's top gas producers, which together produced about 648 bm of gas in 2020, or 15% of the world's total gas production (BP, 2021). Other important gas-producing countries in the region include Indonesia, Malaysia and some Central Asian countries – most notably Kazakhstan, Turkmenistan and Uzbekistan.

Compared with coal and gas, the region's share of crude oil production is relatively low – 28% in 2020. The Russian Federation is the region's leading oil producer. In 2020, it produced about 10.7 million barrels per day, accounting for 12% of the world's total production. China, the Islamic Republic of Iran and Kazakhstan are also important oil producers in the region, and in 2020 were together responsible for about 10% of the world's oil production.

TABLE 4. Fossil fuel production in major Asia-Pacific economies

	Coal (million tonnes)	*Gas (bcm)*	*Oil (thousand barrels per day)*	*Share of the world's total*		
				Coal	Gas	Oil
Australia	477	143	470	6.2%	3.7%	0.5%
China	3,902	194	3,901	50.4%	5.0%	4.4%
India	757	24	771	9.8%	0.6%	0.9%
Indonesia	563	63	743	7.3%	1.6%	0.8%
Iran, Islamic Republic	-	251	3,084	-	6.5%	3.5%
Kazakhstan	113	32	1.811	1.5%	0.8%	2.0%
Malaysia	-	73	596	-	1.9%	0.7%
Mongolia	43	-	-	0.6%	-	-
Pakistan	8	31	-	0.1%	0.8%	-
Russian Federation	400	639	10,667	5.2%	16.6%	12.1%
Turkmenistan	-	59	216	-	1.5%	0.2%
Viet Nam	49	8.7	207	0.6%	0.2%	0.2%
Uzbekistan	4	47	47	0.1%	1.2%	0.1%

Source: BP, 2021.

Asia-Pacific's wealth of fossil fuel resources has brought significant economic benefits, as measured in terms of the revenue (in terms of % of GDP) in excess of all costs of production (also known as economic rents) (World Bank, 2011).[3] As shown in Figure , in 2019, these fossil-related benefits accounted for a substantially large share (more than 15%) of GDP in the region's major fossil fuel exporters, particularly Azerbaijan, Brunei Darussalam, the Islamic Republic of Iran, Kazakhstan, Turkmenistan, and for an appreciable share (5% to 15%) of GDP in Mongolia, Papua New Guinea, the Russian Federation and Uzbekistan.

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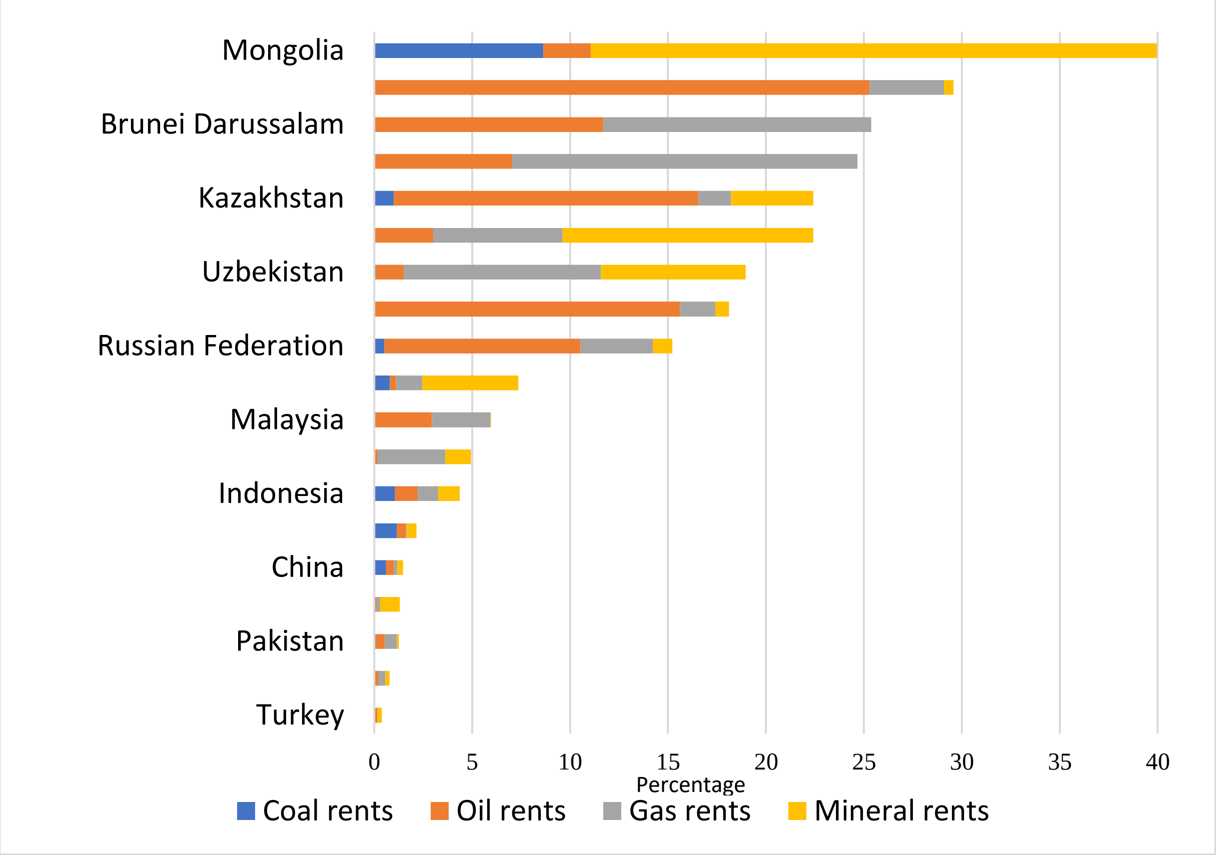
[3] All costs includes those for exploration and development, as well as the normal return to capital.

FIGURE 9. Share of economic rents from fossil fuels and mineral industry in the GDP of Asia and the Pacific countries, 2019



Source: Developed by the Authors based on data obtain from the World Bank.

4.2. ENERGY TRANSITION IN ASIA AND THE PACIFIC

The transition towards a clean energy future is gaining momentum in the Asia-Pacific region. Five large emitters in the region – China, Japan, India, Indonesia and the Republic of Korea – have pledged to become carbon neutral within the next few decades. Other countries have also announced plans to reduce the use of or entirely phase out the use of coal, including a call for a review of existing coal power projects in Bangladesh (Baxter, 2020), a moratorium on new coal capacity in the Philippines (Farand, 2020), and a halt to coal project approval in Pakistan (Lo, 2020). Some specific targets for driving energy transition in major Asia-Pacific countries are summarized in Table 5. These intensified actions on energy transition may have a 'snowball effect', catalyzing more commitments to climate action across the region.

TABLE 5. Officially declared energy transition milestones in selected Asia-Pacific countries

Milestones	Representative countries
Percentage of electricity from renewable sources = 100%	American Samoa (2040), Fiji (2030) and Papua New Guinea (2050).
80% ≤ renewable energy share of electricity < 100%	Australia (2030), China (2060), New Zealand (2025) and Niue (2025).
50% ≤ renewable energy share of electricity < 80%	French Polynesia (2030), Pakistan (2030) and India (2030).
20% ≤ renewable energy share of electricity < 50%	Brunei Darussalam (2030), Malaysia (2025), Myanmar (2025), Republic of Korea (2030), Singapore (2035), Uzbekistan (2030) and Vanuatu (2045)

Source: Authors' compilation from various sources.

Note: The share of renewable energy is the share of renewable energy in the electricity mix, with the target year for achieving the energy share target in brackets.

4.2.1. Energy transition in fossil fuel-producing countries

For fossil fuel-producing countries, the energy transition is a potential source of conflict. Eliminating the use of or carbon emissions from fossil fuels is required to achieve carbon neutrality, but for fossil fuel-producing countries reduced demand creates economic challenges. Due to their comparative advantages in fossils, Asia-Pacific's fossil fuel-producing countries mainly focus on non-renewable energy sources for power generation, such as coal, oil and natural gas. As a result, the share of renewable energy sources in their energy consumption is relatively low.

Despite this, most fossil fuel-producing countries are preparing and improving their energy development strategies and Nationally Determined Contributions (NDC) to be in line with the Paris Agreement targets. For example, the United States and Papua New Guinea have even proposed reaching the goal of 100% renewable energy use of electricity in 2035 and 2050, respectively (Papua New Guinea, 2009; Stokes and others, 2021).

There have been three main drivers the energy transition in fossil fuel-producing countries:

(a) **Global efforts to tackle climate change.** Recognition of the growing impacts of climate change and major milestones such as the Paris Agreement are driving efforts to accelerate the energy transition even in countries that continue to rely heavily on the extraction and use of fossil-fuels. China is a salient example. Since 2006, China has been the world's largest carbon emitter, but in recent years it has dramatically changed its climate policy. One recent milestone is its commitment to achieving carbon neutrality by 2060 (Shi, Sun, and others, 2021). In its recent policy planning document released in October 2021 (Government of PRC, 2021), China states that, by 2030, CO_2 emissions per unit of GDP would drop by more than 65% compared with 2005, while the share of non-fossil energy consumption will reach about 25%. The total installed capacity of wind and solar power will reach more than 1.2 billion kilowatts (1,200 GW). By 2060, the share of non-fossil energy will be more than 80% of China's total energy consumption;

(b) **The depletion of fossil fuel resources.** For many countries, the expansion of fossil fuel extraction has not kept up with rising consumption, and so domestic fossil energy resources are no longer sufficient to meet demand. At the same time, domestic resources are declining and at risk of depletion. Indonesia and the Islamic Republic of Iran are two typical examples. Indonesia's oil, natural gas and coal reserves are estimated to run out in about 10, 22 and 65 years, respectively, assuming no new resources are discovered (Sasmita, 2021). As a result, Indonesia is taking steps to prepare for national energy transition by aggressively shifting to a cleaner, more sustainable energy model. In the case of the Islamic Republic of Iran, despite having the world's fourth-largest oil reserves and the second-largest natural gas reserves, that country's policymakers have considered renewable energy as a key instrument to meet its future electricity demand, reduce dependence on hydrocarbons and improve energy security (Wheeler and Desai, 2016).

(c) Ensuring energy security, in particular in large economic and energy-consuming countries. The dramatic fluctuations in international energy prices due to recovery from COVID-19 and ongoing geopolitical tensions have challenged energy security in many countries. The United States has begun to frame the energy transition as a way to ensure energy security to by protecting itself from future energy crises. For example, the 2022 Inflation Reduction Act includes a number of measures to both expand alternative energy development to reduce reliance on fossil fuels and increase the resilience of clean energy supply chains through “near-shoring” and “friend-shoring”, or incentivizing imports from free-trade or otherwise trusted partners.

4.2.2. Energy transition in fossil fuel-poor countries

Fossil fuel resource-poor countries in the Asia-Pacific region have shown different degrees of dependence on fossil fuels. These countries can be re-grouped into three categories: highly fossil-dependent countries (more than80% fossil energy share), moderately fossil-dependent countries (between 50% and 80% fossil energy share), and countries with low levels of fossil-dependence less than 50% fossil energy share), as shown in Table 6.

TABLE 6. Classification of Asia-Pacific countries by level of fossil energy dependence

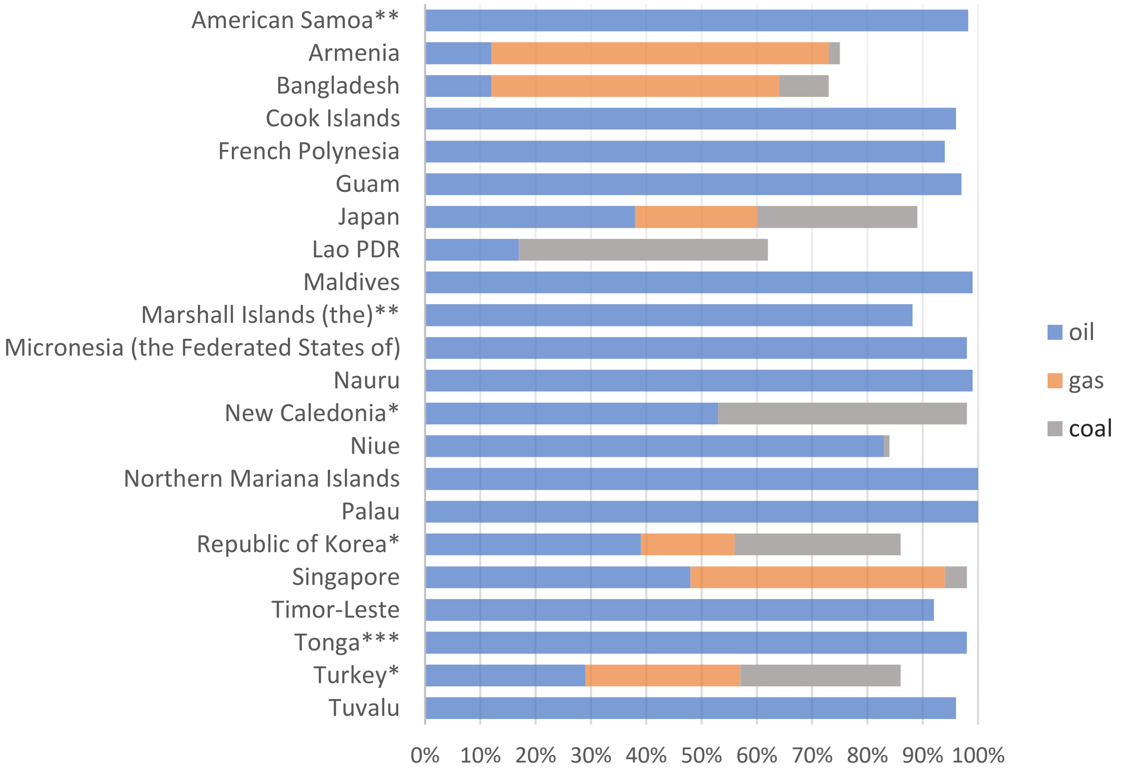
Level of dependence	Share of fossil energy	Country
High	>80%	American Samoa, Armenia, Bangladesh, Cook Islands, French Polynesia, Guam, Japan, Lao People’s Democratic Republic, Maldives, Marshall Islands, Micronesia (the Federated States of), Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Republic of Korea, Singapore, Timor-Leste, Tonga, Türkiye and Tuvalu.
Moderate	50%-80%	Afghanistan, Democratic People’s Republic of Korea, Fiji, Georgia, Kiribati, Kyrgyzstan, New Zealand, the Philippines, Samoa, Solomon Islands, Sri Lanka, Thailand and Vanuatu.
Low	<50%	Bhutan, Cambodia, Nepal, Tajikistan and France

Source: Authors’ classification based on various statistics.

There are 22 highly fossil-dependent, resource-poor Asia-Pacific countries (figure 10). Overall, the energy self-sufficiency rate of these countries is below 30%, and most are below 10%. As a result, these countries are very dependent on imports. However, there are three countries in particular – Timor-Leste, the Lao People's Democratic Republic and Bangladesh, which have a high energy self-sufficiency rate of more than 80%. Timor-Leste and the Lao People's Democratic Republic stand out in particular as having self-sufficiency rates exceeding 100%.

Prompted in part by a desire to improve their energy security and self-sufficiency, countries included in this group are actively promoting low carbon energy transition, with particular emphasis on utilizing indigenous and renewable energy. For example, the Lao People's Democratic Republic is developing solar, bioenergy, wind and hydropower – as well as coal – to both meet domestic energy export electricity to neighboring countries and beyond. Another example is the Maldives, which, with funding from the World Bank and the Asian Development Bank, is actively developing clean energy sources such as solar. Other island countries such as Micronesia (the Federated States of) and the Marshall Islands are working develop non-traditional but domestically abundant energy sources such as coconut oil as an alternative to fossil fuels.

FIGURE 10. Primary energy mix of countries heavily dependent on fossil energy in 2019



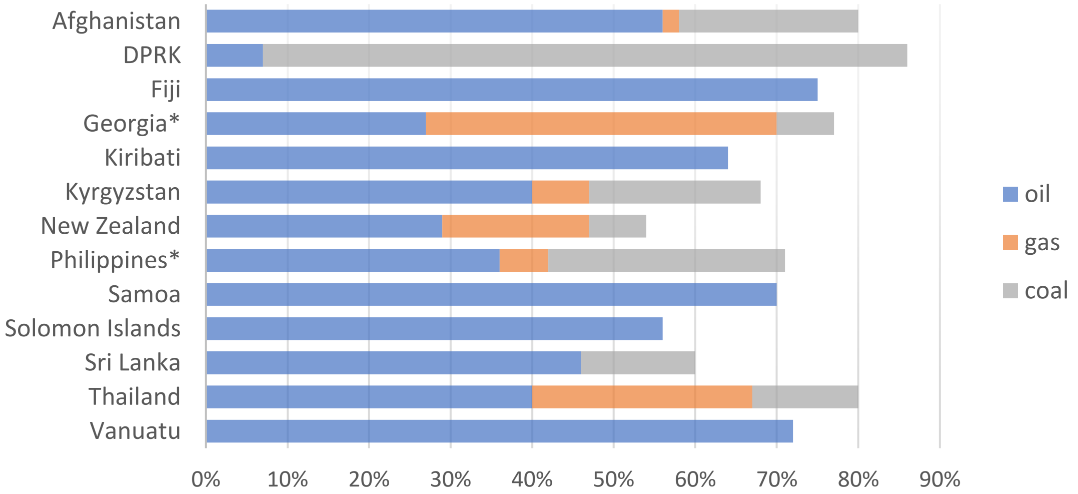
Note: Energy data for the above countries are from IRENA (https://www.irena.org), United Nations (https://www.un.org/en/), United States Department of Energy (https://www.energy.gov/eere/energy-transitions-initiative). *Data year is 2018; **data year is 2017; and *** data year is 2016.

