SUSTAINABLE MINING CHARTER

PART A

Framework and Approach
Towards Sustainable Mining

ADITYA BIRLA
HINDALCO

vikaasa
Together, India progresses

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/ FOREWORD

At Hindalco, we believe in responsible and sustainable business practices. As we move ahead on the path towards a Resilient, Responsible and Reliable future, our approach encompasses several focus areas – responsible operations, resource conservation, innovative product development, circular economy, upliftment of local communities, promoting employee well-being, equal opportunity and workplace diversity, among others.

It is in this context that we created the Sustainable Mining Function within our Mining & Minerals Business, to focus on sustainable mining practices, much beyond the statutory requirements, for the several bauxite and coal mines that we operate. Our team of professionals, in collaboration with Xynteo, the international management consulting firm and our partners in the Vikaasa consortium, have developed this Sustainable Mining Charter. The Charter will help our mining teams to not only appreciate the impact of mining operations on environmental and socio-economic aspects, but also help them in developing and implementing approaches to move towards adding net value to the ecosystem.

While the frameworks prescribed in the Charter can be used across different mines by Hindalco or any other entity engaged in extractive mining, we are adopting the Charter as our guiding document for sustainable mining practices.

I sincerely hope the Sustainable Mining Charter will further accelerate our journey towards achieving our vision of a Responsible, Resilient and Reliable future.

Satish Pai
Managing Director
Hindalco Industries Limited

June 2021

/ PREFACE

Metals and minerals are at the core of human and economic development. In the light of growing world population and increasing per capita income, consumption of metals is expected to grow significantly, providing a boost to the mining sector. In India as well, with government's push towards increasing domestic metal production and increase in per capita metal consumption, the mining sector is expected to witness substantial growth in the coming decades. Although, mining is crucial for continued economic development, the sector itself faces great challenge with respect to its environmental and societal impact.

Unsurprisingly, given its resource intensive nature, the mining sector has been one of the prime targets of the increasing focus on sustainability. Governments and consumers, world over, and indeed in India as well, are demanding that corporates adopt sound sustainability practices. The Sustainable Mining Charter, thus, comes at an opportune time, with sustainability rapidly transitioning to a high-priority business necessity for mining companies.

The Sustainable Mining Charter has been developed with the objective of providing actionable guidance that accelerates Hindalco's (or for any entity, engaged in mining) transformation towards top-class sustainable mining operations. The Ministry of Mines, Government of India, defines sustainable mining as "*Mining that is financially viable, socially responsible, environmentally, technically and scientifically sound; with a long-term view of development; uses mineral resources optimally; and ensures sustainable post closure land use.*" Though frameworks and norms have been developed earlier by a few governments, industry and civil society bodies, the Sustainable Mining Charter is an attempt to provide a comprehensive solution for improving sustainability across mining operations.

To overcome the challenges of linear thinking in an interconnected ecosystem such as mining, the Sustainable Mining Charter employs a systems thinking approach, through which seven focus areas have emerged, actions across which help in achieving sustainable mining operations. These focus areas are:

1) Sustainable Land Use
2) Water Stewardship
3) Waste Management
4) Emissions Reduction
5) Biodiversity Management
6) Local Economic Development
7) Health & Safety

Actions across these focus areas are guided by the principles of environmental stewardship- which focuses on minimizing environmental impact and social performance leadership- which focuses on creating long-term value for the mining communities. Coupled with a strong organisational governance mechanism that ensures that actions are effectively implemented, monitored, and evaluated for timely course correction, these focus areas provide a holistic approach that enables a shift toward economically viable, ecologically sustainable, and socially responsible mining activities.

The Sustainable Mining Charter offers an actionable framework that is aligned with the three guiding principles and defines actions across the seven thematic areas, using a mine life cycle approach and risk management strategies.The Charter is a live document and will be updated at periodic intervals to incorporate learnings, new insights and practices.

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Developed through extensive research and deep collaborative process with industry experts, the document is aligned with various global standards. The Charter is an attempt to provide a unique approach to sustainable mining, as it:

1) goes beyond compliance and operational excellence and focusses on solutions that add net positive value to the environment and the society
2) provides an implementation approach to mining teams, which can be used to develop solutions, based on mine specific factors
3) focuses on sustainability performance across all areas through a mine level scorecard, which can be used to evaluate mine level performance
4) incorporates frameworks and solutions for ensuring sustainable land use - an area where ready guidance may not typically be available to mining teams

For ease of use, the document has been divided into two parts. While the Part-A focuses on providing frameworks and approaches for improving sustainability, Part-B provides guidance on implementation of these approaches. It provides a sustainability implementation roadmap, which guides a mine to develop and implement a sustainability strategy specific to its requirements.

The Sustainability Mining Team sincerely hopes that the Charter document will prove useful to companies, governmental agencies and industry bodies to move towards sound sustainable mining practices.

/ ACKNOWLEDGEMENT

This document has been developed through a collaborative effort between Hindalco and Xynteo, with inputs from internal team members, both operational and SMEs as well as from senior industry professionals. The Charter provides actionable frameworks and guidance for the mining teams, and will support Hindalco's journey towards sustainable mining practices.

We would like to extend our warmest thanks to **Satish Pai,** MD Hindalco for seeding the idea and providing support and encouragement to the sustainable mining team, enabling us to develop this document. Thanks also to **Subhashini Chandran**, MD, Xynteo, India for leading a team of professionals in this endeavour.

Sincere gratitude goes to **Late Pramod Unde**, whose vision, guidance have been invaluable throughout all stages of our work.

We would also like to acknowledge the mining and sustainability leadership teams of Hindalco, including **Deeksha Vats**, now Chief Sustainability Officer, ABG and **Vaishali Surawar**, now Head Sustainability at Hindalco, for extended discussions and valuable insights, which have contributed to developing the framework and ensuring the Charter's alignment with the existing Hindalco and ABG guidelines. We also extend our thanks to **Vivek Mishra**, Head-Coal Mining, and **Bijesh Jha**, Head-Bauxite Mining (Odisha, JH & CG), for providing their expertise on developing actionable frameworks across different thematic areas and in developing the mine level implementation roadmap.

A unique feature of the Charter is its focus on mine level issues and solutions, which were included through thoughtful inputs from experts across Hindalco, including **Bipul Chatterjee**, Head-CSR, **Shouvik Majumdar**, Head-Technical Services, Mining & Geology, **Sunil Bailwar**, Head-Corporate Safety, **Anupam Bagchi**, Head-Safety, Health and Environment, Mining and Minerals, **Vijay Vairalkar**, General Manager-Mining & Minerals, Corporate, **Dipesh Bhatia**, Vice President-Operations, and **Lopamundra Priyadarshini**, General Manager-Sustainability, who provided crucial guidance on understanding issues and risks, and in development of solutions across different thematic areas.

We are grateful for the support and contribution of various industry experts and professionals, who gave their expert comments on the drafts of this Charter and sincerely thank them for their guidance in shaping this Charter.

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AAQ	Ambient Air Quality
BBS	Behaviour Based Safety
BES	Biodiversity And Ecosystem Services
BMP	Biodiversity Management Plan
CCS	Carbon Capture And Sequestration
CDP	Carbon Disclosure Project
CSR	Corporate Social Responsibility
CWQMS	Continuous Water Quality Monitoring Systems
EESG	Employee, Environmental, Social And Governance
ESIA	Environmental And Social Impact Assessment
ETP	Effluent Treatment Plant
FDI	Foreign Direct Investment
FIMI	Federation Of Indian Mineral Industries
GRI	Global Reporting Initiative
GVA	Gross Value Added
ICDS	Integrated Child Development Services
ICMM	International Council On Mining And Minerals
IFC	International Finance Corporation
IFGTB	Institute Of Forest Genetics And Tree Breeding
IIRC	International Integrated Reporting Council
IME	Initial Medical Examination
IUCN	International Union For Conservation Of Nature
KPI	Key Performance Indicator
MCA	Minerals Council Of Australia
MSS	Mining Surveillance System

MT	Million Metric Tons
MTCE	Million Metric Tons Of Coal Equivalent
NEBOSH	National Examination Board In Occupational Safety And Health
NIOSH	National Institute For Occupational Safety And Health
NMDC	National Mineral Development Corporation
OGP	Obvious Geological Potential
PDAC	Prospectors And Developers Association Of Canada
PME	Periodic Medical Examination
RMF	Responsible Mining Foundation
RMI	Responsible Mining Index
SDF	Sustainable Development Framework
SDG	Sustainable Development Goal
SIA	Social Impact Assessment
SIT	Strategic Infrastructure Committee
SME	Subject Matter Expert
SMI	Sustainable Mining Initiative
SMS	Safety Management Systems
SROI	Social Return On Investment
TDS	Total Dissolved Solids
TSDF	Treatment, Storage, And Disposal Facility
TSS	Total Suspended Solids
UNGPS	UN Guiding Principles On Business And Human Rights
VAM	Vesicular-Arbuscular Mycorrhiza
WBCSD	World Business Council On Sustainable Development

Part I / SUSTAINABLE MINING CHARTER

- THE CASE FOR A SUSTAINABLE MINING CHARTER
- SUSTAINABLE MINING CHARTER DEVELOPMENT APPROACH
- SUSTAINABLE MINING - A SYSTEMS THINKING FRAMEWORK
- USING THE CHARTER

Part I / Sustainable Mining Charter

1. THE CASE FOR SUSTAINABLE MINING CHARTER

1.1 INDIA'S METALS AND MINING INDUSTRY

1.1.1A. CRITICAL SECTOR FOR INDIA …

The mining sector is a critical driver of India's economic ambitions. It is vital for the country from both an energy and a raw materials security standpoint. Currently, approximately 53.6 percent (India, Ministry of Power 2020)[1] of India's electricity is generated through coal and lignite. Minerals are also the basic building blocks of manufactured products and many agri-inputs. From an employment perspective, the mining sector generates about 10 million jobs annually; a significant proportion of these are in remote tribal or rural areas where there are few alternative opportunities for employment.

… WITH SIGNIFICANT GROWTH POTENTIAL

India is among the most mineral-rich countries in the world and is among the major mineral producers. It is endowed with a wide range of metallic and non-metallic minerals. Currently, the country produces 95 minerals; these include 4 fuel, 10 metallic, 23 non-metallic, 3 atomic, and 55 minor minerals.

There is significant potential for growth. This is evidenced by the mining sector's contribution to India's GDP which, at approximately 2 percent[3], is much lower than many major mining geographies, including those of developed economies such as Australia and Canada.

India does indeed have the domestic capacity to absorb significantly higher mineral production, as indicated by the country's substantial mineral imports. During 2018/2019, US$ 33.6 billion worth of ores and minerals was imported – an increase from US$ 31.7 billion in the previous year – registering a positive growth of 5.92 percent (India, Department of Commerce 2020).[4]

1.1.1B. KEY DRIVING FACTORS

With a target of US$ 1 trillion for manufacturing gross value added (GVA), and actively promoting Make in India and Atmanirbhar Bharat (Self-Reliant India), the demand for metals is set to increase exponentially. This increase will be driven by a number of factors, including:

Figure 1. India's position in the global market, by production

3rd	4th	5th	7th
COAL	IRON ORE	BAUXITE	LIGNITE
Approx. 689 million tons	Approx. 192 million tons	Approx. 23.2 million tons	Approx. 44.3 million tons

Source: Fiscal Year 2018, Ministry of Mines (India, Ministry of Mines 2018)[2]

1.1.1B. KEY DRIVING FACTORS (CONT.)

- **A rise in infrastructure development and automotive production**: By 2026, the automotive industry (including component manufacturing) is expected to achieve a value of INR 16 to 18 trillion (India Brand Equity Foundation 2020a)[5].
- **Anticipated growth in power generation**[6]: By 2022, power consumption in India is expected to reach 1,894.7 terawatt-hours (TWh), increased from 1,561.1 TWh in 2018 (India Brand Equity Foundation 2020b).
- **Expected increase in demand for iron and steel:** With strong growth expectations for the residential and commercial building industry, the steel demand is expected to grow by more than 7.2 percent[7] in Fiscal Year (FY) 2020/2021 and 2021/2022 (India Brand Equity Foundation 2020c).
- **Rapid urbanisation and economic development**: The rapid rate at which India is urbanising and its economy is developing will contribute significantly to the rise in energy demand; this will in turn drive the growth of the coal mining industry. It is anticipated that coal demand in India will reach 748 million metric tons of coal equivalent (Mtce) in the 2024 calendar year, up from 585 Mtce in 2018 (International Energy Agency, 2019).[8]
- **Growth of Aluminium industry:** Aluminium is regarded as a strategic sector for India's economic development. India's current per capita aluminum consumption in India is at 2.5 kg, compared to global average of 11 kg. This is expected to grow significantly in the coming decades with greater government focus on infrastructure development and increasing income levels.[9]
- **Government support:** The Government of India is taking steps to boost the country's domestic steel sector; it aims to raise the sector's capacity to 300 million metric tons (Mt) (India, Ministry of Steel 2017)[10] by 2030/2031, a significant increase from its 2019/2020 crude steel capacity of 142.98 Mt (India, Ministry of Steel 2020).[11]

1.1.2 STRATEGIC VALUE OF THE SECTOR

The Government of India recognises the critical importance of the mining sector to the nation; through ongoing policy reform, it aims to attract investment and enable its further growth.

In many ways, the Mines and Minerals (Development and Regulation) Amendment Act, 2015 set the foundation for progress. It introduced a new method of block allotment and made changes to the terms of concessions; it permitted an automatic approval route for FDI of up to 100% for mining and exploration of metal and non-metal ores. The cabinet-approved National Mineral Policy 2019 focuses on better regulation and enforcement and on the balanced social and economic growth of the sector.

In May 2020, the Government of India announced the Atmanirbhar Bharat Abhiyaan package of reforms to the mining sector. These reforms are aimed at improving the competitiveness of the mining sector and unlocking new growth opportunities. The multiple reforms in this package include the auctioning of 500 mineral mines and the rationalisation of the stamp duty (a state levy paid to register a document, typically an agreement or transaction between two or more parties); also included is the removal of the distinction between captive and non-captive mines, which is intended to bring a level playing field to the industry and enhance the availability of affordable minerals. In June 2020, the government also launched the auction of 41 coal blocks for commercial mining; this opening of the coal sector to private players will generate jobs, reduce dependence on fuel imports, and catalyse the country's path toward national growth.

The National Institution for Transforming India (NITI Aayog), in its report entitled Strategy for India @ 75 (NITI Aayog 2018),[12] has stated that India's growth is linked to the growth of the mining and minerals sector. It has defined clear objectives for the sector, including:

- Doubling the percentage of the Obvious Geological Potential (OGP) area explored from 10 to 20 percent by 2022/2023; and
- Increasing the number of direct, associated, and indirect jobs in the mining sector from 10 to 15 million by 2022/2023. (There are currently two million people employed in coal and major metals and eight million in minor minerals).

1.1.3 IMPERATIVE FOR SUSTAINABILITY

The strategic and economic importance of the mining industry in India is undisputed. Globally, however, extractive industries have a poor reputation due to either irresponsible or unsustainable practices, historically or in the present. With a greater overall focus on sustainability, the mining sector is being particularly closely monitored. Lawmakers, communities, and business stakeholders have increasingly come to expect mining operations to become environmentally and socially sustainable.

From a business point of view, sustainability-related imperatives now include:

- Mitigating financial and reputational risks, such as future liabilities due to safety breaches or environmental mismanagement;
- Mitigating future liability for currently externalised costs, such as carbon pricing or "green" taxes;
- Building resilience, widespread support, and the social license to operate, through serving the interests of a wider range of stakeholders;
- Creating market opportunities, developing competitive advantages, and responding to consumer demand for transparent, responsible, sustainable value chains;
- Reducing long-term costs through minimising wastage and through substituting in low-carbon sources such as biofuels and solar energy;
- Meeting the mounting global expectation that businesses demonstrate a high level of adherence to human rights and gender equity in their own actions and that they also demand the same from their business partners and supply chains;
- Reducing future financial risks, in an investment climate where more banks and financial market participants are making sustainability performance a key parameter for investment decisions.

A balance of environmental, social, and economic growth must be achieved; this is particularly critical in the mineral-bearing parts of India that are also rich in forests, biodiversity, and tribal populations. Such areas include Jharkhand, Karnataka, Odisha, Chhattisgarh, Madhya Pradesh, Goa, and West Bengal. It is currently the case that:

- Of India's proven coal reserves, 80 percent lie in forested areas which are inhabited mainly by tribal populations. Mining companies operating here thus need to show a heightened sensitivity to the preservation of the culture and heritage of these groups, while also creating sustainable economic value for the area, improving livelihoods, and minimising environmental degradation.
- In last three decades, the mining sector has led to a loss of 5,000 km^2 of forest in India (Ranjan 2019).[13] Mining activities need urgently to incorporate sustainable practices in order to minimise their impact on land, air and water, and especially on forests and biodiversity.
- Mining operations impact the ecosystem that lies beyond their operating lease area and can cause extensive damage to the local ecosystem; this is particularly true if they lack proper infrastructure. With responsible mining operations, these wider impacts are managed rather than externalised.

Operational expansion and economic growth must be balanced with a focus on community and worker well-being, environmental stewardship, and the economic development of local communities. The *National Mineral Policy 2019* reflects this objective, indicating the government's intent to steer the industry in new directions.

1.2 REVIEW OF INDIAN PRACTICES

Over the past few years, the Government of India and industry bodies have introduced multiple initiatives to both drive the focus on sustainability and ensure long-term economic growth.

- **CODE OF CONDUCT:** In 2012, India's Sustainable Mining Initiative (SMI) launched a set of 10 sustainable mining principles, a Code of Conduct that is meant for voluntary adoption by member companies. It provides a framework for mining companies and entrepreneurs in their adoption of best practices, opens them to measurement and scrutiny, and is aimed at improving how the mining sector is perceived. Twenty-six member companies have committed to advancing their sustainability performance and reporting their progress annually.

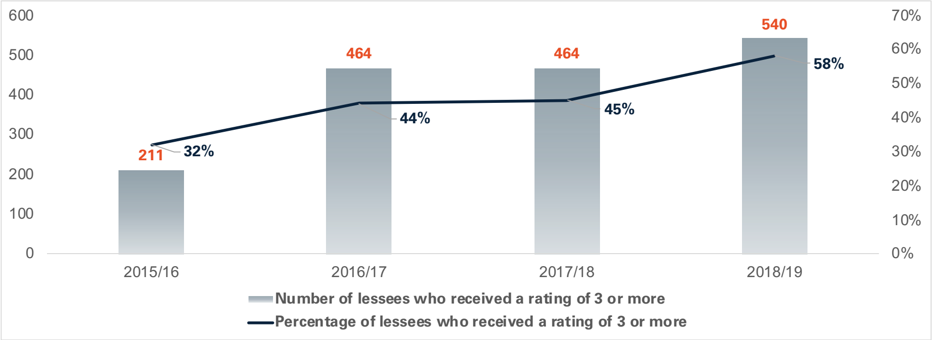
- **STAR RATING OF MINES**: The Ministry of Mines has endeavoured to take up an exhaustive and universal implementation of the Sustainable Development Framework (SDF) in mining. In 2016, it introduced the Star Rating Policy[14] for Coal Mines in India; since the inception of this policy, 9 mines in July 2016, 32 mines in February 2017, and 57 mines in March 2018 have been awarded a "Five Star" rating.

- **FIMI AWARDS:** In 2017/2018, the Federation of Indian Mineral Industries (FIMI) instituted the FIMI Awards to recognise and motivate excellence in the biodiversity conservation and sustainability performance of mines. This annual award includes five categories: Excellence, Sustainability, Environment, Health and Safety, and Social Awareness.

- **SUSTAINABILITY REVIEW**: FIMI's Sustainable Mining Initiative, launched in 2009, has been assisting mining companies to continually improve their environmental, social, and economic performance. It has instituted a Sustainability Review[15] system which helps mining operations to identify and implement measures for further improvement and helps companies reduce long-term risks.

- **DOMESTIC AND INTERNATIONAL COLLABORATIONS**: SMI acts as a nodal agency and works constantly in collaboration with various mining companies, think tanks, and regulators in India; it also engages with various international bodies, including International Council on Mining and Minerals (ICMM), International Union for Conservation of Nature (IUCN), the World Bank, International Finance Corporation (IFC), Prospectors and Developers Association of Canada (PDAC), and Minerals Council of Australia (MCA). Collaborations focus on the development of sustainable mining, in the course of which SMI shares information and captures international best practices.

Figure 2. Lessees with rating 3 and above



- **MINING SURVEILLANCE SYSTEM AND NATIONAL AERO-GEOPHYSICAL MAPPING PROGRAMME**: The Government of India embraces technology as an enabler; to that end, it has initiated protocols such as the Mining Surveillance System (MSS) to curb illegal mining practices. In 2018, the Geological Survey of India launched the National Aero-geophysical Mapping Programme, which aims to cover 2.7 million line km of Obvious Geological Potential (OGP) areas and to digitise mineral exploration in India.

The long-term road map of sustainable growth will require collaboration between key stakeholders in the system, including mining companies, the industry value chain, the Government of India, and civil society.

1.3 REVIEW OF GLOBAL PRACTICES

From 2017 to 2019, global industry has shown signs of recovering, following a multiyear contraction in commodity prices between 2012 and 2016. From 2016 to 2019, demand has risen much faster than supply; this had led the mining sector in both developed and developing markets to undertake increased exploration activities. Governments around the world have also boosted mining sector investments (Western Australia, Department of Jobs, Tourism, Science and Innovation. 2019).[16]

As economic activity increases, multiple international organisations are helping shape the industry agenda by ensuring that the mining, minerals, and metals industry becomes more responsive to global needs and challenges. These organisations include:

- **International Council on Mining and Metals:** The ICMM is working with 28 mining and metals companies and 35 regional and commodities associations to improve environmental and social performance and thus strengthen the sector's contribution to sustainable development.[16.A]

- **World Business Council on Sustainable Development:** The WBCSD has been promoting more systematic and integrated environmental management approaches. Its Vision 2050[17] outlines a new agenda for achieving a sustainable future; the Vision 2050 action plan identifies how businesses can positively influence environmental and social trends while at the same time strengthening their own resilience around issues such as climate change, demographic dynamics, and skills shortages.

- **Responsible Mining Foundation:** The RMF complements international efforts by publishing transparent assessments of company policies and practices on economic, environmental, social, and governance aspects. The Responsible Mining Index (RMI) is a biennial assessment of 40 mining companies that represent 25 to 30 percent of global mining production. Each company is assessed on six parameters: economic development, business conduct, life cycle management, community well-being, working conditions, and environmental responsibility. Indian companies evaluated on the RMI include Coal India, the National Mineral Development Corporation (NMDC), and Vedanta Resources.

- **Carbon Disclosure Project:** CDP runs the global environmental disclosure system. Each year the CDP supports thousands of companies, cities, states, and regions in the measurement and management of their risks and opportunities with regard to climate change, water security, and deforestation. More than 200 metals and mining companies disclose their environmental impact; this disclosure helps these companies assess the environment-related risks that are due to their operations and to develop strategies to mitigate these risks.

1.3.1 EXAMPLES OF GLOBAL SUSTAINABLE MINING INITIATIVES

Mining companies around the globe now understand that their social license to operate demands a balance between robust balance sheets and social and environmental impacts, and that sustainability is not just a compliance requirement. This new understanding is inspiring innovative approaches to rethinking the mine life cycle, tackling climate change, strengthening community relationships, and investigating new ways of creating value (Table 1).

1.3.1 EXAMPLES OF GLOBAL SUSTAINABLE MINING INITIATIVES (CONT.)

Table 1. Sustainability Initiatives by Global Mining Companies

	COMPANY	INITIATIVE	RESULT *(as available)*
SUSTAINABLE LAND USE	**Anglo American**	**Mine Closure Toolbox** (Anglo American 2019a):[18] In-house tool for the integrated planning and carrying out of mine closures	Across the world, 95 percent of Anglo American's mines have aligned their closure plans with the Toolbox
	Teck Resource Limited	**Indigenous Plant Nursery:**[19] The Twin Sisters Native Plants Nursery in Vancouver, Canada, is aimed at maintaining the availability of native plant species and generating local employment (Teck Resources Limited 2017)	In 2017, it earned US$ 1 million in sales of native plant species
WATER USE	**Rio Tinto**	**QMM* partnership:**[20] Collaboration with technical and finance partners to, by 2023, establish water infrastructure solutions for communities and develop an improved integrated site water management approach (International Advisory Panel to QMM 2011)	-
	Fortescue Metals Group	**Water management plan:**[21] System for careful reinjection, storage, and redrawing of water in order to optimise the management of groundwater and minimise drawdown impacts on the surrounding ecohydrological systems (Fortesque 2019:79)	Yearly returns of over 90 gigalitre (GL) of groundwater, which had been extracted to facilitate open-pit mining
	Anglo American	**Regional partnerships:**[22] Partnerships with WeTechs to develop a sensor-based technology for automating and monitoring water levels in 23 rural potable water systems for 55,000 people in the Chacabuco province (Anglo American 2019b)	As of 2019, the project contributed to a 30 percent increase in water availability, a 40 percent reduction in pipe ruptures, and a 25 percent reduction in energy consumption
WASTE MANAGEMENT	**African Rainbow Minerals**	**Enterprises for waste:** Support for local enterprises that specialise in waste management while also generating employment for the local community	Generated over 210 jobs in local communities
	Vale	**Waste management:**[23] Integrated strategy that focuses mainly on lowering generation of waste, reusing waste, and introducing responsible methods of waste disposal (Vale 2018)	Recycling of 53 percent of the total waste generated
	Newcrest Mines	**Deep-sea tailings programmed:**[24] Local dive programmes to monitors ocean coral health;these programmes address waste management as well as environmental objectives 2019)	-

1.3.1 EXAMPLES OF GLOBAL SUSTAINABLE MINING INITIATIVES (CONT.)

	COMPANY	INITIATIVE	RESULT *(as available)*
EMISSIONS REDUCTION	**Anglo American**	**Carbon neutral mine:**[25] Collaborative initiative to research and innovate tech-based operating models in order to, by 2030, achieve carbon neutrality, reduce net GHG emissions by 30 percent, and improve energy efficiency by 30 percent (Anglo American 2019c)	Compared to 2018, 24 percent reduction in GHG emissions and 3 percent decrease in energy consumption
	BHP	**Direct air capture:**[26] Investment in technology to remove carbon dioxide from the atmosphere (BHP 2019)	-
	Rio Tinto	**Carbon emission reduction**: Targets to, by 2030, reduce emissions by 30 percent and emissions intensity by 15 percent	Since 2008, 46 percent reduction in absolute emissions and 29 percent reduction in emissions intensity
BIODIVERSITY MANAGEMENT	**Vale**	**Biodiversity initiative:**[27] In 8,500 km^2 of natural areas, preserve native fauna and flora species and achieve "no-net-loss" in biodiversity (Vale 2019)	Protection of an area approximately six times larger than the area occupied by operations
	Anglo American	**Research and restoration**: Programmes to investigate weed treatments, with the aim of eradicating weeds and encouraging the recolonisation of native species	-
COMMUNITY DEVELOPMENT	**Anglo American**	**Anglo Zimele programme:**[28] Enterprise development initiative to create sustainable and commercially viable local enterprises and entrepreneurs (Anglo American 2020)	Exact number of enterprises incubated is not mentioned
	Vale	**Community investment criteria:**[29] Assessment of opportunities on parameters such as relevance to local stakeholders, innovation, financial viability, and sustainability (Vale 2020)	-
	Exxaro Pty	**Shared Value Initiative:**[30] Supports community youth in identifying and developing enterprise solutions using a shared value-generation approach (Exxaro 2018)	Fifteen youth employed, and generation of a social return on investment (SROI) of 3.25

Note: ** = QIT Madagascar Minerals (part of Rio Tinto)*

1.3.2 EVOLVING TRENDS IN SUSTAINABILITY: HUMAN RIGHTS AND GENDER EQUITY

While mining companies have been held accountable for their impact on environment for some time, companies are also increasingly being scrutinised for their impact on the society in which they operate. Impacts on human rights and gender equality are now being assessed as part of the analysis of a mining company's sustainability, and even global standards such as the Global Reporting Initiative (GRI) and the Responsible Mining Index are now incorporating human rights and gender equity into their assessments.

