Sustainable Mining in India

Overview of legal and regulatory framework, technologies and best process practices

THEME FOR 2017-18

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BREAKING BARRIERS

INDIAN CHAMBER OF COMMERCE

CUTS® International

Table of Contents

List of Tables and Figures

Abbreviations

ALP:	Adriyala Longwall Project
CII:	Confederation of Indian Industries
CIL:	Coal India Limited
CPCB:	Central Pollution Control Board
CTL:	Coal-to-Liquid
DMF:	District Mineral Foundation
DoF:	Department of Forest
DoM:	Department for Mining
EIA:	Environmental Impact Assessment
EPA:	Environment Protection Act
FCA:	Forest (Conservation) Act
FDI:	Foreign Direct Investment
GCV:	Gross Calorific Value
GVA:	Gross Value Added
HCL:	Hindustan Copper Limited
IBM:	Indian Bureau of Mines
ICC:	Indian Chamber of Commerce
MCDR:	Mineral Conservation & Development Rules
MCR:	Mineral Concession Rules
MDPA:	Mine Development and Production Agreement
MECL:	Mineral Exploration Corporation Limited
MMRD:	Mines and Minerals Development & Regulation Act
MoEFCC:	Ministry of Environment, Forest and Climate Change
MoM:	Ministry of Mines
NALCO:	National Aluminium Company Limited
NCMT:	National Centre for Mineral Targeting
NGDR:	National Geo-scientific Data Repository
NMEP:	National Mineral Exploration Policy
NMET:	National Mineral Exploration Trust
NMP:	National Mineral Policy
OB:	Operation for Overburden
PMKKKY:	*Pradhan Mantri Khanij Kshetra Kalyan Yojana*
PPPs:	Public-Private Partnerships
PSUs:	Public Sector Undertakings
SAG:	Semi-Autogenous Grinding
SDF:	Sustainable Development Framework
SPCB:	State Pollution Control Board
UCG:	Underground Coal Gasification
UTs:	Union Territories

Foreword

Mining industry has faced volatility in commodity prices in recent times with prices of several minerals showing a continued downward trend. Despite the underperformance of the Indian mining industry during the last couple of years, the long-term potential of the sector remains intact. Industry experts estimate sector's revenue to increase to over US$35bn in the next few years. To realise this, it will be crucial to focus on achieving economies of scale, strengthening operational management and deploying advanced technology solutions.

Role of mining technology in the given context of economic challenges are likely to be compounded by the fact that mineral resources are geo-technically more complex, and companies have to pursue opportunities in new mining territories. Grades of mineral ores have been falling, henceforth improvements in technology will become key success factors for business. Globally, the use of advanced technology solutions has helped achieve greater efficiencies in terms of increased production, better resource management, enhanced safety, reduction of carbon emission and conservation of natural resources for the next generation.

The Indian government has also begun to lay greater emphasis on improving mining practices through the use of technology. The New Mines and Minerals (Development & Regulation) Bill calls for the deployment of advanced techniques in the areas of exploration, drilling, excavation, loading, beneficiation, etc.In India, the focus is to establish solutions in the core mining production processes of surface mining, underground mining, strategic resource development, resource and reserves estimation, ore body knowledge and mine planning.

Even with these positive developments, there is a significant technology gap in the Indian mining sector as compared to global standards, both in terms of availability and usage. High tax rates and poor equipment financing support are major challenges. Inadequate after-sales services and an underdeveloped market for used equipment are other areas of concern. In spite of adversities, there is a huge scope for technology providers to come forward and meet this challenge of exploration in the mining technology in India.

Against this background, the **Indian Chamber of Commerce** is organising the **India MineTech 2018- A Seminar on Mining Technology at Hotel Hyatt Regency, Kolkata on January 18, 2018.** The conference will focus on the current status of technology deployment in the mining sector and recent global advances in technology, and explore solutions that are best suited for the industry.

CUTS International is the Knowledge Partner of this initiative. I trust the conference would be able to generate new ideas and emerging thoughts among various stakeholders to discuss, share and evolve suitable strategies and development models.