There are 11 moderately fossil-dependent, resource-poor nations countries (figure 11). New Zealand has the highest energy self-sufficiency rate at 78%, with imports amounting to 38% of its energy supply, and exports amounting to 13% of its energy production. Vanuatu has the lowest energy self-sufficiency rate at 27% relying heavily on energy imports to meet domestic demand. This second group of countries are less dependent on fossil energy than the first group, but they still have a high proportion of fossil fuels in their energy mix.

While the energy transition is progressing in these countries, future progress will require increased effort. New Zealand and Vanuatu, which have the highest and lowest energy self-sufficiency rates, respectively, are useful examples.

New Zealand introduced the 1991 "Resource Management Act" (Resource Management Act, 1991, as at 2022) to strengthen sustainable resource management. At the same time, renewable energy sources are being developed, with (a) ongoing exploration of the use of wave, tidal and solar energy for power generation, (b) research into the use and development of geothermal energy, and (c) government encouragement of the marine energy industry and biomass-to-energy production, as appropriate. Vanuatu has maintained a target of 100% new energy supply by 2030, despite its current high dependence on fossil energy. The country approved a National Energy Roadmap in June 2016, covering all aspects of energy development, and is actively pursuing various new energy projects, such as wind and solar, with the assistance of other countries, to achieve the country's energy transition goals.

FIGURE 11. **Fossil fuel share in the primary energy mix of countries with moderate dependence on fossil energy in 2019**

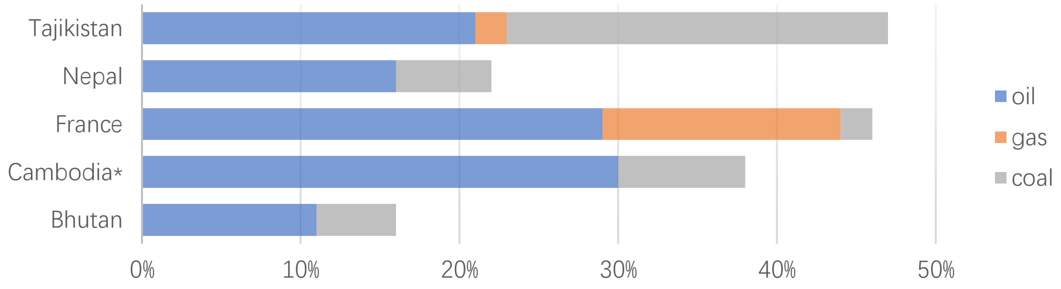


Note: Energy data for these countries are from IRENA (https://www.irena.org). * Data year is 2018. DPRK – Democratic People's Republic of Korea.

The less fossil-dependent, resource poor countries are Bhutan, Cambodia, France, Nepal and Tajikistan (figure 12).

Bhutan imports only 12% of its energy supply, while Nepal and Cambodia import 24% and 55%, respectively. At the same time, 24% of Bhutan's energy production is exported, making it a net exporter of energy overall. Bhutan has already achieved carbon neutrality (i.e., total emissions relative to total emissions removals at the national level) and will remain carbon neutral in the years to come.[4] Cambodia plans to reduce greenhouse gas emissions by 42% from baseline emissions by 2030, to reduce energy consumption by 20% by 2035, and to cut CO_2 emissions by 64.6 million tonnes by 2030 (NCSD, 2020). It also plans to promote the uptake of hydropower, biomass, and solar energy (IEA, 2021). Nepal has a national nuclear policy and a national water strategy aimed at long-term energy sustainability. Nepal also aims is to achieve net zero emissions by 2045.

FIGURE 12. Energy mix of countries with a light dependence on fossil energy in 2019



Note.: Energy data for the above countries are from IRENA (https://www.irena.org). * Marked countries, data year is 2018.

4.3. ASIA-PACIFIC CRITICAL MINERAL RESERVES AND PRODUCTION

The Asia-Pacific region is theoretically well placed to meet increased demand of CRMs, as it has large reserves of CRM resources. ESCAP member States are endowed with about 30% of the world's known reserve of cobalt, copper and lithium, 41% of bauxite, 53% of graphite, 59% of nickel, 75% of REEs and 80% of lead (Table 7).

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[4] Energy data for the above countries are from IRENA (https://www.irena.org).

TABLE 7. Reserve of key critical minerals in top countries in 2020, thousand tonnes (kt) *(ESCAP member States shown in bold)*

Bauxite		Cobalt		Copper		Graphite (natural)	
Guinea	7,400,000	DR Congo	3,600	Chile	200,000	**Türkiye**	90,000
Australia	5,100,000	**Australia**	1,400	Peru	92,000	**China**	73,000
Viet Nam	3,700,000	Cuba	500	**Australia**	88,000	Brazil	70,000
Brazil	2,700,000	**Philippines**	260	**Russian Federation**	61,000	Madagascar	26,000
Jamaica	2,000,000	**Russian Federation**	250	Mexico	53,000	Mozambique	25,000
Indonesia	1,200,000	Madagascar	100	**United States**	48,000	Tanzania	17,000
China	1,000,000	**China**	80	Poland	32,000	**India**	8,000
India	660,000	**United States**	53	**China**	26,000		
Russian Federation	500,000	**Papua New Guinea**	51	Zambia	21,000		
Saudi Arabia	190,000	South Africa	40	**Kazakhstan**	20,000		
RoW	5,550,000	RoW	766	RoW	229,000	RoW	11,000
Total	30,000,000	Total	7,100	Total	870,000	Total	320,000
ESCAP	41%	**ESCAP**	29%	**ESCAP**	28%	**ESCAP**	53%
Lithium (mined)		**Nickel**		**REEs**		**Lead**	
Chile	9,200	**Indonesia**	21,000	**China**	44,000	**Australia**	36000
Australia	4,700	**Australia**	20,000	**Viet Nam**	22,000	**China**	18000
Argentina	1,900	Brazil	16,000	Brazil	21,000	Peru	6000
China	1,500	**Russian Federation**	6,900	**Russian Federation**	12,000	Mexico	5600
United States	750	Cuba	5,500	**India**	6,900	**United States**	5000
Canada	530	**Philippines**	4,800	**Australia**	4,100	**Russian Federation**	4000
Zimbabwe	220	**China**	2,800	**United States**	1,500	**India**	2500
		Canada	2,800	Greenland	1,500	**Kazakhstan**	2000
						Bolivia	1600
						Sweden	1100
RoW	2,200	RoW	14,200	RoW	7,000	Row	6,200
Total	21,000	Total	94,000	Total	120,000	Total	88,000
ESCAP	33%	**ESCAP**	59%	**ESCAP**	75%	**ESCAP**	80%

Source: Courtesy of the International Energy Agency.

The relative position of ESCAP member States in critical mineral production is even more prominent. As of 2019, the region's share of the world's production of bauxite was 63%, lithium was 66%, graphite was 70%, nickel and lead were 74%, and REEs was 96% (table 8). Several countries in the region are among the top producers of more than one key critical mineral, as listed in table 8. In 2019, Australia was the world's largest producer of bauxite and lithium, and the second-largest producer of cobalt. China was also in the top list for production of six of the seven critical minerals, with the exception being cobalt (Table 8).

TABLE 8. Production of key critical minerals in top countries in 2019

Bauxite		**Cobalt**		**Copper**		**Graphite (Natural)**	
kt	2019	kt	2019	kt	2019	kt	2019
Australia	105,000	DR Congo	111.4	Chile	5,787.4	**China**	700,000
China	70,000	**Australia**	5.9	Peru	2,455.3	Mozambique	107,000
Guinea	67,000	**Philippines**	3.9	**China**	1,818.8	Brazil	96,000
Brazil	34,000	Cuba	4.0	DR Congo	1,388.4	Madagascar	48,000
India	23,000	**Russian Federation**	3.7	**United States**	1,318.3	**India**	35,000
Indonesia	17,000	Zambia	4.2	**Australia**	934.1	**Russian Federation**	25,100
Jamaica	9,020	**Papua New Guinea**	2.9	**Russian Federation**	792.2	Ukraine	20,000
Kazakhstan	5,800	Madagascar	2.9	Zambia	804.9	Norway	16,000
Russian Federation	5,570	Canada	3.4	Mexico	768.5	**Pakistan**	14,000
Saudi Arabia	4,050	**New Caledonia**	2.0	**Kazakhstan**	701.4	Canada	11,000
RoW	17,560	RoW	10.8	RoW	4,195.1	RoW	27,900
Total	358,000	Total	155.1	Total	20,964.4	Total	1,100,000
ESCAP	63%	**ESCAP**	12%	**ESCAP**	27%	**ESCAP**	70%

Lithium (mined)		**Nickel**		**REEs**		**Lead**	
kmt	2019	kmt	2019	t rare-earth-oxide equivalent content	2019	kmt	2019
Australia	46.8	**Indonesia**	855	**China**	132,000	**China**	2,000
Chile	18.8	**Philippines**	303	**United States**	28,000	**Australia**	509
China	9.1	**Russian Federation**	232	**Myanmar**	25,000	**United States**	274
Argentina	6.3	**New Caledonia**	208	**Australia**	20,000	Mexico	259
Zimbabwe	1.6	**Australia**	160	Madagascar	4,000	Peru	308
		Canada	188	**Russian Federation**	2,700	**Russian Federation**	230
		China	107	**Thailand**	1,900	**India**	200
		Brazil	60	**Viet Nam**	1,300	Türkiye	71
		Guatemala	41			Sweden	69
		Cuba	53			Bolivia	88
						Tajikistan	65
						Kazakhstan	56
RoW	2.2	RoW	321	RoW	5,100	RoW	591
Total	84.7	Total	2,529	Total	220,000	Total	4,720
EACAP	66%	**EACAP**	74%	**EACAP**	96%	**ESCAP**	74%

Source: United States Geological Survey, 2021.

The Asia-Pacific region is the world's main region for critical mineral exports, and in particular is the world's largest supplier of cobalt, copper, lithium and bauxite. Many resource-rich Asia-Pacific countries export critical minerals to other countries for processing, and therefore play an essential role in the world's critical mineral trade and security of supply.

CHAPTER 5

CRITICAL MINERAL DEVELOPMENT IN SELECTED ASIA-PACIFIC COUNTRIES

While the Asia-Pacific region is the main exporter of critical minerals, the unbalanced distribution of resources within the region creates two distinct types of countries – those that have significant resources of at least one CRM and those that do not. These two categories of countries have different strategies for critical minerals. Some resource-rich countries are focused on implementing measures to manage the opportunities and challenges of CRM development. On the other hand, countries without CRM resources are working to secure supplies located elsewhere, for example through import agreements or direct ownership. This chapter examines CRM reserves and production among Asia-Pacific countries, and provides case studies on how some resource-rich countries have promoted the sustainable development of CRMs and how resource-poor countries have secured their supply.

5.1. PROMOTION OF SUSTAINABLE CRITICAL MINERAL DEVELOPMENT IN SELECTED RESOURCE- RICH COUNTRIES

As CRMs are non-renewable resources, many countries have formulated diversified sustainable development strategies to ensure sufficient supply, such as strengthening domestic mineral exploration and exploitation, securing overseas resources, restricting exports and production, and enforcing legal regulation. For example, India works to ensure the uninterrupted supply of its critical minerals by simultaneously strengthening domestic mineral exploration and securing resources elsewhere (Chadha and Sivamani, 2021). Indonesia (Lim and others, 2021) and Kazakhstan (Rivotti and others, 2019), in contrast, are working to slow the depletion of their critical minerals by restricting exports and production. This subsection presents some typical resource-rich countries that have made attempts to sustain their mineral development.

5.1.1. Australia

Australia is the one of the world's leading CRM producers, with significant production and reserves of CRMs such as lithium and rare-earth elements. As a developed country, Australia also has the key ingredients necessary to foster future CRM development: an existing extractive industry, capital, and expertise. These circumstances favour the long-term sustainability of the Australian minerals industry.

The Government of Australia has implemented several initiatives to better prepare it for future global demand for critical minerals, including:

(a) ***Institutional setting.*** In 2019, the Government of Australia established the Office of Critical Minerals Promotion to provide national policy and strategy recommendations and promote the development of the department. Since then, Critical Minerals Strategy (Australian Government, 2022) documents were published released in 2021 and 2022.

(b) ***Downstream industries.*** The Government of Australia is taking action to grow Australia into a critical minerals powerhouse, capitalizing on its strength of a world-leading resources sector, expertise in processing, and a highly skilled workforce.

Australia has committed A$200 million to the Critical Minerals Accelerator Initiative to support strategically significant projects at challenging points in their development, together with A$50 million to a Critical Minerals Research and Development Centre, and has also established a A$2 billion Critical Minerals Facility to provide loans to the sector, among other initiatives. For example, as global demand for essential minerals grows, Australia is looking to diversify and increase the supply to domestic industries, for example battery companies. It is also looking outward, for exampling signing a strategic cooperation agreement with the Republic of Korea covering rare earth, lithium, graphite, cobalt and nickel, Australia supplies advanced Korean manufacturers with the necessary processed critical minerals for them to play an essential role in producing permanent magnets and batteries at scale (Vella, 2022).

(c) ***Environmental laws and regulations.*** Australia's Mining Act, as amended in 2015, sets high standards of regulation, introducing a new regime to increase miners' obligations for environmental protection and limiting the significant environmental damage caused by the current mining development.

5.1.2. China

China has invested heavily in the development and utilization of its extensive natural resource supplies, including development and utilization of mineral resources, resulting in the production of many critical minerals that rank among the highest in the world. The development of REEs is a salient example.

China has emphasized research into and production of advanced rare earth applications and new materials (CSIS, 2021). Its formal recognition of the strategic value of the mineral dates back to the Seventh National Five-Year Plan for the Rare Earth Industry (1986-1990). For the sustainable development of the country's REEs, China has made the following efforts:

(a) ***Economic aspects.*** China has been actively fostering downstream production capacity for REEs through supportive regulations, state-sponsored financing and subsidies.

Export and production quotas for REEs support companies create additional value through processing (IEA, 2021). China actively creates a fair and open investment environment and encourages foreign investment in rare earth environmental treatment, recycling and reuse of waste products, and high-end application and equipment manufacturing industries. China also supports the development of a circular economy, actively carrying out the recycling and reuse of rare earth secondary resources, and supporting the establishment of specialized rare earth material comprehensive recycling bases. In addition, China encourages domestic enterprises to actively participate in international technical and economic cooperation on REEs through implementation of international best practices and market rules (Government of PRC, 2012).

(b) ***Environmental governance***. China has continuously strengthened and improved the management of high energy consumption, high pollution, resource-based products and related industries. Specifically, this includes the following aspects: First, the State has implemented strong policy measures. 2011 saw the promulgation and implementation of the "Emission Standards for Rare Earth Industry Pollutants", which clarifies the emission limits for rare earth producers of ammoniacal nitrogen, chemical oxygen demand (COD), phosphorus, fluorine, thorium, heavy metals, sulphur dioxide, chlorine gas, particulate matter and other pollutants. Currently, China is studying the establishment of an environmental risk assessment system for the rare earth industry. In addition, the State encourages technological innovation in the rare earth industry. In the National Medium and Long-Term Science and Technology Development Plan Outline (2006-2020), rare earth technology is listed as a key support direction (Government of PRC, 2012).

Second, the State strictly implements the environmental impact assessment system. New construction, expansion and reconstruction of rare earth projects must analyse, predict and evaluate the possible environmental impact. Third, rare earth construction projects must be designed and constructed simultaneously as Environmental Protection Department acceptance(Government of PRC, 2012).

(c) ***Technological innovation*.** The State supports basic research, frontier technology research, industrial key technology research and development, and rare earth promotion and application. It promotes the establishment of an enterprise-oriented, market-oriented, and industry-academia-research combined technology innovation systems (Government of PRC, 2012). China actively develops environmentally friendly rare earth mining technologies and develops rare earth deep processing and new material application technologies.

(d) ***Governance*.** China has strengthened the supervision of key rare earth producing areas, investigating and if appropriate punishing rare earth enterprises that illegally mine and pollute the environment, including re-examining exploration licenses and mining licenses. It publishes a list of legal mining companies. China has also announced draft legislation to strengthen the approval process for rare earth development projects (Nakano, 2021). In addition, China formed the China Rare Earth Group in December 2021. The integration and standardized management of enterprises promote the development of the rare earth industry in a green and sustainable direction.

5.1.3. New Caledonia

New Caledonia is endowed with an abundant reserve of various minerals, including coal, gold, copper, cobalt, chrome and antimony. This reserve has provided New Caledonia with an economic advantage in the South Pacific region. Nickel ore has been, and remains the principal driver of New Caledonia’s mining industry, with the country holding a significant proportion of the world’s nickel ore reserves and is the world fourth largest nickel producer (table 8).

New Caledonia has developed a strategy based on two aspects for the sustainable development of nickel. The first aspect is rehabilitation. There is a general obligation for site rehabilitation after mining that is generally mandated in New Caledonia. The Nickel Fund is responsible for rehabilitating areas of the former mining activity.

The second aspect is about slowing down the exploitation of nickel, by certain restrictions. Specific measures include: (i) restrictions on mining areas by the environmental codes; and (ii) restrictions on exports by prohibiting selling (non-transformed) nickel ore with an average nickel content above 2.15% to an operator whose head office is outside New Caledonia (Baker & McKenzie, 2020).

5.1.4. Pakistan

Pakistan has large mineral reserves and was the world's ninth-largest graphite producer in 2019 (table 8). However, the mineral sector only accounted for 2.51% of the country's GDP in 2019/20 (MOC, 2021). To attract more private investment and increase the mining sector's economic contribution to the Pakistani economy, the federal and provincial governments were jointly responsible for developing the first National Mineral Policy (NMP-1) in 1995. To boost a sustainable approach to development that was consistent with environmental priorities, the Ministry of Petroleum and Natural Resources (MPNR) revised and updated the policy (NMP-2) in 2013 (Government of Pakistan, 2013), adding the objective of exploration, development and production in an environmentally sustainable manner (see table 9 for specific measures).