Mining operations affect an array of human rights, including the right to health, safety, liberty, and security. Land management practices, for example, directly impact traditional livelihoods and settlements, and mining operations have a direct impact on the health and safety of mining communities. Mining businesses are therefore increasingly being expected to be responsible for the assessment and management of human rights risks caused by their own activities and by those linked to their supply chain. The UN Guiding Principles on Business and Human Rights (UNGPs) provide a framework which companies can use to carry out due diligence in the management of their human rights risks and impacts.

Apart from the UN, metal and mineral exchanges , such as the London metal exchange has also come out with responsible sourcing requirements which apply to all companies that participate on the exchange. The responsible sourcing requirements are aligned with the Organization for Economic Cooperation and Development (OECD) Due Diligence[31] Guidance for Responsible Supply Chains of Minerals from Conflict Affected and High Risk Areas. The guidelines provide a five step framework for risk based due diligence of mineral supply chains, through which companies can ensure that they respect human rights and do not contribute to conflict.

Although mining operations affect the entire community, women bear a disproportionate share of the socio-economic and environmental risks. In most households, for example, women are responsible for providing food and water; hence they can be disproportionately affected by any loss of access to fertile land or clean water that is caused by a mining operation. There is therefore an increasing expectation that mining companies assess the particular impact of mining projects on women, and that they develop strategies to mitigate these impacts and to promote women's empowerment and participation. Mining companies are also increasingly being held responsible for gender equality as it relates to both the workforce and communities. Companies must therefore actively recognise women's rights to property and resources; they must also include women as stakeholders in land acquisition and in resettlement and consultation processes, and they must build inclusiveness into job and economic opportunities.

Companies that recognise human rights and gender equity as material issues and who then make efforts to mitigate the risks arising from them are likely to experience increased productivity at mining operations and stronger relationships with communities.

1.4 THE SUSTAINABLE MINING CHARTER: A SYSTEMS APPROACH TO SUSTAINABLE MINING

With an increasing focus on the environmental and social impacts of mining operations, an integrated and holistic growth model is called for, one which simultaneously creates economic, social, and environmental value for a wide range of stakeholders. The Sustainable Mining Charter is proposed to support such a holistic growth model.

The process of developing and implementing a Sustainable Mining Charter must address and transcend the limitations of the existing linear approaches to sustainability. An effective Charter requires:

/ **A systems approach** to identifying and addressing interlinked concerns, mitigating potential risks, and creating sustainable value for all stakeholders;

/ **A life cycle approach** to planning and implementing an effective mine management model as early as possible in the mine's life cycle; and

/ **A multistakeholder collaborative model** for developing new ideas, fostering new partnerships, and designing and testing transformative models of growth.

The Sustainable Mining Charter is aimed at accelerating the shift from compliance-focused to sustainability-focused operations; its design must also be able to meet the rising demand for metals and minerals.

The Charter is envisioned as a means to develop an understanding of shared social, economic, and environmental responsibilities; it should offer a common platform for the dissemination of best practices and for the establishing of benchmarks within India's mining industry.

2. SUSTAINABLE MINING CHARTER DEVELOPMENT APPROACH

2.1 OVERVIEW OF PARTICIPATIVE PROCESS

The Sustainable Mining Charter has been developed through an in-depth participatory process that has included four distinct approaches:

1. SECONDARY RESEARCH

- A review of existing materials published by industry bodies and mining companies around the world;
- Documentation of benchmarked best practices, frameworks, and strategies that have been adopted by mining and non-mining companies globally to achieve sustainability goals.

2. WORKSHOPS

Multiple workshops were conducted which included participants from a range of disciplines. In order to develop new ideas and validate existing approaches, they employed three techniques:

- **Systems mapping**: The ecosystem of mining was understood through breaking it down into its key components (social, economic, environmental) and then examining and analysing the interactions of these components;
- **Backcasting:** This was undertaken in order to identify the preconditions or approaches required to achieve desirable visions of the future;
- **Concept canvas:** This was used to develop an operational and/or financial model of new ideas.

3. CONSULTATIONS

Subject matter experts (SMEs) from the mining industry were consulted to help in understanding key challenges in the mining industry and develop actionable frameworks to address them.

(See Annexure 1 for a list of documents reviewed and stakeholders consulted.)

With the aid of these extensive consultations and inputs, the Sustainable Mining Charter reflects ground realities and a collective consensus on how to address the challenges of achieving sustainability in mining. The Charter aims to present a set of actionable frameworks, approaches, and case studies to support the design and implementation of sustainable mining practices.

3. SUSTAINABLE MINING - A SYSTEM THINKING APPROACH

3.1 SYSTEM THINKING APPROACH

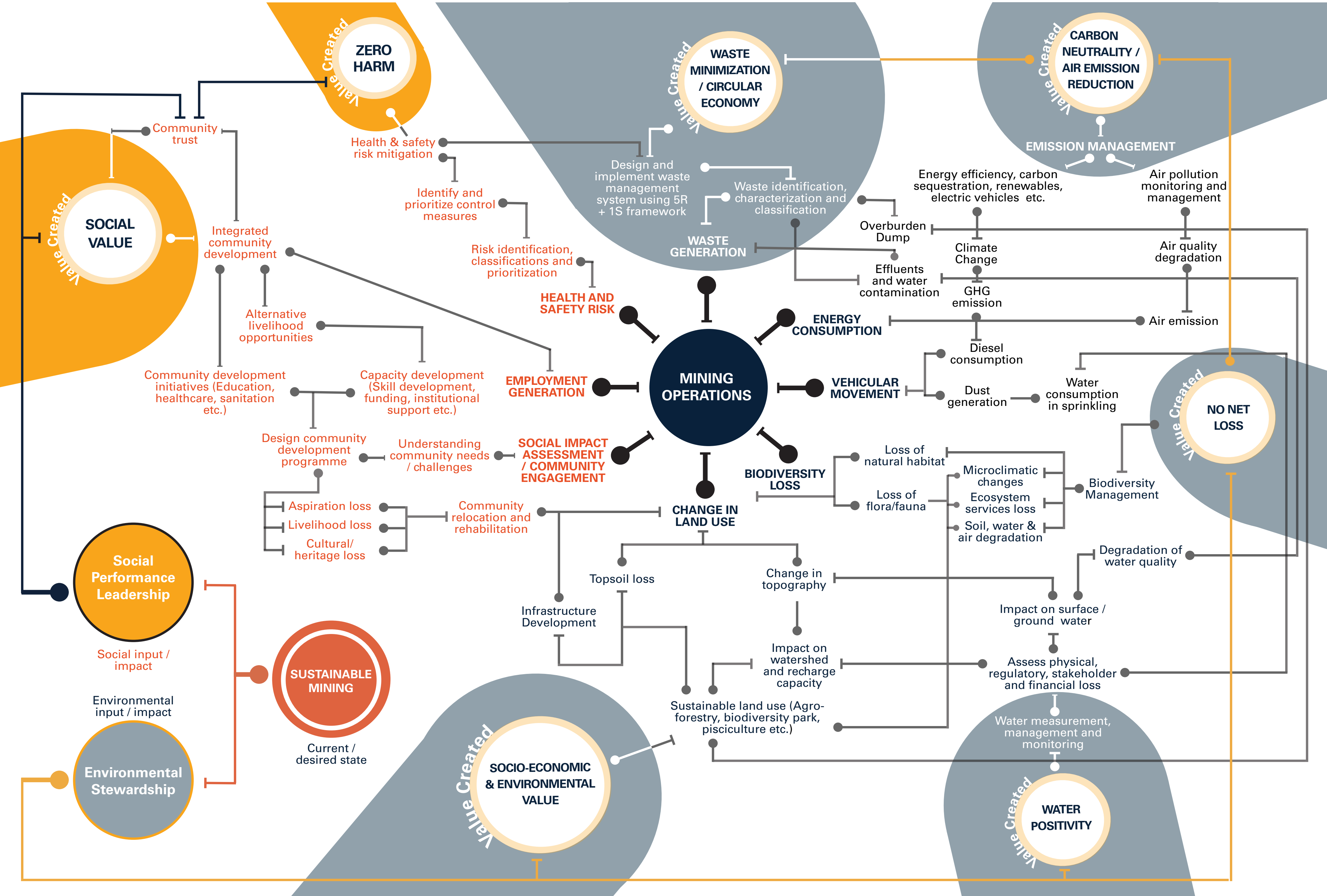
Systems thinking views systems from a broad perspective. Rather than seeing only specific events in a system, it sees overall structures, patterns, and cycles. This broad view can help quickly identify the real causes behind organisational issues and can pinpoint where to intervene. It can suggest solutions to multiple problems simultaneously, thus maximising positive impact. This approach is particularly helpful for complex systems – such as the mining ecosystem – where multiple factors interact.

In the mining's complex ecosystem, it is imperative to identify priority areas for sustainability actions and to clearly understand first- and second-level impacts that such actions may produce in the wider ecosystem. Figure 3 is a systems map representing the ecosystem of a typical mining operation; it provides a starting point for understanding the interconnected behaviour of the system. The map consists of various components which highlight how mining operations affect the environment and the community in which they take place.

The systems map clearly shows the interdependencies among various components of a mining ecosystem. Certain areas are called "leverage points"; actions across these areas have a large secondary impact on other parts of the ecosystem. Efforts to sustainably manage waste, for example, not only prevent or minimise damage to the environment; they also mitigate health and safety risks by preventing contamination of nearby water and land resources used by mining communities. This in turn helps build community trust and reduces reputational risk for the organisation.

Similarly, sustainable land use not only helps mitigate the adverse impacts of changes in land use patterns; it also helps create new employment opportunities for local communities by exploring more commercially beneficial post-mining land uses such as agroforestry, biodiversity parks, and pisciculture. Sustainable land use also affects ground water recharging capacity, thereby impacting water management efforts.

Figure 3. Systems Thinking Map



3.2 SUSTAINABLE MINING FRAMEWORK

Focused actions across these leverage points maximise the positive impact on both environment and society. Coupled with a strong organisational governance mechanism that ensures that actions are effectively implemented, monitored, and evaluated for timely course correction, these focus areas – or leverage points – provide a holistic approach that enables a shift toward economically viable, ecologically sustainable, and socially responsible mining activities.

Actions and efforts aligned with fundamentals of environmental stewardship, social performance leadership, and governance excellence will also create socio-economic and environmental value for a broad range of stakeholders. They will enhance the overall sustainability of mining operations.

Hindalco proposes to incorporate the following guiding principles into all its operations in the mining vertical:

/ **Environmental stewardship:** avoid, minimise, mitigate, or offset any potential negative impacts of mining operations on the environment, for example by creating economic and ecological value through sustainable land use;

/ **Social performance leadership:** improve well-being & enhance the prosperity and resilience of mining communities by, for example, generating sustainable livelihoods through the revival of local art and culture;

/ **Governance excellence:** strong internal controls and mechanisms for implementing changes, measuring and reporting results, and for course correction.

Best practices and pathways are identified and proposed across seven focus areas or leverage points, in order to achieve sustainability in mining operations. Sustainability is achieved in each focus area through a comprehensive life cycle approach and effective risk management strategies.

Focus areas include:

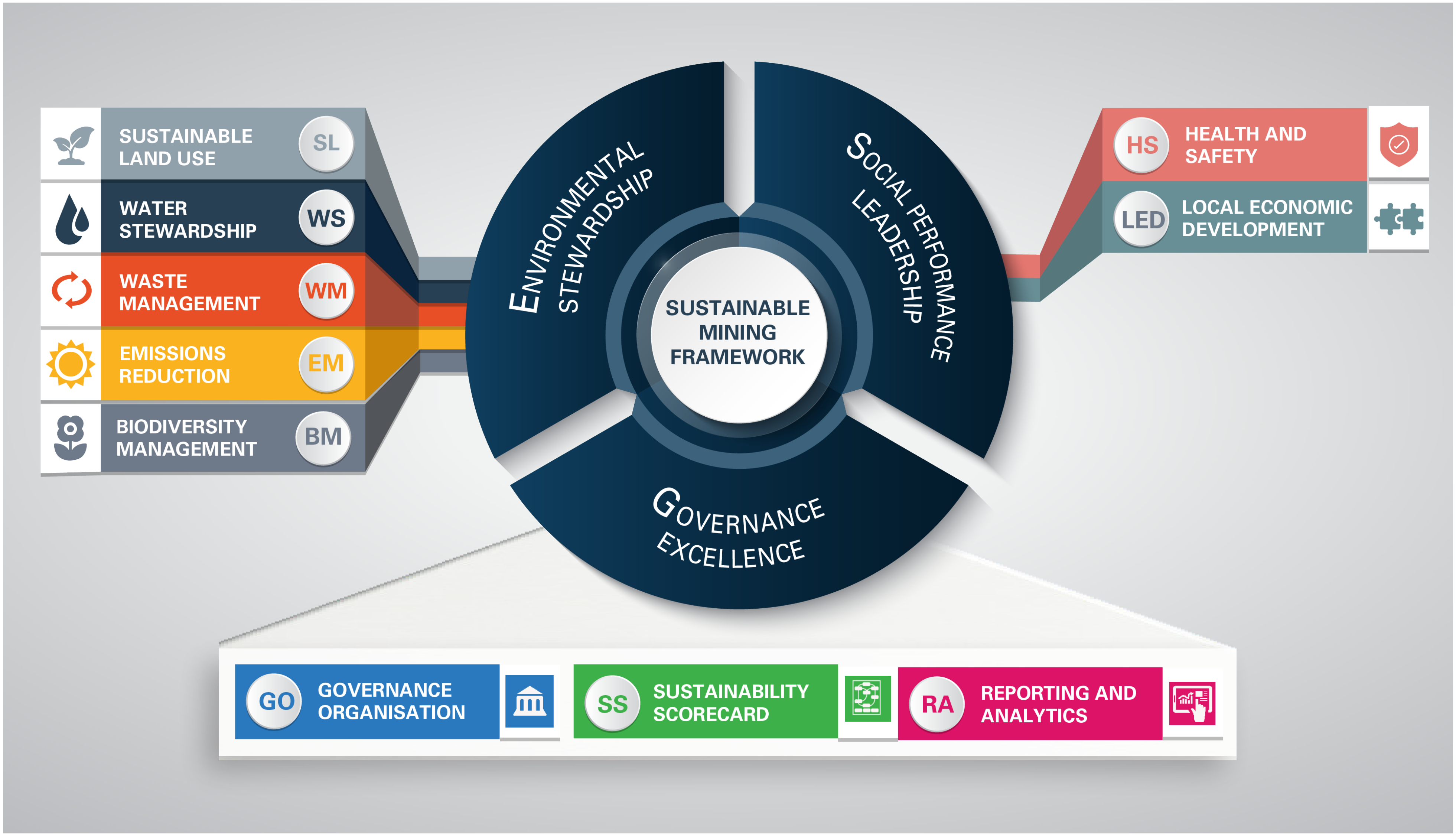
- SUSTAINABLE LAND USE
- WASTE MANAGEMENT
- BIODIVERSITY MANAGEMENT
- WATER STEWARDSHIP
- EMISSIONS REDUCTION
- HEALTH AND SAFETY
- LOCAL ECONOMIC DEVELOPMENT

Stages of mining operations – typically across exploration, excavation, and mine closure – have varied impacts on both the environment and society. Mining affects land not only during the operational phase but also after mine closure; unplanned mine closure and land rehabilitation, for example, can have a lasting impact on land, leaving it in a deteriorated state. Each focus area must therefore integrate a life cycle approach into the planning and implementation of an effective mine management model.

Because of the interconnectedness between different factors in a mining ecosystem, risks emanating in one area can also have an impact beyond that area. Risks due to improper waste management, for example, can affect both water and land, causing health and safety risks for communities. Given the wide range of impacts of mining operations, it becomes necessary to develop a holistic approach to identifying and managing risks.

The sustainable mining guidelines offer an actionable framework that is aligned with the three guiding principles and defines actions across the seven thematic areas, using a mine life cycle approach and risk management strategies.

Figure 4. Sustainable Mining Framework



3.3 ALIGNMENT WITH UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

Although the actions based on the Charter can have an impact on almost all SDGs, they can significantly contribute towards the below SDGs:

Environmental sustainability goals

Sustainable economic development goals

Social inclusion goals

4. USING THE CHARTER

OVERVIEW

4.1 WHO IS IT FOR?

The Charter is intended for two principal audiences:

/ **Corporate teams** that are looking at specific areas for developing corporate strategic, decision-making, and risk management plans; these teams may find the management frameworks – shared in each thematic area – to be relevant and informative;

/ **Mine site teams or technical specialists** who may use the Charter as a toolkit for developing operational strategies and plans for use in mine lease and affected zones.

4.2 HOW SHOULD IT BE USED?

The subsequent parts of this document detail identified focus areas and key enablers for adopting a sustainable mining model.

/ **Part II. Seven Thematic Focus Areas:** Seven areas of activity are presented for the operationalisation of sustainable mining practices. For each thematic area, sustainability objectives and the management approaches to achieving these objectives are offered, as are case studies and metrics for assessing progress. The frameworks provided in each focus area can be used as a toolkit for designing initiatives at the mine site level.

/ **Part III. Governance Excellence:** Suitable approaches to developing governance mechanisms are offered, with a focus on developing governance organisation , providing sustainability scorecard for measuring mine level sustainability performance and developing a framework for understanding and aligning with global reporting standards.

/ **Part IV. Key Enablers:** Guidance is provided on stakeholder engagement models for successful implementation of the Sustainable Mining Charter; an overview of upcoming technologies is presented, which can be adopted at a mine site to help achieve sustainability goals.

Adoption and adherence to the Sustainable Mining Charter requires a commitment to the highest ethical standards across all business operations, functions, and leadership.

Part II / THEMATIC FOCUS AREAS

- SUSTAINABLE LAND USE
- WATER STEWARDSHIP
- WASTE MANAGEMENT
- EMISSIONS REDUCTION
- BIODIVERSITY MANAGEMENT
- HEALTH AND SAFETY
- LOCAL ECONOMIC DEVELOPMENT

Part II / Thematic Focus Area

5. SUSTAINABLE LAND USE

OVERVIEW

Land is one of mining's most important resources. It undergoes transformation during the various phases of the mine's life cycle, which include mineral exploration, mine development, mine operation, and mine closure. Some of these activities can adversely affect the local environmental and sociocultural infrastructure; the impact, however, is not restricted to the boundary of the mine, but can also spread to the surrounding areas.

FIGURE 5. FRAMEWORK FOR SUSTAINABLE LAND USE

SUSTAINABLE LAND USE OBJECTIVES

/ Ensure growth of local environmental and social infrastructure through effective conservation, restoration, rehabilitation and resettlement, and responsible mine closure practices

/ Minimise risk to natural resources, biodiversity, livelihood and to sociocultural and natural heritage

FRAMEWORK AND PATHWAY FOR ACTION

/ Sustainable land use across life cycle

/ Land enrichment approach

/ Mine closure approach

MEASURABLE OUTCOMES – KEY METRICS

/ Total land degraded

/ Percent land reclaimed

/ Plantation density

/ Area having three tier plantation (helps in development of self-sustaining forest ecosystem)

5.1 SUSTAINABLE LAND USE ACROSS THE MINING LIFECYCLE

Mining is a long-term activity which creates a large land disturbance during its life cycle. Specific challenges in sustainable land use in mining may include:

- Deforestation and land clearance for infrastructure development and site preparation
- Rehabilitation and resettlement due to change in land use
- Loss of topsoil and removal of overburden
- Impact on biodiversity, natural resources, and ecosystem

In order to minimise the negative impact on land use, a life cycle approach is important to understanding and creating mitigation strategies throughout the mine's life. A life cycle approach is also necessary to ensure that a progressive reclamation strategy is adopted at the mine location which will leave the land in a better state once the mine is closed (Table 2).

TABLE 2. A Life Cycle Approach to Developing a Sustainable Land Use Strategy

LEVEL 01	LEVEL 02	LEVEL 03
PRE-MINING PHASE	**MINING PHASE**	**POST-MINING PHASE**
Integrated mine planning for use, closure and reclamation	**Sustainable operations to minimise impact on land & adjacent communities**	**Responsible mine closure**
/ Collect data to capture the state of the land through socio-economic and environmental surveys of, for example, water and biodiversity; reconcile data with the local administration in order to create a baseline for socio-economic and environmental parameters / Plan mining activity in a phased manner to enable continuous land reclamation / Plan progressive and final mine-closure activities to ensure effective reclamation of mined-out area	/ Implement phased use and demineralisation of the land area / Implement phased progressive reclamation of land / Monitor stability of dumps and mitigate the impact of operations on land / Deploy mechanisms such as plantations, creation of gabion walls, check dams, and garland drains to ensure the safety and sustainability of the transformed land	/ Develop and implement a technical and biological land reclamation plan / Ensure effective and economic use of reclaimed land, so as to create an advantage for the local community / Restore landscape to original forest / Dismantle surface mine infrastructure or identify its possible uses / Hand the land back to the community in better condition, and exit

Continuous monitoring of land use strategy and implementation plan
Engagement with local communities and local administration

5.2 LAND ENRICHMENT APPROACH

Even after mines are closed and operations have concluded, mining companies have a unique opportunity to create a positive impact on its key stakeholders, especially local communities; however, there is a need for an integrated approach to the development and implementation of a holistic land enrichment plan. It is important to engage with the community and other key stakeholders in the mine planning phase itself, involving them in areas such as land use and rehabilitation planning (Table 3).

TABLE 3. Land Enrichment Approach

Set land enrichment goals	Develop knowledge base plan	Engage with stakeholders	Implement the plan and monitor progress	Handover
/ Define mine closure goals / Develop a mine closure vision as an aspirational description of what it will achieve; guidelines should be followed, and regulatory requirements should be defined / Implement effective resource allocation for planning and implementation	/ Develop an understanding of key areas such as environmental baseline data, operational data, commitments, and compliance requirements / Assess risks and opportunities associated with closure, including physical, social, economic, and ecological considerations	/ Identify and engage with required stakeholders to develop the closure plan / Identify potential land uses while developing the plan / Develop quantitative indicators for assessing the effective implementation of closure activities	/ Implement the closure plan / Monitor progress to evaluate compliance with original objectives / Integrate learnings from implementation in the organisation's knowledge base	/ Engage with the government and other key stakeholders to develop criteria for handover/ relinquishment / At each stage of the mine's life cycle, remain aware of that ways in which temporary or sudden closure could affect the closure plan and final handover

Rehabilitation of land may need physical or biological interventions. Such practices may include:

(i) Physical/technical rehabilitation

/ Backfilling of the mine pit with rocks and soil to a predetermined height

/ Construction of check dams to retain soil and moisture

/ Construction of a slope according to watershed management principles in order to avoid leaching of the dump material and dispersion of the fine dust

/ Conservation of top soil and overburden from an excavation site, for use in post mining revetation

(ii) Biological rehabilitation

/ Plantation of native species on backfilled areas of the mine site

/ Selection of appropriate species for post mining revegetation (nitrogen-fixing trees, forest cover or horticulture and ornamental purposes)

/ In the case of mining in a coastal region, development of wetlands in perennial, buffer, and landmass areas

5.3 MINE CLOSURE APPROACH

Mine closure is an ongoing programme which encompasses post-mine reclamation and rehabilitation processes that are designed to restore the original physical, chemical, and biological quality of land. Mine closure follows the end of the useful life of a mine after ore depletion; however, it can also take place due to economic, social, technical, or political factors that could render the mine unviable.

5.3.1 CLOSURE PLANNING

Closure planning is necessary from the beginning of the mine's life cycle; furthermore, to enhance sustainable post-mine land use, a plan for progressive closure and for end-of-life mine closure needs to be in place in advance.

/ **Progressive closure:** Implementation of closure activities during the operating life of a mine helps minimise the impact on the ecosystem by reducing the total disturbance throughout the mine's life cycle. Progressive closure also enables the testing of pilot interventions during the operating life of the mine; this improves community engagement and allows for the implementation of ongoing course corrections (International Council on Mining & Metals. 2019).[32]

/ **End of life mine closure:** This includes activities to close the mine once useful extraction of mineral resources is completed. The land must be handed over to the owner or community in strict accordance with legal requirements, and rehabilitation of the land to its original state is critical if the community is to benefit in the post-mine phase.

5.3.2 POST-CLOSURE LAND USE THEME SELECTION

The selection of post-mine land use themes requires consideration of a broad range of factors; these include:

/ **Economic and budgetary factors:** These encompass capital and implementation costs, monitoring costs, the economic value generated by the post-mining rehabilitation project, and the increase in community income.