Dr. Rajeev Singh
Director General
Indian Chamber of Commerce

Preface

India's mining industry has a tremendous growth potential which has been exhibited by its dominance of being one of the world leading producers of minerals like iron, coal, zinc, bauxite and so on. India ranks amongst the top ten world producers of several fuel, metallic, non-metallic and industrial minerals. Therefore, taking into consideration the growing nature of the Indian economy, its poverty reduction goals and an aim to substantially improve the demographics' standard of living, the mining sector has and will play a pivotal role in the country's overall development. Thus, it is imperative to look at technological and process solutions to make this sector more efficient and sustainable.

Mining industry is often tagged as a 'polluting' sector since it involves extensive resource exploitation by undertaking activities, such as acquisition of land, clearance of flora and fauna for exploration purposes, infrastructural development on the identified areas, blasting and drilling in the initial stages, and related environmental degradation. In short, this sector represents the classic clash between economic and environmental interests.

Promoting sustainable mineral development is not only the answer to achieve a common ground on bridging economic interests and environmental imperfections but also has the potential to represent India as a global champion that advocates incorporation of sustainable development principles within its mining sector. Deployment of advanced and sustainable technological solution in the entire mining process, fixing the gaps in its regulatory mechanisms and learning from the successes of specific domestic and international mining operations are certain solutions that have the capacity to make this sector more productive.

Against this backdrop, the objective of this paper is to provide an overview of sustainable mining in India by looking at its legal and regulatory framework, a glance on technologies being used, and learnings from sustainable mining practices being practiced by India's leading mining enterprises. In doing so, it looks into technological aspects to mining that has the potential to make this sector resource-efficient and sustainable.

This paper is written for the Indian Chamber of Commerce (ICC) as a knowledge partner of its 'India MineTech 2018 - A Seminar on Mining Technology'. I thank ICC for this opportunity and hope to continue our partnership on many more relevant issues serving the developmental needs of our country as well the vision of the respective organisations. In the end, I would like to thank my colleagues: Akshat Mishra, Senior Research Associate and Mohini Ganguly, Research Associate, for writing this paper under the overall guidance of Veena Vidyadharan, Fellow, CUTS International and Deputy Head, CUTS Centre for International Trade, Economics & Environment.

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Executive Summary

Introduction

India is a significant producer and exporter of minerals. As per the Annual Report 2016-17 of the Ministry of Mines (MoM), India produces as many as 95 minerals. Mining is a vital contributor to the country's economy, forming a fundamental raw material for many important industries.

It is unfortunate but true that the mining process, from exploration to reclamation of exhausted mines, is highly destructive to the environment. Amongst common problems are drilling and explosives that degrade the local environment, dust pollution, water contamination due to poor tillage management, noise pollution and incomplete or inadequate waste management.

Understanding the Indian Mining Scenario

The Indian mining industry is characterized by a large number of small operational mines along with a presence of few large-scale mining that contributes a significant share to the overall production. The total value of mineral production during 2016-17 has been estimated by the Ministry of Mines at INR 2,57,882 crore. From a macro view, India's domestic demand is likely to motivate production growth in several minerals. Sustained growth in India's automotive sector has been driving demand for steel and aluminum, while the power sector demands great proportions of fuel minerals. Another likely driver is the construction industry. In sum, the future for mining in India looks quite progressive but there are certain challenges that need immediate attention.

The Indian mining sector is highly regulated with strong legal and regulatory mechanisms with the government introducing cum revamping several acts, policies, rules at the central and state levels. Since mining sector is a 'highly polluting industry' causing severe environmental and social problems, India has been quite progressive in establishing institutions and regulatory framework in order to counter balance the negative externalities caused by mining activities. But unfortunately the governance system has been stymied by political and administrative hurdles that need immediate attention to act upon.

From the regulatory point of view, the most urgent necessity is to ensure effective, efficient and purposive administration of the existing mining and environmental laws. In regards to this, India has formulated several regulatory and legal mechanisms to promote environmentally sustainable mining which includes mandatory environmental impact assessment, forest clearance provisions, coastal zone regulations, water and air pollution prevention act, adherence to the sustainable development framework under MMRD 2015, mineral concession rules and so on.