TABLE 9. **Environmental Management Measures in Pakistan NMP-2**

Institutional level	Environmental level	Extraction and utilization level
Implementation of the regulatory environmental management measures, including Environmental Impact Assessment, as well as an environmental management system, plan and audit.	Ensuring effective implementation of progressive post-mining rehabilitation.	Promoting the recovery, recycling, and reuse of minerals, metals, and mineral-based products.
Compliance with the national environmental protection law and other appropriate national and international standards, codes, guidelines and policies..	Ensuring the implementation of effective mine waste management measures.	Promoting and disseminating information on the use of best mining practices, public disclosure and corporate social responsibility (CSR).

Note: specific measures are taken from National Mineral Policy 2013.

NMP-2 also has the following requirements regarding mineral processing and beneficiation: (i) more beneficiation and mineral elemental analysis of ores and ore dressing products by the research organization;

(ii) cooperation between and among all organizations in the public and private sectors; and (iii) the promotion of upstream and downstream industries for higher local value-addition.

5.1.5. Türkiye

Türkiye has the world's largest reserves of graphite (table 7), making it a critical country for supplying different versions of graphite (natural, synthetic, or graphene). Türkiye's graphite mining extends back more than 30 years. However, due to a lack of exploration knowledge and technological capability to increase ore grades, Türkiye has only one active graphite mine. In view of the prospective demand and its world-first reserve, Türkiye has attracted foreign investments such as CVMR from Toronto, Canada, which has invested in two high-grade graphite mines in Turkey (MiningSEE, 2021).

Türkiye places a high priority on its sustainable mining and considers minimizing the environmental impact while reaching the maximum production capacity is the most important aspect of mining. The Regulation on Recovery of Natural Sites Degraded due to Mining Activity, which was put in force in 2007, ensures the balance between environmental protection and resource exploitation. Under the Mining Law (Commission on Sustainable Development, 2010), licence holders must prepare an "Environmental Compliance Plan". In the case of the exhaustion of mine ore reserves, the licence holder must take the relevant safety measures and make the operation site environmentally sound.

The Ministry of Economy has the authority to restrict or prohibit exportation of minerals on the grounds of an extraordinary event affecting the market – for example, a shortage of domestic supplies of exported goods, public safety, public morality, health, environmental protection, etc.

5.2. SECURING A CRITICAL MINERAL SUPPLY IN SELECTED RESOURCE-POOR COUNTRIES

Since the supply of critical minerals plays a vital role in national security and energy transition, securing the supply of critical minerals becomes more urgent and essential for those countries that have small mineral reserves or exploitation. Many resource-poor countries have developed plans for critical minerals in line with their security strategy needs and the changing competitive landscape in the resource sector.

5.2.1 Overall strategies and actions

Based on the current status of critical minerals in each country and subsequent planning, resource-poor countries can be divided into two main categories.

The first group of countries has some, but very limited, production for mineral extraction. As those countries have some mining potential, the subsequent plans of such countries are either mainly focused on exploring and extracting minerals on their own or attracting external investment to leverage external forces for mineral extraction and utilization (Table 10). For example, Bhutan, a country an energy mix that is more than 80% renewable, has plans to diversify its renewable energy mix further and has an increasing demand for various critical minerals. In recent years, Bhutan has been improving its national mining plan. Under the Mineral Development Policy 2017, 33% of the country's land has been geologically mapped in sufficient detail to allow for exploration. In 2019, Bhutan launched the Bhutan Mineral Resources Development Plan Project, to analyse and formulate a mineral resources development strategy considering world mining and metals market trends in order to develop an optimal development plan for Bhutan's mineral resources.

Unlike Bhutan, which is involved in mining on its own, the Lao People's Democratic Republic is cooperating with external investors in the further exploitation of minerals. The Lao People's Democratic Republic has reserves of copper resources. In 2020, the country exported $309 million worth of copper ore, and there is still some potential for future mining (OEC, 2020). However, mining projects developed in the Lao People's Democratic Republic are relatively small due to limited investment and technical expertise. In 2016, the Lao People's Democratic Republic formulated the "The eighth Five-Year National Socio-Economic Development Plan," which sets out to further develop and, utilize mineral resources, capitalize on the country's comparative advantages, and strengthen international and regional cooperation (Manyphone, 2022).

TABLE 10. Representative measures for countries with mining potential

Country	Critical minerals	Representative measures
Bhutan	Copper	• Nationwide Geological Mapping • Implementation of the "Bhutan Mineral Resources Development Program Project" in 2019
Lao People's Democratic Republic	Copper	• "The eighth Five-Year National Socio-Economic Development Plan." • Mining Agreement with Nixon Mineral Development Corporation

Countries in the second category have almost no reserves of critical minerals. These countries have to rely on imports, foreign cooperation, investment, processing or the development of new technologies and products to reduce the actual consumption of scarce minerals and relieve the long-term pressure on the supply of critical raw materials. For example, Singapore is importing large quantities of critical minerals such as cobalt, nickel and copper to meet its domestic supply and energy transition targets. At the same time, Singapore is also actively investing overseas and is the fourth-largest investor and third-largest trading partner of mineral-rich Myanmar. In addition to traditional means such as imports and foreign investments, Japan has proposed strategic measures such as recycling and developing alternative materials to ensure a sustainable supply of critical minerals. In addition, island countries such as Kiribati, Tonga and Cook Islands, which do not have mineral reserves of their own, are actively exploring deep-sea mining in the hope of developing mineral resources through that method.

Table 11 shows that critical minerals play a significant role in energy transition, and that resource-poor countries actively take measures to meet the domestic supply of critical minerals according to their circumstances. Countries such as Japan and Singapore do not limit themselves to a single mode of mineral supply, but take diversified supply measures to ensure the security of the supply of critical minerals. The global solid mineral resource management capabilities of both countries have placed them among the few mineral resource powerhouses in the world and a world centre for mineral trading, despite having no notable domestic resources. These countries' comprehensive strategies are worthy of further analysis and discussion to serve as a further reference for other countries.

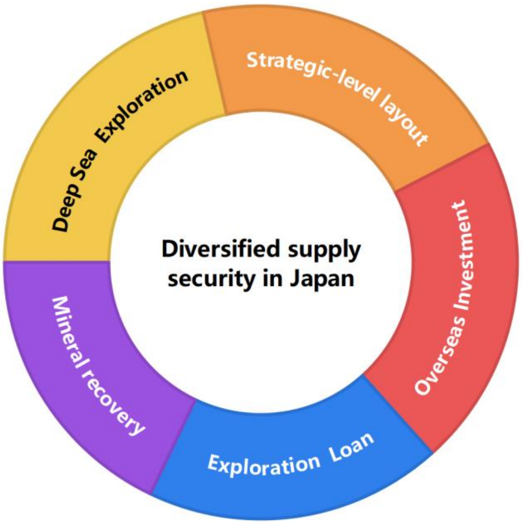
TABLE 11. Representative measures for countries with no mining potential

Country	Critical mineral needs	Representative measures
Japan	Nickel, aluminium, zinc	Diversified supply measures include import, investment, processing, recycling
Singapore	Cobalt, nickel, copper	
Nepal	Copper, manganese, nickel	Importing
Kiribati	—	Exploring the deep sea
Tonga	—	
Cook Islands	—	

5.2.2. *Japan*

Japan is one of the world's poorest countries in terms of domestical supplies of mineral resources. However, it is one of the world's largest consumers of mineral resources, and one of the world's largest economies. Therefore, securing a stable and inexpensive supply of critical mineral resources is vital to Japan's industrial base and economic development. Japan has adopted a diversified supply strategy divided into five areas (figure 13).

FIGURE 13. Diversified supply security in Japan



(a) ***National strategy***. Since the beginning of the twenty-first century, Japanese policymakers have taken a more strategic approach to secure critical mineral supply chains. They have launched the "Strategy for Securing Rare Metals," which articulates four significant areas of focus for the strategy – securing overseas resources, recycling, developing substitutes, and stockpiling of critical raw materials (Nakano, 2021). Japan's Ministry of Economy, Trade, and Industry (METI) released the "Japan's Energy White Paper 2021" (METI, 2021), which sets out development strategies and a roadmap for optimal energy development, explicitly mentioning vigorous promotion of overseas energy supply strategies. Japan has identified 30 strategic minerals to be studied with special attention, and provided preferential policies and financial support (Nakano, 2021).

(b) ***International cooperation***. The Government of Japan supports and encourages the multinational operations of mining companies as well as the establishment of mineral resource supply bases overseas through various means, such as fiscal, financial, taxation and diplomacy. It also cooperates with international investment institutions and multinational mining companies with European and American backgrounds to participate extensively in the exploration and development of global mineral resources. It has equity participation in the pre-exploration and development of mines, thereby obtaining a right of first refusal over mineral resources. For example, the Japan Oil, Gas and Metals National Corporation (JOGMEC), Japan's State-owned energy agency, launched an equity investment programme in 2010 to help Japanese companies acquire overseas mining interests.

(c) ***Financial support***. The Government of Japan provides investment and low-interest loans to companies that undertake overseas mining in order to encourage offshore mining and gain access to strategic global mineral resources. JOGMEC has launched programmes such as the Overseas Exploration Financing Loan and the Overseas Exploration Fund Investment to provide financial support to companies conducting overseas exploration (JOGMEC, 2022b). For example, on 22 March 2022, JOGMEC provided a 10-year, yen 620 million loan to Dowa Metal Mountain Ltd., for the exploration of zinc, copper and rare metals at the Palmer mine in Alaska (Takaya and others, 2018; JOGMEC, 2022a).

(d) ***Mineral recovery and recycling***. Given the increasing competition around essential resources in significant economies globally, the Government of Japan has called for a reassessment of the particular importance of minerals and related policy tools, a review of the reserve system, the promotion of international research cooperation and a focus on innovations related to mineral recovery. In addition, Japan has expanded the scope of rare metal reserves from the original seven products and increased the reserve level for some minerals from 60 days of domestic consumption to 180 days (METI, 2020).

(e) ***Exploring deep-sea minerals***. Between 2013 and 2017, six deposits containing cobalt and nickel, among other minerals, were discovered off the southern island of Okinawa. Resource surveys and various technical assessments were conducted to determine their commercial viability. Research conducted jointly by Waseda University, the University of Tokyo and other institutions in Japan in 2018 revealed that they had found rare earth resources totalling approximately 16 million tonnes at 5,600 metres depth of the seafloor near Japan’s easternmost islands (Takaya and others, 2018).

5.2.3. Singapore

As an island nation in South-East Asia, Singapore has a land area of only 728.6 square kilometres and is highly resource-poor. Nevertheless, Singapore has become the world’s second-largest metals and minerals trading centre, largely thanks to its ability to build on its strengths and formulate mineral policies accordingly.

(a) ***Import diversification***. Imports of minerals make up 18.5% of Singapore's imports (ITC, 2022). The major importing countries for Singapore's minerals include mineral powerhouses such as China and Australia. It's strategic location near the Straits of Malacca gives Singapore an advantageous natural port, enabling a large amount of overseas import and export trade. Therefore importing minerals is an important strategic choice for the country.

(b) ***Overseas partnerships and investments***. The year 2022 saw the signing of a cooperation agreement between Aslan Energy Capital (AEC), Singapore LNG Alliance Ltd and PT Agri Maritim Sulteng (AMS) for Aslan Energy Capital to invest, develop and implement a project in Central Sulawesi Palu to invest in, develop and execute a multi-faceted green energy hub project (Palu Green Energy Hub) (Henry, 2022). By partnering with other countries for mutual benefit, Singapore is finding ways to expand its business and solve its resource woes while providing energy solutions to other countries.

(c) ***Global minerals trading hub***. As of 2020, more than 200 commodities have set up ferrous metal teams in Singapore to conduct global iron ore marketing and sales, sourcing, risk control, supply chain management, chartering and other operations. At the same time, as a trading hub Singapore has a certain degree of international pricing power for some minerals. As a result, a series of active mineral trading activities also provide strong assurance of mineral supply in Singapore.

5.3. COMPARATIVE ANALYSIS OF SUSTAINABLE MINERAL DEVELOPMENT BETWEEN RESOURCE-POOR AND RESOURCE-RICH COUNTRIES

5.3.1. Similarities between resource-poor and resource-rich countries

Since critical minerals are non-renewable resources, both resource-poor and resource-rich countries pay great attention to the sustainable development of their essential minerals. Countries have taken actions to guarantee the sustainable development of their critical minerals according to their resource endowments. Both groups value international cooperation, innovation, and circular economy practices as key means to ensure the security of supply. The three similarities are summarized below (see also Table 12).

The first is to ensure the reliability of the supply of critical minerals. In order to achieve this goal, the two types of countries start from three points:

(i) the formulation of national critical minerals development strategies. Regardless of the resource-poor or resource-rich countries, Governments have successfully formulated national critical minerals development strategies to ensure the sustainable development of critical minerals from various aspects;

(ii) They actively carry out international cooperation and strategic investment, and participate in the exploration and development of mineral resources of other countries through project cooperation in order to create a more diversified and secure supply chain of critical minerals; and

(iii) several developed countries and regions have developed new circular economy plans. Mineral recovery and recycling are how critical minerals can be sustainably developed.

Both types of countries have also developed relevant policies. China, for example, has introduced a policy called the "the Fourteenth Five-Year Plan" for developing a circular economy. China proposes the establishment of a resource recycling industry system, promotion of the recycling rate of non-ferrous metals and other resources, and ensuring the supply of such materials so that the recycling of critical minerals is developed in a green and sustainable direction (NDRC, 2021).

Second, the exploration, production and innovation of critical minerals is reflected in the following two aspects. Both types of countries provide financial support to enterprises through government subsidies, low-interest loans, tax incentives and other means to improve mineral extraction technology and mineral exploration capacity. The objective is to ensure the sustainable supply of critical minerals in their countries. In addition, in terms of mineral geological exploration, both groups of countries conduct joint resource exploration with other countries to determine the geological control of the current distribution of critical minerals in certain deposits as well as identify new sources of supply through critical mineral potential mapping and quantitative mineral assessment.

TABLE 12. Similarities between resource-poor and resource-rich countries

Commonality	Resource-rich countries	Resource-poor countries
Policy development	1. China has formulated the "Fourteenth Five-Year Plan" for developing the raw materials industry, which proposes strengthening rare earth enterprises and encouraging them to merge and reorganize (MIIT, 2021). 2. Australia's Critical Minerals Strategy, released in 2019, sets out to achieve sustainability in the critical minerals sector through environmental creation, international cooperation and other aspects (Australian Government, 2022).	Japan launched the Strategy for the Protection of Rare Metals, taking several measures to reduce the risk of supply disruptions.
International cooperation	1. China encourages domestic enterprises to actively participate in global rare earth technology and economic cooperation through international practices and market rules (Government of PRC, 2012). 2. Australia signed memorandums of understanding with the Republic of Korea, India and Japan to enhance investment in key Australian mineral projects.	1. Japan encourages mining companies to develop multinational operations and establish mineral resource supply bases overseas. 2. Singapore cooperates with other countries to jointly develop critical mineral projects and achieve mutual benefits through overseas investment and cooperation.
Mineral recovery and recycling	China has formulated relevant policies to actively carry out the recycling of rare earth resources and support the	The Government of Japan has called for a reassessment of the particular importance

	establishment of specialized comprehensive recycling bases for rare earth materials.	of minerals and related policy tools, and for a focus on innovation related to mineral recovery.
Financial support	1. China is actively fostering downstream rare earth production capacity through supportive regulations, State funding and subsidies 2. The Government of Australia established a A$2 billion Critical Minerals Fund in 2021, which will help projects consistent with the Critical Minerals Strategy to overcome gaps in private funding to start projects (Australian Government, 2022).	The Japanese Government supports and encourages mining companies to develop multinational operations through various means such as fiscal, financial, taxation, and diplomacy.

Source: Authors' compilation.

5.3.2. Differences between resource-poor countries and resource-rich countries

Although resource-rich countries and resource-poor countries take some of the same measures to achieve sustainable development of critical minerals, they often have a different focus. CRM-rich countries focus on processing of CRMs and related environmental protection schemes, while CRM-poor counties focus on innovation for new supply or alternative products, as summarized in table 13.

Resource-rich countries do not have all types of critical minerals, but have an endowment of certain minerals. These countries have for the most part concentrated on developing their critical minerals and therefore already have significant experience, at least in the early stages. Resource rich countries tend have certain key elements in common:

(1) They focus on environmental protection by setting more regulations and standards for two purposes: to repair the environmental damage caused by mining minerals, and to reduce the environmental pollution caused by processing minerals.

(2) Although these countries are rich in mineral resources, they also face the potential for resource depletion. In some cases they have taken a series of restrictive measures to prevent a large-scale decline in mineral reserves by limiting exports and restricting mining.

(3) In order to better utilize mineral resources, resource-rich countries work to develop critical mineral industry supply chains through investment and technological innovation to promote the joint development of upstream and downstream industries, and to be able to improve the innovation capacity of related fields further.

Since resource-poor countries do not have the means to achieve self-sufficiency by relying on domestic resources, they must take measures to ensure the sufficient supply of critical minerals.

(1) These countries emphasize their dependence on imports, a need for foreign cooperation, and investments to supplement their scarce mineral resources with the help of other countries as appropriate.

(2) They focus on innovation ability and developing new technologies and products. This strengthens the refining technology of minerals, reduces the waste rate of ores, and achieves higher quality and more efficient utilization of minerals. It also helps to further develop critical mineral exploration technologies, such as conducting deep-sea and polar exploration, to expand access to critical minerals. At the same time, it strengthens the recovery and recycling of minerals to alleviate long-term pressure on the supply of critical raw materials.