/ **Environmental factors:** These consist of climate-related elements such as rainfall, wind speed, moisture, and temperature, as well as topography, geology, and hydrology.

/ **Social and cultural factors:** This consideration encompasses population characteristics such as age distribution, education level, household income, and population, as well as local employment opportunities and community needs.

/ **Regulatory factors:** This includes various applicable statutory guidelines and laws that are applicable to post-mine-closure land use.

/ **Technical factors:** Included here is location and accessibility of land, historic and current land use, availability of land area, soil quality, and availability of technology.

5.3 MINE CLOSURE APPROACH (CONT.)

Figure 6 provides a framework for the selection of a theme for post-mine closure land use. It suggests the development of a knowledge base for various post-mine land use opportunities, the use of selection factors in prioritising possible themes, and the conducting of a cost–benefit analysis in the final selection of the project.

A Strategic Infrastructure Committee (SIT) can be constituted to better implement an effective stakeholder engagement strategy for mine closure.

FIGURE 6. POST-MINE THEME SELECTION FRAMEWORK

5.4 EFFECTIVE RISK MANAGEMENT IN LAND REHABILITATION

The specifics of post-mine closure land rehabilitation can have important impacts on ecological and socio-economic activities and well-being; long-term value can be generated by a properly planned and implemented mine closure that focuses on the alignment of land rehabilitation with local environment and stakeholder needs. Mitigation of the possible risks of mine closure requires a clear understanding of how mine closure and land management practices can affect the company. Table 4 maps the risks of improper closure management practices, while Table 5 details risk-mitigating strategies.

5.4 EFFECTIVE RISK MANAGEMENT IN LAND REHABILITATION (CONT.)

TABLE 4. Identification of Risks in Mine Closure Land Management

Risk	Description	Causes
PHYSICAL RISK	/ Risks related to environmental impact on land, air, water, and local communities	/ Inadequate planned progressive and final closure / Improper implementation of progressive closure plan, increasing the likelihood of environmental and social challenges during final closure / Failure to anticipate the environmental issues and challenges that may arise during mine closure / Failure to prevent acid mine drainage
REGULATORY RISK	/ Risks related to stricter regulations that can lead to delays in permits, restrictions in operations, and increased costs	/ Non-compliance with regulations during mine closure and rehabilitation / Unsuccessful land rehabilitation, leading to greater regulatory scrutiny of current and future projects
STAKEHOLDER RISK	/ Conflict with stakeholders in the ecosystem which can lead to protests/community unrest, loss of reputation, and revoking of license to operate	/ Impact on community well-being and safety due to unsafe mine closure; this can include leaving behind open pits, an unstable overburden dump, and unsafe water sumps, as well as residual air pollution and water contamination / Poor land rehabilitation practices, leading to an adverse impact on traditional livelihoods such as agriculture / Long-term environmental problems due to inadequate rehabilitation, including an adverse impact on water sources, changes in microclimatic conditions, and soil contamination
FINANCIAL RISK	/ Risk of increased or unanticipated cost of land rehabilitation	/ High remediation costs during closure, due to poor closure planning that does not incorporate site-specific conditions

5.4.1 RISK MITIGATION STRATEGIES

TABLE 5. Risk Mitigation Strategies in Post-Mine Closure Land Management

Risk	Mitigation Strategies
PHYSICAL RISK	/ Improve closure success by evaluating baseline soil, environmental, and socio-economic data and incorporating these into progressive and final closure and rehabilitation planning / Institute regular reviews of the processes that guide progressive closures; rehabilitate areas that are no longer required for operational purposes; integrate knowledge gained from on-site experience to update closure management plans and practices
REGULATORY RISK	/ Ensure proper understanding of, and adherence to, national- and local-level regulations / Prioritise successful land rehabilitation as part of closure plans; develop a team which includes representatives from the company, from the industry, and from academia, and task this team with identifying best practices in land rehabilitation and ensuring rehabilitation success
STAKEHOLDER RISK	/ Involve local communities in closure planning and in the identification of the best post-mining land use / Contribute to environmental and community resilience by developing social investment plans that are aimed at developing sustainable livelihood opportunities
FINANCIAL RISK	/ Ensure a better estimation of closure costs through gaining a detailed understanding of site conditions and through benchmarking across different mine operations / Manage and optimise closure costs by integrating feedback obtained from progressive closure

5.5.1 Case Study

Use of Microbes for Soil Contamination Remediation, Gare Palma Coal Mines, Hindalco, Chhattisgarh

The Sustainable Mining Impact Track of the India2022 Coalition, powered by Hindalco, is testing the usage of vesicular-arbuscular mycorrhiza (VAM) biofertilisers for rehabilitation of mine closure sites in Gare Palma coal mines, Chhattisgarh.

BACKGROUND:

Microbes play a key role in biogeochemical cycling, soil fertility maintenance, and biodegradation of waste. Such microbes include a symbiotic group of fungi called mycorrhiza (meaning "fungal root"), the potential of which has been identified for the rehabilitation of mine closure sites. Mycorrhiza fungus helps transfer phosphorus and other essential nutrients from the soil to the plant system; in the process, it improves seedling growth by enhancing the uptake of nutrients and water. It thus promotes the survival of plants in new and reclaimed sites and strengthens the establishment of a functional forest ecosystem.

INTERVENTIONS:

The project has been designed in partnership with the Institute of Forest Genetics and Tree Breeding (IFGTB) in Coimbatore, Tamil Nadu. Key project activities include:

/ A survey of roots and rhizosphere soil samples from in and around the closure site

/ Analysis of samples to estimate the root colonisation and soil spore population of mycorrhizal fungus and of beneficial microbes such as plant-growth-promoting rhizobacteria

/ Production of various biofertilisers in the laboratory, and experimental application on seedlings of economically important forest tree species

/ Supply of experimentally successful biofertilisers for mass production

/ Imparting training and demonstration on 1-acre land for VAM biofertiliser production and application techniques as well as afforestation of overburden dumps and other mined-out areas

IMPACT / OUTCOME:

/ Restoration and/or enhancement of soil fertility on mine closure sites on an experimental basis and

/ Mass production of various types of biofertilisers from mine closure sites

5.5.2 Case Study

Development of Bio-Parks in Bagru Bauxite Mines, Hindalco, Jharkhand

At Bagru Mines, in Jharkhand, Hindalco has developed a 5.5 hectare biopark as part of the land reclamation process that has been carried out at a mine closure dump site; this is an initiative that helps create social and environmental value. The biopark has the following themes:

/ **The Nakshatra Garden** depicts 27 constellations that are believed to have a direct effect on human well-being and prosperity; a particular plant represents each constellation.

/ **The Butterfly Garden** contains a particular species of plant for each type of butterfly found in the region.

/ **The Rose Garden** has roses of different colours and shapes from across India.

/ **The Panchavati Garden** has plants that are associated with the five human senses.

/ **The Medicinal and Spice Garden** contains a variety of medicinal plants and spices.

The biopark also demonstrates other themes which can commercially benefit the community at the point of post-mine handover. These themes include:

/ **Bamboo:** A bamboo pavilion is set among varieties of Indian bamboo; here, demonstrations on the use of bamboo as a construction material are offered. The pavilion has been developed according to sustainable design principles and is currently being used for training.

/ **Pisciculture and duck rearing:** This includes demonstrations of the potential use of mine pits as rainwater collection ponds where fish and ducks can be raised.

IMPACT / OUTCOME:

/ Enhancement of biodiversity at the Bagru Mines site

/ Demonstration of sustainable livelihood opportunities that offer enhanced earning potential to members of the community

6. WATER STEWARDSHIP

OVERVIEW

Water is a vital natural resource for all stakeholders in an ecosystem. Water stewardship in mining focuses on the economic, social, and environmental benefits of sustainable management of water. The Alliance for Water Stewardship defines water stewardship as "the use of water that is socially and culturally equitable, environmentally sustainable and economically beneficial, achieved through a stakeholder-inclusive process that involves site and catchment-based actions" (Alliance for Water Stewardship 2019).[33]

The water stewardship framework (Figure 7) addresses the stages from mineral exploration to mine closure, with a focus on avoiding damage to the ecosystem, maintaining a positive water balance through reduced water consumption, recycling discharged water, and the recharging and restoration of water bodies.

FIGURE 7. WATER STEWARDSHIP FRAMEWORK

WATER STEWARDSHIP OBJECTIVES

/ Rethink and redesign mining activities to avoid and minimise impact on watershed

/ Conserve, restore and equitably share water resources among the stakeholders in order to maintain a positive water balance in the watershed

FRAMEWORK AND PATHWAY FOR ACTION

/ Water management across the life cycle

/ Positive water balance

MEASURABLE OUTCOMES – KEY METRICS

/ Specific water consumption (per tonne of ore)

/ Water positivity index for the mine

/ Percent of water recycled

6.1 WATER MANAGEMENT ACROSS THE MINE'S LIFE CYCLE

The challenges and magnitude of water risks shift over the life cycle of the mine as the site evolves and the intensity of operations increases. Key concerns in and around the mine lease area must be continuously assessed, and an integrated approach must be developed to address these concerns.

Specific challenges in water management differ depending on hydrogeological conditions; some of the potential water management challenges in India include:

- Impact on watershed and recharging capacity
- Disruption of surface water such as natural streams and ponds and changes in the contour of rivers
- Increase in turbidity and levels of contamination
- Disruption of access to safe water for watershed stakeholders

Table 6 shares potential strategies for addressing water stewardship management issues across the mine's life cycle.

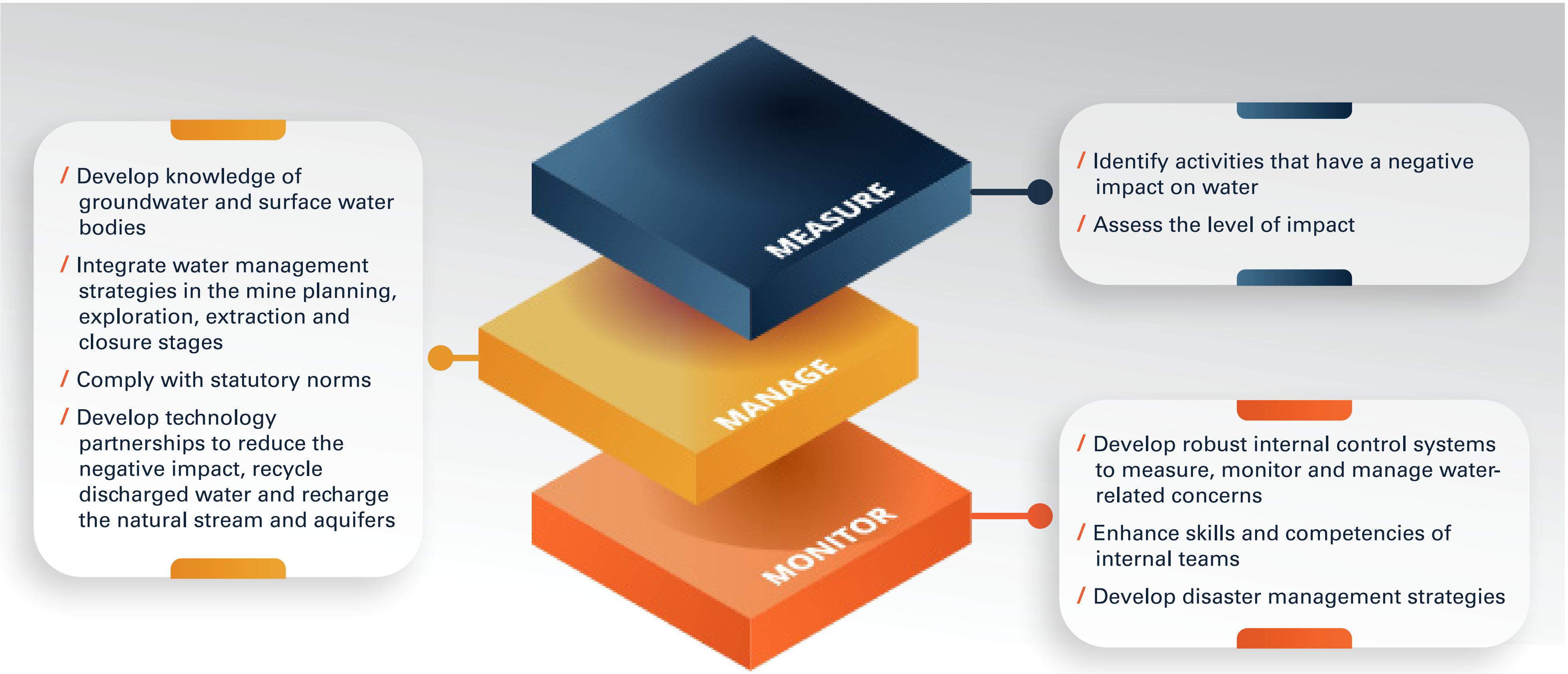
TABLe 6. Strategies for Water Stewardship Management Across the Life Cycle of the Mine

LEVEL 01 — PRE-MINING PHASE	LEVEL 02 — MINING PHASE	LEVEL 03 — POST-MINING PHASE
Conduct a hydrogeological study of the watershed	Monitor water table, run off, and usage	Set up water management committees for maintenance of infrastructure such as check dams
Identify socio-economic and hydrogeological stress points	Set up infrastructure for water recharge, such as rainwater harvesting	Develop artificial aquifer recharge infrastructure
Select mining technology and develop an operations plan to minimise impact on water	Set up infrastructure and technologies for the reduction of water consumption and for reuse and recycling	Implement plantations for enhancing water conservation
Plan for required disruptions and diversions of surface water	Implement only unavoidable surface water disruption and diversions	Implement measures to prevent leaching of exposed minerals
Plan for watershed development as part of the mine closure design	Deploy measures to assess and correct water quality (total suspended solids and total dissolved solids) and contamination (due to heavy metals, toxic elements, etc.)	Utilise voids as water reservoirs and develop projects with socio-economic value such as duck rearing and park development
Develop a water risk mitigation plan	Implement clean water supply solutions for communities	
	Identify alternative water supply sources for risk mitigation	

6.2 POSITIVE WATER BALANCE

A positive water balance refers to a net increase in water quantity in the watershed in which mining activities are conducted. It involves water management activities aimed at avoiding and minimising damage to water resources, with a focus on reducing consumption and on reuse, recycling, and water table restoration. Rethinking and redesigning mining activities and innovations in water-intensive processes can support improvements in the water balance, as can rainwater harvesting, artificial aquifer recharge, and borewells. A positive water balance can be achieved at the mine site and watershed level by following a "3M approach" that measures, manages, and monitors impacts on surface and groundwater (Figure 8).

FIGURE 8. A 3M APPROACH TO WATER MANAGEMENT



6.2 POSITIVE WATER BALANCE (CONT.)

Actions can be taken to manage the impact on surface water and groundwater at the mine site level and at the level of the watershed. These include:

(i) At the mine site (catchment) level:

/ Performance of a water consumption assessment, including a water audit, and wastage and stress-point identification;

/ Innovations in water-intensive processes to eliminate or reduce water consumption. Interventions to reduce, reuse, and recycle water can be introduced; for example, chemicals or other methods can be used instead of using water for dust suppression on roads and during drilling, blasting, crushing, loading and unloading;

/ Introduction of rainwater harvesting and artificial aquifer recharge borewells to improve the water balance.

(ii) At the watershed level:

/ Identification of hydrogeological and socio-economic stress points;

/ Development of efficient infrastructure for household water supply, irrigation, and sanitation;

/ Implementation of water source augmentation through check dams, ponds, greenbelts, and water recharge borewells.

6.3 EFFECTIVE RISK MANAGEMENT OF WATER STEWARDSHIP ISSUES

Four types of potential challenges and risks in water stewardship management can be identified: physical, regulatory, stakeholder, and financial. A comprehensive risk register must be developed and appropriate responses identified for addressing these risks. Table 7 describes water-related risks at mine sites, and their potential causes.

TABLE 7. Water-Related Mine Site Risks and their Potential Causes

Risk	Description	Causes
PHYSICAL RISK (CONT.)	/ Risks related to the physical quantity of water, such as scarcity (low quantity or drought), excess (high quantity or flooding), quality (polluted or high turbidity)	/ Inadequate hydrogeological assessment; failure to accurately map the location of aquifers / Improper planning for groundwater recharge / Change in land use planning or improper sequencing of material dumping, leading to impacts on water infrastructure / Inadequate infrastructure for water quality management / Meteorological data inadequate for the mitigation of drought and flood scenarios / Changes in the catchment area, such as deforestation and soil erosion, bunding and obstruction of flow, and an increase in water users
REGULATORY RISK	/ Risks related to stricter regulations, leading to potential delays in permits and restrictions in operations	/ Non-compliance with regulations / Low capacity for water treatment / Poor infrastructure management, leading to contamination and lack of availability of water to stakeholders / Poor monitoring and governance / Official declarations of groundwater in mine site areas as being critically or severely low or threatened
STAKEHOLDER RISK	/ Conflict with ecosystem stakeholders leading to protests or community unrest, in turn causing loss of reputation and revoking of the license to operate	/ Disruption or diversion of water resources / Negative impacts on vegetation, biodiversity, and human settlements due to lack of access to quality water / Inadequate infrastructure to ensure the availability of water to stakeholders
FINANCIAL RISK	/ Risk of increased costs of managing water resources, leading to unviability of business operations	/ Increased cost of a license to access water, due to regulatory changes / High cost of infrastructure and treatment facilities / High cost of stakeholder management due to poor governance

6.3 EFFECTIVE RISK MANAGEMENT OF WATER STEWARDSHIP ISSUES (CONT.)

6.3.1 RISK MITIGATION STRATEGIES

TABLE 8. Possible Strategies for Mitigating Risks

PHYSICAL RISK	**MITIGATION STRATEGIES**	**FOR RISKS RELATED TO WATER QUANTITY:** **Integrate a hydro-ecological study of mine and mine-affected areas in the mine planning stage** / Map location of aquifers and natural streams / Assess locations of surface structures such as ponds, and identify mechanisms for groundwater recharge / Maintain surface structures by desilting ponds and nallas/canals, to ensure the capacity of the infrastructure **Measure and monitor water stress in and around the mine locations** / Install piezometers and sensors across in-house and community borewells to monitor the pressure and depth of groundwater **Develop local infrastructure for the water management plan through public–private partnerships** / Develop rainwater harvesting structures such as ponds and check dams for continuous restoration, recharging, and replenishment of water at mine sites; introduce artificial rainwater harvesting structures to direct rainwater into aquifers, thus replenishing the groundwater table / Deploy a pipeline network for village water supply from a central unit **Build capacity of community and develop infrastructure for water conservation and disaster management (floods and drought)** / In disaster-prone areas such as flood and drought regions, collaborate with district disaster management units to build the community's disaster preparedness / Develop prevention infrastructure such as drainage lines, and protection infrastructure such as shelters and grain banks **Integrate a hydro-ecological study of mine and mine-affected areas in the mine planning stage** / Map location of aquifers and natural streams

6.3.1 RISK MITIGATION STRATEGIES (CONT.)

PHYSICAL RISK (CONT.)

MITIGATION STRATEGIES

FOR RISKS RELATED TO WATER QUANTITY (Cont.):

Deploy mine closure and effluent treatment measures to ensure the mine's water-positive status within the community

/ Restore water bodies to their original forms at the time of mine closure

/ Create water bodies such as canals or ponds that can store and supply water

/ Arrest contamination by developing infrastructure to ensure safe drainage and storage of mine seepage water, storm water, and mine run-off

/ Treat water containing mine effluents – such as discharge from workshops and equipment washing – before release or reuse

FOR RISKS RELATED TO WATER QUALITY:

Deploy monitoring and preventive strategies to control or minimise total suspended solids (TSS) and total dissolved solids (TDS) in discharged water.

Automated monitoring and measurement mechanisms

/ Deploy Continuous Water Quality Monitoring Systems (CWQMS) for real-time monitoring of TSS/TDS in water across critical discharge points

/ Raise automatic alerts when TSS/TDS levels in water breach limits, and deploy corrective actions

Deploy control measures

/ Depending on water chemistry, a combination of measures can be deployed to control suspended and dissolved solids in water, including adding chemical dosages to remove specific solids such as sulphates and nitrates

/ Water can be recycled for household use and farm irrigation

/ Infrastructural measures, such as check dams and settling ponds, can be implemented for management of water flow

/ Biological measures such as the use of biochar can be deployed

/ Planting of high-water-use trees can be avoided.

6.3.1 RISK MITIGATION STRATEGIES (CONT)

Risk	Mitigation Strategies
REGULATORY RISK	/ Partner with global research laboratories and R&D centres to understand advanced water management practices / Propose an industry task force to take up issues related to water in and around the mine operations with state or central government departments / Advocate stringent monitoring mechanisms to identify and investigate malpractice / Create an internal team to gain knowledge about water-related issues, policies, compliance, and funding sources, who will then design and implement programmes for mine locations
STAKEHOLDER RISK	/ Implement water management steps to ensure minimum disruption of the area's water resources
FINANCIAL RISK	/ Ensure regular tracking of the regulatory environment to ensure that any change in regulation is being tracked / Focus on optimising water usage to ensure minimal impact on the resources of local communities / Explore new methods and technologies for reducing water usage and improving water treatment

6.4.1 Case Study

Integrated Approach to Water Management at Samri Bauxite Mines, Hindalco, Chhattisgarh

BACKGROUND:
In order to achieve water positivity, Hindalco's Samri Bauxite Mine has developed and implemented an integrated approach focusing on understanding water consumption, improving measurement systems and implementing water conservation initiatives.

INITIATIVE:
The mine has undertaken the following steps to improve water management -

/ 6 Rainwater harvesting structures have been constructed in the reclaimed area of the mine and another 5 such structures are under construction

- 5 Water meters, 3 Piezometers, 6 depth meters for measurement of various water consumption, ground water level paramters, have been installed
- To ensure ground water recharge, three structures have been created in different areas of the mine
- A systematic approach has been deployed which focuses on regular monitoring and review of water consumption at mine level
- Based on measurements, a water balance study has been conducted and it has been established that Samri mines is water positive
- For assessing and certifying water positivity, an external agency has been engaged

IMPACT / OUTCOME:
Implementation of different initiatives has helped the mine

- Minimize impact on water resources from operations
- Reduce freshwater consumption by re-use and recycling water
- Increase awareness and engagement among employees, thus contributing water conservation efforts

6.4.2 Case Study
Augua Rural Program, Anglo American, Chile

BACKGROUND:
Program Augua Rural- For over a decade, Chile has faced a critical water crisis, with reservoirs running low owing to severe droughts. Recognising the impact that the water crisis was having on Anglo's operations and communities, in 2017 Anglo commissioned a hydrogeology study to understand impact on groundwater sources. This gave the mine, an understanding of water availability and local infrastructure (reservoirs, wells, irrigation and drinking water systems). A door-to-door census provided locals' perception of water supply. It became clear that the real challenge was distribution, due to inefficient water management.

INITIATIVE:
Anglo set about sourcing and implementing a sustainable local solution around three pillars:

- **Technology** – introducing telemetrics and automatisation to improve the systems and make their use intuitive. Working in collaboration with WeTechs, a small local company specialising in internet of things systems, Anglo adapted its systems to meet community needs. Implementation of the innovative solution is being followed by months working with communities to transfer knowledge so that they can manage their water supply independently
- **Integration** – connecting with stakeholders such as governments, public and private institutions, communities, and academia
- **Infrastructure** – making necessary upgrades, based on the data acquired from the diagnostic systems

IMPACT / OUTCOME:
The initiatives taken have led to measurable improvement in water operations for around 100,000 people in Los Bronces, El Soldado and Chagres. Metrics are monitored every three months, and by December 2020 showed an overall 20% increase in water availability, a 50% decrease in water pipe ruptures and a 20% energy saving. By applying the data collected to the streamlining of water management, the project has also achieved a reduction in public spending.

7. WASTE MANAGEMENT

OVERVIEW

Waste is generated across the mining life cycle. Mining wastes can be broadly categorised into extraction waste (such as overburden and waste rock), processing waste (tailings and wastewater) and other types of waste (such as waste oil, metal scrap and grease). If not handled properly, several of these types of wastes have the potential to cause significant environmental challenges such as soil contamination, leaching, surface water contamination, or impacts on the local flora and fauna. It is imperative to understand the characteristics of waste in order to assess its hazard potential and to ensure adequate waste management planning and disposal methods.

The Waste management framework (Figure 9) focuses on identification, characterisation, classification, and management of waste generated throughout the mine's life cycle.

FIGURE 9. WASTE MANAGEMENT FRAMEWORK

WASTE MANAGEMENT OBJECTIVES

/ Manage waste responsibly and go beyond mere compliance in the reduction, reuse, recycling and recovery of waste

/ Transform towards circular economy and create value out of the waste

FRAMEWORK AND PATHWAY FOR ACTION

/ Know your waste

/ 5R + 1S framework

MEASURABLE OUTCOMES – KEY METRICS

/ Hazardous and Non-hazardous waste generated (Quantities)

/ Percent waste recycled

7.1 KNOW YOUR WASTE (KYW)

The prerequisite for safe and sustainable waste management is an assessment of the inherent properties of the waste and its classification into relevant categories. The generators of waste should identify, characterise, and classify the generated waste in order to apply efficient waste management practices (Figure 10).

FIGURE 10. KNOW YOUR WASTE (KYW) FRAMEWORK

WASTE IDENTIFICATION

EXTRACTION WASTE
Overburden, rejects, waste rocks etc.

PROCESSING WASTE
Tailing waste, wastewater and effluents etc.

OTHER WASTE
Waste oil, grease, tyres, scrap, municipal waste etc.

WASTE CHARACTERISATION

CHEMICAL PROPERTIES
Presence of toxic chemicals, pH levels, flammability etc.

PHYSICAL PROPERTIES
Leaching, solubility, physical state etc.

MINERAL COMPOSITION
Presence of heavy metals, sulphides etc.

WASTE CLASSIFICATION

HAZARDOUS WASTE
Acid drainage, tailings with heavy metals, used oil, used cotton, oil filters etc.

NON-HAZARDOUS WASTE
Overburden, non-toxic tailings, scrap, office waste etc.