The first National Mineral Policy, (NMP, 1993) which recognized the need for encouraging private investment including Foreign Direct Investment (FDI) for advance technological use, was revised in 2008 in order to explicitly note the importance of sustainable practices in mining. The Mines and Minerals (Development and Regulation) Amendment Act, 2015 replaced the MMRD, 1957 for making business practices smoother and more transparent but also took into account local disturbances, providing for the creation of a District Mineral Foundation (DMF). Under this act every mine lease holder is mandated to contribute between 10 and 30 percent of the royalty amount to the DMF for socio-economic development and environment protection activities in and around the mining locale.

These institutional and regulatory interventions to an extent have been able to control the activities of mining operators but rampant presence of illegal mining across the states has negated the efforts. Apart from a few notable exceptions, it is large-scale mining enterprises that have been pioneering the move towards advanced technological solutions for achieving resource efficiency along with adoption of environmentally and socially sustainable mining practices.

Key Messages

India's domestic reserves are considerable in many minerals, and require prudent exploration and development in order to ensure sustainable and safe mining. Given this and further problems dogging the sector (such as unfavorable characteristics of geological mines, degrading quality of mineral ores, problems with as well as increased volatility in commodity prices) the need for technology development and adoption has become urgent.

Currently, demand for advanced technology is already present in India. In order to achieve resource efficiency, the Indian mining sector is already looking forward to adopt advanced mine surveying and exploration technologies (using geophysics applications using 2D and 3D seismic surveys) along with the usage of software solutions by utilizing 3D software packages (like Micromine, Gemcom Minex, Surpac, CAE Mining Datamin and Vulcan) in the mine planning and design stage.

With regards to active mining processes, underground mining (longwall mining in case of coal extraction) and resource-efficient surface drilling technologies (usage of large equipments for dumpers and excavators for improving loading and haulage, hydraulic mining by replacing hand held drills with hydraulic and jumbo drills, etc) are increasingly being adopted by large-mining operations apart from the traditional open-cast mining techniques.

Furthermore, large-scale Indian mining operators like Coal India Limited (CIL), Tata Steel Limited, Hindustan Zinc Limited, et al are seen moving towards increased adoption of automation in mining technologies through in-house capacity building initiatives by their respective R&D departments.

In the front of sustainable mining practices, CIL has done pilot projects on longwall mining (which is already accepted as standard by many countries across the world) along with other eco-friendly technologies developed by their R&D branch. Sesa Strelite Limited has done notable work in adopting biotechnology solutions in order to recover the mine site after closure of the mines by improving the degraded land to acceptable levels. Noamundi Iron Ore Mine under Tata Steel Limited and Rampura Agucha Zinc Mine under Hindusthan Zinc Limited have adopted world-class sustainable mining interventions with regards to the disposal of mine-tailings and reuse of mine-water after beneficiation process. These operations have remarkably carried out efficient and sustainable means of solid and water waste disposal and reuse interventions through advanced engineering and technological adoption mechanisms.

Taking into account the growing levels of innovations worldwide, more advanced technologies like Acid Mist Suppressants, Dust Control Systems, Electrostatic Precipitators, Scrubbers, Process Ventilation Systems and Pollution Control Systems are now available for deployment to efficiently control the alarming rise of pollutants in the environment. As depicted in the case study analysis, such new advanced technologies are increasingly being adopted by major mining companies but mass-scale adoption is still a long way to go for the India mining sector. Moreover, it is mostly the private sector entities that have progressed more in this direction as compared to the public entities. Thus, it is necessary for this industry to stop its reliance over older technologies and adopt newer technologies and processes.

There are many technologies that are being adopted in small ways by large-scale individual operators as they find themselves benefiting. But these practices are only limited to big players (public and private entities) that have the financial capabilities to adopt advanced technological solutions and alongside have also been able to incorporate sustainable mining practices.