TABLE 13. **Differences between resource-poor countries and resource-rich countries**

Resource-rich countries	Resource-poor countries
Overall situation differences	
1. Repair environmental damage caused by mineral extraction, strengthening environmental protection, and promoting sustainable mineral development. 2. Prevent a large-scale decline in mineral reserves by restricting exports, limiting mining, etc. 3. Vigorously develop key mineral industry chains through investment, technological innovation, etc.	1. Import, foreign cooperation and investment. 2. Further improve innovation capacity, and develop new technology and new products. 3. Policy level to increase the importance of crucial mineral reserves and enhance the level of mineral reserves.
Typical country differences	
Australia	1. Promote constructing an international standard system for critical minerals to ensure a sustainable global production environment (Australian Government, 2022). 2. Leverage its resource and technology advantages to vigorously develop the key minerals industry chain (Vella, 2022).
Japan	1. Vigorously promote overseas energy supply strategies. (METI, 2021). 2. Develop alternatives and stockpile critical raw materials. 3. Conduct deep-sea mineral exploration (Takaya and others, 2018).
China	1. Promote upstream and downstream development of key mineral industry chains through supportive regulations, State-funded financing and subsidies (IEA, 2021). 2. Continuously strengthen and improve the management of high energy consumption, high pollution, resource-based products and related industries 3. Promote establishing an enterprise-oriented, market-oriented and industry-academia-research integrated technology innovation system.
Singapore	1. Take advantage of the port to import large quantities of critical minerals (ITC, 2022). 2. Establish a mineral trading centre to ensure mineral supply.

Source: Authors' compilation.

5.3.3. Cooperation between resource-rich and resource-poor countries in the Asia-Pacific region

Cooperation between resource-rich and resource-poor countries for the sustainable development of critical minerals is divided into three main types of cooperation: financial, information sharing and technical support.

(1) Financial cooperation: Resource-rich countries have invested in developing critical minerals in resource-poor countries, such as Newcrest Mining, a major Australian gold producer, in advancing one of the world's most extensive undeveloped copper resources, the Namosi project in Viti Levu, Fiji (Wood Mackenzie, 2021). A new partnership between Australia and Japan on critical minerals will help establish a secure supply chain for critical minerals that will ultimately help both countries achieve their emissions reduction targets. The partnership will establish a framework to build a secure supply chain for critical minerals between the two countries, help open up more foreign investment in the critical minerals sector, and promote opportunities for information sharing and cooperation, including research, investment and commercial arrangements between Japanese and Australian projects (Prime Minister of Australia, 2022).

(2) Information sharing: Resource-rich countries and resource-poor countries organize forums and exchanges to promote opportunities for technology sharing and cooperation, support sustainable mineral development through through peer-to-peer learning and development of toolkits, and to learn advanced mining techniques. For example, in terms of peer-to-peer learning, on 21 September 2015, as one of the series of activities of the China-ASEAN 2015 Multilateral Cooperation Program and China-ASEAN Mining Cooperation Forum, a workshop on comprehensive utilization technology of low-grade bauxite in ASEAN countries was organized in Nanning, China. The workshop mainly taught comprehensive utilization technology of low-grade bauxite, and included participants from Cambodia and the Lao People’s Democratic Republic (China Geological Survey, 2015). On the other hand, the United States Department of State has developed the Energy Resource Governance Initiative (ERGI) Toolkit, which provides targeted learning modules for mining industry professionals, covering everything from production and management to working with indigenous communities and supporting economic development and growth in all relevant economies in a way that ensures supply chain security (United States Department of State, 2020).

(3) Technical support: By focusing on technological development and innovation, resource-poor countries may have technological solutions that can be deployed in less developed resource-rich countries opening up opportunities for mutually beneficial cooperation. For example, Vietnam and Japan have established a research centre in Hanoi to improve the extraction and processing of rare earths (Gao, 2012). Japan also provides technical support, capacity building, trainings, and other forms of technical aid through the Japan International Cooperation Organization (JICA). For example, through JICA, Japan provides technical support and infrastructure construction work around mines in resource-rich countries (JICA, 2022).

5.4. INTERNATIONAL COOPERATION

A number of international initiatives have emerged in recent years to promote the development of secure, sustainable and responsible supply chains. The Global Commission on People-Centred Clean Energy Transitions was established on 26 January 2021 to examine the social and economic impacts of the shift to cleaner energy technologies (IEA, 2022). In 2022, the Organisation for Economic Co-operation and Development (OECD) Development Centre launched the Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT), an actionable blueprint for policymakers from emerging and developing countries to plan fand implement a low carbon transition (OECD, 2022c).

TABLE 14. International initiatives on sustainable and responsible extraction

Name	Climate	Sustainability	Responsible sourcing	Rights of workers	Fairness and inclusivity	Governance	Security of supply
World Bank Climate Smart Mining Initiative	🟧	🟧				🟧	🟧
European Battery Alliance							🟨
European Raw Materials Alliance							🟨
Extractive Industries Transparency Initiative						🟧	
Global Battery Alliance	🟪	🟪	🟪				
Energy Resource Governance Initiative		🟧	🟧	🟧		🟧	
Fair Cobalt Alliance				🟨	🟨		
International Council on Mining and Metals	🟪	🟪	🟪	🟪	🟪	🟪	
Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development		🟧	🟧	🟧	🟧	🟧	
Initiative for Responsible Mining Assurance	🟪	🟪	🟪	🟪	🟪	🟪	
Towards Sustainable Mining	🟪	🟪	🟪	🟪	🟪	🟪	
OECD Responsible Business Conduct			🟧	🟧	🟧	🟧	
Responsible Minerals Initiative			🟪	🟪			
Responsible Minerals Foundation	🟩	🟩	🟩	🟩	🟩	🟩	
Women's Rights and Mining			🟩		🟩		

Note: Primary activity type: 🟧 Technical assistance. 🟪 Industry standardization. 🟨 Investment/funding. 🟩 Research and analysis.

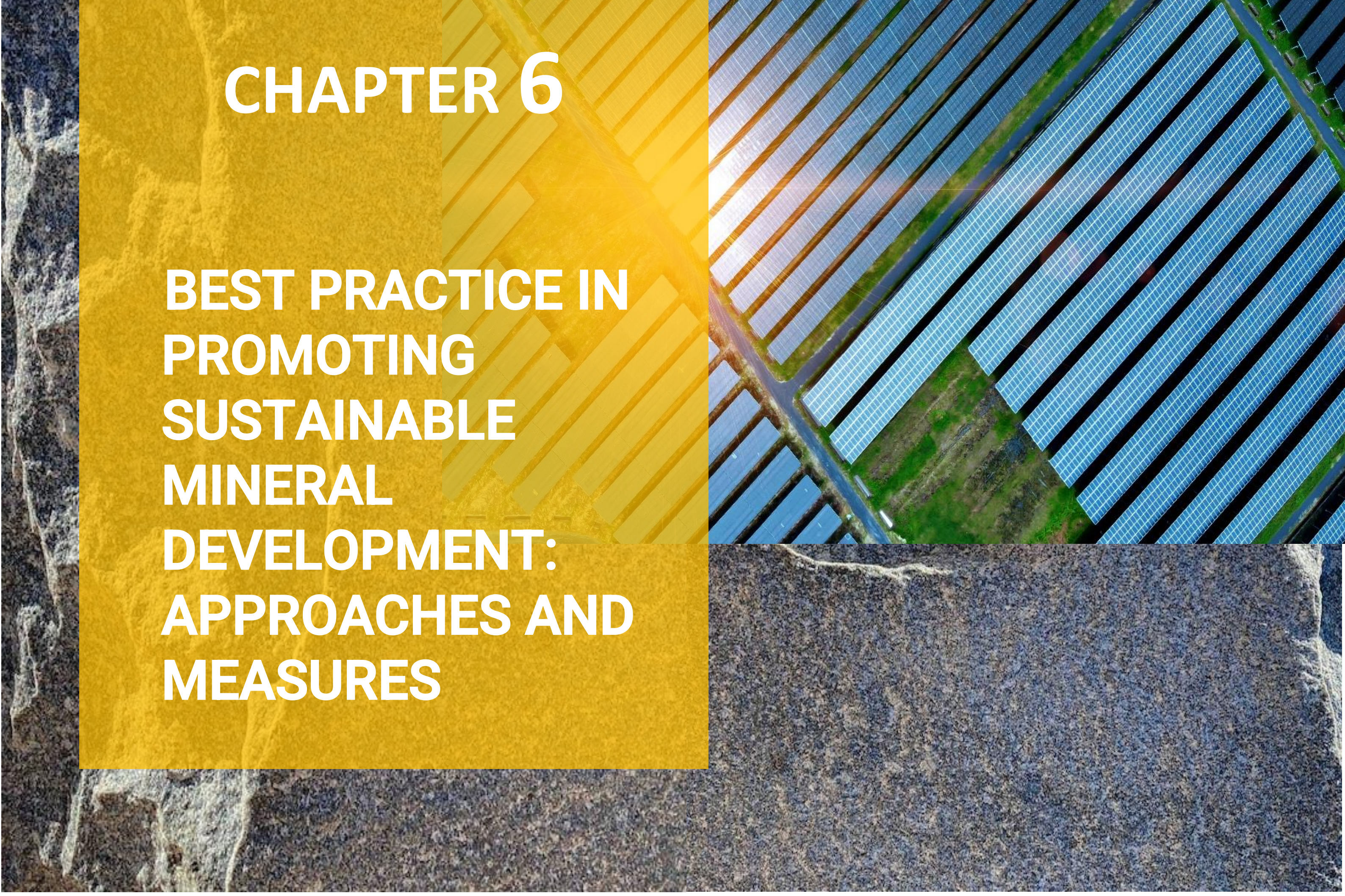
Source: Replicated from International Energy Agency, 2021.

Another relevant form of international cooperation is joint research projects and studies. For example, a study jointly developed by the United Nations Development Programme, the World Economic Forum, the Columbia Center on Sustainable Investments, and the Sustainable Development Solutions Network illustrates how mineral extraction is connected with SDGs (figure 14).

FIGURE 14. Mining and the 17 SDGs

Source: UNDP (2016), Mapping Mining to the SDGs: An Atlas. United Nations Development Programme, New York. Available at https://www.undp.org/publications/mapping-mining-sdgs-atlas

Separately, Governments have set up some extractives-specific initiatives to provide technical assistance, such as the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), which has 80 member countries, and ERGI, which was established by Australia, Botswana, Canada, Peru, and the United States. Many aspects of critical mineral supply chains are also being addressed through public-private collaborations (IEA, 2021).



CHAPTER 6

BEST PRACTICE IN PROMOTING SUSTAINABLE MINERAL DEVELOPMENT: APPROACHES AND MEASURES

The development of critical minerals touches on issues well beyond the extractive industries, extending to include regional economic development, industrial restructuring, the need to reskill workers, governance, regulations and as well as political and international issues. This chapter mainly summarizes the best practice in promoting sustainable development in energy and resource development that can inform future sustainable development policy design and implementation for the critical minerals industry. Following the E2SG framework, a brief summary is given of these gaps in economic, environmental, social and governance aspects. In the governance aspects, international coordination is considered separately as it is a key area of interest.

6.1. ECONOMIC DIMENSION

Promotion of sustainable economic development for mining projects requires meeting the investment requirements, diversifying the economies of mining communities countries more broadly, and ensuring equitable sharing of mining revenues with a broader number of stakeholders as well as future generations.

6.1.1. Economic diversification

Economic growth, industrialization, and diversification are all aided by moving up the critical minerals value chain. Successful case studies highlight the fact that economic reorientation has worked better when new projects (e.g., engineering and transport services sectors for supporting extraction activities and mineral processing) were closely related to the extractive industries in resource-rich regions in order to take advantage of economies of scale. In Canada, Australia, the United States and the Scandinavian countries, for example, the development of equipment and engineering services sectors that provide important inputs for mineral extraction have made major contributions to their resource-driven industrialization (Lebdioui, 2020a). Likewise, Malaysia's major oil suppliers have sought to expand their business into the upstream of the industrial chain – including oil extraction technology (e.g., offshore and deep-water oilfield extraction technologies) and equipment manufacturing – as a main strategy to sustain long-term growth (Lebdioui, 2020b). In addition, the potential for indirect job creation depends largely on local conditions, such as the existence of a well-trained, diversified workforce as well as local suppliers of the relevant goods and services to the mining industry (UNEP, 2020).

Failing to add value to mineral exports means a loss of opportunity for economic development because once the metal is gone, it is gone. However, it has proven difficult for export-oriented mining countries to develop industries further along the value chain (Manley and others, 2022). Countries with significant critical mineral reserves are nevertheless focused on the feasibility of adding value to their production through participation in the global markets. For example, growth in demand for lithium is an opportunity for Bolivia and Chile to discuss energy transition, mining governance as well increasing electromobility in producing countries (Anna, 2021).

An extractive-focused industrialization strategy, however, could result in resource dependency that would be a barrier to long-term sustainable growth. While mining does provide development benefits such as jobs and economic growth, educational and health facilities and infrastructure, the ultimate result is typically mine closure, as mining sites have finite resources. Sustaining extractive-dependent economies means developing alternative industries. In general, diversified economies perform better in the long term, as they are less susceptible to commodity price volatility, have broader and more diverse job markets, and have greater potential to boost productivity and incomes (Hesse, 2009; Alsharif and others, 2017). Economic diversification is therefore a key requirement for sustaining the development of extractive industries.

Many resource-rich countries perceive economic diversification as a priority. A range of structural reforms and industrial policies have been implemented to achieve structural transformation and economic diversification (Bastida, 2014; Meller and Simpasa, 2011). Some countries tax the rents from mineral extraction and develop sovereign wealth funds to manage revenues. They often fund critical investments, such as in human capital, infrastructure and institutional assets, and provide funding to start-up firms, resulting in more inclusive development (OECD/WTO, 2019). In addition, they build forward and backward production linkages from extractive industries to increase value-addition, reduce resource dependence, and promote economic diversification by improving the quality of minerals extraction and exporting processed products (Alsharif and others, 2017; Harvie, 2019). Attracting foreign direct investment by creating suitable institutional conditions and international integration also plays a vital role in developing new non-resource industries (Lashitew and others, 2021).

6.1.2 Investment attraction

Securing the supply of critical minerals requires more investment in their extraction and in resilient supply chains. The development and use of clean energy requires large amounts of capital investment, not only in the technologies themselves, but also in the extraction and recycling of critical minerals.

However, critical minerals projects are complex and technically challenging. Projects are expensive, have high investment risks and sometimes compete against countries with lower labour and environmental standards. Moreover, mining companies face the unique challenge of uncertainty in mine's lifespan. For example, a copper mine could operate for anywhere between five and 70 years (Aggreko, 2020).

The risks associated with the development of critical minerals can be mitigated by government interventions. National Governments can play critical active roles in promoting investment by providing policy certainty, a conducive institutional environment, and fiscal and financial assistance (World Bank, 2017). Governments are aware of the importance of setting a clear, credible and consistent long-term policy direction for critical minerals; this instils confidence in the private sector to invest in industries downstream from critical minerals extraction (Manley and others, 2022; Theophilus, 2022).

Governments in resource-rich countries or regions have various policies to develop critical minerals while protecting the environment and accelerating economic development. Australia's 2022 Critical Minerals Strategy points out that de-risk projects can be realized through project facilitation, technical support and strategic investments to scale up processing, and lock in finance and offtake for production. It established the A$2 billion Critical Minerals Facility in 2021 and issued its first loans to two Australian companies in 2022. The loans can help them expand the facility and create plenty of jobs in the project lifespan (Australian Government, 2022).

Government investment can overcome the hurdle between financing and the commitment to future critical minerals. Government funds, both domestically and overseas, play an active role in facilitating the extraction and trade of critical minerals. One example is Lynas Corporation, an Australian rare earth materials company, which received financial support from the Japan Organization for Metals and Energy Security, an independent agency of the Government of Japan, to successfully develop a rare earth deposit in Western Australia.

The project now supplies around one-sixth of the global market for rare earth oxides (Sovacool and others, 2020). The Government of the United States provides $320 million to fund a programme of above- and below-ground mapping of mineral resources. It also allocates a $140 million grant to build a Rare Earth Demonstration Facility (Rumsey, 2021).

Driven by the scale and urgency of the challenge of financing sustainable development, green finance is becoming more prominent, especially for developing countries with abundant critical minerals (UNEP, 2016). In addition, green banks are increasingly being used as financial tools by setting sustainable goals to achieve credit enhancements and loan programmes (Boettcher, 2022). It is worth noting that green banks have a dramatic environmental impact as well as being revenue positive when properly managed (Weiss and Konschnik, 2018).

6.1.3. Resource revenue management

Ensuring that mining revenues are enablers of inclusive economic growth and sustainable development requires their efficient and transparent management (Anna, 2021). At the start, merely collecting revenues can be a challenge. While global mining players regularly report financial figures publicly and transparently, some mining companies lack full financial transparency, interfering with the ability of Governments to implement effective royalty schemes; this enables corruption, siphoning off profits, and illicit financial flows (United Nations, 2020a). To address this, Governments can enact or revise relevant governance, administration and compliance regulation in the tax laws. For example, income tax, value-added tax, resource rent tax and stamp duties on companies can help enable efficient revenue management (Ezenagu, 2021).

The more experienced mining nations (e.g., Australia) have installed robust and fairly reliable royalty schemes, which have worked in the interest of government and society for many decades. This includes ensuring that the benefits from the extractions of transition minerals are fairly distributed across stakeholders, in particular among disadvantaged groups and across generations.