7.1 KNOW YOUR WASTE (CONT.)

WASTE IDENTIFICATION

Every type of waste generated in mining should be identified according to its source and type. Mine waste can be identified into at least three broad categories:

a. Extraction wastes: Waste generated during the development of the mine and during extraction activities, such as overburden, waste rock, and ore rejects

b. Processing wastes: Waste generated during enrichment of ore concentration, such as tailings, and wastewater

c. Other waste: Waste generated from non-extraction activities, such as metal scrap, waste oils, packaging waste, and office waste

WASTE CHARACTERISATION

All the identified wastes should be assessed to understand their physical, chemical, and other relevant characteristics. At least three broad categories of assessment criteria apply, including:

a. Chemical properties: Identification of relevant chemical properties to assess their hazard potential, such as toxicity, flammability, and pH levels

b. Physical properties: Assessment of physical characteristics of waste, such as solubility, density, boiling point, and physical state

c. Mineral composition: Checking of the composition of the mineral to identify the presence of toxic substances such as heavy metals and sulphides

WASTE CLASSIFICATION

Based on its characteristics and hazard potential, waste can be classified into two main categories:

a. Hazardous waste: Any waste which, due to its inherent characteristics, has the potential to cause significant harm to the environment or to human life; this includes tailings with heavy metals, acid drainage, and used oil

b. Non-hazardous waste: Waste that does not have hazardous characteristics, including non-toxic tailings, and scrap metal

7.2 5R + 1S framework

The 5R+ 1S framework is a comprehensive approach to the management of mining waste. The objective is to adopt waste management practices which reduce the generation of waste, reuse mined-out rejected material, recycle, and recover value from waste (5Rs), and responsibly store waste (1S). (Table 9).

Reduce waste generated from mining activities by:

- adopting technologies to enhance material recovery and/or ore extraction efficiency
- use dry deshaling to reduce effluents

Reuse waste that does not require treatment, including by:

- using overburden in the backfilling of mining voids
- using waste rock as construction material for roads, pavements, and embankments
- using mine seepage water for sprinkling

Recycle waste after certain treatments, which may include:

- treating canteen effluent water through a vermifilter
- using treated mine effluent in horticulture
- recycling municipal solid waste, such as paper and plastic

Recover valuable resources from wastes, for example by:

- extracting metal from tailings and acid mine drainage
- blending low-grade ores with high-grade ores
- recovering usable assemblies and/or sub-assemblies from discarded equipment
- generating energy from process waste
- using fine coal that has been separated from the runaway water of coal washeries as fuel

TABLE 9. 5R + 1S Framework of Waste Management

CORE PRINCIPLES AND KEY OBJECTIVES

REDUCE	Reduce waste generation
REUSE	Reuse the mining waste
RECYCLE	Recycle the waste generated to extract maximum value
RECOVER	Recovery of valuable resources from waste
REHABILITA-TION	Rehabilitation of mine-out land and overburden dump storage areas
STORAGE	Storage of the waste in a safe and sustainable manner

7.2 5R + 1S framework (Cont.)

Rehabilitation of mined out lands and overburden dump storage areas by:

- Post mining land use that maximises environment and socio-economic value
- Ensuring circularity by utilizing overburden dump for backfilling of mined out areas and ensuring separate storage for topsoil, which can be later utilized for land rehabilitation purposes

Store residual waste safely and sustainably, ensuring that:

- the stability of the overburden dump is maintained
- that tailings dam is well managed
- hazardous waste is stored separately in a specially designated area and manner
- topsoil is stored for future use

7.3 RISK MANAGEMENT IN WASTE MANAGEMENT

Waste generated during mining operations can have different but significant environmental impacts; if not managed properly, it can affect the life and health of local communities. Ineffective waste management can impact the local ecosystem; this in turn can lead to multiple challenges for a company, including regulatory challenges and the revoking of the license to operate in that area, or in nearby areas. It is therefore important to clearly understand and manage the potential risks of ineffective mining waste management.

TABLE 10. Risk Identification in Waste Management

Risk	Description	CAUSES
PHYSICAL RISK	/ Risks related to damage to human health and the environment; these can be caused by the waste generated by mining, which can impact water resources and change the mineral characteristics of the soil	/ Lack of proper identification of hazardous waste, which poses risks to the health and safety of mining communities / Inappropriate disposal of potentially hazardous waste / Poorly engineered or maintained impounds giving rise to toxic spills
REGULATORY RISK	/ Risks related to increasing regulations; these can lead to potential delays in the granting of permits and restrictions in operations	/ Non-compliance with regulations / Poor waste management, leading to damage to human health and the environment from soil and ground water contamination

		CAUSES
STAKEHOLDER RISK	/ Conflict with ecosystem stakeholders; this can lead to protests and/or community unrest, loss of reputation, and revoking of the license to operate	/ Damage to human health due to poor waste management practices / Negative impacts on vegetation, biodiversity, and human settlements due to soil and/or water damage
FINANCIAL RISK	/ Increased costs of managing water resources, leading to the unviability of business operations	/ Regulatory changes which require development of further infrastructure and adoption of advanced techniques for waste treatment, thus requiring further monetary investment

7.3.1 RISK MITIGATION STRATEGIES

TABLE 11. Risk Mitigation in Waste Management

	MITIGATION STRATEGIES
PHYSICAL RISK	/ Clear characterisation and quantification of the different types of waste generated during mining operations / Detailed assessment of potential impacts on the environment and on human health from different types of wastes generated / Development and implementation of plans for managing different types of wastes in order to reduce the quantity generated, identify options for reuse/recycling or, in the case of hazardous waste, identify suitable treatment and disposal methods
REGULATORY RISK	/ Ensure proper understanding of, and adherence to, national- and local-level regulations / Identify regulations related to the disposal and management of different types of hazardous waste
STAKEHOLDER RISK	/ Avoid pollution of local water bodies and air by waste generated / Collect and treat polluted water, ensure that soil is not affected due to heavy metal seepage, develop soil treatment plans to ensure that contamination is avoided
FINANCIAL RISK	/ Identify new developments in waste management and treatment / Understand and track how regulations are changing in the mining industry; identify future liabilities that may arise due to stricter requirements for waste treatment

7.4.1 Case Study

Waste Management Processes at Kathautia Coal Mines, Hindalco, Jharkhand

BACKGROUND:

Hindalco's Kathautia mine has taken several steps to improve the waste management processes. The key focus has been on identifying the different types of waste generated and developing management plan for each category. Waste generated in the mine is categorized as Hazardous waste (includes burnt oil, filter batteries etc.) Non-Hazardous waste (includes overburden and domestic waste) and Biomedical waste (includes syringes, guage, cotton, injection vials and ampoules).

INTERVENTION:

The mine utilizes different management approach for different types of wastes :

/ **Reduction Non-Hazardous waste:** Overburden dumps are used for reclamation and backfilling of mined out area and stabilized using plantations. Domestic waste generated at mine site is stored in pits close to the mine area and is incinerated at regular intervals.

/ **Hazardous waste-** relatively smaller amount of hazardous wastes are generated in the mine which includes burnt oil, filter batteries, etc. The waste generated is stored properly before being sent to authorized recycling agents.

/ **Biomedical waste-** three types of biomedical waste is generated at the mine, plastic, non-plastic and infectious sharp waste. Biomedical wastes are first segregated into color coded bins and transported to local government hospital for further treatment and disposal.

IMPACT / OUTCOME:

Separate waste management plan for different categories has enabled the mine team to better manage waste, thus mitigating any impact on the environment and community.


धुम्रपान निषेध
NO SMOKing
BURNT
OIL SHED

7.4.2 Case Study

Lithium Production from Waste Rock at Boron Mine, Rio Tinto, USA

BACKGROUND:

Rio Tinto has begun production of battery-grade lithium from waste rock at a lithium demonstration plant in California, marking the next step in scaling up a new lithium production process. Developed at the Boron mine site in California, the process will help recover the critical mineral and extract additional value out of waste piles from over 90 years of mining operations.

INTERVENTION:

An initial small-scale trial in 2019 successfully proved the process of roasting and leaching waste rock to recover high grades of lithium. The California demonstration plant has a design capacity of 10 mt/year of battery-grade lithium and will be run throughout 2021 to optimize the process

IMPACT / OUTCOME:

Rio Tinto plans to usw the plant as a feasibility assessment for progressing to a production scale plant with an initial capacity of at least 5,000 mt per year, or enough to make batteries for approximately 70,000 electric vehicles. It will thus serve as an useful example for effective waste utilization from mining operations.

8. EMISSION REDUCTION

OVERVIEW

Mining processes and operations generate a wide range of air pollutants, including micro-pollutants (fugitive dust), meso-pollutants (sulphur oxides, nitrogen oxides, etc.) and macro-pollutants (greenhouse gases); this creates an adverse impact on the environment, biodiversity, and community health. An increased stripping ratio and declining ore grade further increase energy consumption, which in turn leads to higher emissions.

There are three areas of energy consumption in the mining industry: equipment, electricity, and explosives. Each activity contributes significantly to air pollution and the emission of green house gases (GHGs) . The environment is also impacted by deforestation during the mine development phase and the release of methane that occurs during coal extraction. The emission reductions framework (Figure 11) provides an exhaustive approach to managing and reducing mining-related emissions.

FIGURE 11. EMISSIONS REDUCTION FRAMEWORK

EMISSION MANAGEMENT OBJECTIVES

/ Become carbon positive by adopting a low-carbon growth strategy

/ Ensure a healthy and safe environment by balancing the benefits on mining operations with concerns for their environmental and climate change impact

FRAMEWORK AND PATHWAY FOR ACTION

/ GHG emission management

/ Non-GHG emission management

MEASURABLE OUTCOMES – KEY METRICS

/ Specific diesel consumption for the mine

/ Specific electricity consumption for the mine

/ Total GHG emissions from mining activity (in million tons CO_2)

/ Other air emissions from mining activity

/ Percent of energy from renewable sources

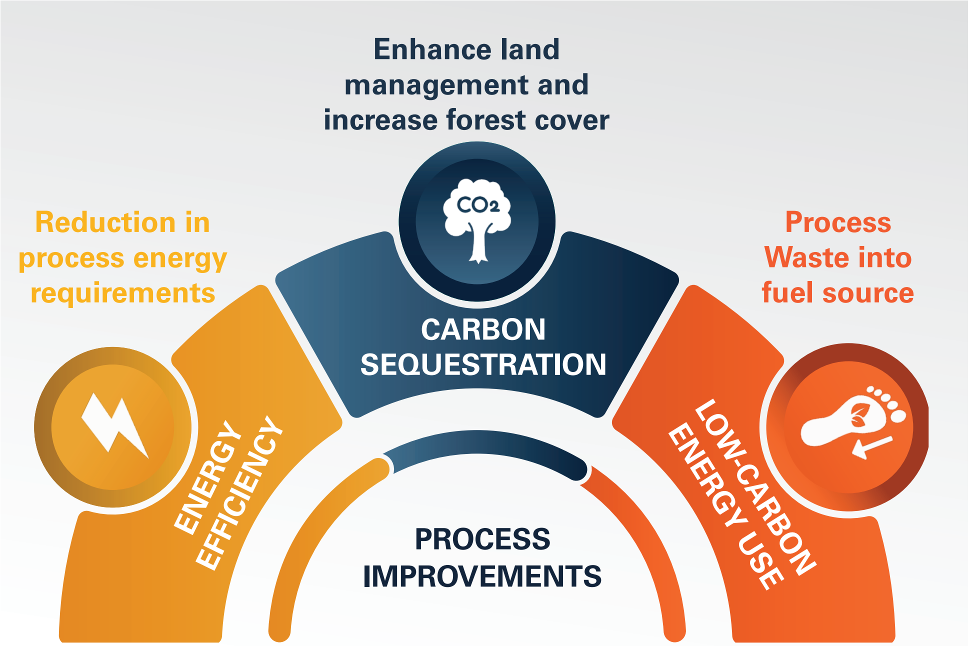
8.1 GHG EMISSIONS REDUCTION

The mining industry is an energy-intensive sector. It consumes large quantities of fossil fuels and electricity, which are the major causes of GHG emissions. Fugitive emissions from coal mining (including of methane) and large-scale deforestation also contribute to climate change. Key steps in the management of GHG emissions include:

- / Using the boundary approach for calculation of GHG emissions
- / Measuring GHG emissions (including Scope 1, Scope 2 and Scope 3)[34]
- / Defining an emissions reduction strategy and setting the target for emissions reduction and offsetting
- / Developing and implementing an action plan for the reduction of emissions (Figure 12)
- / Introducing carbon offsets through the adoption of renewable energy and the development of carbon sequestration infrastructure (Figure 12)
- / Verification and disclosure

The GHG emissions reduction framework portrayed in Figure 12 presents a comprehensive approach to the development of an emissions reduction strategy and the transition to a “carbon positive” organisation.

FIGURE 12. GHG EMISSIONS REDUCTION FRAMEWORK



8.1 GHG EMISSIONS REDUCTION (CONT.)

The GHG emissions reduction framework (United States, Environmental Protection Agency 2005)[35] provides four broad categories for identifying and reducing GHG emissions:

A) IMPROVEMENTS IN ENERGY EFFICIENCY: Improvements in energy efficiency not only reduce GHG emissions but also reduce costs through reductions in overall energy consumption. Energy efficiency measures include (but are not limited to) improvements in the efficiency of industrial energy systems, optimum use of daylight, development and implementation of energy management systems, introduction of energy-efficient buildings, and increased vehicle fuel efficiency.

B) IMPROVEMENTS IN PROCESSES: Process improvement measures focus on the optimisation of existing operations, leading to reductions in the intensity of emissions and the optimisation of material consumption; it includes measures such as technological interventions, lean manufacturing, and waste minimisation.

C) USE OF LOW-CARBON ENERGY: This replaces conventional energy with clean, low-carbon energy in industrial processes. Low-carbon energy includes renewable energy, coal mine methane, and energy generated from waste. Electrical equipment powered by low-carbon or renewable energy may also be used instead of diesel-powered equipment. Adopting the concepts of green logistics, which focuses on minimizing the ecological impact of logictics activity, can further reduce GHG emissions.

D) CARBON SEQUESTRATION: Carbon sequestration measures include the capture and long-term storage of atmospheric carbon dioxide. Carbon sequestration commonly takes the form of afforestation, reforestation, the development of green corridors, and forest conservation. CO2 from carbon capture and sequestration (CCS) units may be used for urea production, concrete curing, and polymer processing.

The implementation of a systemic relationship among these emissions reduction approaches provides new opportunities to reduce GHG emissions:

/ PROCESS ENERGY REDUCTION: Process energy reduction is a collaborative approach to reducing overall energy consumption; it occurs through an amalgamation of process improvements and the implementation of energy efficiency measures.

/ USING PROCESS WASTE AS FUEL: Generating energy from process waste reduces net energy consumption; examples of this are the use of biomass waste to generate energy, or the use of process-generated steam for heating or for other purposes.

/ ENHANCED LAND MANAGEMENT: Enhanced land management ensures minimal disruption of land in the area of the mine during the exploration and operational phases as well as effective post-mining rehabilitation.

8.2 AIR QUALITY MANAGEMENT

Management of air quality in mining primarily centres on reducing fugitive dust from drilling, blasting, crushing, and vehicular movement, and reducing emissions of sulphur oxides (SOx), nitrogen oxides (NOx), and other air pollutants from the burning of fossil fuels. A continuous monitoring and remediation framework is required to mitigate air emissions and restore ambient air quality (AAQ) (Figure 13), and compliance with existing regulations should be exceeded in order to achieve a high level of self regulation:

This framework provides the user with a systematic approach to the continuous monitoring and maintenance of ambient air quality.

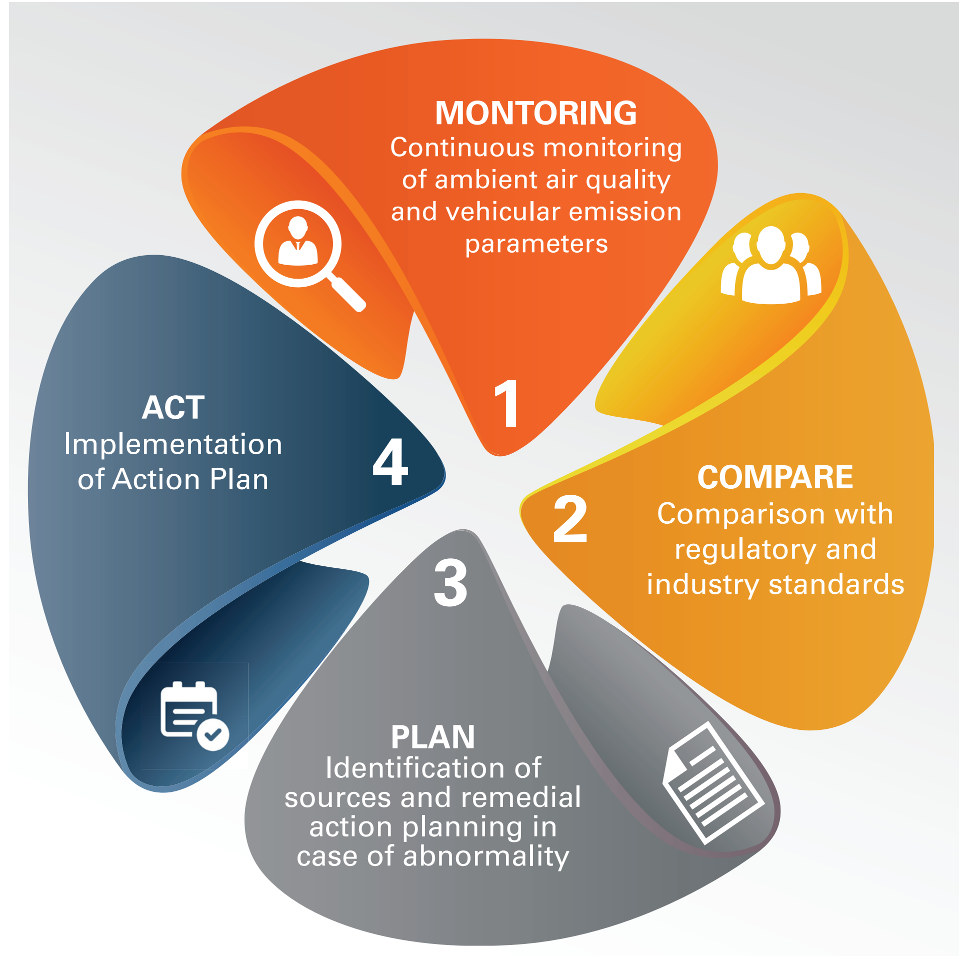
STEP 1: MONITOR AND MEASURE ambient air quality parameters such as particulate matter (PM10 and PM2.5) and sulphur dioxide (SO2), and vehicular emission parameters such as carbon monoxide (CO), hydrocarbons (HC), NOx, etc.

STEP 2: COMPARE the measured emission parameters with regulatory and industry standards and identify any abnormalities.

STEP 3: PLAN for the maintenance of air quality by identifying sources of abnormality and developing corrective actions (such as adoption of the best available technology); examples include increasing the frequency of sprinkling, planning for regular machine overhauling, installing wet drilling systems, using dust extractors in crushers, and using mist spray.

STEP 4: ACT to implement plans to maintain emissions within required limits; once the mitigation measure is implemented, air quality parameters should again be checked to ensure effectiveness and to maintain emissions levels below statutory norms.

FIGURE 13. AIR EMISSIONS REDUCTION FRAMEWORK



8.3 RISK MANAGEMENT IN EMISSIONS REDUCTION

Increasing the focus on greenhouse emissions and their resultant environmental impacts has meant that companies – especially mining companies – have a greater imperative to manage emissions. Not only must regulatory challenges be avoided; financial risks must also be considered, as financial markets and banks increasingly focus on the environmental impact of the companies in which they invest. Mining companies can start by first understanding the different types of emissions from various mining operations and the impacts these have on the ecosystem; they can then identify and implement effective strategies for minimising environmental impacts. New technologies should also be identified, which can help reduce emissions from specific mining operations.

TABLE 12. Risk Identification in Emissions Reduction

Risk	Description	Causes
PHYSICAL RISK	/ Risks related to damage to human health and the environment, caused by direct and indirect emissions from mining activities / Global warming and climate change	/ Improper mapping and poor understanding of the different types of emissions and their impacts on the environment and human health / Lack of measures for managing emissions, especially those that have direct impacts on the environment and human health
REGULATORY RISK	/ Risks related to increasing regulations, leading to potential delays in permits and operational restrictions	/ Non-compliance with regulations / Lack of proper Emissions Reduction systems, leading to higher emissions than regulations allow / Requirement for changes in systems, mining methods, and equipment due to more stringent regulations
STAKEHOLDER RISK	/ Conflict with stakeholders in the ecosystem leading to protests and/or community unrest, which can cause loss of reputation and revoking of the license to operate	/ Damage to human health due to higher emissions / Impact on living conditions in surrounding areas due to higher emissions
FINANCIAL RISK	/ Risk of increased costs due to stricter regulations for Emissions Reduction / Increased costs for mitigation, offsets or financial compensatory actions or obligations, including taxes and royalties	/ High costs of implementing systems that may be required to reduce or control emissions / Increased regulatory scrutiny requiring more investment for Emissions Reduction

8.3.1 RISK MITIGATION STRATEGIES

TABLE 13. Risk Mitigation in Emissions Reduction

Risk	Mitigation Strategies
PHYSICAL RISK	/ Develop internal performance criteria for emissions (including GHGs) in the absence of government regulations or when government regulations are insufficient to ensure protection of the environment and/or community health and livelihoods / Characterise and document ambient air quality and meteorological characteristics to support risk and impact analyses / Identify, characterise, and document all potentially significant air emission sources from the operation, as well as impacts on the environment and/or on community health and livelihoods / Investigate and take appropriate actions when material deviations from impact predictions are identified or when internal performance or compliance criteria are not met
REGULATORY RISK	/ Mitigate exposure to risks arising from current and emerging policy and regulations regarding operational emissions / Develop, maintain, and implement management strategies for all significant air emission sources; demonstrate that – under normal and worst-case operating conditions and in adverse meteorological conditions – emissions from the operation (current or after modification) will not cause violation of either currently applicable criteria or reasonably foreseeable future compliance regulations
STAKEHOLDER RISK	/ Air dispersion modelling can be used to demonstrate that impacts and risks, even conservatively assessed, are negligible and that they have limited or no impact on the environment and/or on community health and livelihoods
FINANCIAL RISK	/ Identify cost-effective and robust carbon offsets to meet emissions reduction regulations and manage reputational risk

8.4.1 Case Study

Emissions Reduction by Adoption of Renewable Energy at Gare Palma Coal Mine, Hindalco, Chhattisgarh

BACKGROUND:

At Gare Palma Mine, Hindalco is transforming its energy mix by increasing the share of renewable energy, thus reducing its carbon footprint. It has installed ground-mounted solar PVs at IV/4 coal mine.

INTERVENTIONS:

Installation of 12,960 solar PV (325 watts each) panels at the IV/4 coal mine

- Installation covers approximately 18 acres of land and has a cumulative capacity of 3 MW AC/4.25 DC
- Solar panels are ground-mounted and are connected with the service room
- The service room monitors the daily production of solar energy

IMPACT / OUTCOME:

This project will generate 6.25 million kWh of electricity per annum and will reduce carbon emissions by 5.12 million kg of CO2 annually.

8.4.2 Case Study

Dust Management System at Mt. Arthur Coal Mines, BHP, Australia

BACKGROUND:

In the Hunter Valley, where Mt Arthur Coal mine is located, dust is an issues given the proximity of large towns nearby, and the proximity to other local dust sources. Further, due to stringent air quality standards, it is imperative that any dust generated through mining at Mt Arthur Coal is rigorously controlled and managed.

INTERVENTIONS:

In 2018 BHP launched a comprehensive Dust Control System (DCS) which has transformed the dust management processes at Mt Arthur mine. The mine can now continually track dust levels through a network of 11 real-time dust and weather monitors that feed into an intelligent real-time data platform. The system triggers an alert when dust levels start to rise in a specific area. It also measures wind direction to automatically calculate the directional source of the dust. If the dust appears to be coming from the mine, there are a series of high-resolution live cameras that can be individually accessed and operated to isolate the cause, so solutions such as watering, machinery or process changes can be implemented.

IMPACT / OUTCOME:

By delivering real-time dust measurement and response capability, the DCS allows mine activity to be managed efficiently while preventing dust levels from exceeding regulatory requirements. The Mt Arthur Coal team uses the system to determine the optimum time for blasting to ensure dust, fume and noise impacts on the local community are minimised. In the six months the DCS has been operational, there has been a significant reduction in dust alerts at the mine, with a 69 percent reduction in the month of December 2019, and zero incremental dust exceedances.

9. BIODIVERSITY MANAGEMENT

OVERVIEW

Earth's biodiversity includes all organisms, species, and populations; it encompasses their genetic variations and their complex assemblages of communities and ecosystems (United Nations Environment Programme 2017).[36] Biodiversity is impacted across all phases of a mine's life cycle, from exploration to closure. Sustainable biodiversity management is a structured approach to avoiding and minimising the impact of mining on the ecosystem.

FIGURE 14. BIODIVERSITY MANAGEMENT FRAMEWORK

BIODIVERSITY MANAGEMENT OBJECTIVES

/ Strive for No-Net-Loss of biodiversity by avoiding, minimizing and if necessary, by offsetting impacts on biodiversity and by restoring mine land to its original state or an improved state after closure

FRAMEWORK AND PATHWAY FOR ACTION

/ Biodiversity baseline assessment

/ Know your ecosystem

/ No-net-loss approach

MEASURABLE OUTCOMES – KEY METRICS

/ Percent improvement in Biodiversity Index

/ No-net-loss

9.1 BIODIVERSITY BASELINE ASSESSMENT

Mining activities impact biodiversity directly, through land clearance, exploration drilling, overburden stripping, tailings impoundment construction, discharge into water bodies, and air emissions. There are also indirect impacts in the form of social and environmental changes; these are often harder to immediately identify. While direct impacts can be addressed through various interventions, indirect impacts need far more comprehensive strategies.