On the whole, the key for creating a sustainable mining industry is moving from individual adoption to a large-scale adoption by the entire mining industry which has to be supported by a robust regulatory and legislative mechanism. While legislative and regulatory reforms have to an extent led to many better practices, the government and industry leaders must designs best-practices to ensure an overall profitability and sustainability of the mining sector.

With regards to this, developing affordable technologies are imperative for India so that it can be easily adopted by small-scale mining enterprises as well. This would require putting more impetus to the “Make in India” programme, increased government funding and subsidies (for carrying out R&D specifically in the exploration stage), effective implementation of National Minerals Exploration Policy 2016 (for increasing private sector participation in the exploration process), learnings from domestic and international best process practices, and a conducive regulatory and legislative environment to support India’s vital mining sector.

1. Current State of the Mining Sector in India

India is endowed with significant and vast amounts of diverse mineral resources which are mainly divided into five categories: fuel, metallic, non-metallic, atomic and minor minerals. As per the Annual Report 2016-17 of the MoM, as on date India produces as many as 95 minerals, which includes 4 fuel, 10 metallic, 23 non-metallic, 3 atomic and 55 minor minerals including building materials and other such minerals. On a global scale, India is a significant performer in terms of mineral production and ranks amongst the top producers of valuable minerals like chromite, iron ore, coal, and bauxite. India is also a major exporter of many minerals, including coal, bauxite, iron, limestone, sandstone and mica, to name a few (Ministry of Mines, 2016a).

The Gross Value Added (GVA) accrued from mining and quarrying sector (at 2011-12 prices) for the first quarters of 2016-17 was estimated at INR 86,091 crore, indicating a decrease of 0.4 per cent over the same period of the previous year. The mining and quarrying sector contribution to GVA accounted for about 3.0 per cent for the first quarter of the year 2016-17.

India's mining sector is recognised as a success story and policies have been set over the years in order to encourage the minerals industry, including relaxed FDI norms such as allowance of FDI of up to 100 per cent under the automatic route to explore and exploit all non-fuel and non-atomic minerals. During April 2000-March 2016, cumulative FDI inflows into the metals and mining sector stood at US$11.91bn and this accounted for 4.13 per cent of total cumulative FDI inflows during this period.

Private investment in all aspects of minerals production is being encouraged, but despite that, Table 1 shows that the public sector currently still has a dominant role to play in the mining industry. In Table 1, the public sector clearly accounts for only 8 per cent of the total leases of minerals that are not fuel, atomic or minor and accounts for 30 per cent of the total leased area. The leases in the public sector are clearly for large areas rich in important mineral deposits.

Table 1: Distribution of Mining Leases as on 31-3-2015*

Sector	No. of Mining Leases Granted/Executed	% of Total Leases	Area ('000 ha)	% of Total Area
Total	3868	100	340	100
Public	294	8	103	30
Private	3574	92	237	70

*(Excluding fuel, atomic & minor minerals and also the minerals declared as 'Minor')
Source: Indian Bureau of Mines, Indian Mineral Industry at a Glance 2014-15

During the period 2015-16, the public sector accounted for 72.65 per cent or INR 1,70,121 crore of the total value of mineral production. Small mines, which were mostly in the private sector, continued to be operated manually either as proprietary or partnership ventures. The minerals which were wholly mined or recovered by the public (or sometimes joint) sector in 2015-16 were copper ore and concentrate, diamond, graded fluorite, selenite, and sulphur. Nearly wholly mined by the public sector was the production of sand (others), lignite and gypsum. Additionally, a sizeable 93 per cent of production of coal, 68 per cent of tin concentrate, 69 per cent of petroleum (crude), 99 per cent of gold, 96 per cent of phosphorite, 67 per cent of graphite, and 56 per cent of magnesite was produced by the public sector.

During 2016-17, mineral production was reported from 34 states/Union Territories (UTs) but actual reporting of Mineral Conservation & Development Rules (MCDR) and fuel minerals only came from 22 states/UTs. The data shows that largely, about 92.56 per cent of production value is confined to 13 states including off shore areas. As is clear in Table 2, about half of the value comes from offshore areas and the top three states only, Rajasthan, Odisha, and Chattisgarh. Mining is consequently confined to a small part of the country. Therefore, impacts on the environment can be more problematic as it is confined. Issues, such as land degradation or water quality degradation which reduce the ability of people to live safely have more intense impact.