Revenues should ideally be invested in long-term savings, infrastructure development and economic development efforts that can stabilize and diversify the economy in the communities and regions (Haggerty and others, 2018). For example, resource revenue should be invested in a way that increases (or does not deplete) national wealth through investment in infrastructure, social service provision, financial assets and alternative sources of growth, depending on the country's level of development and needs (UNDP, 2018).

Sustainable mining revenue also requires extending the economic benefits of resource exploitation beyond the mine's lifetime and for future generations. Due to the finite nature of mineral resources, future generations will not benefit from the wealth created by extraction without proper policy intervention. Moreover, future generations will bear the environmental impacts that exist long after mining ends, such as destroyed landscapes or continuously emitted pollutants (O'Faircheallaigh, 2015). Distribution of the CRM development benefits fairly among stakeholders, including future generations, is similarly a major task. Governments must ensure a fair redistribution of benefits from CRM development within and among countries, and mitigate inequalities between developed and developing countries and among regional stakeholders. In addition, a portion of revenues should be set aside so that future generations can benefit from it.

Natural resource management policies that include multi-stakeholder and democratic governance can improve resource efficiency and sustainably manage scarce resources (Anna, 2021). Natural-resource-based Sovereign Wealth Funds (SWFs) are a tool that is often set up to ensure a proportion of the wealth derived from the extraction of non-renewable resources is available for future use (McIntosh and others, 2022). Norway's SWF is restricted to making investments outside the country, thereby protecting its currency and market against Dutch Disease (Spencer and others, 2021). Past experience shows that this aspect of the resource curse can be managed with a combination of policy measures, robust project management and technological solutions. Empirical evidence shows that the average GDP growth rate positively correlates with SWF investments (Bortolotti and others, 2015). Countries receiving SWF investments grow faster, and these investments positively affect economic growth, illustrating the transformative potential of SWFs in sustainable development.

6.1.4. Supply chain security

Some countries, mainly developed ones, have focused on boosting supply through a national security agenda from sources that are politically more feasible to access. The Minerals Security Partnership (MSP) was initiated in 2022 to ensure the production, processing and recycling of critical minerals in ways that support resource-rich countries in realizing the full economic development potential of their mineral wealth. Australia, Canada, Finland, France, Germany, Japan, the Republic of Korea, Sweden, the United Kingdom, the United States and the European Union have joined the partnership. Clear and high standards for extraction transparency along the extractive industry value chain are a related method for reducing supply chain conflicts (Tsafos, 2022).

6.2 ENVIRONMENTAL DIMENSION

Environmental challenges from mineral development are often addressed through a life-cycle management approach that includes planning and design, production and consumption. A circular economy approach involving reusing, recycling, repairing, and refurbishing existing materials and products can play a significant role in promoting the sustainable development of CRMs.

6.2.1. Planning and design

Integrated mining planning that considers the full life cycle (exploration, construction, extraction and closure) is necessary for managing various impacts of mining activities on sustainable development, especially those related to land use (Manley and others, 2022). Planning for closure as early as possible and ideally during the project design stage is key for mitigating potential negative impacts to air, soil, water and ecosystems local to the site, and in optimizing post-closure land-use opportunities and social transition outcomes. Special attention should be paid to creating in advance not only the conditions for sustainable development of regions and communities, but also plans for workers and communities mine closure. This is relevant in particular to investments that have potential impacts beyond the life of the mine itself, including investments in rail, road and port to bring products to the market, the support for training workers to stimulate labour mobility, and the establishment of an education system (Syahrir and others, 2020).

6.2.2 Responsible production

The extractive industries in developed, emerging and developing countries as well have begun to respond to broader efforts to remain compatible with a low-emissions, climate-resilient future (World Bank, 2020b). More than two-thirds of the top 20 mining companies have established emissions reduction targets for 2030. In addition, companies are also adopting voluntary environmental impact disclosures (IEA, 2021).

One key method of improving the environmental impact of the extractive industry is to promote the low-emission production of critical minerals. One attractive option is to reduce their reliance on fossil fuels through the adoption of clean energy technologies (e.g., renewables) and innovations (Nasirov and Agostini, 2018). Market-based solutions can and should be employed to address environmental and climate related market failures within the extractive industries. For example, mining companies should be incentivized to invest in renewable and clean energy projects. A prime example of a market-oriented solution is a cap-and-trade programme for carbon emissions, such as the European Union's emissions trading scheme (ETS). Another method is to establish sector-wide voluntary (or better, statutory) carbon compensation schemes, including cap-and-trade mechanisms (United Nations, 2020a). Taxation of carbon, including border taxes, may also be used to combat emissions leakage (Fischer and Fox, 2012). The main point is that mines and other portions of the extractive industries should be included in such schemes.

Renewable electricity has already been used in some remote mining locations where grid electricity is either technically challenging or uneconomical as well as in areas with poor quality electricity supply from the grids. Major mining companies like Rio Tinto and Antofagasta have also sought to clean up their production by purchasing renewable energy certificates (RECs) or establishing their own electricity supply based on renewable technologies (Infomineo, 2020). Relevant efforts, including for example the World Bank's Climate-Smart Mining Initiative, could be adopted to support the responsible extraction and processing of minerals and metals for clean energy transition and sustainable development. This new World Bank initiative aims to minimize the life-cycle social, environmental and climate footprint of those materials in resource-rich developing countries (World Bank, 2020b). Hydrogen produced from renewable energy also provides a potential power and storage solution for mining companies to decarbonize their operations, and has been discussed in, for example, Australia (COAG Energy Council, 2019).

Water use, another important environmental issue, can be reduced by controlling losses (e.g., minimizing wet areas or filtrating tailings) or using dry processing technologies. For example, Anglo-American upgraded the water delivery system and used automated loops for recycling, enabling its Los Brondes mine to recover more than 78% of the water it uses (IEA, 2021). Mining operations can also use lower quality water, such as water from mine dewatering and surface runoff, as well as recycled process water, produced water, treated wastewater or desalinated seawater (Tomás, 2022).

Mining wastes and areas should be properly dealt with. Simply depositing extractive wastes in disposal facilities could adversely affect the environment, especially in areas in close proximity to the mining sites. Proper treatment of former extraction areas could also help to reduce the environmental risks associated with, for example, mine gas leakage, and water and soil contamination caused by waste rocks and mining tailings stored around mining areas (SDGs 13-15) (Agboola and others, 2020). The global tailings review group developed by UNEP, PRI and ICMM initiated global industry standards on tailings management in 2020 to prevent tailings disasters (Rio Tinto, 2022).

6.2.3. Circular economy and consumption

The only two effective ways of meeting rising demand for critical minerals are increased extraction and recycling, reusing, reducing (3Rs). Efficient recycling of extractive wastes (metals, ores, coal, oil and gas) is highly desirable (Kalisz and others, 2022), as breaking down used materials and reforming them for alternative use (recycling) can reduce the need for extraction. However, while recycling can reduce the need for mining and associated environmental impacts like carbon emissions, it could also increase energy use and water footprints.

Reuse is another important strategy. Many low-carbon technologies, such as batteries, can be reused for other purposes without changing their original components. For example, lithium-ion batteries that are retired from use in electric vehicles could potentially be used in other types of energy storage applications, thus extending their life (World Bank, 2020b).

Reducing overall environmental footprint and other circular economy approaches are equally important. Substitution may help to increase materials available for the energy transition by reducing demand for inputs that are difficult or expensive to obtain. For example, battery cathode materials can be adjusted to avoid or minimize the use of cobalt, copper cabling can be replaced with aluminium, and copper water pipes can be replaced with a number of other materials (IRENA, 2021). The successful future mine is not only the one with the highest technology but the one with the lowest environmental footprint.

Recycling, reusing, reducing and better resource efficiency extend and enhance the lifetimes of products and stretch out mineral reserves, and thus contribute to the sustainable development of minerals. A United States study suggested that 65% of the United States domestic cobalt demand in 2040 could be supplied by end-of-life lithium-ion batteries with the presence of a robust take-back and recycling infrastructure (Sovacool and others, 2020). Europe is a leader in the recycling of critical minerals, with more than 50% of its base metals (e.g., aluminium, copper, lead, nickel, tin and zinc) coming from recycled sources (Tomas and Gauri, 2020). Denmark's exercise in the 1990s to increase the collection of nickel-cadmium batteries suggest that deposit-refund schemes, traditionally applied to drinks containers, could be used to boost the collection rates of electronics and batteries (IEA, 2021).

An integrated approach to the production, use and reuse of CRMs can reduce the environmental and carbon footprints. E-waste recycling could help reduce the environmental and human health impact of mineral extraction. It could also boost the security of mineral supply. For example, lithium is widely used in the production of mobility batteries for electric vehicles. Considering the soaring demand for lithium – fuelled by the global trends towards transport electrification – better recycling of mobility batteries can provide an additional supply of lithium. This will help to reduce extraction activities, import dependence and the exposure to volatility in the international markets.

Innovation is essential for reducing demand for CRMs. Some initiatives have already been undertaken to improve the design of mobility battery and electric vehicles, to facilitate recycling and re-use of mobility batteries. Design innovation can reduce the use of permanent magnets in wind turbines and mobility batteries. This could, in turn, help to alleviate the pressure on the supply of cobalt, a widely-used rare earth element for making permanent magnets (IRENA, 2021). It has recently been reported that the United States Department of Energy (DOE) has developed a plan to "eliminate cobalt and nickel in lithium-ion batteries" by 2030, and DOE has supported research and development efforts to reduce the consumption of critical minerals, including REEs (Tsafos, 2022). Such innovations are expected to substantially modify the overall global demand figures for these CRMs.

Leading consuming companies can also play a driving role in the sustainable development of their upstream and downstream enterprises (Buchanan and Marques, 2018; Freeman, 2022). Tesla requires that its suppliers ensure that their parts and products do not contribute to armed conflict, human rights abuses or environmental degradation, regardless of sourcing location. New suppliers are required to disclose the details of their supply chains so Tesla can verify sources and identify risks via third-party audits. When sourcing conflict minerals or other materials (e.g., cobalt, nickel, lithium and mica), suppliers must implement due diligence programmes for the value chains of these materials. Tesla requires all suppliers to provide information upon request on their sourcing, due diligence efforts and findings for all materials included in this responsible materials policy (Freeman, 2022; Tesla, 2021).

6.3. SOCIAL DIMENSION

Aligning mineral development with SDGs is a complex endevour which cannot be accomplished by any single actor. There are many stakeholders at the nexus of mineral development and SDGs, including, but not limited to, 'home' and 'host' Governments, intergovernmental organizations (IGOs), private commercial entities and 'third' sector actors such as non-governmental organizations (NGOs), the finance sector and institutional investors, shareholders, industry associations, labour, consumers and civil society.

Inclusive decision-making and implementation processes that involve all key stakeholders are required. Efforts should also be made to minimize the social and environmental impacts of critical mineral exploitation and extraction, especially on island communities, indigenous peoples, and first nations communities' ways of life.

6.3.1. Private sector

The private sector contributes to resource recycling in a variety of ways, such as building the resource recovery institutions, collaborating with the public sector in public–private partnerships, driving innovation and facilitating technology use, and contributing to recycle financing (Chandra and others, 2016).

The private sector, including the extractive industries, recycling sector and end users, is critical for achieving sustainable mineral development. In many cases, private companies are the ones delivering the mineral development while contributing to the SDGs. Integrating SDGs into mining and energy companies' core business activities could be in line with their interests because such integration could bring greater efficiencies, cost savings, and competitiveness, which can enhance the industry's social licence to operate (UNDP and others, 2017). But balancing these goals is too complicated for a one-size-fits-all recommendation, And often it is ultimately better to leave final decision to the relevant stakeholders including from the private sector.

Nevertheless, the private sector's activities, are being shaped by policies, regulations, and pressure from society as a whole. Appropriate institutional frameworks can help align the interests of the private sector with sustainable development. For example, extended producer responsibility, which extends the manufacturers' responsibilities to cover all stages of the product lifecycle, including design, logistics, recycling and disposal, could be an attractive approach for attaining such an alignment. This approach incentivizes manufacturers to design the products in ways that could reduce the environmental impacts of production and lower the costs of recycling and/or disposal. At the same time, attention should be paid to strengthening the capacity of product manufacturers to assume their assigned responsibilities.

6.3.2. Civil society engagement

Civil society engagement is vital to information disclosure and promoting government and corporate accountability. Even with appropriate institutional frameworks and the presence of responsible private sector actors, civil society organizations and other third-party stakeholders can help monitor the performance of extractive industries, raise concerns on behalf of under-represented segments of society, inform the public, and facilitate multi-stakeholder partnerships and dialogue (UNDP and others, 2017).

International civil society groups have played an indispensable role in the past, and local civil society groups in many resource-rich States are increasingly becoming involved in promoting public participation in mining development. A civil society organization-led process can deliver very different but ultimately positive results from an industry-led initiative tackling the same issue (UNEP, 2020). An inclusive, multi-stakeholder approach to coalition building is an important avenue for critical mineral development (Ladislaw and others, 2019).

Enabling collaboration with civil society organizations helps to ensure a just and inclusive transition, improving not only company-community relations, but economic performance as well. Those organizations can monitor the implementation of energy transitions and the SDGs, voice the concerns of under-represented segments of society, inform the public, facilitate multi-stakeholder partnerships and hold other stakeholders accountable (UNDP and others, 2017). For example, members of the climate community need to work closely with mineral producers – including resource-rich developing countries and the mining industry (World Bank, 2020b). Ultimately, however, civil society engagement can succeed only if Governments and companies are willing to facilitate civil society participation.

Stakeholder engagement and participatory approaches are particularly critical for developing long-term strategies and plans, particularly considering the need for transformational change across all sectors (IPCC, 2018; Schaeffer and others, 2019). There are several multi-stakeholder initiatives with coalitions of industry, non-governmental and public actors in critical mineral extraction, such as the Alliance for Responsible Mining, the International Council on Mining and Metals (ICMM), and Extractive Industries Transparency Initiative (EITI) (Agusdinata and others, 2022).

For example, EITI, which has a multi-stakeholder membership, requires its partners to disclose payment information and gain more traction.

Mining industry associations play a positive role in mitigating adverse environmental and social impacts for sustainable development. Compared with other sectors, mining industry associations have a greater reliance on the collective organization (Buchanan and Marques, 2018). Most public statements about sustainability and general statements made by the country-level mining industry can be translated into formal policies. It presents an opportunity for the diffusion of leading practice norms and standards in the mining arena. The Minerals Council of Australia (MCA) and the Mining Association of Canada (MAC) designed a sustainable framework and used their powerful platforms to encourage member companies to meet agreed standards across a range of operational activities and impacts (Vivoda and Kemp, 2019).

Furthermore, the role of civil society, Governments and mining companies seeking better practice should ensure there are serious financial, reputational and legal consequences for unscrupulous companies and individuals. One essential avenue to achieving this is holding companies accountable for their ESG commitments (Peter and Pavlenko, 2021). In addition, civil society engagement also includes identification and training of persons involved in collecting and treating electronic/hazardous waste.

6.3.3. *Local acceptance*

Different actors have different perspectives on the need for, and potential impacts (positive and negative) of developing mineral resources. Inconsistent or conflicting interests among relevant stakeholders – in particular national Governments, local interests, and project developers – are often the norm.

Mineral production is already facing increasing scrutiny by consumers and investors to ensure practices are sustainable and responsible. Increasing awareness of social and environmental impacts has put mining activities under increasing scrutiny. Increased public scrutiny can incentivize companies and communities to properly manage the environmental and social issues of mineral production (IRENA, 2021).

An essential factor for the timely and adequate growth of primary materials supply is local acceptance (IRENA, 2021). Social licences issued by the mining community are considered a standard requirement for mining projects to operate (Lacey and Lamont, 2014). Public acceptance, or “Social Licence to Operate” (SLO) (Prno, 2013), has become a key indicator for the sustainability of projects of all types, including mining projects (Kamenopoulos and Agioutantis, 2021).

6.3.3. Gender equality

Some mining companies are aware of the essentials for building gender-inclusive workplaces, which among other benefits tend to be safer (EITI, 2020). These companies make an effort to integrate gender equality, inclusion, and women’s economic empowerment into aspects of their operations. For example, many mining companies hire women to drive trucks and operate machinery because they find female employees have better safety records than male counterparts and that they reduce equipment maintenance requirements (World Bank, 2013).

6.4. NATIONAL GOVERNANCE DIMENSION

An essential cross-cutting condition for extractive industries to achieve the economic, social and environmental pillars of sustainable development is good governance. Governments are responsible for establishing conducive environments that incentivize the private sector and other stakeholders to align future critical mineral extraction and trade with the SDGs. Good governance has a broad scope, including revenue collecting and sharing, effective regulation, anti-corruption and international cooperation. Good governance is critical for translating economic benefits from the extractive industries, including those for critical minerals, into broader positive socio-economic and environmental outcomes (Addison and Roe, 2018).

6.4.1. Revenue collecting framework

Ensuring fair sharing across stakeholders of the benefits from the extraction of transition minerals requires the presence of effective institutions. The economic benefits of mining must be managed with carefully designed legal frameworks. This includes a transparent revenue management regime and socio-environmental regulations and legislation. This topic is discussed further in ESCAP's earlier background paper on effective resource governance discussions (ESCAP, 2021b).

In this context, an efficient, transparent and accountable tax system is fundamentally important, not only to collect revenues necessary to provide infrastructure and public services, but also to promote transparency and accountability by ensuring taxpayers' representation in the Government affairs. A transparent revenue management regime can also help to prevent illicit financial flows. However, the performance of the existing tax systems in resource-rich countries is mixed.

Due to differences in the levels of natural resources, political structures, economic policies and socio-political ideologies, there is not a 'one-size-fits-all' approach to taxation reforms (Ezenagu, 2021). Nevertheless, a few conductive factors have been demonstrated. For example, linking the tax rate of critical minerals production to a price levels has been found helpful in managing price volatility (Manley and others, 2022). In addition, the collection of reliable price data and international price transparency can prevent companies from using tax-base erosion tactics (Ezenagu, 2021).