Key challenges pertaining to biodiversity include:

- Degradation of the quality of soil, water, and air
- Reduction in water availability for ecosystem functions
- Loss of native flora and fauna due to loss of natural habitat
- Changes in microclimatic conditions
- Altered landscape aesthetic, reducing the area's recreational and cultural value

Guidelines for a biodiversity baseline survey:
The area's flora and fauna must be documented in advance, and ecosystem services must be implemented from the beginning in order to develop and prioritise restoration measures. Guidelines for generating a baseline survey include:

- Survey the mine lease area and at least a 10 km radius of the surrounding area; the survey should be led by a trained ecologist/biologist who has expertise in ecosystem services
- Identify terrestrial and aquatic habitats
- Identify critical habitats and globally threatened ecosystems/habitats as per
  - Schedule I, and Part II of Schedule II, of Indian Wildlife Protection Act 1972
  - Vulnerable (VN), Endangered (EN) and Critically Endangered (CR) species of the IUCN Red List of species
- Carry out a faunal survey to collect information on butterflies, mammals, birds, reptiles, amphibians, fish, and representative terrestrial and aquatic invertebrates
- Conduct a flora survey to collect information on species richness, abundance, and regeneration, noting the general distribution of trees, shrubs/climbers, herbs, and grasse/ s
- Gather local information from individuals in the community who are working in the domains of agriculture and natural resource harvesting
- Collate secondary data from surveys by governments, non-profits, and private sector agencies
- Collect surveys in all seasons that are relevant for the geography, such as monsoon, post-monsoon, winter, and summer

Data gathered in the baseline can help in designing avoidance, minimisation, restoration, and offset measures. Engagement with the local community and area experts can help ensure the sustainability of the programme. (For more details on stakeholder engagement, see Chapter 12).

9.2 KNOW YOUR ECOSYSTEM

Addressing the challenges related to biodiversity requires an understanding of the ecosystem, including its abiotic (air, water, earth) and biotic (plants and animals) components and their interactions and interdependencies. A variety of ecosystem services can be identified; these can be grouped into four categories – provisioning, regulating, supporting, and cultural services (Table 15).

TABLE 14. Types of Ecosystem Services

PROVISIONING SERVICES	REGULATING SERVICES	SUPPORTING SERVICES	CULTURAL SERVICES
Goods and products obtained from the ecosystem	Services that the ecosystem provides through regulation and/ or control of natural processes	Natural processes that support abiotic and biotic components	Non-material benefits obtained from the ecosystem
Food	Climate regulation	Soil formation	Recreation
Medicines	Disease control	Nutrient cycling	Spiritual values
Minerals	Water-flow regulation	Plant photosynthesis	Aesthetic enjoyment
Timber	Protection from natural hazards		
Freshwater			

Mining-induced modifications of the ecosystem and its biodiversity can alter ecological functions and supporting services, both in terms of magnitude and the stability of ecosystem processes. Maintenance of ecosystem services should therefore be included as an integral part of biodiversity conservation policies.

9.3 NO-NET-LOSS APPROACH

With systems-level planning and stakeholder engagement throughout, the achievement of a biodiversity objective of no-net-loss is possible. A no-net-loss approach recommends avoidance, minimisation, restoration, and offsetting of any negative impact on critical habitats and ecologically sensitive areas (Table 16).

TABLE 15. Achieving No-Net-Loss of Biodiversity[37]

AVOIDANCE	MINIMISATION	RESTORATION	OFFSET
Measures taken to avoid impacts of mining project	Measures to reduce the duration, intensity, and/or extent of unavoidable impacts	Measures to rehabilitate, improve, or restore to their original condition sites or ecosystems that have been degraded by the impacts of the mining operation	Measures to compensate any significant residual impacts that exceed the compensatory conservation efforts provided by offsets
Placement of infrastructure so as to avoid impacts on protected land, critical habitats, or threatened species	Retain areas of undisturbed forest or pasture to provide habitats for species	Use native species for afforestation and reinstate the types of animals that originally inhabited the region	Develop more ponds and parks than are required to restore biodiversity

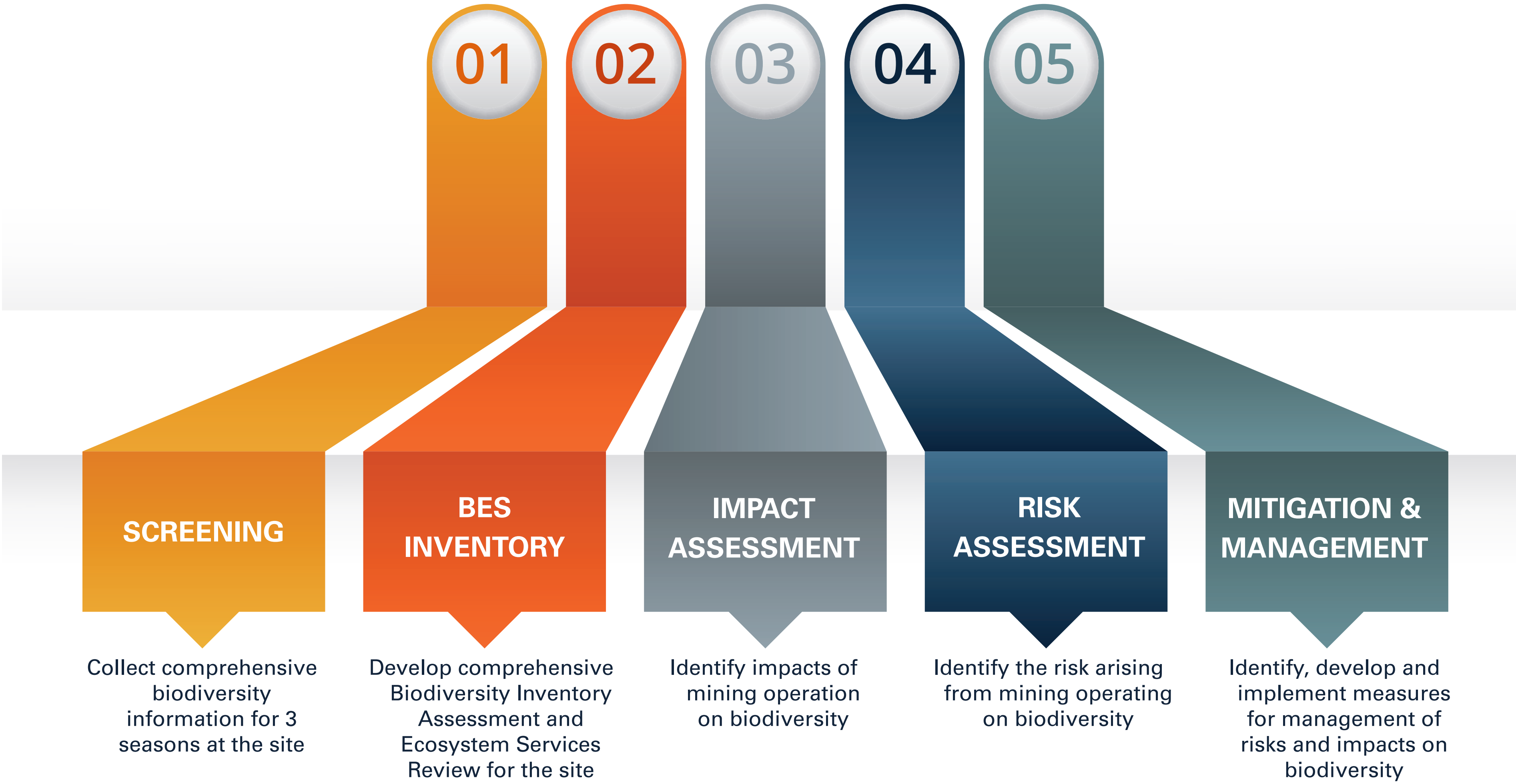
Source: International Union for Conservation of Nature (2012).

Using this approach helps avoid degradation of critical habitats and ecologically sensitive areas and promotes no-net-loss of biodiversity. The application of a mitigation hierarchy seeks to minimise impacts and, in the end, restore land to its original condition; this is further augmented by offset measures which recommend a like-for-like approach to be taken as close as possible to the area of impact. A baseline assessment is used to set a biodiversity index in the area of the mine and in the surrounding (at least 10 km radius) area before operations begin; this baseline is then used to track and implement a no-net-loss approach through the mine's life cycle.

9.4 BIODIVERSITY RISK MANAGEMENT

Achieving the No-Net-Loss biodiversity objective is possible with systems-level planning and stakeholder engagement throughout the process. The stages of biodiversity management process (exhibit 9.4) which need to be adopted by mine site include screening, BES (Biodiversity and Ecosystem Services) inventory, impact assessment, risk assessment, mitigation and management.

TABLE 16. Biodiversity Risk Management Stages



9.5.1 Case Study

Biodiversity Management at Gare Palma Coal Mines, Hindalco, Chhattisgarh

BACKGROUND:

Mining has a lasting impact on Biodiversity owing to the transformations of land accompanying it. A robust Biodiversity Management Plan is therefore required for effective sustainable mining. Hindalco's Gare Plama coal mines, located in Chattisgarh, has piloted a biodiversity management plan to strengthen its biodiversity conservation efforts.

INTERVENTION:

In the Gare Palma mines, a baselines study was conducted by IUCN which spanned over 2 years. The study covered a total of 136 sampling points across an area spanning 5 km radius around the core mines (1388 ha) over 4 seasons each year.

The study identified 8 habitats (grassland, forest, agricultural land, aquatic, etc.) which are home to almost 450 plant and 300 animal species, of which 6 are of special and immediate concern due to their conservation status (IUCN red list or Schedule I).

IUCN also conducted an extensive ecosystem services study. Based on these two inputs, a comprehensive biodiversity management plan has been developed by the mine.

IMPACT / OUTCOME:

The biodiversity plan identifies 8 major recommended activities based on which the short, medium and long term biodiversity goals of GP mines have been defined.

Some initiatives that have been taken up as part of the BMP include, soil amelioration through VAM technique, three tier plantation with native forest species (to secure habitat for the concerned species) and installation of bird nests to facilitate nesting of avifauna. The three tier plantation includes flowering species which act as host plants for butterflies and is an active effort towards butterfly conservation.


HINDALCO
Rock
Garden

9.5.2 Case Study
Reforestation of Former Mine Area, Minhasa Mines, Newmont, Malaysia

BACKGROUND:
In 2011, after planting hundreds of thousands of trees on a former mine site in Southeast Minahasa, PT Newmont Minahasa Raya (PTNMR), Newmont's Indonesian subsidiary, delivered 443 hectares (1,095 acres) of revegetated land to the Government of Indonesia. Today, the area is a thriving forest of mahogany, teak, nyatoh and sengon trees, and the future site of Indonesia's newest botanical garden.

INTERVENTION:
Reforestation of the former PTNMR mine area, as well as several other initiatives to improve the long-term environmental, social and economic landscape of Southeast Minahasa, demonstrates how responsible mining and closure can result in long-term benefits to local communities. The reforestation strategy was incorporated into PTNMR's closure plan and Sustainable Development Program very early in the mine's lifecycle. Over time, it evolved to include working with the Ministry of Forestry to designate 221 hectares (546 acres) of the forest as a botanical garden.

IMPACT / OUTCOME:
Both the reclaimed forest and botanical garden have the potential to create positive economic and environmental conditions for local inhabitants. In addition, the site's botanical garden designation ensures the habitats of hundreds of species of plants, birds, insects and other animals will be protected. The reclaimed forest also has become a model for carbon absorption – the first of its kind in Indonesia. And because of their rich biodiversity, the forest and garden are expected to serve as an outdoor classroom and laboratory for environmental research and education.

10. HEALTH AND SAFETY

OVERVIEW

Health and safety risks in mining primarily include fatalities, physical injuries, musculoskeletal disorders, noise-induced health impacts, respiratory diseases, and lifestyle diseases. With a dearth of adequate medical infrastructure, and poor health and hygiene awareness, communities are also susceptible to various health risks such as vector-borne diseases, communicable and non-communicable diseases, and poor maternal health. It is therefore imperative that mine management understand the prevalent health risks and identify every opportunity to mitigate these risks and enhance health, safety, and the well-being of employees and members of the community.

These health and safety risks are spread across all phases of a mine's life cycle, from development to mine closure. Mining companies are required to take all possible measures to eradicate workplace injuries and fatalities and to institute and maintain effective and efficient health and safety management systems. Figure 18 provides a comprehensive risk management based approach to identifying and mitigating safety risks.

FIGURE 15. HEALTH AND SAFETY FRAMEWORK

HEALTH AND SAFETY OBJECTIVES

/ Achieve 'zero harm' through institutionalising systems, controls, and standards

/ Ensure safe environment for mine workers and communities with focus on employee well-being

FRAMEWORK AND PATHWAY FOR ACTION

/ Health and safety risk management

/ Technology adoption

/ Employee and community engagement

MEASURABLE OUTCOMES – KEY METRICS

/ Percent reduction in incidents within and outside the mine boundary

/ Reduction in Lost time injury frequency rate (LTIFR) and Lost time injury severity rate (LTISR)

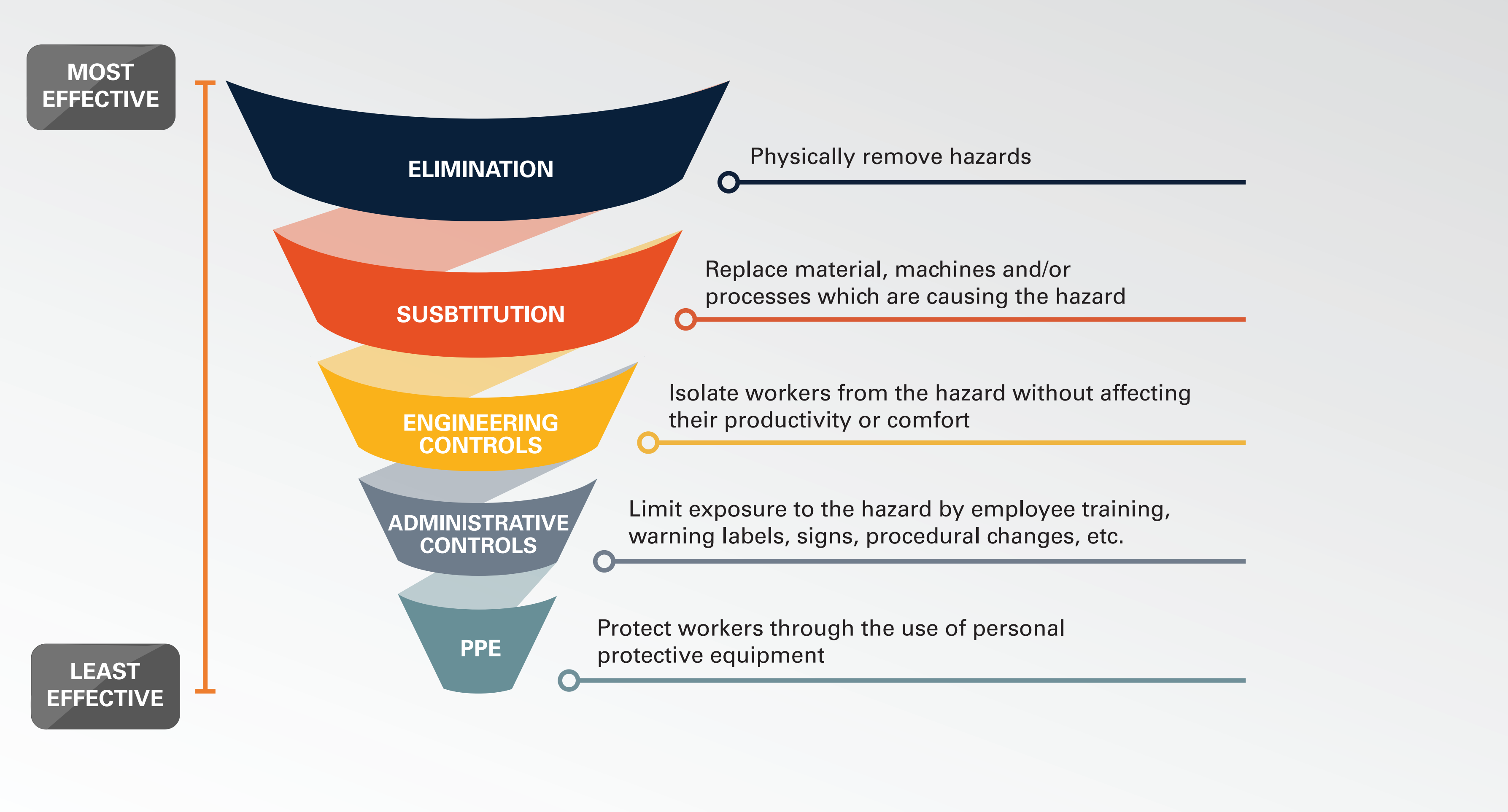
10.1 HEALTH AND SAFETY RISK MANAGEMENT

The Directorate General of Mines Safety administers the health and safety of mines across India; it has provided comprehensive regulations and guidelines for ensuring the safety of mine workers and mining operations. The occurrence of frequent accidents around mine sites, however, highlights the need to focus on the safety of non-mine workers as well as that of nearby communities. Mining activities impact communities during their operations and can continue to pose a threat even after mine closure. Risk management at mine sites needs to be addressed at a local level through identification, prioritisation, and management of safety risks (Figure 19).

In order to implement an effective health and safety management system, it is imperative to prioritise training in health and safety and the implementation of risk control measures. The National Institute for Occupational Safety and Health (NIOSH 2015)'s hierarchy of control[38] framework (Figure 20) provides a prioritisation matrix for selection of interventions according to their effectiveness.

FIGURE 16. HEALTH AND SAFETY RISK MANAGEMENT FRAMEWORK

FIGURE 17. NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH) HIERARCHY OF CONTROL FRAMEWORK[38]



10.1.1 Key health and safety risks at mine sites and potential interventions

1 PHYSICAL RISKS

These include risks caused by mining activities or gaps in infrastructure, including:

- Road accidents owing to poor road conditions, driving habits, traffic control, and condition of vehicles, as well as overloading and lack of parking and maintenance points
- Damage or failure of infrastructure, such as a landslides from an overburden dump, tailings dam failure, etc.
- Ergonomic hazards and musculoskeletal disorders due to working in confined spaces, engaging in repetitive motion, fixed postures, etc.
- Respiratory diseases due to exposure to dust caused by vehicular movement
- Noise-induced health risks such as hearing loss
- Accidents occurring in the course of unauthorised access to, or trespassing on, mining sites
- Ground vibrations and flying rocks due to poor blasting plans or inadequate precautionary measures
- Methane explosions in underground coal mines because of inadequate ventilation
- Coal dust explosions in underground coal mines due to inadequate coal dust treatment and suppression
- Flooding in underground or open cast mines resulting in fatalities
- Fatalities due to subsidence of earth in old mining areas
- Casualties occurring in the course of illegal mining/theft of coal or minerals from operational or abandoned mines

POTENTIAL INTERVENTIONS TO ADDRESS PHYSICAL RISKS

ELIMINATION

- Improve planning for interventions such as roads and railway lines before mining operations begin
- Ensure adequate mine operation planning to mitigate future risks and hazards
- Ensure that design, construction, operation, and decommissioning of all buildings is in accordance with building codes, fire regulations, legal/ insurance requirements, and internationally accepted Life and Fire Safety standards

SUBSTITUTION

- Monitor and maintain infrastructure using automated systems which can also send alerts in case of malfunction

10.1.1 Key health and safety risks at mine sites and potential interventions (CONT.)

POTENTIAL INTERVENTIONS TO ADDRESS PHYSICAL RISKS (CONT)

ENGINEERING CONTROLS

- Institute effective tailings dam management, if applicable
- Plan and implement well-designed dedicated freight corridors in mining clusters
- Design transport vehicles to eliminate spillage and overloading
- Rehabilitate mined-out areas and implement measures to reduce/mitigate the possibility of accidents

ADMINISTRATIVE CONTROLS

- For all operations, prepare and implement a safety management plan based on risk analysis
- Prepare and implement an emergency response plan
- Deploy electric vehicles in mining operations to minimise vehicular pollution and adopt stringent emissions regulations for motor vehicles plying in mine areas
- Conduct driver training programmes focused on improved driving skills, adherence to traffic regulation, and maintenance of vehicles; clearly demarcate roads for heavy vehicles and light commercial vehicles
- Manage traffic safety to reduce the risk of accidents
- Manage the safety and security of the mine site to prevent unauthorised access
- Conduct frequent training of employees on standard operating procedures in order to improve work habits
- Implement site-specific arrangement and management of first aid, emergency medical response, and emergency medical care
- Facilitate access to adequate insurance for damages to the health and life of stakeholders
- Conduct regular medical examinations of employees and members of the local community
- Coordinate and collaborate with the local administration, National Disaster Management Team, State Disaster Management Team, Rescue Station, etc.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Use standard PPEs and conduct training on standard operating procedures and safety; conduct periodic health and safety audits
- Install an adequate number of first aid kits at mine sites

10.1.1 Key health and safety risks at mine sites and potential interventions (CONT.)

2 CHEMICAL RISKS

These include risks due to pollution and hazardous working environments, including:

- Health impacts due to exposure to hazardous substances such as dust, gases, blasting fumes, radioactive elements, etc.
- Skin problems and disorders from contact with chemicals such as alkalis, acids, fuels, solvents, lubricants, etc. (International Council on Mining & Metals. 2021)[39]
- Contamination of surface water and other water reservoirs due to seepage of untreated water; reduced availability of potable water; exposure to waterborne diseases
- Improper monsoon preparation, which may lead to rainwater going through active mining areas and contaminating the natural water course
- Air pollution caused by blasting operations

POTENTIAL INTERVENTIONS TO ADDRESS CHEMICAL RISKS
ELIMINATION: / Implement a proper monsoon preparation plan before the onset of monsoon rains and direct rainwater drainage back to its natural course via settling ponds
SUBSTITUTION / Deploy electric vehicles in mining operations in order to minimise vehicular pollution; adopt stringent emissions regulations for motor vehicles plying in mine areas / Identify and deploy technological solutions for precision blasting/controlled explosions / Substitute material or processes which generate hazardous residues/wastes with other cleaner materials or processes
ENGINEERING CONTROLS / Install an effective dust suppression system / Effectively treat mine seepage water; implement water quality testing and monitoring / Install sensors in selected community locations to detect heavy elements and/or radioactive material in water and soil
ADMINISTRATIVE CONTROLS / Develop an inventory of chemicals used in the mine's operation, including quantities, potential impacts, and interventions required in case of accidents or emergencies / Impart training to all stakeholders on chemical disaster handling and management both at on-site and off-site locations / Handle, store, and transport hazardous material as per industrial best practices
PERSONAL PROTECTIVE EQUIPMENT (PPE): / Use standard PPEs during handling of chemicals

10.1.1 Key health and safety risks at mine sites and potential interventions (CONT.)

3 BIOLOGICAL RISKS

These include risks to the health and well-being of communities and employees, including:

- Limited awareness of sanitation and hygiene practices such as maternal health, malnutrition, menstrual hygiene, etc.
- Depression, anxiety, and post-traumatic stress disorder (PTSD) in communities due to sudden changes in their surroundings and, in some cases, due to loss of livelihoods and displacement
- Susceptibility to vector-borne communicable and non-communicable diseases because of inadequate health infrastructure
- Susceptibility of employees and communities to lifestyle diseases such as hypertension, heart disease, etc.
- Prolonged exposure to mining areas that are polluted with radioactive elements; this may result in genetic mutations that cause abnormalities in newborn children
- Absence of properly staffed centres for conducting Initial Medical Examinations (IMEs) and Periodic Medical Examinations (PMEs)

POTENTIAL INTERVENTIONS TO ADDRESS BIOLOGICAL RISKS
ELIMINATION: / Provide livelihood opportunities to community members to mitigate adverse health impacts that are due to livelihood loss and displacement / Eliminate breeding grounds for mosquitoes, insects, vermin, and other pests
SUBSTITUTION / Install community water purifiers and/or supply piped water to communities in order to minimise usage of untreated surface water, borewell water, etc.
ENGINEERING CONTROLS / Strengthen and support health infrastructure in communities / Implement the Water, Sanitation and Hygiene (WASH) Pledge in the mine area and surrounding areas / Set up properly equipped and staffed medical centres for carrying out IMEs and PMEs

10.1.1 Key health and safety risks at mine sites and potential interventions (CONT.)

POTENTIAL INTERVENTIONS TO ADDRESS BIOLOGICAL RISKS (CONT.)

ADMINISTRATIVE CONTROLS

- Improve awareness about health, hygiene, and sanitation practices among employees and within communities
- Provide hygiene material such as soap, hand towels/napkins, hand dryers, litterbins, and sanitary disposal kits, as necessary
- Monitor water quality and maintain it as per internationally recognised standards for drinking water
- Ensure provision of a septic tank or access to a sewage treatment plant for adequate disposal of sewage
- Design and implement community health programmes; organise health camps to ensure regular check-ups
- Identify opportunities for alignment and collaboration with government, NGOs, and other organisations in the implementation of community health programmes

PERSONAL PROTECTIVE EQUIPMENT (PPE): / Provide PPEs such as dust masks, ear plugs, and eye protectors to the community

10.2 TECHNOLOGY ADOPTION

Technology works as an enabler for an effective safety management system, reducing potential harm to employees and communities. Interventions that can be deployed at mine sites include:

- **Safety Management System (SMS):** These are targeted at managing risks within mining operations. They include the use of specific tools for injury prevention, and involve pre-task hazard assessments and process safety risk management. Control plans, audit plans, and work plans should be created in alignment with the safety management system.
- **Automation of weighbridge:** Radio frequency identification (RFID)-based weighbridges, peripheral sensors, and control equipment can be deployed for safety and traffic management at mine sites and railway sidings.
- **Drones for monitoring:** Manual monitoring can be replaced with drone-based monitoring in hazardous locations.
- **Simulator training:** Simulators can be used to create safe, real-life training to upskill dumper, payloader, and excavator operators for day-to-day operations and emergency situations.
- **Artificial Intelligence:** Use of AI in accident prediction, SOP sequencing, PPE adherence, manpower tracking, remote health monitoring, etc.