Table 2: Value of Mineral Production and Number of Reporting Mines in India

State/Area	Estimated proportion of value of mineral production (in %)	Number of reporting mines
Offshore areas	19.93	--
Rajasthan	12.29	79
Odisha	11.10	150
Chhattisgarh	7.32	143
Jharkhand	6.96	203
Gujarat	6.94	178
Andhra Pradesh	5.98	106
Madhya Pradesh	5.88	231
Telangana	4.52	82
Assam	3.93	-
Karnataka	2.65	137
Uttar Pradesh	2.65	--
West Bengal	2.37	100
Tamil Nadu	2.45	208
Maharashtra	2.35	133

Source: (Ministry of Mines, 2016a)

The Indian mining industry is characterised by a large number of small operational mines. The number of mines which reported mineral production (excluding minor minerals, petroleum, natural gas and atomic minerals) in India was 1,899 in 2016-17 as against 2,100 in 2015-16. The above, along with Goa (with 80 mines) account for about 9 per cent of the total number of reporting mines in the country in 2016-17. Rajasthan, with the highest value of production, has the smallest number of mines indicating large areas are covered by each mine.

The total value of mineral production (including minor excluding atomic minerals) during 2016-17 has been estimated by the MoM at INR 2,57,882 crore, which shows a decrease of about 6.78 per cent over that of the previous year. Estimated value for fuel minerals accounted for INR 178,953 crore or 69.39 per cent of the total value, metallic minerals for INR 29,163 crore or 11.31 per cent and non-metallic minerals (including minor minerals) for INR 49,767 crore or 19.30 per cent. In reference, the total value of mineral production (including minor minerals but excluding atomic minerals) during the year 2010-11 and 2011-12 was about INR 2,12,499 crore and INR 2,26,522 crore respectively as estimated in the MoM Annual Report of 2011-12.

Similarly, looking at the values of exported and imported minerals over the years, it can be seen that exports have remained fairly steady. In 2012-13, export value total was INR 175,309 crore whereas in 2016-17 it was INR 170,946 crore. While exports of chromite have come down over the years from about 225 thousand tonnes in 2012-13 to less than 72 thousand tonnes in 2016-17, export of bauxite has gone up from 401 thousand tonnes to 8,914 thousand tonnes in the same period.

Export of Natural Gas has similarly gone up significantly from about 22 thousand tonnes to nearly 127 thousand tonnes over the same periods. Salt (other than common salt) has gone up to a staggering 5,926 thousand tonnes and limestone and building and monumental stones NES have similarly high export values. However, imports have gone down significantly, from INR 944,430 crore in 2012-13 to INR 738,788 crore in 2016-17. Zinc ore imports particularly have reduced from 63 thousand tonnes to a mere 385 tonnes from 2012-13 to 2016-17. This indicates that India has achieved greater self-sufficiency in minerals than previously.

India has tended historically towards self-sufficiency in minerals that are necessary for raw materials to fundamental industries such as iron & steel, thermal power generation, cement, various other types of refractories. India is also self-sufficient in coal and lignite but not the particular type of coking coal required by steel plants. One form of mineral in which imports are still significant is uncut diamonds, emerald and other precious and semi-precious stones which are imported by the polishing and cutting industry in India, in order to re-export.

India’s domestic reserves are considerable in many minerals, but require prudent exploration and development in order to ensure sustainable and safe mining.