6.4.2. Good regulation and implementing mechanisms

Ensuring 'good' governance of the extractive industries requires sound regulations focusing on various aspects (e.g., technology, safety and environmental) of resource extraction and production, and their effective implementation.

Environmental and social impact assessments (ESIAs) as well as monitoring and oversight protocols, are essential to protecting the environment and reducing negative impacts on local communities. ESIAs can support decision-making by providing an understanding of present environmental conditions and future consequences of proposed actions, and by supporting the development of mitigation measures and compensation schemes. These can be consolidated in environmental management plans, which integrate regulatory requirements and company mitigation efforts, such as pollution control, environmental monitoring, compensation projects and risk management (IEA, 2021).

Information disclosure, through clear and regular environmental reporting, plays an important role in safeguarding a sustainable critical mineral sector. Environmental reporting, or environmental disclosure, is important to building functional company-community relationships and maintaining the social license to operate (Miklosik and Evans, 2021).

The Extractive Industries Transparency Initiative (EITI), which was established by a coalition of supporting Governments, companies and civil society organizations, aims to help countries develop transparency practices in the mining sector. The EITI views environmental reporting as necessary to raise awareness among affected communities, stimulate debate and promote responsible natural resource management (EITI, 2022). With that in mind, the EITI has developed an environmental reporting standard to inform regulatory compliance, and disclose the environmental impacts of operations and environmental payments made by companies (EITI, 2022).

A holistic approach also requires governments to assume more responsibility not only for monitoring mining companies' responsibility for addressing environmental, health and safety issues, but also for addressing long-term socio-economic development issues beyond the life of a mine, such as the re-employment of mine workers and development of alternative economic activities in the mining community (UNDP, 2018). In India, the District Mineral Foundation (DMF) launched a scheme aimed to mitigating the adverse impacts of mining activities and mine closure on the environment, people's health, and local economy, in order to promote long-term sustainable development of the mining communities (EY, 2022). Better integrating the need for mitigating adverse environmental impact of extraction activities and mine closure into the planning process could lower the costs of the mitigation efforts (IEA, 2021).

6.4.3. Anti-corruption and transparency

Corruption is a major challenge to good governance and can affect all aspects of government decision-making. Corruption undermines the ability of Governments to effectively implement policies, such as tax reform or value-added investments, to maximize the value of critical minerals to the country and deliver benefits to citizens (Manley and others, 2022). The new United States Strategy on Countering Corruption calls for global cooperation to bolster the ability of civil society, media and private sector actors to prevent corruption and push for accountability (Manley and others, 2022; OECD, 2022).

Important areas of transparency for critical mineral development include licensing processes, mining agreements, and company ownership. The EITI has developed a global standard-setting of transparency principles for Governments concerning licensing and contracting, and managing extraction operations, collection of revenue, and government expenditure. When contracts are transparent and comparable with each other, government officials are less likely to conclude illegal, unfair or disadvantageous contracts, or contracts that result in personal gain.

Combating corruption requires effective preventative measures and enforcement efforts to ensure licences are awarded to competent and well-governed companies (Manley and others, 2022). Disclosure of beneficial ownership makes it possible to identify mining licences and contracts awarded to politically-connected companies (Sebastian, 2022). The multi-stakeholder (e.g., government, companies, civil society and international organizations) anti-corruption efforts are required to incorporate across the mining project life cycle and supply chains (Manley and others, 2022; OECD, 2022).

6.5. INTERNATIONAL GOVERNANCE

As supply chains become more global, policy changes in one country will affect other countries and regions. The presence of spillover effects of coal phase-out is one example that calls for regional coordination to manage shocks and smooth the transition process. For example, when China cut coal production capacity in 2016, Australian coal companies recorded a significant increase in profits due to higher prices (Zhang and others, 2019). However, such price spikes may be countered by reduced prices resulting from lower demand. One recent study suggests that new coal-consuming countries could emerge if coal prices are suppressed by energy transition in current leading coal-consuming countries (Shi and others, 2021). These spillover effects may delay overall progress towards a low-carbon future in the extractive industries, as restricted production in one country could be offset by increased production by others.

International coordination and cooperation are increasingly important in the globalized world. While Governments are the key players, the international community should promote sustainable investments by rewarding supplies from countries and companies that follow good environmental practices (such as through carbon footprint labelling and other standards and labels (Shi, 2013b), formulating regional guidelines for investment and operations, and implementing recycling practices that fully consider environmental and safety costs (World Bank, 2020b). A possible example is the World Trade Organization, where member countries interact with each other in the creation, revision and enforcement of rules that govern international trade.

Supply chain due diligence is a critical tool for identifying, assessing and mitigating risks, while increasing traceability and transparency. International frameworks for due diligence, with the support of organizations like the OECD, have developed standards for responsible and sustainable sourcing of minerals (OECD, 2016b). To safeguard supply security and ensure reasonable and sustainable utilization of critical minerals, the extraction and trade of minerals need to follow internationally agreed standards. The United States Energy Resource Governance Initiative (ERGI), which aims to promote sound mining sector governance and resilient global supply chains for critical minerals, has been expanded to engage other major global producers (ERGI, 2020).

Multilateral efforts to enhance capacity-building and knowledge sharing can address key resource gaps between countries. To facilitate cross-border supply chains and develop partnerships with a wide range of consumer economies, Governments should share geological and other relevant data, and develop business and customs regulations through coordination with neighbouring countries (Manley and others, 2022). For example, to help ensure a safe and secure supply of critical material, Geoscience Australia, the Geological Survey of Canada, and the USGS are coordinating their critical mineral mapping and research efforts (USGS, 2020).

6.6. KEY OBSERVATIONS

Critical mineral development needs to address broader socio-economic, environmental, and governance issues, including sufficient investment, economic diversification and mining revenue sharing;

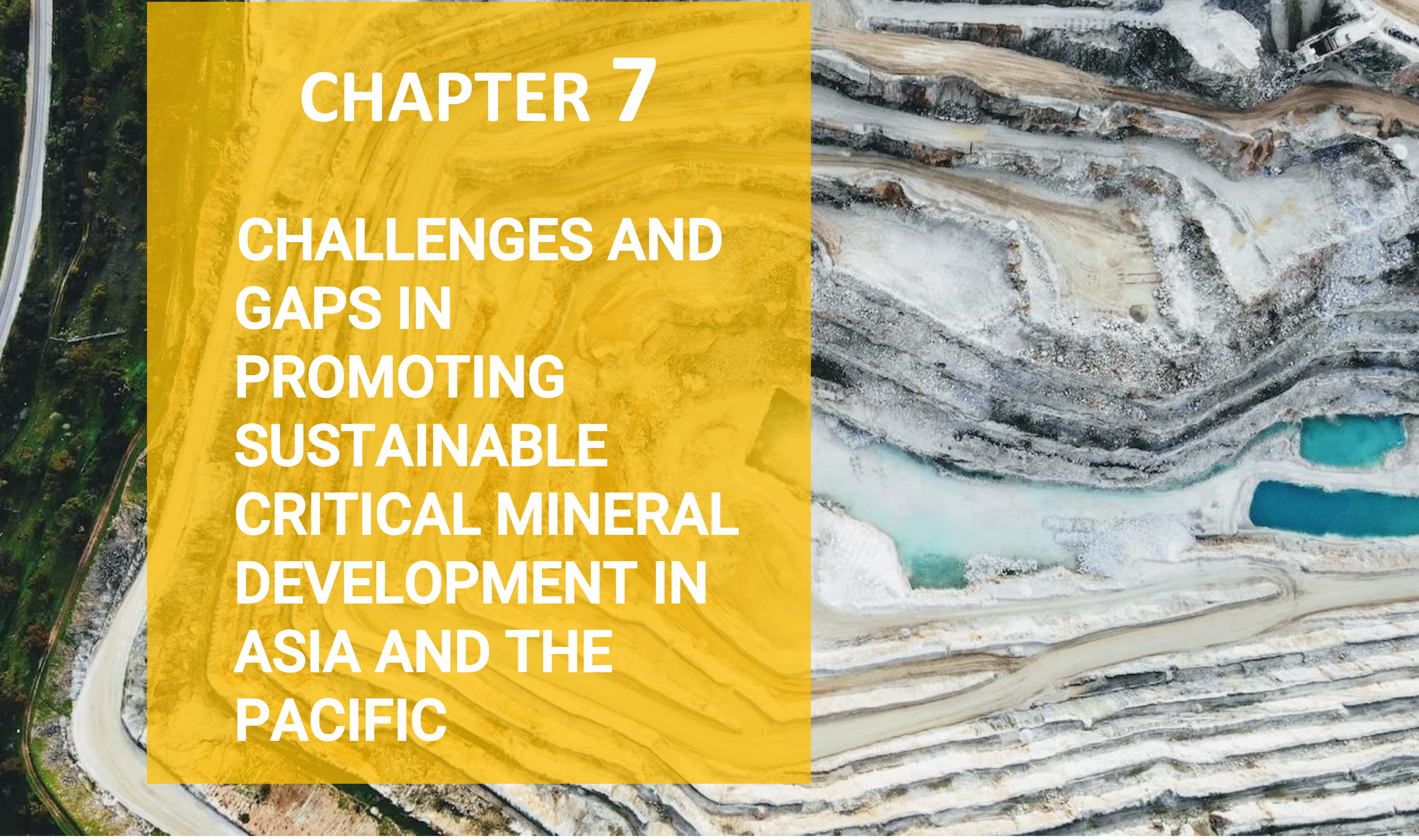
a life-cycle environmental management approach and circular economy; inclusive decision-making and implementation processes and gender equality; good national governance; and close international cooperation.

First, promoting economic development is one of the crucial goals of developing critical minerals. Evidence from the extractive industries shows that economic diversification, increased investment, and fair sharing of mining revenues can drive sustainable economic development. As to economic diversification, adding value to critical minerals and establishing a stable supply chain of minerals are effective paths. In this process, continuous investment is evitable for critical minerals while those mineral projects have high investment risks. Thus, it will be conducive to attracting investment in critical minerals if Governments take measures to provide policy certainty, establish a responsible institutional environment, and financial assistance. In addition, innovation plays a significant role in reducing demand for critical minerals. It is also essential to formulate resource revenue policies effectively, enabling inclusive economic growth and sustainable development.

Second, the experience from extractive industries shows that it is necessary to adopt a life-cycle management approach that covers planning and design, production and consumption to manage environmental risks. Mining companies should plan for protecting the environment at the earliest stage of the project development and include the whole life of the development, including setting emission reduction targets, low-carbon production and properly disposing of mining wastes. Moreover, critical mineral industries can be better governed by establishing sound regulations that focus on the whole mining activities. For consumers, driving a circular economy is helpful for critical mineral sustainable development. It is also noted that leading consuming companies can assist in the sustainable development of their upstream and downstream enterprises.

Third, mining development needs to mitigate social impacts, including community development, social equality, health, safety and human rights, which involve multiple stakeholders. For mining companies, integrating SDGs into their core business activities can enhance the energy sector’s social license to operate. In addition, civil society groups play an indispensable role in promoting public participation, which ensures a just and inclusive transition in mining development. It can improve company-community relations and economic performance. In addition, creating gender-inclusive workplaces in mining companies is also essential to improving mining safety.

Fourth, good governance helps achieve the economic, social and environmental goals for the sustainable development of critical minerals. Effective approaches of benefits sharing, effective regulation, anti-corruption, and international cooperation are necessary. Under an efficient, transparent and accountable tax framework, the mining revenue can be taxed to provide infrastructure and public services. It also increases transparency and accountability. Furthermore, adopting preventative measures, such as expanding transparency and granting licences to well-governed mining companies, is critical to combatting corruption. In addition, international cooperation is increasingly consequential for the sustainable development of minerals. Therefore, building a global governance framework for minerals can lessen environmental and social impacts alongside coordination on security of supply.



CHAPTER 7

CHALLENGES AND GAPS IN PROMOTING SUSTAINABLE CRITICAL MINERAL DEVELOPMENT IN ASIA AND THE PACIFIC

The discussion presented in the previous chapters suggests that the expansion of the CRM industry poses several major challenges to sustainable development. This raises the question of how to address these challenges. Chapter 6 considered some best practice approaches to aligning the development of the CRM industry with sustainable development. That discussion is extended in this chapter, with particular emphasis on identifying major gaps in these approaches. This chapter again follows the E2SG framework, considers the role of international cooperation, and briefly examines COVID-19 as an ongoing challenge.

7.1. ECONOMIC CHALLENGES AND GAPS

The economic challenges are primarily insufficient investment, supply chain vulnerability and weak core technologies.

Lack of investment has been a prevailing challenge for many developing countries. Clean energy investment is likely to exceed $2.4 trillion in 2022, accounting for almost three-quarters of the growth in overall energy investment (IEA, 2021). Nevertheless, a shortage of project funding is a chronic problem. For example, Indonesia’s development of geothermal projects is seriously hindered by a lack of investment. As a result, Indonesia has introduced several incentives. For example, the Government's exploration drilling will hopefully attract developers to continue investing or start new projects (Tim, 2021).

Investments in the mining sector are undermined by a lack of transparency in the minerals market (IEA, 2021), which leads to increased trading risks, as mineral trading quotes change rapidly, and limits the ability of buyers to hedge against the risk of price fluctuations. Supply diversification would be needed to reduce system vulnerable to political instability, geopolitical risks and possible export restrictions.

Weak core technologies of critical mineral, including extraction, purification, reduction, refining and production, are also identified as a real challenge for many developing countries in the energy transition process in general. For example, China's current energy science and technology development plan (NEA and PRC Ministry of Science and Technology, 2021) states that there are still many challenges in crucial core technologies in China, leading to dependence on foreign countries for key technologies (NEA and PRC Ministry of Science and Technology, 2021).

7.2. ENVIRONMENTAL CHALLENGES AND GAPS

Unmitigated emissions during CRM extraction, insufficient recycling and inappropriate e-waste disposal are prevailing environmental challenges.

The emissions during the extraction of CRMs are not well-mitigated. Large land, water and carbon footprints are associated with the production and use of CRMs. While many initiatives have been implemented to control emissions, the emissions generated in the procurement and production stage of the mineral supply chain are often ignored (Golroudbary and others, 2019).

Insufficient recycling of critical minerals is another environmental challenge. The lack of attention to the recycling of mineral resources has led to the waste of many resources. While recycling is regularly practiced for bulk metals, such as steel, equivalent practices have not been established for others, most notably lithium and rare earth elements (World Bank, 2017). The current recovery rate of cobalt, copper and nickel is around 28.5%, 32% and 35%, respectively (World Bank, 2020b). The low recycling rates imply significant potential.

E-waste recycling is not well developed. Most e-waste is still recycled into low-value products, and more e-waste ends up in landfills and incinerators than is being recycled in many countries (OECD, 2020). In 2021; less than 20% of the e-waste is collected and recycled. A study estimated that the amount of e-waste generated is growing by about two million tonnes every year. In addition, people are worried about the environmental effect of unused devices they have in their homes and they do not know how to deal with their own e-waste (Gill, 2022).

Another primary concern is the illegal export of e-waste to countries with lower environmental standards and which lack the capacity to handle these materials appropriately.

7.3. SOCIAL CHALLENGES AND GAPS

Major remaining social challenges and gaps are social acceptance of mining, women's participation, artisanal and small-scale mining.

Social acceptance of mining is under increasing stress. While effective civil society engagement can minimize the negative impacts of mining on the local community and increase social acceptance, it becomes more difficult for civil society to engage with the operational and marketing decisions of private companies (Cameron and Stanley, 2017). A CIVICUS (2017) report suggests that civil society organizations in most EITI member countries are facing serious obstacles to participating in the governance of extractive activities. Some key obstacles include surveillance and censorship, threats to personal safety and denial of the right to protests.

Although the situation has improved, the mining industry is still struggling to attract and retain women at all levels of employment. The most common challenges are physical requirements, and complexities involved in accommodating the needs of women in workplaces (Minerals Council South Africa, 2020). Evidence shows that once employed, on-the-job challenges in mining activities lead to women leaving jobs due to lower pay and fewer advancement opportunities, under-utilized advanced education, and a sideline in technical roles (McKinsey Company, 2021).

Despite the prominence of gender inequality (SDG 5), it has been reported that the planning, implementation and closure of extraction sites often ignore women's needs and their relations to land and water, affecting their ability to provide food and clean water for the family (UN Women, 2016).

In some cases, a mining boom may encourage artisanal and small-scale mining, which could bring with it several major challenges, including mining conflicts related to water and land access as well as disenfranchisement of impacted citizens. All of this means that the energy transition's minerals demand could harm communities and damage the environment (Sebastian, 2022).

7.4. GOVERNANCE GAPS

The Asia-Pacific region faces various governance challenges that impact the sustainable development of the extractive industries, for example limited ability managing mining revenue, and to put in place and enforce regulations to mitigate negative environmental and social impacts.