Collaborations with startups, government research institutions, and R&D centres to identify and adopt new innovations and enhance technical capabilities can also be explored. (See Chapter 13 for further details on technology selection and adoption)

10.3 EMPLOYEE AND COMMUNITY ENGAGEMENT

Employee and community engagement processes must include consultation with, and participation by, employees and members of the community in the design, implementation, monitoring, and communication of health and safety programmes. This can be achieved through the following measures:

- Participation of employees and community members in health and safety meetings
- Constitution of health committees which include employees and community representatives
- Mass communication meetings and awareness sessions
- Training and awareness sessions on health, safety, and hygiene
- Health camps

10.4.1 Case Study

Safety Commando Concept at Hindalco

BACKGROUND:

Hindalco has adopted the Safety Commando concept which has been developed according to Indian Army norms and implemented in the mining industry. As part of this programme, workers are trained in handling and remedying emergency situations. Safety Commandos are trained in:

- Rapid action
- Advance assessment of risks and hazards
- Rapid action during an emergency
- Rescue and recovery
- Tackling any underground mining emergency

INTERVENTION:

Selection of commandos is a four-step process that includes a physical fitness assessment, training in the National Examination Board in Occupational Safety and Health (NEBOSH)/Safety Committee, first aid training, and training in Behaviour Based Safety (BBS). Once the candidate is selected for the commando role, the following four phases of training are imparted.

FIGURE 18. IMPLEMENTATION OF A MINE SAFETY CHAIN OF COMMAND

IMPACT / OUTCOME:

Safety commandos are identified by the Safety Commando logo on their helmet, reflective jackets, and t-shirts with badges. Commandos are part of all teams within the mine and embody leadership characteristics combined with a proactive attitude towards safety. The presence of Safety Commandos enhances the efficacy of emergency preparedness and reduces response time.

FIGURE 19. TRAINING OF SAFETY COMANDOES


ADITYA BIRLA
HINDALCO
जागरूकता कार्यक्रम
ADITYA BIRLA
HINDALCO
कोरोना वायरस का खतरा घटायें, यह महत्वपूर्ण सावधानियाँ अपनायें
तिरस्कार नहीं
स्वीकार करें ।
अस्वस्थ लोगों एवं उनके परिवार का तिरस्कार ना करें ।
मरीजों और उनके परिवार के सदस्यों का सहयोग करें ।
कोविड–19 से ठीक हुए मरीजों का मनोबल बढ़ायें ।

10.4.2 Case Study

Community Wellbeing Program, Olympic Dam Mine, BHP, Australia

BACKGROUND:

BHP Olympic Dam's vision is to 'contribute to a sustainable and resilient workforce and communities by supporting healthy lifestyles in both a physical and mental capacity and across all ages'.Roxby Downs, a remote South Australian mining town nearly 600 kilometres north of Adelaide, supports BHP's Olympic Dam operation. BHP-driven social research, along with the community itself, has identified health and wellbeing as a priority, with the need to address physical health risk factors and to support social wellbeing, especially for residents living remotely from their extended family and support networks.

INTERVENTION:

Strated in 2015 ,the Time for Wellbeing Community Health Partnership, is a collaborative initiative of BHP, the Roxby Health Forum and Healthy Environs. The program recognises the challenges of living and working remotely and aims to deliver community-wide health outcomes for Roxby Downs and nearby towns and focuses on three priority pillars: Early childhood development; Mental wellbeing; and Physical health.The programs adopts a model of community collaboration and takes a broad approach to promoting community health through healthy places, healthy lifestyle education and promoting the health support services available.

IMPACT/ OUTCOME:

By 2018, the initiative had achieved a range of outcomes across the three partnership pillars:

- **Early childhood development** – Education partners in the region are establishing kitchen gardens and teaching students about positive food habits
- **Mental wellbeing** – The partnership has supported the Rock and Water self-awareness and social functioning program for 170 students in Roxby Downs, while local community members have participated in mental health awareness training through the Rural and Remote Mental Health Service
- **Physical health** – The initiative has focused on educating local communities about healthy food preparation methods and promoting physical activity.

11. LOCAL ECONOMIC DEVELOPMENT

OVERVIEW

Activities across the mine's life cycle, from exploration to closure, typically occur in a social ecosystem inhabited by indigenous communities. Mining companies can have a positive impact on adjacent communities, but they can also cause harm if the engagement with the local community is not based on its needs and on mutual trust and respect.

The ICMM Community Development Toolkit (International Union for Conservation of Nature 2012)[39] defines community development as the process of increasing the strength and effectiveness of communities, improving people's quality of life, and enabling community participation in decision-making in order to achieve greater long-term control over their lives. The quality of life of tribal communities in India is deeply

FIGURE 20. LOCAL ECONOMIC DEVELOPMENT FRAMEWORK

LOCAL ECONOMIC DEVELOPMENT OBJECTIVES

/ Develop an integrated, equitable and sustainable growth model that creates synergistic and symbiotic socio-economic value for the community

FRAMEWORK AND PATHWAY FOR ACTION

/ Building trust through community engagement

/ Integrated development strategy

/ End-to-end programme design approac

MEASURABLE OUTCOMES – KEY METRICS

/ Numbers of offsite jobs created/ supported

/ Expenditure in infrastructure development projects

/ Percent improvement in indicators such as education (enrollment, attendance, passing percentage, school dropout rate, girl child education), health (MMR, IMR, nutrition, disease outbreak instances), livelihood (employment rate, youth with vocational skills, new jobs created), etc.

OVERVIEW (CONT.)

affected by their shared values; consideration of these values must thus be incorporated into the development of community assets and sustainable livelihood opportunities and must underlie forms of improved access to basic amenities and services. In ensuring community development, two strategic areas need to be focused on (Figure 15):

/ LOCAL ECONOMIC DEVELOPMENT MODELS: Sustainable models of community development should focus on areas such as livelihood, education, health, sanitation and hygiene, skill-building, local infrastructure, and basic amenities for sustainable development.

/ COMMUNITY ENGAGEMENT MODELS: An integrated model of stakeholder engagement should be developed in order to build confidence, trust, and social equity within the community.

Each community has its own sociocultural and economic characteristics, any of which may be impacted by mining activities. Potential direct and indirect impacts need to be studied in detail and strategies need to be developed accordingly.

Concerns pertaining to mining-affected communities include:

/ Relocation and rehabilitation of project-affected people

/ Loss of livelihood due to change in land use patterns such as loss of agriculture, reduction in grazing land for cattle, loss of pisciculture, and loss of access to forest-based products

/ Loss of traditional skills and livelihood opportunities due to changes in the products and services traditionally used by communities

/ Overdependence on the mining company for livelihood support

/ Aversion to change which can limit the economic growth of the community

/ Lack of the infrastructure necessary for community development

11.1 BUILDING TRUST THROUGH COMMUNITY ENGAGEMENT

The success of local economic development interventions will depend on the nature of the engagement with key stakeholders. Building trust with the community is critical for achieving positive outcomes. Trust can be developed by addressing short-term needs; it can also be enhanced through designing and implementing long-term programmes to address issues in livelihood, education, healthcare, infrastructure, and skills development. Effective long-term programmes can be developed through partnerships between local governments and communities, private businesses, and philanthropic or non-profit institutions.

Actions that can help build trust within the community include:

/ Identifying gatekeepers and key stakeholders who can help in understanding and addressing the community's short-term and long-term concerns;

/ Helping enroll community members in government schemes through registration as Aadhar card holders; catalysing the implementation of government welfare schemes such as Mahatma Gandhi National Rural Employment Guarantee Act

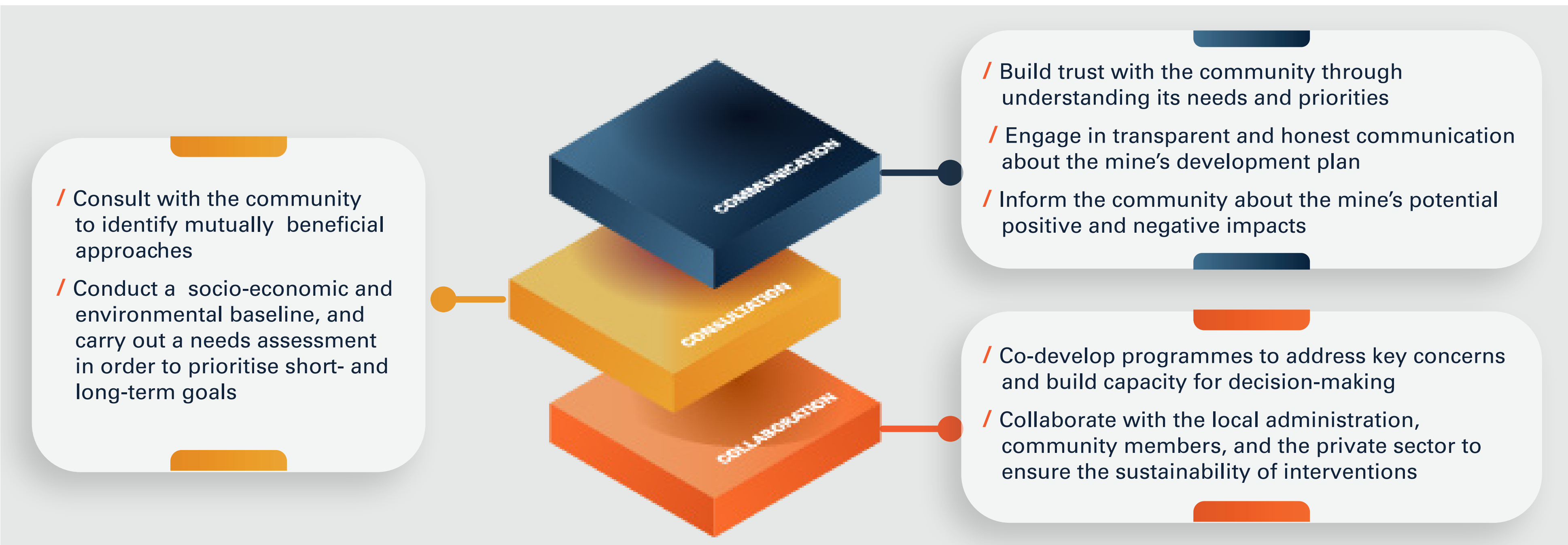
11.1 BUILDING TRUST THROUGH COMMUNITY (CONT.)

(MGNREGA), as well as helping in the enrollment in insurance and healthcare schemes and eligibility for educational scholarships, housing, electricity, water, cooking gas, and agriculture subsidies;

- Establishing a platform for periodic open dialogues and engaging actively in the gathering of insights on current issues, plans for development, and feedback on interventions;
- Ensuring contractual trust (trust in a contract), communication trust (consistent and meaningful communication that avoids misleading information), and competency trust (trust that new jobs with the company will be accompanied by training in new skills and that request for input will be responded to);
- Ensure that a Relocation and Rehabilitation (R&R) assessment and an Environmental and Social Impact Assessment (ESIA) are done in a transparent manner and comply with the regulations and standards of the local administration.

Proactive engagement with all stakeholders is key to building community trust. The community must participate in decision-making throughout the mine's life cycle and beyond. Effective community engagement involves the 3Cs strategy of communication, consultation, and collaboration (Figure 16).

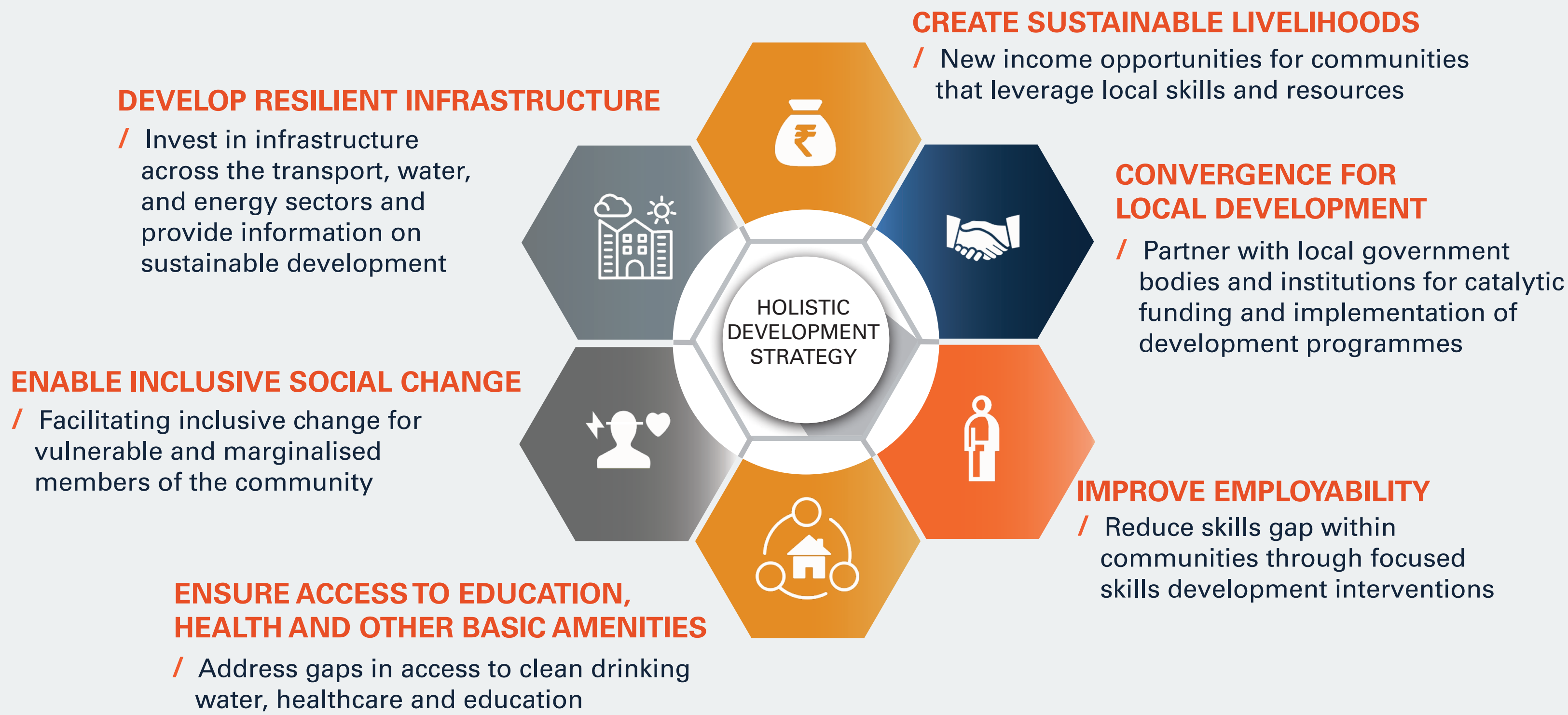
FIGURE 21. 3C STRATEGY FOR COMMUNITY ENGAGEMENT



11.2 INTEGRATED DEVELOPMENT STRATEGY

An integrated approach to local economic development for a sustainable future requires the development of programmes that can support livelihood generation, enhance employability of local youth, and develop infrastructure; programmes should help improve access to basic amenities such as education (formative education, sports, etc.), health (family health and hygiene, reduction in maternal mortality rate, infant mortality rate, etc.), water (domestic, agriculture and other purposes), and they should be carried out in partnership with local administrations to enhance their long-term sustainability (Figure 17).

FIGURE 22. INTEGRATED DEVELOPMENT STRATEGY FOR MINING COMMUNITIES



11.2 INTEGRATED DEVELOPMENT STRATEGY (Cont.)

An indicative list of interventions is given below.

1. CREATING SUSTAINABLE LIVELIHOODS

- Supporting farm and non-farm livelihoods which may include horticulture, vegetable growing, livestock rearing, pisciculture, and apiculture
- Restoring livelihoods based on non-timber forest products (NTFPs), or creating alternate opportunities
- Supporting small businesses through training, infrastructure, and funding

2. CONVERGENCE FOR LOCAL DEVELOPMENT

- Identifying key stakeholders and engaging them in a common platform for sharing each other's concerns
- Pooling financial resources, skills, knowledge, and manpower for implementation
- Working together to unlock and avail of government and private sector funds for the development of the community, including the District Mineral Fund, government schemes, and support programmes

3. IMPROVING EMPLOYABILITY

- Develop skills for locally accessible and aspirational trades to fill current and future industrial demand
- Developing entrepreneurship and supporting incubation of youth in farm, off-farm, and non-agriculture livelihoods; establishing a local sourcing preference for the contractual services that are required by the mining company

4. ENSURING ACCESS TO EDUCATION, HEALTH, AND OTHER BASIC AMENITIES

- Supporting the local public health centre, ambulance, and mobile check-up van; addressing issues of infant mortality, maternal mortality, women's hygiene, etc.
- In convergence with government schemes, supporting education through enhanced staffing in schools, creation of scholarships, establishment of bridge programmes and adult literacy training, establishing or supporting local libraries, etc.

5. ENABLING INCLUSIVE SOCIAL CHANGE

- Facilitating inclusive change for vulnerable and marginalised members of the community
- Creating behavioural change through awareness programmes and capacity building for all development interventions
- Making special provisions for financial aid for old, sick, disabled, and other vulnerable individuals
- Improving financial literacy for better use and planning of funds by the community; facilitating access to different financial instruments

6. DEVELOPING RESILIENT INFRASTRUCTURE

- Developing regional public–private platforms to plan and monitor development of necessary infrastructure
- Develop essential infrastructure for services such as transportation, water, electricity, communication, banking, courier, etc.

11.3 END-TO-END PROGRAMME DESIGN APPROACH

Local economic development programmes must be inclusive and sustainable, and must achieve a long-term positive impact; this requires a thorough understanding of the community's needs, local resources, and key challenges. Table 17 lists the key stages and interventions that are required to develop and implement effective local economic development intervention programmes.

TABLE 17. Programme Design Stages and Activities

Stage	Key Interventions	Expected Outcome
STAKEHOLDER ENGAGEMENT AND CONSULTATION	/ Identify and engage with key stakeholders - community members, gatekeepers, local influencers, local administration, politicians, activists, and NGOs / Identify the community requirements	/ Initiation of engagement and consultation with community members to build trust / Identification of interventions based on the requirements of the community
BASELINE, COMMUNITY RESOURCE MAPPING, AND NEEDS ASSESSMENT	/ Assess a socio-economic baseline, map community resources, and conduct needs assessment	/ Establishment of socio-economic status and demographic profiles which include educational status, health status, occupational details, poverty incidence, human development attainment, etc. / Identification of potential livelihood opportunities such as farm and off-farm interventions or non-farming interventions / Assessment of available resources such as natural assets, community institutions (for example, self-help groups), physical infrastructure (schools), human capital (skilled labour) and economic status (wage rates) / Designing of capacity-development interventions after assessing the existing community skill sets, and gaps therein

11.3 END-TO-END PROGRAMME DESIGN APPROACH (CONT.)

	KEY INTERVENTIONS	EXPECTED OUTCOME
STRATEGIC PLANNING, INTERVENTIONS DESIGN, AND IMPLEMENTATION	/ Identify areas of short- and long-term interventions that meet the priorities of key stakeholders / Collaborate with the local administration, the community, and the technical agency on implementation	/ Co-development of the strategy with the community and the mining company to ensure the sustainability of the design and implementation of interventions / Introduction of design interventions in areas such as agriculture, livestock, non-farm enterprises, healthcare, education, nutrition, skills development, water, etc. / Building of partnerships to ensure the convergence and participation of the community, technical experts, and implementation agency / Building of awareness for positive change and inclusive growth / Building capacity of stakeholders for synergetic, symbiotic, and sustainable implementation of interventions / Constitution of the required governance mechanism to ensure transparent and ethical conduct by stakeholders
MONITORING AND COURSE CORRECTION	/ Develop a monitoring and review framework / Introduce course corrections as required to achieve desired objectives	/ Assessment of progress and performance against planned milestones for each intervention / Strategy redesign as per requirement, in case course correction is recommended
IMPACT ASSESSMENT AND REPORTING	/ Assess socio-economic and environmental indicators as per project design	/ Assessment of effectiveness of each intervention on various parameters such as inclusiveness, convergence, efficiency, impact, governance, sustainability, etc. / Reporting of project performance to various stakeholders

11.4.1 Case Study

Rejuvenation of Kosa Silk Artform, Gare Palma Coal Mines, Hindalco, Chhattisgarh

BACKGROUND:

Kosa (Tussar) Silk rearing, reeling and weaving is a traditional art form practiced by local communities in and around Hindalco's mining areas in Gare Palma, Raigarh, Chhattisgarh. However, certain endemic challenges such as lack of awareness of this art form among urban consumers, lack of market linkages, lack of innovative and modern designs exist. These are forcing the local artisans to move away from this art-form thereby endangering its existence.

Though focused interventions, there exists significant potential to create sustainable livelihood opportunities for the local community and enhance their resilience and prosperity by rejuvenating the Kosa silk value chain and realising the full potential of 'Kosa Silk' in domestic and international markets.

INTERVENTIONS:

A social enterprise 'Kosala and Social Foundation' has been setup in FY21, which will interact and transact with the community members on one hand and the marketing partners and governmental agencies on the other. With the objective of improving this cluster awareness and creating long term value for the local communities, several interventions will be executed by the enterprise along the following dimensions:

- Marrying old age techniques prevalent in the cluster with contemporary designs to create beautiful products that are globally appealing
- Integration of the entire value chain from cocoon farming, reeling to weaving so as to assure supply and ensure control over product quality
- Establish market channels to improve product penetration, while working with marketing partners to increase the Kosa cluster awareness
- Capacity building of the artisans in the areas of financial literacy and digital know-how, so as to make them self-sufficient in the long run

IMPACT / OUTCOME:

The initiative will help the local communities in multiple ways by:

- Establishing a thriving eco-system encompassing the entire value chain (cocoon farmers, reelers, weavers, ancillary activities to weaving)
- Creating sustained livelihood opportunities for ~800 weavers and alternative livelihood opportunities or 750 weavers by FY26
- Providing a model for sustainable livelihood generation in this cluster, which can be further replicated across other mining locations and for different art form

The initiative has already started creating impact through:

- Establishing 2 new reeling training centres , where 36 women have already been trained till March 2021
- Providing critical support to the weaver community through a festive campaign, under which 20 weaver households were engaged for 2 months generating an average income of Rs 23,000 per household


HINDALCO

11.4.2 Case Study
Indigenous Development Programs, BHP, Australia

BACKGROUND:
A successful Indigenous Development Program (IDP), run since FY2015, has helped BHP Minerals Australia progress its goal of developing Indigenous employees for leadership roles.

INTERVENTIONS:
The program targeted Indigenous employees in entry-level roles. In addition to addressing the opportunities raised through the research, the program helped participants develop or enhance skills in communication, emotional intelligence, project management and business acumen.

IMPACT / OUTCOME:
The program has created career pathways for Aboriginal and Torres Strait Islander employees to move into new roles, including leadership roles, across BHP.

It has proven to be a success; 49 per cent of employees who have completed the program have moved into new roles, and 20 per cent have been promoted into leadership roles.

Part III /

GOVERNANCE EXCELLENCE

- GOVERNANCE ORGANISATION
- SUSTAINABILITY SCORECARD
- REPORTING

Part III / GOVERNANCE EXCELLENCE

12. GOVERNANCE EXCELLENCE

OVERVIEW

This chapter focuses on providing mining companies with approaches to the development of a sound governance mechanism to support the ideation and implementation of sustainable mining initiatives. Setting up a good governance mechanism enhances efficiency, participation, transparency, accountability, and continuous improvement; it also provides a structured framework for aligning sustainability with business strategy.

GOVERNANCE TOOK KIT // The toolkit offers the following approaches:

- **12.1** Governance organisation
- **12.2** Sustainability scorecard and maturity index
- **12.3** Reporting

12.1 GOVERNANCE ORGANISATION

A robust and integrated organisational structure consisting of cross-functional teams can enable an organisation to implement sustainable mining strategies across various focus areas, and to manage goals, set targets, and monitor progress.

Table 18 proposes a three-tiered organisational structure for effective governance of sustainable mining initiatives at the company level.

The governance organisation operates at three levels

1. APEX-LEVEL: The role of an apex-level committee is to raise the awareness of the apex committee members about sustainable mining practices and its importance, and to demonstrate the highest level of commitment to sustainability practices. It also plays an instrumental role in monitoring the performance of sustainable mining projects.
2. CORPORATE-LEVEL: The corporate-level committee provides oversight and strategic guidance to site-level committees on the implementation of sustainable mining practices. It also promotes the sustainability culture throughout the organisation. The team is headed by the Business Head of the organisation. The team consists of Mineral Head, Head of Mine Planning and Operations, Chief Sustainability Officer, CSR Head, Sustainability Head (M&M), Health and Safety Head and Head Legal and Compliance.
3. CLUSTER/MINE-LEVEL: The site-level committee is headed by Mineral Head. It is instrumental in the planning and implementation of different initiatives and the monitoring of day-to-day activities. It identifies opportunities and development areas, develops the project plan, defines key performance indicators (KPIs), onboards implementation partners, measures and monitors performance, and reports to the corporate committee.

12.1 GOVERNANCE ORGANISATION (CONT.)

In addition to the three levels of governance, companies may have a pool of subject matter experts who have domain expertise across the seven focus areas, and who act as an advisory committee. Their areas of expertise may include sustainable land use, waste management, water stewardship, emissions reduction, biodiversity management, local economic development, and health and safety.

TABLE 18. Governance Organisation

Committee	Role	Composition
APEX LEVEL COMMITTEE	/ Monitoring and performance review	/ CEO/MD / CXOs
CORPORATE-LEVEL SUSTAINABLE MINING COMMITTEE	/ Project planning / Goal and target setting / Resource allocation and Budget approval / Guidance on potential risks and opportunities / Performance review and monitoring / Training and capacity building / Cross-sector learnings and partnerships / Technology adoption	/ Business Head / Mineral Head / Head of Mine Planning and Operations / Chief Sustainability Officer / CSR Head / Sustainability Head (M&M) / Health and Safety Head / Head Legal and Compliance
CLUSTER/MINE-LEVEL SUSTAINABLE MINING COMMITTEE	/ Development and monitoring of key performance indicators / Development and review of project proposals / Due diligence of implementation partners / Training and capacity building / Development of in-house implementation team / Implementation and monitoring of pilot projects / Developing and scaling up projects / Stakeholder engagement and management / Site level review and feedback on projects	/ Mineral Head / Mine Head / Sustainability Head (M&M) / CSR Head (M&M) / Health and Safety Head (Cluster Level) / Land and R&R Head (Cluster Level) / HR Head (Cluster Level) / Materials and Store Head (Cluster Level)

Governance Organization will depend typically on the organizational structure.

12.2 SUSTAINABILITY SCORECARD AND MATURITY INDEX

The sustainability scorecard focuses on internal reporting. It provides a structured framework for quantifying the sustainability performance of a mine using a defined set of KPIs and weightages assigned to each focus area. The maturity matrix provides the user with a set of maturity levels which may be assigned to a mine based on its sustainability score.