Table 3: Reserves of Some Important Minerals in India as of 2010-2013*

Mineral	Proved (STD111)	Probable (STD121)	Probable (STD122)	Total	Feasibility (211)
Barytes	29,557	90	1,935	31,584	179
Bauxite**	401,993.15	52,253.86	375,947.67	830,194.68	134,705.66
Copper Ore	40,650.36	6,521.00	190,401.40	237,572.76	53,789.43
Copper Metal	370.31	61.44	2,565.22	2,996.97	511.15
Chromite	56,890.11	14,045.05	36,286.29	107,221.45	28,010.98
Iron Ore (Heamatite)**	5,029,221.00	746,910.00	830,431.42	6,606,562.42	2,742,272.00
Iron Ore (Magnetite)**	18,180.44	NA	16,412.02	34,592.46	206,758.42
Lead & Zinc Ore**	34,289.30	66,200.00	2,306.00	102,795.30	7,653.75
Lead Metal	657.00	1,422.30	35.61	2,114.91	181.62
Zinc Metal	3,716.40	7,041.10	135.60	10,893.10	488.97
Manganese Ore**	64,104.63	23,460.89	8,305.96	95,871.48	65,550.63
Talc/ Steatite /Soapstone	54,614.50	8,772.13	26,639.80	90,026.43	9,732.11

*Units in '000 tonne; **Values from 2013; The classification used is from the United Nations Framework Classification (UNFC) of Mineral Reserves/Resources; Source: (Ministry of Mines, 2016a)

India's domestic demand is also likely to motivate production growth in several minerals. Sustained growth in India's automotive sector has been driving demand for steel and aluminum, while the power sector demands great proportions of fuel minerals. Another likely driver is the construction industry. Infrastructure buildup is seeing strong growth, not only on housing, but also on projects like roads, rail and airport development, luxury buildings, and other necessities in a rapidly urbanizing landscape. This will create opportunities for steel, zinc and aluminium producers in the near future.

While this is a laudable success story, as the demand for mineral resources increases, so will the pressure on the environment. It has been widely recognised that the need for mineral production is likely to lead to widespread environmental degradation, including but not limited to, land quality degradation (erosion of topsoil) reduction of water resources and contamination of groundwater, and air pollution from dust and other pollutants. These processes need to be addressed in the initial stages, in order to ensure that best practices are internalised in the structure of the industry.

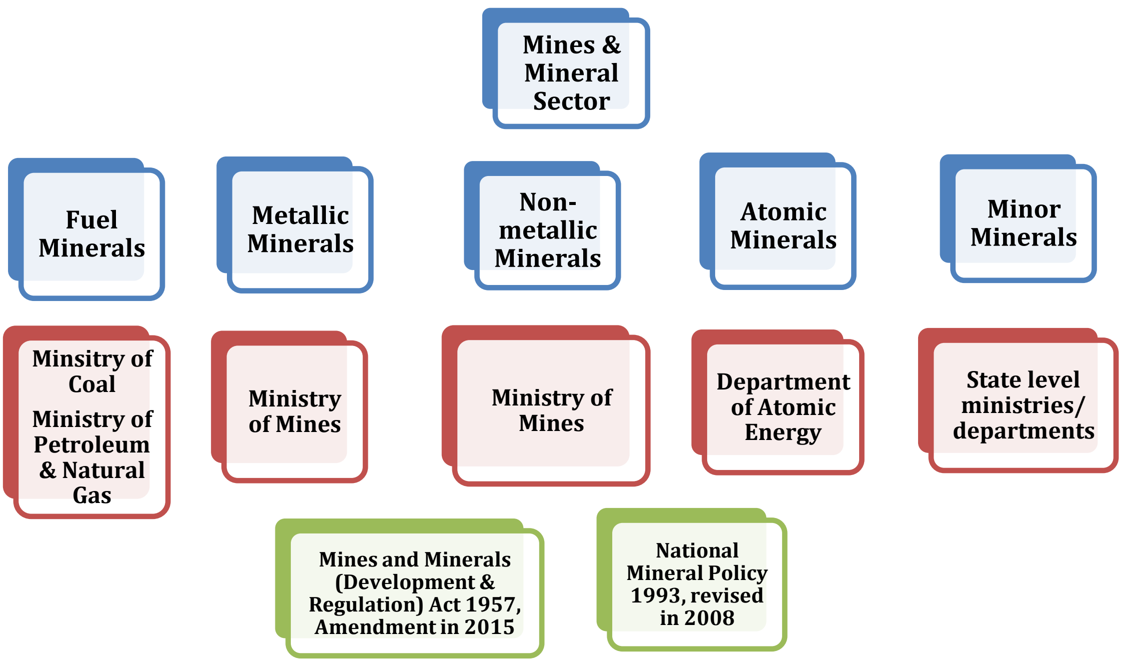
2. Governance of Mineral Resources in India: Institutional, Regulatory and Legal Framework