The opportunities for socio-economic development provided by fossil fuel extraction have not always been fully leveraged in the Asia-Pacific region. Indeed, the extractive industries are found to have made limited impact on socio-economic development in some of the resource-exporting countries in Asia-Pacific, such as the Lao People's Democratic Republic, Myanmar, Mongolia, the Russian Federation and some Central Asian countries (Dagys and others, 2020; Egert, 2012; Insisienmay and others, 2015; Jayanthakumaran and Bari, 2019; Oomes and Kalcheva, 2007; Taguchi and Khinsamone, 2018).[5]

The causes of resource curse, as discussed in the literature, include weak institutions, corruption and poor management of resource revenues. While a range of policy

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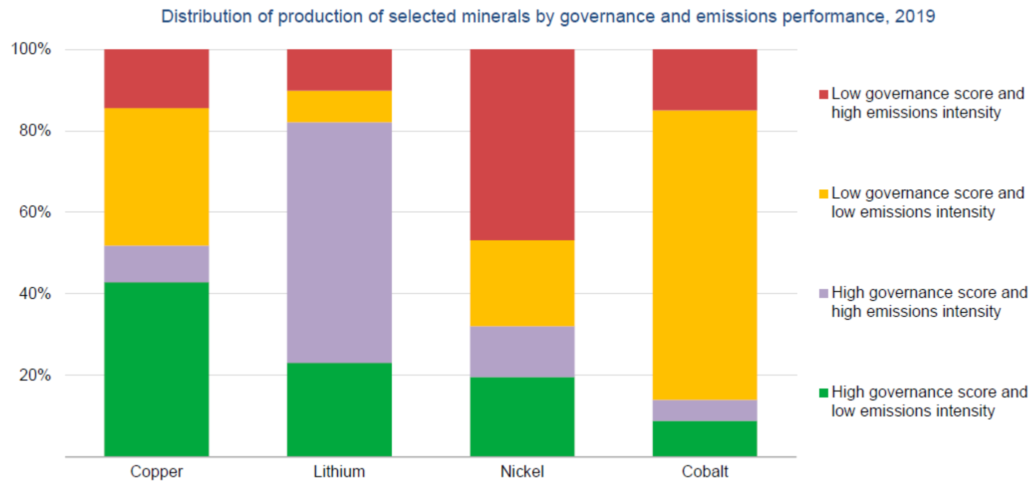
[5] However, there is also a counter argument that it is difficult to confirm the presence of the Dutch Disease in these countries, because the observed symptoms can also be explained by other factors (Oomes and Kalcheva, 2007).

approaches exists for addressing these issues, their effective implementation would be largely determined by the capacity of governance processes.

The countries with the largest potential for minerals and metal extraction are mainly emerging and developing economies, which often have weak resource governance and limited capacity to mitigate the economic and environmental consequences of increased extractive activities (Ali and others, 2017). One study found that more than one-quarter of known copper resources are in countries considered to have unsatisfactory governance and that given total levels of demand for copper, and it is inevitable that some products will come from countries with poor levels of governance (Ali and others, 2017). As of 2019, around 10%-15% of copper, lithium and cobalt production and almost half of the nickel production came from regions with low governance scores and high emissions intensity (figure 15).

FIGURE 15. Distribution of production of selected minerals by governance and emissions performance (2019)



Source: IEA, 2021.

Weaknesses in the legal and judicial system in many emerging and developing countries may undermine host Governments' capacity to effectively detect and prevent corruption. Although alleged corruption cases in the mining industry occur frequently, corruption is rarely on the agenda when consumer countries consider critical minerals supply chains (Alexandra and others, 2021).

The industry's own practices can contribute to corruption. Gaps and discrepancies in internal corporate anti-corruption compliance and due diligence procedures contribute to weakening detection and prevention efforts against corruption. Shortcomings in corporate integrity measures, both in host and home Governments – particularly with regard to beneficial ownership disclosure – provide opportunities for corruption to thrive (OECD, 2016a). For example, even though many companies already have due diligence policies, they need further coordination to ensure consistency and increase uptake (IEA, 2021).

In addition, there seems to be a general lack of coordination between critical minerals policy and policy actions in other domains, such as climate change (Theophilus, 2022), and employment (ILO, 2021). This may preclude local communities from accessing benefits. It also fails to obtain the benefits of synergy across multiple policy actions (United Nations, 2020a).

A lack of coordination across sectors and stakeholders is particularly disadvantageous to impacted communities, which are often not sufficiently represented in the development or management of extractives industry projects, and which therefore do not benefit fully from local development. Lack of coordination may also hinder the process of economic diversification (United Nations, 2020a).

How to form global and regional frameworks to ensure the secure supply and trade of critical minerals is an urgent policy challenge. Due to increase geopolitical tensions among major countries, there may be decoupling among country groups, which breaks the global value chains and create uncertain shocks to the critical mineral markets. While large countries may have options with regard to how supply chains diversify, small countries are more likely to be passively affected.

At the global level, there is no overarching international framework for critical minerals and insufficient coordinated policy action (IEA, 2021). In fact, despite many success stories, the proliferation of international initiatives – including Africa Mining Vision, the United Nations Guiding Principles on Business and Human Rights, EITI, the Dodd-Frank Act, the Global Reporting Initiative (GRI), the Model Mining Development Agreement, the Initiative for Responsible Mining Assurance and the Natural Resource Charter – increases the risk of duplication and inconsistency (UNEP, 2020a). In addition, there is no overarching international governance framework for critical minerals or coordinated policy action, leaving room for enhanced alignment and coordination (IEA, 2021).

7.5. UNDERSTANDING CHALLENGES FROM COVID 19 AND ONGOING POLITICAL TENSIONS

While present challenges may be *ad hoc*, some of them have long-lasting impacts that have not been clearly understood. The two examples are Covid-19 and ongoing political tensions.

The Covid-19 pandemic has evolved from a health and humanitarian crisis to become a once-in-a-lifetime global economic and development emergency. How to effectively use Covid-19 recovery packages and how to adapt the extraction, recycling and supply/trade of critical minerals to the post-Covid-19 world is a question for the international community and Governments. Mining activity has been hit directly by Covid-19, such as the low capacity of operation and suspension of production (Laing, 2020). Financing development of the extractive industries has also become more difficult.

Ongoing geopolitical tensions are expected to have profound impacts on critical minerals due to its immediate impact and induced consequence. The immediate impacts are mainly caused by disruptions to supply chains, the imposition of sanctions and potential retaliations. The Russian Federation is a top producer of all the critical minerals listed in table 8, except lithium. The OECD notes that export restrictions, bilateral dependencies, a lack of transparency and persistent market asymmetries, including the concentration of production in just a few countries, have contributed to these supply chain vulnerabilities (OECD, 2022a).

The long-term impacts are related to the impact of ongoing geopolitical tensions on the energy transition process. Growing concerns about energy security have led many countries to reconsider their paces of the clean energy transition. The potential impacts are hard to predict and potentially mixed, with some viewing it an incentive for a faster clean energy transition, and others viewing fossil fuels as more affordable and reliable (Vivekananda International Foundation, 2022). The two opposing directions will shape different futures for critical minerals.

CHAPTER 8

CONCLUSION AND RECOMMENDATIONS

Drawing from the analysis of current practice in the Asia-Pacific region, and best practice, the gaps to achieve sustainable critical mineral development, the following recommendations are provided to help align Asia-Pacific's critical mineral sector with the Sustainable Development Goals and the Paris Agreement.

8.1. GUIDING PRINCIPLE: A HOLISTIC AND LIFE-CYCLE APPROACH

Better alignment of the development of the mineral resource sector with sustainable development is a complex task, involving changes in various domains of investment attraction, resource revenue management, workforce upskilling, decarbonization of mining practices and better governance. These changes are also interrelated and interdependent. A more efficient systemwide, holistic and life-cycle approach should be adopted to better align critical mineral development with SDGs and the Paris Agreement.

A holistic and life-cycle approach means, among other things, looking at the upstream and end-of-life activities of clean energy technologies to ensure that extractive industries will adopt sustainable and responsible practices to meet rising mineral demand by 2050 (World Bank, 2020b). It should also devote some direct attention to promoting circularity in minerals and mining through, for example, better recycling of industrial wastes and mine-tailings.

Policymakers need to incorporate CRM development into responsible mining policies, regulations and legislation, and Governments need to combat corruption, build regulatory capacity and protect communities (Manley and others, 2022) directly and through indirect means like economic diversification. It is useful to develop downstream processing industries of critical minerals when thinking about economic diversification policies.

At the planning stage, countries or regions that are rich in CRM resources need to prepare for a future with depleted or less demanded resources (Breul and Nguyen, 2021).

At the design stage, a mine-closure plan should be included. Financial resources should be available to manage mine closure and the critical mineral extraction needed to support low-carbon technology development. In many cases, there are no reserved financial resources for mine closure. This will weaken the sustainable ability of extractive industries from a life-cycle perspective. In recent years, more jurisdictions have started using Environmental Financial Assurance (EFA) in the mining sector, commonly referred to as environmental bonds (UNDP, 2018), which could be considered by others.

At the operation stage, the extractive industries and related stakeholders must decarbonize the process of extracting and producing mineral and energy resources, while at the same time contributing to government revenue and enabling better access to modern energy services in developing countries (United Nations, 2020a). Ensuring transparent and responsible production of CRMs is also essential to de-risk investments.

At the trade and supply stage, Governments and private sector stakeholders must develop strategies to reduce geopolitical risks related to critical minerals and the extractives industry more generally. As the role of critical minerals in global supply chains increases, relevant geopolitical concerns are emerging. Broadly speaking, Governments should address potential supply risks due to long-term geopolitical issues, while the private sector manages market fluctuations (IRENA, 2021).

8.2. STRATEGIC PRIORITIES

To meet the increasing demand for critical minerals in a just, equitable and sustainable manner in the Asia-Pacific region, following the E2SG framework, the following four strategic priorities have been identified:

(a) Ensuring supply sufficiency and affordability. The global transition towards a clean energy future will lead to an increase in the deployment of mineral-intensive, clean energy technologies, such as clean power (*e.g.,* wind turbines and solar panels), battery storage, electric vehicles, and network infrastructure (to enable the cost-efficient uptake of renewable energy by allowing its deployment in areas with the most favourable conditions). Massive quantities of CRMs would be needed to deploy low-carbon technologies. The outcome will therefore be a substantial rise in the demand for critical minerals (see sub-section 2.2.2 for details). The provision of sufficient amounts of mineral resources at affordable prices is critical for facilitating the energy transition. Ensuring a sufficient supply of these critical minerals will reduce energy security concerns and lead to lower prices, which can then help accelerate energy transition. To ensure that producing countries can sustainably and securely meet rising demand, attention should be devoted to addressing issues such as commodity market price volatility, supply chain bottlenecks and diversification, mining safety and efficiency, recycling and circular economy, and the potential for increased social and geopolitical tensions.

(b) Equitable sharing of benefits. Growing demand for clean technologies can be leveraged to develop a thriving and durable critical mineral sector in the Asia-Pacific region – one that contributes to the socio-economic prosperity of resource-rich countries and the Asia-Pacific region. Yet, ample experience, as selectively discussed in section 3.2, suggests that resource revenue has not always been translated into broad-based socio-economic benefits – a phenomenon known as the "resource curse" (Badeeb and others, 2017). How to better manage the large deposits of critical minerals in Asia and the Pacific countries is therefore a critical issue.

(c) People-centered and inclusive planning. Fully realizing the critical mineral sector's transformative potential, and better management of the social and environmental trade-offs that may emerge over the course of the sector's development, requires a shared and inclusive vision. The development of this vision should be people-centered and participatory involving all relevant stakeholders, especially the most vulnerable ones. This would enable the articulation and inclusion of differing interests and cross-cutting issues into decision-making – essential for developing insights into the underlying trade-offs required to reconcile differing viewpoints, perspectives and interests.

(d) Maintaining environmental and social integrity. Managing the environmental impacts of mineral development often includes adoption of a life-cycle management approach that covers planning and design, production and consumption. Full life cycle integrated mining planning is necessary if the critical minerals supply chain is to be included as a growth anchor for the sector (Manley and others, 2022). This means going beyond the core element of critical minerals development – the extractives industry – to also consider the sustainable development of regions and communities, including investment in rail, road and port infrastructure, to deliver products to the market, support for worker training re-training to stimulate labour mobility, and the establishment of an education system that can support economic diversification for enhancing the socio-economic resilience of the mining regions (Syahrir and others, 2020), and mitigation of negative environmental impacts.

Mineral extraction is an energy-intensive, process that currently results in large amounts of CO_2 and methane emissions. It is also connected with a range of other environmental problems, such as air pollution, water and soil contamination, and deforestation. These issues have potentially significant negative implications for biodiversity,, and pose significant risks to public health, especially in communities in proximity to extractive activities (see section 3.3). Minimizing the adverse environmental impact of mineral extraction should therefore be a priority.

8.3. POLICY MEASURES FOR NATIONAL GOVERNMENTS

To accomplish these strategic priorities, the following policy measures are suggested.

8.3.1. Investment, research and development

Innovative instruments should be introduced, both to secure investments in the production of critical minerals and to incentivize environmentally sustainable mining practices, and governments should fund research and development of sustainable criticial minerals extraction and circular economy practices.

Financing investments that provide environmental benefits, i.e., green finance (Boettcher, 2022), can enhance the financial flows from the public, private and not-for-profit sectors to sustainable development priorities that better manage environmental and social risks (Lee, 2020). Green finance is growing quickly in the form of specialized financial instruments (e.g., green bonds, green loans, sustainable bonds, sustainability-linked bonds and blue bonds) and institutions (e.g., green banks and green funds). For example, Environmental Financial Assurance (EFA), commonly referred to as environmental bonds, are increasingly being introduced (UNDP, 2018), and their use should be encouraged.

However, challenges for green finance remain, including a lack of or weak policy signals, too-short loan periods, the absence of coherent definitions of green investments (taxonomies), and a low degree of standardization and transparency. If not addressed, the growth of green and sustainable finance worldwide will be limited (EBF, 2017; Spinaci, 2021). Therefore, an enabling framework with more transparency that promotes green finance should be established to better align stakeholder expectations and practices. Information disclosure must be mandatory, and fiscal policies also need to be adjusted, such as increasing green products subsidies and eliminating fossil fuels subsidies (Lee, 2020). In addition, the Covid-19 pandemic has underlined the urgent need for scale-up green finance and coordinated finance actions for global sustainable development.

The financial stimulus packages developed in response to the COVID-19 pandemic should, when relevant, be used as opportunities to prepare Asia-Pacific's extractive and recycling industries for a sustainable future. The pandemic has demonstrated the potential to advance the energy transition (Li and others, 2022). The recovery from COVID-19 offers an opportunity to consider the need for investments in critical minerals to support the energy transition. Economic recovery plans can facilitate investment in the production and recycling of the critical raw minerals required for renewable energy development (World Bank, 2020b), which could in turn contribute to sustainable development by, for example, fostering growth and creating jobs. The Financing for Development in the Era of Covid-19 and Beyond Initiative (FFDI), organized by the United Nations, provides a useful platform to mobilize financial resources for fulfilling the investment needs of the critical mineral sector.

Continuous investment in R&D can help the smooth development of critical minerals that keep depth mining operations longer, minimize the negative environmental impacts, increase economic opportunities and improve mineral recovery from wastes (Ontario, 2022). Connecting critical minerals projects with the scientific and technical expertise is required to overcome barriers in the critical minerals value chain and scale up critical minerals R&D (Government of the United Kingdom, 2022). It can inform R&D investment in areas perceived as high-risk, such as deep mining in exploration and production or priority areas like accelerating the development of electric vehicles.

8.3.2. Lower emission mining

Existing technical and process solutions to reduce the emissions intensity of critical mineral production – for example, by switching to clean fuels and low-carbon electricity, and by improving efficiency – should be promoted among CRM producers that currently demonstrate significant variations in their emissions footprint. Increased research and development efforts in technological innovation, both on the demand and production side, can lead to more efficient use of materials, allow for material substitution and unlock significant new supplies, resulting in significant environmental and safety benefits.

Reducing the extractive industries' carbon footprint requires a well-designed and enforced regulatory framework, covering the entire life-cycle of mining sites. Some key aspects of such a framework include: conducting an environmental impact assessment in the planning phase of a mining site, enforcing minimum performance standards during its operational phase, and restoring the environment and natural landscapes affected by mining activities in its decommissioning phase (United Nations, 2020a).

A life-cycle approach should be developed to minimize the environmental footprint of mineral extraction, transportation and consumption, to promote the recovery of all useful minerals and reduce mining waste (IRENA, 2021). This approach should include measures (for example, World Bank's Climate-Smart Mining Initiative) to promote the uptake of clean energy in mineral production, for example, by replacing diesel equipment in underground mines with electric mobile mining equipment (Government of Canada, 2022).

8.3.3. Recycling and circular economy

The recycling of e-waste and other products that contain critical minerals must urgently be ramped up. Manufacturers and retailers need to take more responsibility for recycling. Furthermore, the recycling rate of critical minerals (e.g., lithium and rare earths) is low, in part because of technological limitations. Addressing technological gaps and increasing recycling rates will require a global effort and international technological (Gill, 2022).

Policies can play a crucial role in preparing for the rapid growth in waste volumes by (i) encouraging the recycling of products that have reached the end of their useful life, (ii) supporting the effective collection and sorting activities, and (iii) funding research and development of new recycling technologies. Policy measures should incentivize the recycling of mineral resources from waste products and to reduce mining waste (World Bank, 2020b). Asia-Pacific countries should formulate plans to promote a circular economy. Promoting a circular economy means raising of awareness, building capacity and developing recycling and reuse strategies.

8.3.4. Resource revenue management

Effective tax collection and fair distribution are required to ensure that revenue from CRM development can contribute to sustainable development. Improving the tax collection system is the first step towards good revenue management. For example, a digitized tax collection system could make payments more convenient, encourage compliance among taxpayers and ensure accountability amongst the tax administrators and collectors, hence discouraging corruption and encouraging fairness and accountability (Ezenagu, 2021).

Governments and the extractive industries should work together to eradicate illicit financial flows from extractive industries by supporting multi-stakeholder financial transparency and anti-corruption initiatives to improve transparency (UNDP, 2018). Governments should require companies operating under their jurisdictions to disclose detailed financial information on extractive projects. This is one of the many agendas that EITI is promoting (Marques, 2020).

Resource-rich countries should where possible use their resource revenue to finance other programmes and projects essential for their long-term development. Such programmes and projects may focus on infrastructure development, labour force upskilling and economic diversification.