STEP 1: DEFINE SCORING PARAMETER

The scoring parameter will define a quantitative metric for measuring the performance of each focus area at different levels of the implementation plan. Table 19 presents the scorecard used in each of the focus areas.

TABLE 19

Scorecard of Performance for each Focus Area

Scorecard of Performance for each Focus Area	Maximum Total Score
Level 1: Baseline Assessment	1.00
No baseline assessment is conducted	0.00
Baseline assessment is conducted internally	0.50
Baseline assessment is conducted by an external party	0.75
Baseline assessment is conducted by an external party and published publicly	1.00
Level 2: Goal & Target Setting	1.00
Goals setting not completed	0.00
Quantitative goals have been set for the focus area	0.50
Goal have been set and have been disclosed in public domain	1.00
Level 3: Action Plan Development	1.00
Annual work plan is not developed for the assessment year	0.00
Annual work plan is developed for the assessment year	1.00
Level 4: Implementation, Monitoring and Review	1.00
Less than 20% of the target is achieved	0.00
20% of the target is achieved	0.20
40% of the target is achieved	0.40
60% of the target is achieved	0.60
80% of the target is achieved	0.80
100% of the target is achieved	1.00
Level 5: Reporting, External Audit and Assurance	1.00
No audit is conducted	0.0
Internal audit is conducted	0.25
External audit is conducted	0.50
Performance reported in public domain (with internal and external audits)	0.75
Performance results are assured by a third party	1.00
Total Maximum Score Possible	5.00

12.2 SUSTAINABILITY SCORECARD AND MATURITY INDEX (CONT.)

STEP 2: DEFINE WEIGHTAGE

Each focus area will be assigned a weightage to measure the overall score of a mine. These weightages should be defined by the corporate-level committee and should be based on the type of local risks (social, environmental, and economic), the mineral extracted, and the topography, hydrogeology, and mining methods.

TABLE 20.A Sustainability Scorecard showing Weightage of Each Focus Area of the Mine's Operations

Focus Areas	Weightage
Sustainable Land Use	[x1]
Water Stewardship	[x2]
Waste Management	[x3]
Emission Reduction	[x4]
Biodiversity Conservation	[x5]
Local Economic Development	[x6]
Health and Safety	[x7]
Total Score	1.00

STEP 3: DEVELOP SCORECARD

Depending on the weightage assigned and score generated for each of the focus areas, the overall mine site score can be generated.

TABLE 20.B Calculation of Total Sustainability Score of a Mine, as Determined by the sum of Weighted Scores

Focus Areas	Weightage (W)	Score (S)	Weighted Score (W*S)
Sustainable Land Use	[x1]	[y1]	[x1 * y1]
Water Stewardship	[x2]	[y2]	[x2 * y2]
Waste Management	[x3]	[y3]	[x3 * y3]
Emission Reduction	[x4]	[y4]	[x4 * y4]
Biodiversity Conservation	[x5]	[y5]	[x5 * y5]
Local Economic Development	[x6]	[y6]	[x6 * y6]
Health and Safety	[x7]	[y7]	[x7 * y7]
Total Score (out of 5)			[sum]

MATURITY INDEX

The index shown in Table 22 can be used to define the level of maturity of a mine on the path of sustainability.

TABLE 20.C Maturity Index Showing Level of Maturity of a Mine's Sustainability Path

Maturity Level	Score Range	
	Minimum	Maximum
Stage 1	0	2
Stage 2	2	3.5
Stage 3	3.5	4.5
Stage 4	4.5	5

12.2 SUSTAINABILITY SCORECARD AND MATURITY INDEX (CONT.)

SUSTAINABILITY DASHBOARD AND REVIEWS

A sustainability dashboard can be developed at the company level to keep track of performance across mine locations. This dashboard will capture performance across seven focus areas. Performance will be measured using a defined set of KPIs, and the performance score will be used by the site committee, corporate committee, and board committee to monitor and review performance and take corrective action if required. Different timelines can be defined for reviews at different committee levels; for example, at the site-committee level, a performance review should take place every quarter to suggest improvement measures. Similarly, the frequency of corporate- and board-level reviews can be planned to ensure a continuous review and correction mechanism.

12.3 REPORTING

A key element of governance is the tracking and reporting of a company's performance along various sustainability parameters. Sustainability reporting can help organisations gain a better understanding of how sustainability issues impact their business and where to find opportunities for improving competitiveness and shareholder value. Such reporting can also help organisations build trust and credibility with a growing number of internal and external stakeholders who demand greater insights into how the organisation manages risks and opportunities related to material, environmental, social, and governance matters.

Types of reporting that are applicable to sustainable mining include:

/ Internal reporting, which focuses on how the company reports and reviews its own performance;

/ Public disclosures, which include sustainability reports (under international frameworks such as the Global Reporting Initiative [GRI], International Integrated Reporting Council [IIRC], the Responsible Mining Index [RMI]), the Environmental, Social and Governance (ESG) Index (for example, the former Carbon Disclosure Project [CDP], the Dow Jones Sustainability Indices [DJSI]), Corporate Social Responsibility (CSR) reports, and social return on investment (SROI) studies;

/ Statutory reporting, which includes mandatory filings such as environmental returns, returns under waste management rules, Business Responsibility Reports (BRRs), etc.

Reporting standards vary depending on the external agency to whom the report is being made; they differ primarily in their coverage, audience, and industry focus, and in the particular benefits that a company can expect from scoring well according to a particular agency's standards.

12.3 REPORTING (CONT.)

TABLE 21. External Reporting on Sustainability to Specific International Agencies

STANDARDS	DETAILS	BENEFITS
DJSI (Dow Jones Sustainability Index)	**Background:** The DJSI was launched in 1999 as the first global sustainability benchmark; it tracks the stock performance of the world's leading companies according to economic, environmental, and social criteria. **Purpose:** The DJSI's indices serve as benchmarks for investors who integrate sustainability considerations into their portfolios; it provides an effective engagement platform for investors who wish to encourage companies to improve their corporate sustainability practices. **Industry focus:** Agnostic	/ Increased visibility among investors / Improved access to capital markets / Increased market price and shareholder value
GRI (Global Reporting Initiative)	**Background**: GRI standards create a common language for private or public organisations of any size to report on their sustainability impacts in a consistent and credible way; this enhances global comparability and enables organisations to be transparent and accountable. **Purpose:** GRI standards help organisations understand and disclose their impacts in a way that meets the needs of multiple stakeholders; in addition to their use to the reporting companies, the standards are highly relevant to many other groups, including investors, policy makers, capital markets, and civil society. **Industry focus**: Agnostic	/ Most widely recognised standards / Greater visibility to the company even among stakeholders beyond the sector
RMI (Responsible Mining Index)	**Background**: The RMI assesses companies from the perspective of societal expectations of large-scale mining companies; it examines the extent to which companies are addressing employee, environmental, social and governance (EESG) issues in a systematic manner across all their mining activities and throughout the project's life cycle. **Purpose:** The assessment is based on publicly available information on the companies and their mine sites. **Industry focus:** Mining	/ Focuses on mine-site-level disclosures which provide a detailed understanding of a company's operations

12.3 REPORTING (CONT.)

With multiple reporting standards available, it becomes critical for an organisation to assess which standard is most suited to its needs. Companies can use the following criteria to assess which standard to follow:

- **Alignment with organisational priorities:** A company can be guided in the selection of the most suitable standard by gaining a clear understanding of different areas across which an impact is being tracked by the standard, and the alignment of these areas with the company's organisational priorities; for example, a mining company might prefer a standard such as the Responsible Mining Index, which specifically tracks impacts due to mining operations and focuses on detailed site-level disclosures.
- **Target audience:** The choice of a particular reporting standard is also impacted by the report's target audience; the company may wish the report to target government agencies, NGOs, or investors. Companies that want to attract sustainability-focused investors or obtain better rates in the capital market may, for example, prefer the Dow Jones Sustainability Index, which is generally preferred by the investor community.

An organisation can select a single standard or it can choose to follow multiple reporting standards, depending on its requirements. Once a reporting standard has been selected, key performance indicators from the standard can be implemented across the seven thematic areas.If the organisation decides to report its sustainability performance across different standards, then key indicators from different standards can be incorporated into the tracking of performance across thematic areas.

Part IV / KEY ENABLERS

STAKEHOLDER ENGAGEMENT

TECHNOLOGY OVERVIEW

Part IV / KEY ENABLERS

13. STAKEHOLDER ENGAGEMENT

OVERVIEW

Mining occurs in a social ecosystem. Throughout the mine's life cycle, local stakeholder engagement and management provide a foundation for the creation of shared value and for earning the social license to operate. Early, frequent, and clear communication with stakeholders helps manage expectations and avoid risks, potential conflicts, and project delays. The stakeholder engagement process is guided by the following principles:

- **Create shared value** by aligning business goals and competencies with the development priorities of local affected stakeholders;
- **Demonstrate commitment and inclusiveness** by understanding the needs of stakeholders and engaging in a programme of addressing those needs across the mine's life cycle;
- **Ensure integrity** by conducting communications and operations in a manner that fosters mutual respect and trust;
- **Create respect and trust** by establishing open and meaningful dialogue and by recognising the rights, cultural beliefs, values, and interests of stakeholders;
- **Demonstrate transparency** by responding to stakeholders' concerns in a timely, open, and effective manner.

Stakeholders are defined as organisations, interest groups, households, and individuals who are likely to be directly or indirectly affected by a mining project at various stages of its life cycle. Stakeholders may include:

- Local communities and settlements
- Government (district administration, state and national government departments)
- Migrant communities (for example, migrant workers)
- Vulnerable groups (women, youth, elderly, disabled, marginalised groups)
- Mine site workforce
- Contractors
- Local civil society organisations (community-based groups, NGOs)

Stakeholder engagement is a continual process requiring ongoing analysis of its local context and interactions (CDA Collaborative Learning Projects, PDAC, World Vision Canada 2012).[41] Stakeholder needs may also change over time, and the resources that a mining company is able to devote to stakeholder engagement may differ at each stage of the mine's life cycle.

STAKEHOLDER ENGAGEMENT TOOK KIT // The toolkit offers the following approaches:

13.1 A stakeholder engagement plan across the mine's life cycle
13.2 Stakeholder mapping and analysis
13.3 A gender-inclusive approach

13.1 STAKEHOLDER ENGAGEMENT PLAN ACROSS THE MINE'S LIFE CYCLE

The stakeholder engagement plan aims to define a technically and culturally appropriate approach to consultation with all the relevant stakeholders. Table 25 provides a quick guide and reference for users to plan and implement key initiatives to engage with stakeholders in a timely manner (International Finance Corporation 2007).[42]

Key objectives of the stakeholder engagement plan are:

- Build an understanding of the local context, including stakeholder mapping and analysis
- Ensure consistency in stakeholder engagement and communication
- Manage stakeholder expectations through a graduated, phase-appropriate approach
- Establish an early, accessible, and responsive grievance mechanism for conflict management
- Minimise risks and maximise opportunities to create and protect value for the project and local communities

TABLE 22. Stakeholder Engagement Plan

1. PRE-MINING PHASE

Key Elements	/ Become familiar with the social landscape and identify key stakeholders / Determine the budget, scope, and timeline for the stakeholder engagement plan / Develop relevant, culturally appropriate, and consistent communication strategies / Identify, avoid, and mitigate social risks
Actions	/ Define the company's commitment to corporate social responsibility and to a local economic development plan / Evaluate the impacts of operational activities / Understand legacy issues / Develop a stakeholder and community map through a literature review, government information, and interviews / Design a roadmap for ongoing stakeholder engagement / Focus on an initial stakeholder engagement process to lay the foundation for mutual respect and trust / Establish a dialogue oriented around the local context / Learn about activities of other projects/companies in the area
Monitoring & Evaluation	/ Observe perceptions about the company in the community / Observe which stakeholders are attending meetings and/or inviting the company to their meetings

2. MINING PHASE

Key Elements	/ Conduct a scoping social impact assessment (SIA) study to help develop a comprehensive stakeholder engagement plan that is aligned with regulatory requirements and company operations / Design and implement effective, transparent, and consistent communication with stakeholders / Expand the engagement strategy to other relevant stakeholders (government, interest groups, civil society) / Develop consultative multistakeholder forums
Actions	/ Identify core competencies and non-financial resources to support the stakeholder engagement plan / Seek external stakeholder input and suggestions / Conduct a public perception survey / Integrate the perspectives of gender and other marginalised/under-represented groups / Assess operational impacts (current and expected future) / Establish a grievance mechanism / Identify and scope local institutions and potential partners for initial stakeholder engagement
Monitoring & Evaluation	/ Observe community, civil society, and/or NGO feedback / Observe tone of media coverage / Observe the number of complaints and the complaint-redressal rate / Look for third-party endorsements

3. POST-MINING PHASE

Key Elements	/ Communicate closure plans / Build capacity of stakeholders for efficient handover and exit
Actions	/ Discuss mine closure plans with all stakeholders / Close forums such as grievance management platforms / Assess operational impacts (current and expected future)
Monitoring & Evaluation	/ Observe tone of media coverage / Look for third-party endorsement of successful closure and exit

13.2 STAKEHOLDER MAPPING AND ANALYSIS

This toolkit[43] suggests an approach to the identification and analysis of stakeholders (International Finance Corporation 2010). It aims to help develop a proactive, site-specific communication plan, address social risks, and take advantage of opportunities to positively impact its area of operations.

STEP 1: IDENTIFY STAKEHOLDERS

List all stakeholders that can impact mining operations directly or indirectly at various stages of its life cycle and who have the ability to positively and negatively influence project outcomes.

STEP 2: MAP AND ANALYSE STAKEHOLDERS

Once stakeholder groups have been identified, they should be mapped and analysed to assess the degree to which they are affected by the project and their capacity to influence project outcomes.

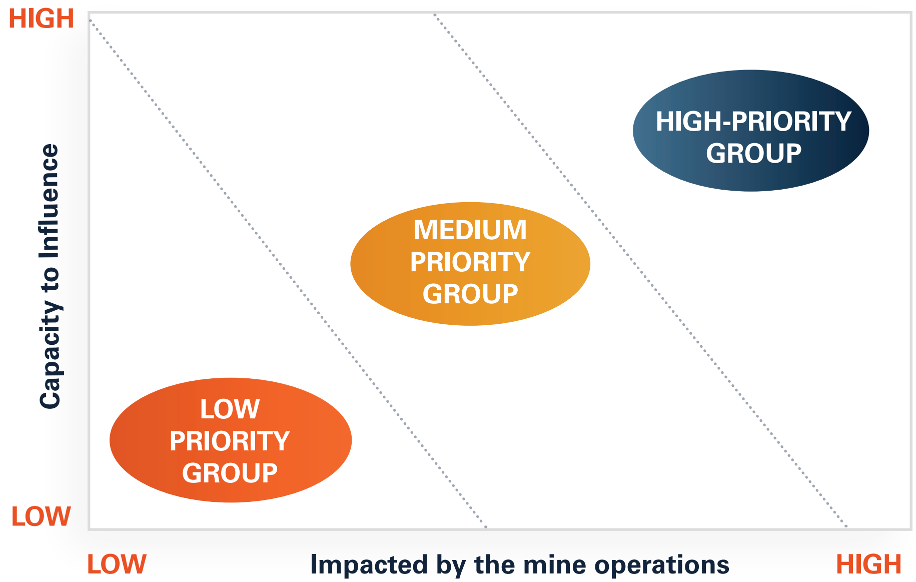
Key questions to consider in stakeholder analysis are:

- How and to what degree is each stakeholder positively and negatively impacted by the mine operations?
- How and to what degree are impacted stakeholders benefiting from the mine operations?
- Which stakeholders are not benefiting, or are negatively impacted, and does this pose any risks to the company's business objectives?
- Which stakeholder groups support the mine operations, and to what degree?
- Which stakeholder groups are neutral or opposed to the mine operations, and to what degree?
- What type of power relationships exist between stakeholder groups?
- What are the key interests of each stakeholder group?
- What type of engagement approach is most appropriate for each stakeholder group?
- What level of engagement is required for each stakeholder group (inform, consult, involve)?
- How might the stakeholder engagement strategy address the various identified stakeholders, maintain supportive stakeholders, and help address the concerns of less-supportive stakeholders?

STEP 3: STAKEHOLDER PRIORITISATION

Once stakeholders have been identified and analysed according to the degree to which they can positively or negatively impact the project and their capacity to influence it, a strategic approach can be developed. This strategy can help determine the optimal frequency and level of engagement with individuals and stakeholder groups. Figure 23 presents a stakeholder prioritisation matrix to prioritise stakeholder groups.

FIGURE 23. STAKEHOLDER PRIORITISATION MATRIX



13.3 GENDER-INCLUSIVE APPROACH

Mining companies need to incorporate a gender-inclusive approach into their stakeholder engagement plan in order to ensure a positive impact on women, including women in the workforce and those living in affected communities. The Stakeholder Engagement Toolkit[44] contains a stepwise approach to ensuring gender inclusivity in the stakeholder engagement plan (International Finance Corporation 2007).

STEP 1: UNDERSTAND WOMEN'S SITUATIONS AND PERSPECTIVES

Integrate methods like interviews into the initial stakeholder research process in order to understand the situation of women and include their perspectives. Areas where gender-inclusiveness needs to be studied are:

AT THE HOUSEHOLD LEVEL:

- What are the roles of women in the household and what is the division of labour?
- What are women's sources of income?
- What is the position of women in household decision-making?

AT THE COMMUNITY LEVEL

- How are women involved in public decision-making processes?
- What type of positions are held by women (sarpanch, Anganwadi Worker, members of district administration, etc.)?

ISSUES AND CHALLENGES

- Do women face domestic violence, prostitution, sexual abuse, alcoholism, etc.

CAPACITIES AND SKILLS

- What are the capacities and skill levels of women and how can these be increased in order to improve their access to job opportunities?

STEP 2: DEVELOP A GENDER-RESPONSIVE APPROACH

Based on the position of women in the local area and the challenges faced by them, mining companies can integrate a gender-responsive approach into its community engagement, social programmes, resettlement programmes, and employment practices. These key immediate delivery areas can have significant positive impacts on gender responsiveness with minimal additional cost or effort.

14. TECHNOLOGY OVERVIEW

OVERVIEW

Technology is a crucial enabler of sustainable mining operations. Sustainable operations for a mining company not only focus on minimising the negative environmental and social impacts caused by mining operations; they also safeguard the continuity of business operations. Advancements in technology over the last decade have improved the efficiency of mining operations, especially in terms of safety and productivity. Applying new technologies in mining can help create a more comprehensive understanding of the available and accessible resources, optimise business processes, reduce safety hazards, and enable accurate and real-time monitoring of operations.

TECHNOLOGY TOOK KIT // The Technology Toolkit offers the following approaches:

14.1 Guidelines for technology selection

14.2 An overview of emerging technologies

14.1 GUIDELINES FOR TECHNOLOGY SELECTION

As discussed earlier in the Charter, technology has applications across the seven thematic areas. Selection of appropriate technology for a mine site will depend on its geological, environmental, technical, financial, and social parameters.

Key considerations to be made in each of these parameters are as follows:

1. GEOLOGICAL PARAMETERS

/ **Resource quality:** Grade of ore or resource from which material is to be extracted (such as tailings)

/ **Depth of mining activity:** Depth at which mining activity is being carried out

/ **Stripping ratio:** Volume of overburden removed to extract one ton of ore

/ **Geological strata:** Geological structure and characteristics of rock layers

2. TECHNICAL PARAMETERS

/ **Production requirement:** Planned capacity and/or production rate

/ **Service availability**: Availability of technology, required equipment, and its service

/ **Workforce skillset**: Capacity, skillset, and technical competence of the workforce

/ **Infrastructure availability**: Availability of adequate infrastructure to support technology adoption

3. FINANCIAL PARAMETERS

/ **Capital investment required**: Requirement of capital expenditure in technology adoption

/ **Operational cost:** Operation and maintenance cost of technology

14.1 GUIDELINES FOR TECHNOLOGY SELECTION (CONT.)

4. SOCIAL PARAMETER

- **Social impact:** Social impact before and after technology adoption
- **Environmental impact:** Environmental impact before and after technology adoption

The technology selection parameters will help define the need and scope of requirements. Mining companies need to further explore technologies and shortlist the most probable solution and service provider. This may require a further demonstration or proof of concept and validation of technology for the selected mine site. A stepwise approach for selecting the right technology includes:

STEP 1: IDENTIFY REQUIREMENT SPECIFICATIONS

- Identify key technical factors for selection

STEP 2: SHORTLIST TECHNOLOGY

- Screen and shortlist of technology

STEP 3: VIEW DEMONSTRATIONS OF TECHNOLOGY & SELECT VENDOR

- View on-site or concept demonstration
- Perform due diligence on service provider

STEP 4: EVALUATE PROPOSAL

- Evaluate technical specifications
- Assess economic benefits and social and environmental impact

STEP 5: IMPLEMENT TECHNOLOGY

- Conduct training and knowledge transfer
- Implement technology at mine site

14.2 AN OVERVIEW OF EMERGING TECHNOLOGIES

1. ADVANCED ANALYTICS AND MACHINE LEARNING: Advances in analytics, from machine learning to improved statistical techniques for integrating data, help turn vast data sets into insights about the probability of future events. Complex mining tasks such as geological modelling, on-the-day scheduling, and predictive maintenance are increasingly in the domain of smart statistical and optimisation algorithms. Machine learning is helping to improve operational efficiency and reduce processing costs. Cases where analytics and machine learning can be used include:
   - Analysis of patterns of safety incidents to make necessary changes
   - Optimisation of blast design to achieve more consistent particle-size distribution
   - Discovery of new greenfield prospects with significant copper, zinc, lead, and vanadium mineralisation
   - Optimisation of truck movements to achieve greater capacity utilisation and increased material movement
   - Preventive maintenance planning of rail tracks through analysis of images obtained from a camera mounted on trains
   - Early prediction of dumper faults during ore unloading

2. AUTOMATION: Automation of mobile and fixed assets in mining operations helps maximise safety while increasing production. Autonomous machinery is becoming increasingly prevalent in mining operations due to a reduction in the costs of innovative products. Over the past 30 years, the average price of a robot has fallen by half in real terms, and even more in relation to labour costs. Use cases for automation include:
   - **Robotic loaders and drills**, which are used both on the surface and in underground operations to increase productivity, enhance worker safety, and improve cost efficiency;
   - **Drones for monitoring and inspection of deep shafts**, which ensure that workers are safe from hazards such as rock falls, humidity, gas leaks, dust explosions, and floods;
   - **Drones for automatic surveying and 3D mapping of landscapes,** which are used in the exploration phase to save cost and time;
   - **Drones for surveillance**, which are used to inspect tailings dams and for monitoring structural integrity to detect faults.

3. BLOCKCHAIN: Encryption technology provides security and transparency in business transactions and tracks and records changes made to designs, documents, and other business agreements. Blockchain can be helpful in the tracking of materials in the mining value chain, in providing transparency across the system, and an in the validation of workflow activities. Use cases include:
   - **Custody and control of documents** created and approved in exploration, resource estimation, mine design, and planning processes;
   - **Traceability/record-keeping** of material flow from pit to port.

4. RENEWABLE ENERGY SOURCES AND STORAGE SOLUTIONS: Energy costs can account for up to 30 percent of a mine's operating expenses and many companies have started implementing various options to achieve a low carbon footprint. Use cases include:
   - **Off-grid energy solutions** to reduce the use of diesel generators, bring down electricity costs, and minimise carbon footprint;
   - **Energy storage solutions** in remote and undeveloped locations where grid access is both difficult and cost-prohibitive; energy storage solutions can include hydrogen and a flywheel (for wind power), and solar PV batteries.

14.2 AN OVERVIEW OF EMERGING TECHNOLOGIES (CONT.)

5. SENSORS: It has become increasingly affordable to embed vast numbers of sensors into physical objects;. These churn out large volumes of data for analysis and enable communications among machines. Mining companies already produce huge amounts of sensor data, which enables them to obtain a more and more accurate and consistent picture of reality at the rock face. Advances in Internet of Things (IoT) technology are enabling a connected network of low cost, highly capable sensors to capture data in real time; this supports integrated planning, control, and decision-making. Use cases include:
   - / **Gas sensors** on walls and machinery, to detect hazardous gases;
   - / **IoT and GIS (Geospatial Information System)** to perceive floor water inrush;
   - / **Smart wearables**, such as smart helmets fitted with gas sensors, for detecting hazardous fumes.

6. AUGMENTED AND VIRTUAL REALITY: Augmented and virtual reality technologies are rapidly maturing at both the consumer and commercial levels. In mining operations, these technologies have the potential to improve mine productivity, reduce equipment maintenance costs, and ensure the safety of personnel. Use cases include:
   - / **Remote guidance** for technicians to perform complex tasks and reduce downtime;
   - / **Virtual reality** for equipment training, safety training, field solutions, and site tours.

TABLE 23. Technology Matrix

Sustainable Mining Focus Areas	Analytics and ML	Automation	Blockchain	Renewable Energy	Sensors	AR & VR	Electric Vehicles	3D Printing
Sustainable Land Use	✓		✓	✓	✓		✓	
Water Stewardship	✓	✓	✓		✓		✓	
Water management	✓	✓	✓		✓		✓	
Emissions Reduction	✓	✓		✓	✓			✓
Biodiversity Management	✓	✓	✓		✓		✓	
Local Economic Development	✓		✓		✓	✓	✓	
Health and Safety	✓	✓			✓	✓	✓	✓

14.2 AN OVERVIEW OF EMERGING TECHNOLOGIES (CONT.)

7. ELECTRIC AND HYBRID VEHICLES: As underground mining progresses to deeper levels, ventilation for mobile vehicles becomes a greater challenge. The inclusion of electric and hybrid vehicles in mining operations helps reduce overall emissions and improve productivity, efficiency, and safety. Use cases include:

/ **Electric or hybrid trucks** in underground mines to optimise costs and to prevent hazardous fumes generated from diesel.