Institutional Governance of Mineral Resources

Mineral resources in India are mainly divided into five categories: fuel, metallic, non-metallic, atomic and minor. India has set up dedicated ministries for undertaking the work of survey, exploration, mining, production, demand-supply management, auctioning, marketing and pricing of minerals in correspondence to the different mines and mineral categories.

Ministry of Mines is the apex institutional organisation responsible for formulation and administration of polices, rules, regulations and laws relating to mines in India with regards to survey, exploration, mining, production, auctioning, pricing and revenue collection of all minerals (including minor minerals), other than natural gas, petroleum, atomic minerals and coal. **Ministry of Coal** solely deals with survey, exploration, mining, production, auctioning and pricing of coal and lignite reserves while the **Ministry of Petroleum & Natural Gas** is responsible for exploration, production, supply distribution, marketing and pricing of petroleum including natural gas and petroleum products. **Department of Atomic Energy** is responsible to carry out geological exploration and discovery of mineral deposits (mainly uranium reserves) required for the Atomic Energy power programme of India.

Figure 1: Institutional Architecture of Minerals Sector in India



Source: Compiled by the authors

National Policies, Acts, Rules and Regulations

After independence, India saw a paradigm shift in tapping the economic potential through exploration and exploitation of the mineral reserves. But due to technical, financial and regulatory constraints, this sector has not has been able to utilise its full potential specifically with regards to exploration of new mineral reserves. The Indian mining sector is governed by several policies, acts, rules and regulations that are jointly managed by the Central and state governments. The main policies and acts are deliberated, formulated and administered by specific ministries through a central legislation under the leadership of cabinet ministers, while the state governments are required to enact these regulatory policies.

The main acts that govern entire mineral sector of India are the Mines Act, 1952 and Mines and Minerals Development & Regulation Act (MMRD) of 1957 under the administration of MoM while the National Mineral Policy of 1993 is the key reference document of rules, regulations, principles and procedures for regulating, developing and controlling the mineral sector (excluding coal, petroleum and atomic minerals). Significant rules are in force under the MMDR-1957 are the Mineral Concession Rules (MCR), 1960 and the Mineral Conservation and Development Rules (MCDR), 1988. This act was amended in 1972, 1986, 1994, 1999 and 2015 and after each amendment corresponding changes were carried out in MCR and MCDR (Randive, Jawadand, & Raut, 2017). Formulation and administration of polices for the coal, petroleum, atomic energy sector is respectively done by the Ministry of Coal, the Ministry of Petroleum & Natural Gas, and the Atomic Minerals Directorate.

Mines and Minerals (Development & Regulation) Act, 1957

The Mines and Minerals (Development & Regulation) Act, 1957 (MMRD 1957) is the principal legislation that lays down the regulatory and governance framework of mineral and mining sector at the central level in India. Over the years of economic developments and corresponding changes in the mineral sector, this Act was amended multiple times. This Act is divided into eight chapters with 33 specific sections that put forward detailed requirements for obtaining and atomic minerals) is controlled by the Central Government while administration and regulatory governance of minor minerals are entirely delegated to respective state governments (Ministry of Mines, 1957). Section 3 (e) of MMRD 1957 gives the Central Government the power to notify ‘minor minerals’ (by adding or deleting the minerals in the list) while per Section 15 provide state governments complete powers for making rules regarding minor mineral mining, levy, collection of royalty and so on.

On the other hand, mining activities for all types of major and mineral minerals in offshore areas (territorial waters, continental shelf, exclusive economic zone and other maritime zones of India) is the exclusive responsibility of the Central Government. For regulating the mining and development of minerals in the offshore area, the Parliament has enacted the Offshore Areas Minerals (Development and Regulation) Act, 2002 which empowers the Central Government under the administrative authority of the Indian Bureau of Mines (IBM) to grant mineral concessions for offshore areas and collect royalty (Ministry of Mines, 2016b).