Resource-consuming countries also have a major role to play in preventing corruption in resource exploiting countries. If consumer countries ignore mineral governance and corruption risks, they will not only lose secure, reliable supplies but also reduce the potential for citizens of producer countries to benefit from the extraction of these minerals (Alexandra and others, 2021).

8.3.5. Better governance

To improve the governance of mining activities, the decision-making process for CRM development should include the involvement of all key stakeholders, particularly disadvantaged groups and civil society. Increasing the social inclusiveness of the extractives industry requires cooperation between Governments, international organizations and private sector actors. Different actors, including but not limited to Governments, need to cooperate in identifying and addressing risks as well as navigate a patchwork of legal frameworks and local contexts. Reconciling the contradictory goals among different stakeholders requires Governments to create enabling and inclusive environments while still allowing the private sector to drive investments (ESCAP, 2021b). Governments should design and implement integrated policies to manage natural resources through a multi-stakeholder and democratic governance approach that upscales resource efficiency and sustainably manages scarce resources.

Civil society participation is beneficial to achieving a just and inclusive transition. Furthermore, civil society should enhance its capacity to collect, analyse, explain and disseminate information. It also needs to develop independent monitoring capabilities and lobby Governments, companies and financial institutions (Cameron and Stanley, 2017). For example, members of the climate community need to work closely with mineral producers—including resource-rich developing countries and the mining industry (World Bank, 2020b). An inclusive process in close consultation with local stakeholders will be a key requirement in developing strategies appropriate to local contexts, as contextual factors significantly influence the energy transition process (Zhou and others, 2020).

A life-cycle approach requires that the critical minerals need to be sourced sustainably and responsibly (Willige, 2020; Manley and others, 2022). Mining companies should actively take on responsibility of protecting the environment, human rights and staff safety while creating wealth for society. The extractive industries need to continuously improve their environmental and social performance.

The extractive industry should adopt good practices in initiatives such as E2SG and EITI to reduce their negative social and environmental impacts. While reserve and resource data are imperative for ramping up supply, institutional factors such as the social acceptance of mining projects and the consideration of the geopolitical implications of critical mineral supply would also be needed to ensure a secure supply of critical minerals (IRENA, 2021). The low environmental impact will gain public acceptance for project development and help minimize supply disruptions due to environmental damage, regulations and legal actions (IEA, 2021d).

Governments in CRM-rich countries will need to address the various economic, social and environmental impacts of critical mineral extraction. For example, Governments in resource-rich countries should learn from the experience of managing mining revenue. Countries with unlicensed CRM reserves should invest in building capacity to conduct license rounds, manage geological data and attract companies. Governments in countries that do not have domestic critical minerals resources will need to develop proactive and evolving trade regimes to secure their critical minerals supply. Increased capacity to effectively govern the resources and revenue of extractive industries is necessary to ensure a fair distribution of benefits to communities and stakeholders, and an investment in a sustainable future.

Many initiatives that seek to prevent undesirable outcomes, such as regulations and their implementation initiatives in the social and environmental areas, should be strengthened. Lack of regulation and poor law enforcement exacerbate the social and environmental impacts of extractive activities. Therefore, the existing socio-environmental regulation and legislation in some resource-rich countries must be significantly strengthened. This also should be prioritized by multilateral development agencies (such as the World Bank), international organizations (for example, UNEP), and local NGOs (Bazilian, 2018).

Legal, regulatory and policy frameworks for social and environmental impacts as well as transparent and accountable management of resources revenue (Addison and Roe, 2018), should be implemented or continuously improved. These policies and regulations will, in turn, yield an adequate appropriation, distribution and allocation of economic rents from the extraction and production of natural resources as well as safeguard human rights and the environment, and promote progress in socio-economic development that will eventually lead to achieving the SDGs. However, attention should be paid to unnecessarily increasing momentum to improve environmental performance, which could also lead to a higher cost of critical minerals and will undermine the paces of energy transitions (IEA, 2021d).

When implementing the above-noted regulatory reform, attention should also be given to reducing red tape for the industry. For example, the regulatory and approval processes of critical minerals might need to be optimized in some countries. Many critical minerals companies face the same cumbersome and time-consuming regulatory and approval processes. The delay and uncertainty in any resource project would be undermining the supply of CRM, and simplifying approval processes is highly desirable for critical minerals development (Pickford, 2022).

Leveraging existing institutional frameworks and tools (such as EITI, OECD EFFECT, the Blue Dot Network, the Mining Awards Corruption Risk Assessment tool and the Infrastructure Anti-Corruption Toolbox) or developing new tools can identify and reduce the corruption risks of the critical minerals supply chain (EITI, 2022; OECD, 2022). In addition, the International Labour Organization (ILO) has developed several useful works on how to promote participatory governance. They identify different types of participation including, for example, a formal, institutionalized tripartite interaction between the representatives of the Government, labour unions, and the industry on issues of common interests (e.g., labour market policies), and more informal dialogue among various stakeholders, mainly for the exchange of information. Furthermore, these works also identify several key pre-requisites for improving the effectiveness of the participatory governance including, for example, sufficient technical capacity of the labour and industry organizations, strong political will of Governments to engage in the dialogue, and the provision of necessary institutional support (ILO, 2022b).

8.3.6. Workforce upskilling

To meet the growing workforce demand driven by the critical minerals industry, there is a need for training, upskilling and reskilling of a diverse relevant workforce. Governments in the Asia-Pacific region should create sustainable jobs for local people, immigrants and women to participate and work in critical minerals supply chains and service sectors (Government of Canada, 2022).

Programmes that attract and retain talent are pivotal for expanding the diverse labour force to meet current and future needs in critical minerals sectors. The Skills Development Fund (SDF), an industry-driven workforce upskill programme in Cambodia, is an example. It aims to help the industry fulfill the workforce demand by providing financial and other assistance in the training and educational programmes (Ontario, 2022).

Innovative pathways for training and employment are also needed to increase the mining and recycling sectors' labour force. Increasing educational opportunities is imperative for labour development related to critical minerals supply chains. By cooperating with universities, colleges and specialized training institutions, appropriate and experiential training opportunities can be provided for people and help them get the certifications and training programmes needed in the critical minerals sector (Government of the United Kingdom, 2022). Furthermore, building the pipeline of skilled and experienced employees has a crucial role in addressing the labour shortage by identifying the demand for critical minerals sectors.

The Guidelines for a Just Transition towards Environmentally Sustainable Economies and Societies for All, developed by ILO, provide some useful suggestions as to how to better prepare the workforce for opportunities arising from the development of a clean economy.

They include, for example, providing financial support to help workers access skills that could improve their employability, and matching the supply and demand of skills through close collaboration with the industry in assessing its skill needs (ILO, 2015).

8.3.7. Data and transparency

Governments should work together to develop a common database of, or at least a harmonized approach to collecting data on, geographical resources, reserves, production, recycling and trade related to CRMs. During the preparation of this report, it was found that there are no globally authoritative sources of data. Resource and production data were extracted mainly from the United States Geography Survey. Together, countries can share some common data. Existing platforms, such as the Asia-Pacific Energy Portal, which is managed by ESCAP, could be expanded to include the collection of data for the region.

Public disclosure of the environmental, social and governance performances of mining companies should be promoted. A standardized and harmonized approach to CRM production with a focus on environmental, social and governance (ESG) aspects at a global level will be essential.

8.4. IMMEDIATE PRIORITY ACTIONS

Based on the analysis in the previous three subsections, this section further suggests the top three priority actions for the extractive industry, Governments and the international community .

For the industry, the immediate prioritized actions needed are:

(1) **greening mining activities**, which means minimized the environmental footprints of CRM mining, including water, waste and GHG emissions. A sustainable extractive industry that is line with SDGs and Paris Agreement requires minimizing environmental footprints;

(2) **develop circular economy practices throught the critical minerals supply chain**. Such mineral savings activities will contribute to the sustainable use of CRMS while also avoiding unnecessary mining activities; and

(3) **mobilize investment** to meeting the increasing demand for critical minerals, including directly in projects and through R&D efforts.

For CRM-rich Governments, the top three immediate actions needed are:

(1) **holistic planning of CRM development** to minimize the life-cycle costs and negative environmental and social impacts of CRM development (mining, processing, land reclamation and recycling). Such strategic planning can avoid unnecessary pollution that incurs costly clear-up action later;

(2) **establish environmental regulations and operational standards** that prevent unsustainable CRM development activities, including both mining and consumption; and

(3) **collect and manage revenue from CRM development.** This includes a taxation system and revenue distribution and investment plans that ensure benefits from the CRM development will be fairly shared across communities as well as between the current and future generations.

For the CRM-poor Governments, the top three priorities are:

(1) secure supplies, mainly through diversified supply chains as well as by enabling the development of efficient and transparent international markets;

(2) promote recycling and a circular economy for the more efficient use of critical minerals and to reduce long-term demand; and

(3) cooperate on investment, information sharing and technical development, including R&D.

8.5. ROLE OF THE INTERNATIONAL COMMUNITY

For the international community, the top three priority actions are:

(1) **develop international standards and practices** to enhance security through transparent markets for critical minerals;

(2) **build international forums** to sharing knowledge and experience on policies and regulations, best practice, data on production, consumption and ESG practices for companies; and

(3) **coordinate environmental and other governance practices** to protect the environment and transparency of mine tax and revenue management.

Promoting the sustainable development of critical minerals needs coordination among countries. Due to the resource concentration in a few countries, planning regionally and working closely with neighbours has become necessary and desirable for CRM development (Manley and others, 2022). Helping the developing countries manage revenue for green investment and financing SDGs should also be an international priority for development banks, international donors and think-tanks. In such settings, mechanisms need to be put in place to coordinate policy actions in driving changes on multiple fronts in a concerted manner.

The Asia-Pacific countries should work together to support national efforts to improve legal and regulatory practices, adopt more sustainable operational practices, and manage revenue and risks.

8.5.1. Establish common operational rules for markets, green finance and standards

International institutions should work together to create norms and more formal arrangements to promote free markets for critical minerals which can help ensure a sustainable and secure critical mineral supply. An international agreement to mitigate the impact of supply disruptions and promote sustainable use of scarce mineral resources should also be explored (Henckens and others, 2016).

An international framework for governing green finance is also required to facilitate regulatory harmonization and standardization of market practices (Sachs and others, 2019; Spinaci, 2021). Digital technologies, such as blockchain and big data, can provide important support for this process of regulatory harmonization and market standardization by enabling more effective sharing of data and information with diverse stakeholders while maintaining data security and privacy (Singh, 2022).

Collectively working is necessary on international standards, such as forming a standardized and harmonized approach to the production of CRMs with a focus on environmental, social and governance (ESG) aspects at the global level. In addition, international cooperation is necessary to enhance the security of supply chains and develop and implement circular economy strategies.

8.5.2. Knowledge-sharing and capacity-building

Sharing knowledge and experience among regions and countries to enhance government capacity is an important method for cost-effective in aligning the extractive industry with sustainable development goals. Building the capacity of resource-rich developing countries for resource management and other governance areas will help those countries and the global community as a whole to achieve the energy transition and the SDGs. Many international initiatives, such as EITI (Marques, 2020), play a role in safeguarding the sustainable development of the extractive industry, something which should be encouraged and expanded. Areas for focusing on are policy design, legislation and regulation, environmental governance, revenue management and international cooperation. International organizations should promote and help in the adoption of best practices as early as possible. A deep understanding of the links of minerals to poverty reduction and human development is also required in order to integrate minerals into the SDG framework (Franks and others, 2022).

8.5.3. Regional and international coordination

Coordination among relevant international stakeholders should be approved. Some international organizations, such as UNEP, the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development and civil society organizations, such as the World Resources Forum and Future Earth, have existing knowledge generation and sharing programmes, but more is needed to improve policymaking (Ali and others, 2017), and more in particular should be done to align and coordinate messaging and approaches. A regional committee with membership comprising all Asia-Pacific countries, could become an important policy coordination body for the region. Such a committee could act as a focal point for articulating interests and cross-cutting issues regarding mineral resource sectors, help in reconciling differing interests, and facilitating regional policy coordination.

Establishing appropriate regional institutions, such as the United Nations agencies, NGOs, development banks and WTO, can support the development of and coordination of forums and expert groups, to facilitate regional coordination and knowledge exchange.

APPENDIX:

A quantitive analysis on the interactions between extractive industry developments and SDGs

A quantitative analysis on the trade-off and synergy between extractive industries developments and SDGs is presented here, using the fossil fuel sector as an example. The analysis can also be extended to investigate the impacts of critical minerals when data are available. In particular, an analysis is given of how developments in fossil fuel extractive industries interacted with 17 SDGs during 1990-2019, across 140 countries, based on the application of big data linear regression and network analysis. Fossil fuel sector developments are proxied by the share of fossil fuels in primary energy supply, and fossil revenues. This analysis utilizes the network architecture to identify barriers and opportunities for maximizing SDG implementation through their interactions with extractive industries.

A.1. DATA

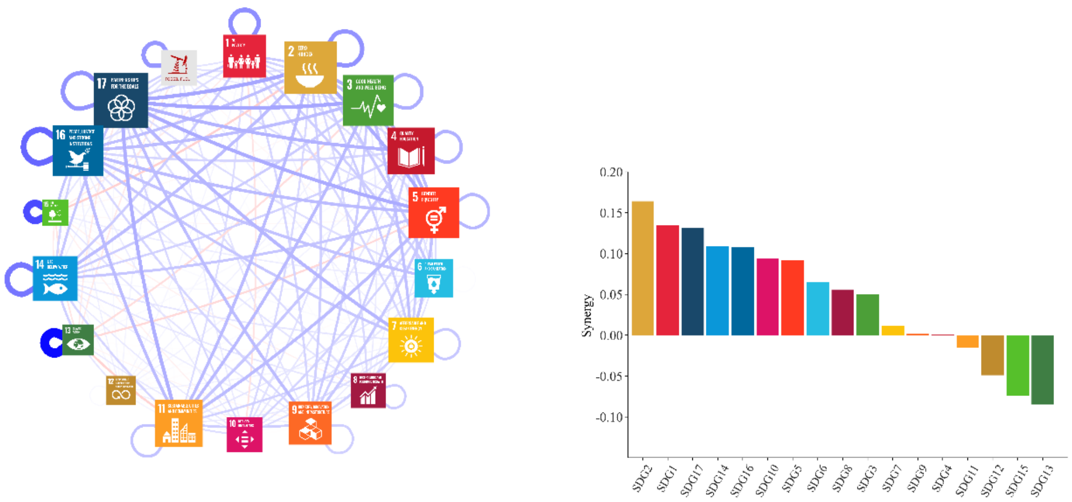
There are three major resources that provide SDG data: (i) the official Global SDG indicators by the United Nations Statistics Division (United Nations, 2020b), the World Bank Atlas of Sustainable Development Goals (World Banks, 2020), and Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN) (Sachs and others, 2021). This report used the World Bank indicator time series to inform about the SDG targets. One advantage of the World Bank dataset is that it draws on globally-renowned World Development Indicators, which include 1,600 indicators for 217 economies. In general, it provides more countries and years for each SDG indicator, which is essential for the regression-based meta-analyses. It also had transparent metadata, including a description of the statistical concept and methodology for each indicator, and a description of the limitations associated with each indicator. SDG data can be obtained from World Bank Atlas of Sustainable Development Goals (https://datatopics.worldbank.org/sdgatlas/), and the data related to the fossil fuel sectors are available from the IEA World Energy Balance Table at https://www.iea.org/reports/world-energy-balances-overview

A.2. METHOD

The partial correlations are estimated by the linear regression with fixed effects. The partial correlations of each target and SDG were converted to a network graph object and analysed by the igraph R package. In the network, the nodes represent the 17 interactive SDGs and fossil fuel extractive industries, and links between nodes represent positive/negative correlations between two nodes and their weights. The report estimated the eigenvector centrality of each node in its respective networks. The eigenvector centrality provides a measure of the relative contribution of a goal/target to the overall topology of the network. A goal with large eigenvector centrality will have large indirect effects on other goals, not only those with which it is associated, but also effects spreading through its neighbours. Hence, it provides an integrated estimate of the overall weight of a goal in shaping the fate of all goals.

A.3. RESULTS

FIGURE A.1. Trade-off and synergy networks



(a) The SDG and fossil fuel network **(b) Synergies and trade-offs**

In figure A.1., **t**he nodes in (a) represent SDGs or development in fossil fuels extractive industries for all countries. The network reflects the positive (blue) and negative (red) correlation between all SDGs and extractive industries. The size of a node reflects the contribution to the entire network. The width of edges indicates the strength of the correlation between connected nodes. In (b)**,** synergies and trade-offs strengths are illustrated. The length of the bar corresponds to the magnitude of the relationship, and the direction of the bar corresponds to the type of relationship (synergy or trade-off).

The results in figure A.1. show that development in fossil fuels extractive industries plays a non-negligible role in the SDG network. Overall, synergies dominate the trade-off effects on SDGs in the extractive industry developments. In particular, based on the observable data, developments in fossil fuel extractive industries primarily contribute to the achievements in SDG 1 (No poverty) and SDG 2 (Zero hunger). However, expansion in fossil fuel sectors could place further pressure on the achievements of SDG 13 (Climate action) and SDG 15 (Life on land). This result suggests that the developments in fossil fuel extractive industries contribute to the achievement of economic- and social-related SDGs in history, and thus promotion of the low-carbon energy transition needs to deal with its potential trade-off effects on achieving the SDGs. Such need is especially important for less developed countries, and even for some developing countries that are still facing challenges to meet basic human need such as SDG 1 and SDG 2. Given that the energy sector is transitioning from fossil-intensive to more mineral-intensive as the process of energy decarbonization deepens in order to meet the climate change targets, effective and responsible production of CRMs is essential to mitigating the possible negative socio-economic impacts caused by fossil fuel phase-out.

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