8. 3D PRINTING: Operational delay is a major problem for mining companies. One of the key reasons for operational delay is an increase in down time due to the unavailability of spare parts used in mining equipment such as bulldozers, dumpers, trucks, wheel loaders, etc. 3D printing is a technology that can economically and efficiently manufacture spare parts and reduce down time. Use cases include:

/ **Printing parts that have failed** instead of waiting for replacements;

/ **Rapid redesign of components.**

14.3.1 Case Study

14.3.1 Blockchain: De Beers tracked diamonds on industry blockchain (Anglo American 2018a)[45]

BACKGROUND: In 2018, De Beers used industry blockchain to successfully track 100 high-value diamonds from mine to retail using a blockchain technology platform called Tracr™; this was the first time blockchain had been used to track diamonds. Five leading diamond manufacturers (Diacore, Diarough, KGK Group, Rosy Blue NV, and Venus Jewel) have been working with De Beers during the development of Tracr and have played an integral role in creating the first blockchain platform to span the entire diamond value chain.

INTERVENTION: Through Tracr, this initiative was able to create a secure digital trail for a selection of rough diamonds mined by De Beers as they moved from the mine, to the cutter and polisher, then through to a jeweler. As the diamonds travel along the value chain, Tracr employs the following process:

/ A unique Global Diamond ID is automatically created for the diamond. Through integration with the participants' existing record-keeping systems, this stores the diamond's individual attributes, such as carat, colour, and clarity.

/ This then allows Tracr to consolidate the data into an immutable digital trail for each physical diamond.

/ To support this process, Tracr uses stone images, planned outcome images, and a diamond's physical properties to verify authenticity through data science and physical identification techniques.

/ At each key milestone of a diamond's journey, Tracr verifies the uploaded data; this ensures its accuracy and continuity, while also enabling users to use privacy controls on order to remain in full control of what they share with other participants.

A first of its kind for the diamond industry, this technology is likely to be available to the industry by 2019. When fully operational, it will provide consumers with confidence that registered diamonds are natural and conflict-free; it will also improve visibility and trust within the industry and enhance efficiencies across the diamond value chain.

OUTPUT / IMPACT: Traceability and transparency will be enabled throughout the value chain. Besides ensuring the quality and authenticity of the diamond, it will mitigate social risks such as human rights violations, child labour, and sourcing from conflict areas.

Part V / ANNEXURES

ANNEXURE 1 / LIST OF INITIATIVES BY GLOBAL MINING COMPANIES

1. SUSTAINABLE LAND USE INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Mine Closure Toolbox (Anglo American 2019a) [46]	Mine Closure Toolbox is an in-house tool developed by Anglo American to carry out integrated mine closure planning. This tool focuses on the integration of Life of Asset Planning (LoAP) with designing, planning, operating, and carrying out closure at mining sites.	Anglo American
Finance for Forest (BHP, Conservation International and Pollination 2020) [47]	Finance for Forest is a joint initiative of BHP and Conservation International to harness private sector finance to conserve the world's forests. International Finance Corporation issued a first-of-its-kind US$ 152 million Forests Bond, developed with BHP and Conservation International, with a US$ 12 million price support mechanism provided by BHP.	BHP
Renewable energy at closed mine sites (BHP 2018a) [48]	BHP has collaborated with the Rocky Mountain Institute to convert closed mine sites into independent solar or wind power plants.	BHP
Indigenous plant nursery (Teck Resources Limited 2017) [49]	Teck Resource Limited, in collaboration with the Twin Sisters Native Plant Nursery, in West Moberly, British Columbia, Canada, developed a nursery for indigenous plants. This initiative maintains the availability of native plant species and generates local employment.	Teck Resource Limited
Mine closure plan (Tellus. 2016) [50]	The Sandy Ridge Facility of Tellus Holdings, in Australia, published a mine closure plan with details of observations regarding seasonal weather conditions, flora and fauna, soil analysis, hydrogeology, and an aboriginal heritage conservation plan. The plan details implementation timelines, monitoring measures, and financial provisions.	Tellus Holdings Limited
Rehabilitation using native seeds on waste land (Fortesque 2019: 81) [51]	The Fortesque Metals Group (FMG) conducted a native seed metering study to assess the use of waste land and tailings for enhancing seed emergence and reducing soil erosion. Computer-aided models have been used to develop post-mine land forms and water systems.	Fortescue Metals Group Limited

2. WATER STEWARDSHIP INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
QMM partnership for mutual benefit (International Advisory Panel to QMM 2011) [52]	The project focus is to establish a water infrastructure solution for 50,000 community members; this will ensure access to clean drinking water in Fort Dauphin, Madagascar. Rio Tinto has designed the technical solution; they have worked in partnership with the World Bank (for financing and engineering support) and JIRAMA (for project implementation).	**Rio Tinto**
River health partnerships in Queensland, Australia (BHP 2018c) [53]	BHP has joined Fitzroy Partnership for River Health; this initiative brings together government, agriculture, resources, industry, research, and community interests across the Fitzroy Basin in central Queensland. The partnership has implemented multiple interventions at the catchment level.	**BHP**
Sustainable groundwater management (Fortesque 2019: 79) [54]	FMG designed systems for careful reinjection, storing, and redrawing of water to form a hydraulic barrier between dewatering operations. This recharge is achieved with abstraction bores, injection bores, and recharge ponds.	**Fortescue Metals Group Limited**
Engaging with stakeholders on water (Anglo American. 2019b) [55]	As a strategy, Anglo American set up regional partnerships with local stakeholders, including communities, the private sector and government, to identify and address concerns. It set up Olifants River Mine Coordinating Body to address issues such as acid mine drainage and the feasibility of using water from mines for irrigation. At Polokwane, Anglo American is working with AB InBev and the Strategic Water Partners Network to fix water leaks that lead to loss of 54 percent of the potable water supply.	**Anglo American**
Water stewardship planning (Newcrest 2019) [56]	As part of mines planning, Newcrest diligently plans use of water from a variety of sources, such as surface water, groundwater, seawater, and mine dewatering. Seawater, for example, is used for cooling and tailings dilution; water acquired from mine dewatering is used for dust suppression, water for services in camps, and potable water supplies.	**Newcrest Mines**

3. WASTE MANAGEMENT INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Enterprise development for waste management (African Rainbow Minerals 2020) [57]	ARM mine is building and supporting enterprises in the domain of waste management by including the local community at the Khumani and Two River mines. In addition to managing the waste, these enterprises are also generating employment for people in the local community.	**African Rainbow Minerals**
Saving used linen from landfill (Fortesque 2019: 79) [58]	FMG collected and donated used linen from operations sites to charitable organisations for reuse; they also donated used accessories and office tools after upgradation. This helped in waste reduction and reuse.	**Fortescue Metals Group Limited**
Deep-sea tailings management (Newcrest 2019) [59]	Tailings are discharged as dense slurry into containment areas, into a tailings storage facility, or by deep-sea tailings placement in suitable deep-ocean locations. At Newcrest Lihir mine, the local dive programme monitors coral health in the ocean around Lihir where the divers complete essential compliance tasks, checking sediment loads and assessing coral health. This addresses waste management as well as environmental monitoring objectives.	**Newcrest Mines**
Research collaborations (Anglo American. 2018b) [60]	Anglo American is participating in a three-year research project in Australia that involves four universities and six major mining companies; in order to reduce the risk of dam failures, this project investigates the material behaviour of tailings and evaluates the potential for static liquefaction of tailings. The research, led by the University of Western Australia, has received global attention among researchers and practitioners as it deals with one of the least-understood failure mechanisms in tailings dam safety management.	**Anglo American**
Waste management (Vale 2018) [61]	Vale's waste management programme focuses on performance on three main fronts: reduced generation of waste from awareness in the operational areas; reuse of waste with actions and projects for insertion of waste material into new production chains and new disposal technologies; and reduction of risks related to improper control of disposal processes through the application of rigid environmental assessment protocols.	**Vale**

4. EMISSION REDUCTION INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Investment in direct air capture technology (BHP 2019) [62]	BHP invested US $6 million in Carbon Engineering Ltd., a Canadian-based company, for the development of direct air capture technology which can remove carbon dioxide from the atmosphere.	BHP
Adoption of electric vehicles (BHP 2018b) [63]	At the Olympic Dam site in South Australia, which is the largest underground copper mine in the world, BHP is investing in the adoption of light electric vehicles powered by lithium-ion batteries. This initiative is aimed at reducing air pollution and carbon emissions.	BHP
Carbon emissions reduction target (Rio Tinto 2020a) [64]	Rio Tinto has set emissions reduction targets for 2030 at 30 percent of 2018 levels for emissions intensity, and 15 percent of 2018 levels for absolute emissions. To achieve these targets, the company plans to invest US$ 1 billion in the next 5 years.	Rio Tinto
Carbon neutral mine (Anglo American 2019c) [65]	Project Minera is an ambitious initiative by Anglo American to make mining carbon neutral. Together with experts from the Universities of British Colombia and Alberta, Trent University, University of Queensland, and Bond University, the company is testing different mineral carbonation technologies in laboratories (carbon dioxide injection, cation exchange, and biotechnology) to find the optimal operating model.	Anglo American
Emissions reduction strategy (Fortesque 2019) [66]	FMG has set a target to reduce emissions by 25 percent of 2005 levels by 2030. The group has invested heavily in low-emissions technology and renewable energy generation. It has installed long-distance conveyor belts to displace haulage trucks, which has significantly reduced emissions.	Fortescue Metals Group

5. BIODIVERSITY MANAGEMENT INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Vale biodiversity initiative (Vale 2019) [67]	Vale protects 8,500 km^2 of natural areas (an area 6 times larger than its operations occupy); they protect native fauna and flora, mainly endemic and endangered species. Vale adopts international standards to benchmark its key performance indicators on biodiversity.	Vale International
Tata Steel biodiversity (Tata Steel 2020) [68]	Over the years, Tata Steel has undertaken various measures to conserve biodiversity through reclamation and afforestation of land. It has released a biodiversity policy which focuses on degradation and destruction of natural habitats, global warming or climate change, deforestation, and pollution.	Tata Steel
Drones for biodiversity conservation (Fortesque 2019: 77) [69]	FMG implements the mitigation hierarchy of avoid, minimise, rehabilitate, and offset impacts on biodiversity from mining. The Chichester Environment team is using drones to map streams, capture high-resolution images for the identification of species, and deliver targeted conservation measures.	Fortescue Metals Group Limited
Biodiversity planning (Newcrest. 2019) [70]	Newcrest has incorporated biodiversity planning into each of its operational sites. Planning includes ongoing assessment of the potential risks to endangered species as per the IUCN Red List, as well as the application of site-based monitoring and environmental management systems, and the application of a mitigation hierarchy to avoid, minimise, mitigate, and offset potential impacts.	Newcrest mines
Biodiversity research and restoration action programmes	In association with the Australian government, Anglo American conducted research at Dawson mine, which is located in Central Queensland's Bowen Basin; they undertook a study of a flowering perennial shrub called Tecoma stans, which is listed as a Class 3 declared pest, and which has impacted native bushland. The research programme investigated the success of different weed treatments across various life stages. Ultimately, the research will enable eradication of the weed population, which will encourage the recolonisation of native species.	Anglo American

6. LOCAL ECONOMIC DEVELOPMENT INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Tata Steel community development initiative (Tata Steel 2017) [71]	Tata Steel strives to be a good neighbour to the communities in which it operates; it works to contribute to their equitable and inclusive development. Its community development programmes are developed in collaboration with community representatives in order to ensure inclusive solutions that can lead to better futures for the community's members.	**Tata Steel**
Shared value enterprise (Exxaro 2018) [72]	Exxaro uses a shared value-generation approach to support community youth in identifying and developing enterprise solutions. The Siyathuthuka Butterfield Bakery Project in South Africa is one such initiative to employ youth and a create self-sustaining operating model.	**Exxaro Pty**
Anglo Zimele Programme	This is an enterprise development initiative whose aim is to create sustainable and commercially viable enterprises and entrepreneurs in the communities in which Anglo American operates. To support this initiative, a network of 30 Small Business Hubs have been set up in South Africa in close proximity to mining operations. These hubs provide local entrepreneurs with a strategic blend of financial support and incubator-style mentorship. Support is extended in areas such as financing, developing business plans, coaching on the essentials of developing a business model, tax advice, mentorship, and training sessions. Since its inception, the programme has funded 1,500 businesses, generating jobs for 30,000 individuals of which 41 percent were women and 37 percent were youth.	**Anglo American**
Billion opportunities programme for local businesses (Fortesque 2019: 90) [73]	FMG awarded two contracts to enterprises owned by aboriginal Yindjibarndi communities: one for infrastructure operations and another for road maintenance and safety. This helped local communities build self-sustaining businesses, and also generated employment within the community.	**Fortescue Metals Group Limited**
Community Investment Criteria (Vale 2020) [74]	Vale has aligned its community investment criteria with national funding criteria, local funding criteria, and exclusion criteria. The criteria include relevance to local stakeholders, degree of innovation, financial viability, sustainability over the long term, and the existence of an outcome monitoring plan.	**Vale Canada**

7. HEALTH AND SAFETY INITIATIVES BY OTHER MINING COMPANIES

INITIATIVE	FOCUS	COMPANY
Robots for high-risk jobs (Rio Tinto 2020b) [75]	Rio Tinto Kennecott's Bingham Canyon copper mine, in Utah, uses remotely operated vehicles (ROVs) for inspection of old, unused underground mining tunnels.	**Rio Tinto**
Unmanned aerial vehicle (UAVs) for road safety (BHP 2016) [76]	At Goonyella Riverside Mine, BHP Billiton has implemented a road safety programme to avoid light vehicle rollover and collisions with heavy vehicles. Three key elements of this programme are: separating light and heavy vehicles, adoption of the Australasian New Car Assessment Program for light vehicles, and use of unmanned aerial vehicles (UAVs). UAVs provide data which helps monitor road conditions and environmental hazards.	**BHP**
Remotely controlled HEMM (Teck Resources Limited 2018) [77]	Teck has deployed remotely operated bulldozers and backhoes to access hazard-prone areas. A custom-build control cab is used for driving this heavy earth-moving machinery, and an operator can monitor the operation of the equipment through the use of four cameras.	**Teck**
Real-time data collection and analysis for safer operations (Cisco 2017) [78]	Barrick, in collaboration with Cisco, uses real-time data insights to operate mines in safer, more efficient, and more environmentally friendly ways. This technology enables miners to spend less time in underground mines, which reduces exposure to toxic environments and protects them from the hazards of blasting and other underground activities.	**Barrick**
Stops for safety (Fortesque 2019: 42) [79]	At its own sites and across its partner agencies, FMG organised a one-hour pause of work to come together and discuss safety concerns and looking out for co-workers. Through introducing elimination and engineering controls, it also implemented a risk-reduction programme to reduce fatal exposure to harmful materials by 15 percent across all its operations.	**Fortescue Metals Group Limited**
Safety framework (Anglo American. 2018c) [80]	Anglo American has introduced its vision of Zero Harm, whose principles are Zero Mindset, No Repeats, and Simple Non-negotiable Standards. The implementation model for the policy has five layers: policy, planning, operations, feedback, and management review.	**Anglo American**
Finance for Forest (BHP, Conservation International and Pollination 2020)	Finance for Forest is a joint initiative of BHP and Conservation International to harness private sector finance to conserve the world's forests. International Finance Corporation issued a first-of-its-kind US$ 152 million Forests Bond, developed with BHP and Conservation International, with a US$ 12 million price support mechanism provided by BHP.	**BHP**

ANNEXURE 2 / BASELINE ASSESSMENT PARAMETERS

BASELINE ASSESSMENTS

FOCUS AREA	BASELINE ASSESSMENTS
SUSTAINABLE LAND USE	/ Location, Topography & Geological map / Types of land available with sizes / Local flora and fauna / Slope / Soil Fertility / Soil Depth / Access to water sources
WATER STEWARDSHIP	/ Hydrogeological study of core and buffer zone / Annual rainfall and trend / Projection of water consumption in mining operations / Projection of impact on water resources (quality) / Current source of water for drinking, household use, irrigation, and other usages / Watershed and rainwater harvesting structures in reclaimed and community land
WASTE MANAGEMENT	/ Assessment of slope for slope stability of overburden dump / Assessment of necessary condition of waste management in clearances, consents and other documents / Projection of waste produced under various categories / Availability of authorized waste recycler/handler
EMISSION REDUCTION	/ Analysis of ambient air quality (AAQ) standards as laid out by the Ministry of Environment, Forestry and Climate Change / Assessment of AAQ parameters in core and buffer zones / Calculation of Scope 1 and Scope 2 GHG emissions / Conducting of energy audit to identify energy efficiency improvement areas / Conducting of feasibility study for renewable energy adoption

ANNEXURE 2 / BASELINE ASSESSMENT PARAMETERS

BASELINE ASSESSMENTS (Cont.)

Third Party assessment, In-house assessment

FOCUS AREA	BASELINE ASSESSMENTS
BIODIVERSITY CONSERVATION	/ Inventory of: o forest trees and orchids o avian species o mammal species o other relevant biodiversity parameters o density and list of endangered species (if any) / Assessment of forest and animal migration patches / Assessment of weather and seasonality trends
LOCAL ECONOMIC DEVELOPMENT	Assessment of: / demographic details (gender, age) / education, skills development, healthcare, livelihoods, connectivity, infrastructure status / short- and long-term needs and aspirations / local resources and skills available / local heritage, art and culture status
HEALTH & SAFETY	/ Assessment of the physical, chemical, and biological safety of the community / Assessment of leading and lagging indicators / Assessment of the global and Indian industry averages of leading and lagging indicators / Pre-Medical Examination of employees

ANNEXURE 3 / GLOSSARY

GLOSSARY (1/5)

TERMINOLOGY	DESCRIPTION
Backfilling	Backfilling is a way to fill excavated zones created by mining operations using sand, overburden, mine tailings or aggregate materials. It is an integral part of mine planning and is required for disposal of mining waste, stabilisation of mining voids, and restoration of lost biodiversity.
Biofertiliser	Biofertiliser is a special type of fertiliser that contains living micro-organisms. It promotes the growth of plants by enhancing the availability of primary nutrients to the host plant. It facilitates nitrogen fixation, solubilising of phosphorous, and the synthesis of growth-promoting substances. It can replace chemical fertilizers which have harmful impacts on the environment.
Biodegradation	Biodegradation is a process by which the molecular structure of a material is broken down through a metabolic or enzymatic process (Poznyak, Oria, Poznyak 2019).[81] Enzymes are produced by living microbial organisms which break down the organic substance.
Biodiversity Index	The biodiversity index is a quantitative method of identifying and documenting the different types of species that are present in a selected geography and measuring their numbers. It is an indication of the diversity and richness of species of flora and fauna, and measures their evenness of availability.
Biogeochemical cycle	A biogeochemical cycle is a process by which different types chemical substances (such as calcium, nitrogen, oxygen, and hydrogen) move through the biotic and abiotic spheres of the earth, including the biosphere, lithosphere, and atmosphere.
Buffer zone	In the case of a mining lease area of up to 25 hectares, a buffer zone is a 5-km–wide zone around the entire periphery of the core zone; for a mining lease area of above 25 hectares, there must be a 10-km–wide buffer zone around the entire periphery of the core zone.
Check dam	A check dam is small, locally constructed dam that is built across waterways, drainages, nallas, etc. to reduce the velocity of water and soil erosion; it is also used for water distribution. Check dams facilitate the infiltration of water into aquifers.
Civil society organisations	Civil society is the network of associations, social norms, and relationships that exist separately from government or market institutions. Civil society organisations may include various non-governmental organisations (NGOs) such as religious organisations, foundations, professional associations, labour unions, academic institutions, media, pressure groups, and environmental groups.
Consultation	Communication, in this context, is the two-way communication between project developers and stakeholders to improve decision-making, reduce risk, and build understanding; it should actively involve all individuals, groups and organisations who have a stake in the project. Their involvement increases the project's long-term viability and enhances its benefits to locally affected people and other stakeholders. To be meaningful, consultation should be carried out in a culturally appropriate manner, with locally appropriate time frames and in local languages.

GLOSSARY (2/5)

Contour bund	A contour bund is an earthen embankment across a sloped piece of land which works as a barrier to the flow of water. A contour bund restricts the flow of water outside the contour and thus reduces the velocity and run-off. It serves as a barrier to run-off and checks soil erosion.
Core zone	The core zone is the mining lease area.
Deforestation	Deforestation is a process of clearing or removing forests from land and preparing it for a non-forest use such as mining, or construction. Large-scale deforestation causes impacts such as the destruction of habitats, loss of biodiversity, and desertification.
Fugitive emissions	Fugitive emissions are unintended and irregular releases of gases, pollutants, or dust from leaks, blowdown, blasting, and other similar events. A social, environmental, and economic cost is associated with these fugitive emissions as they result in loss of material and damage to the environment, and can have negative impacts on the community.
Gabion walls	A gabion wall is made of boulders and steel wire mesh; it limits, but does not entirely stop, water flows. It supports infiltration of water into aquifers and prevents soil erosion.
Garland drains	Garland drains are shallow trenches for draining surface or subsoil water. In the case of mines, they are built around overburden dumps to collect run-off water and silt.
Gully plug	A gully plug is a smaller version of a check dam.
Horticulture	Horticulture is the art of growing fruit, vegetables, nuts, flowers, or ornamental plants; it helps in land and soil restoration and in plant conservation.
Hydrospectral imaging	Hydrospectral imaging is a technique for analysing and monitoring the condition of aquifers.
Macro-pollutant	This refers to pollutants that have a geographical scope of impact which extends from the state to the national, and even to the global level. Macro-pollutants cause global challenges such as global warming and shifts in weather patterns.
Meso-pollutant	These are pollutants that have a geographical scope of impact ranging from a few hectares up to the size of a city. Pollutants such as SOx, NOx, PM10, and PM2.5 can cause air pollution which impacts human health.
Micro-pollutant	Micro-pollutants have the potential to impact an environment at the micro-scale, for example spreading from a room to a building.
No-net-loss	No-net-loss is an approach whose goal is to avoid net impacts on biodiversity; it involves pre-planning to avoid or minimise impacts, restoring losses of biodiversity in affected areas, and offsetting any residual impacts.

GLOSSARY (3/5)

Obvious Geological Potential (OGP)	Areas with OGP are those where there are surface indications of mineral deposits.
Piezometer	This is a device that measures the pressure of liquids by measuring the height to which a column of the liquid rises against gravity. It is used for measuring the pressure of ground water.
Pisciculture	Pisciculture is a form of commercial fish rearing; it includes breeding, rearing, and transplantation of fish and involves rearing of fish in cages, fishponds, or tanks.
Rhizosphere soil	Rhizosphere soil is soil that is found adjacent to plant roots. It is where biogeochemical processes actively influence a host of landscape and global-scale processes (McNear 2013).[82]
Scope 1 emissions	Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, or vehicles, and emissions from chemical production in owned or controlled process equipment. Direct CO2 emissions from the combustion of biomass are not included in Scope 1 but are reported separately. GHG emissions not covered by the Kyoto Protocol (including chlorofluorocarbons, NOx, etc.) shall not be included in Scope 1 but are reported separately (India GHG Program 2012).[83]
Scope 2 emissions	Scope 2 emissions account for GHG emissions from the generation of electricity that is purchased and consumed by a company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated (McNear 2013).[84]
Social impact assessment	This is a systematic analysis of the impact of a business project or operation on the social and cultural condition of affected communities.
Social license to operate	The social license to operate refers to the ongoing acceptance of any given project by the people who live and work in the area of its impact and influence. The idea is that there is more to running a business successfully and sustainably than just legal and regulatory compliance; a business also needs to earn the support of the community and society in which it operates.
Stakeholder	Stakeholders are defined broadly as (a) groups or individuals who can reasonably be expected to be significantly affected by the organisation's activities, products, and/or services; or (b) individuals whose actions can reasonably be expected to affect the ability of the organisation to successfully implement its strategies and achieve its objectives. A stakeholders can be an individual, community, interest group, government agency, corporate organisation, or any organisation that affects, or is affected by, the operations of a company. They may include politicians, commercial and industrial enterprises, labour unions, academics, religious groups, national social and environmental groups, public sector agencies, and the media.
Stakeholder analysis/ Stakeholder mapping	This is a process that seeks to identify and describe the interests and relationships of all the stakeholders in a given project. Stakeholder analysis and mapping is a necessary precondition to participatory planning and project management.
Stakeholder engagement plan	This is a process of identifying and communicating with those people who have a legitimate interest in a proposed activity.

GLOSSARY (4/5)

Stripping ratio	The stripping ratio is the volume of overburden removed to extract one ton of ore.
Sustainable Development Goals	The SDGs were adopted by all United Nations Member States in 2015 and are a call for action by all countries to promote prosperity while protecting the environment.
Total dissolved solids (TDS)	TDS is a measure of the total dissolved substances in a liquid, including organic and inorganic materials.
Total suspended solids (TSS)	TSS is a measure of the particulates of soil, metals, organic material etc. suspended in a liquid.
Vesicular-arbuscular mycorrhiza (VAM)	VAM is a biofertiliser that that improves soil health; it is based on mycorrhizal fungal and infected root bits.
Watershed	¬A watershed is an area of land that feeds all the water running under it and draining off of it into a body of water. It combines with other watersheds to form a network of rivers and streams that progressively drain into larger water areas.

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ABOUT HINDALCO INDUSTRIES LIMITED

Hindalco Industries Limited [HIL] is the metals flagship company of the Aditya Birla Group. An $18 billion metals powerhouse, Hindalco is the world's largest aluminium company by revenues, and a major player in copper. It is also one of Asia's largest producers of primary aluminium.

Guided by its purpose of building a greener, stronger, smarter world, Hindalco provides innovative solutions for a sustainable planet. Its wholly-owned subsidiary Novelis Inc. is the world's largest producer of aluminium beverage can stock and the largest recycler of used beverage cans (UBCs). The Company operates several bauxite and coal mines in India for captive consumption in its aluminium business.

Hindalco's copper facility in India comprises a world-class copper smelter, downstream facilities, a fertiliser plant and a captive jetty. The copper smelter is among the world's largest custom smelters at a single location.

Hindalco's global footprint spans 47 manufacturing units across 10 countries.

ABOUT VIKAASA: Founded as India2022, Vikaasa is a business-led coalition creating new a growth model for India in line with the United Nation's Sustainable Development Goals. The member companies of Vikaasa will incubate and pilot new growth models creating impact at scale.

Core team members for this project: Debashis Ghosh, Susant Kumar Guru, Anoma Basu from Hindalco and Nakul Gupta, Vaibhav Doshi, Nishant Shekhar, Ashish Verma from Xynteo.

In case of any queries on the Charter, please write to **anoma.basu@adityabirla.com**

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SUSTAINABLE MINING CHARTER

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