Mines and Minerals (Development and Regulation) Amendment Act, 2015

MMRD 1957 had certain flaws as it did not permit auctioning of mineral concessions; there were issues regarding the historically non-transparent process for grant of mineral concession; and the process of granting and renewing of mineral concessions was quite slow which led to a decline in mineral production affecting the manufacturing sector as a whole. Considering the lacunas in various clauses under this Act, the MoM amended it for the fifth time in 2015.

As a result, the MMRD Amendment Act, 2015 replaces the MMRD, 1957 with the following amendments (PRS Legislative Research, 2015); (Ministry of Mines, 2015):

- Adds more minerals in the notified minerals category under an additional Fourth Schedule: bauxite, iron ore, limestone and manganese ore with further amendments are notified by the Central Government;
- Creates a new category of mining licence, i.e. the prospecting licence-cum-mining lease, which is a two stage-concession for the purpose of undertaking prospecting operations (exploring or proving mineral deposits), followed by mining operations;
- Provides relaxation for maximum area limits by amending the provision of just providing a single entity with one mining lease for a maximum area of 10 sq km. Now the Central Government can increase the area limits for mining, instead of providing additional leases.
- Under this act the mining lease period for all minerals other than coal, lignite and atomic minerals has been increased from 30 years to 50 years and after the license lapses, the lease will be put for auction and cannot be renewed.
- Specifies that any lease granted before the commencement of the Act shall be extended: (i) up to March 31, 2030 for minerals used for captive purpose (specific end-use) and up to March 31, 2020 for minerals used for other than captive purpose, or (ii) till the completion of renewal period, or (iii) for a period of 50 years from the date of grant of such lease, whichever is later.
- Provides state governments the power for granting mining leases and prospecting license-cum-mining leases for both notified and other minerals with the approval of Central Government. All leases are granted through auction by competitive bidding, including e-auction.
- Provides the holder of a mining lease or prospecting license-cum-mining lease (obtained through auction process) the right to transfer the lease to any eligible person, with the approval of the state government as specified by the Central Government.
- Provides for the creation of a DMF. Under this Act requires every mine lease holder is mandated to contribute 30 per cent of the royalty amount (for leases granted prior to January 12, 2015) and 10 percent of royalty (for leases granted after January 12, 2015) to the DMF which is required to be utilised by the District Collector/Magistrate for development and socio-economic and environmental activities in and around areas where mining operations are carried by the lease holder (Ministry of Mines, 2016a)
- Lays down rules and regulations for the creation of a National Mineral Exploration Trust (NMET) regional and detailed mine exploration. Licencees

and lease holders are mandated to contribute two per cent of royalty towards NMET exploration activities.

National Mineral Policy, 2008

The first National Mineral Policy (NMP, 1993) (for non - fuel and non - atomic minerals) was implemented in the year 1993 and is one of most important legal framework for the mines and mineral sector in India. The policy lays down provisions with regards to regulation of minerals, role of the state in mineral development, survey and exploration, national inventory of mineral resources, strategy of mineral development, foreign trade, fiscal aspects and research and development. NMP 1993 recognized the need for encouraging private investment including Foreign Direct Investment (FDI) and for attracting state-of-art technology in the mineral sector. The policy shall continue to formulate measures for the regulation of mines and the development of mineral resources to ensure basic uniformity in mineral administration (Randive, Jawadand, & Raut, 2017). Over the last two decades there have been considerable changes in the Indian mining sector which led to the revision of this policy and enactment of NMP, 2008 (for non-fuel and non-coal minerals). This policy stresses the importance of practicing sustainable mining in order to preserve and augment the exhaustible minerals reserves and aims for optimal utilization of natural mineral resources of the country. In brief the policy states (Indian Bureau of Mines, 2008):

- *Conservation of minerals shall be construed not in the restrictive sense of abstinence from consumption, or preservation for use in the distant future.*
- *Conservation is a positive concept leading to augmentation of reserve base through improvement in mining methods, beneficiation and utilisation of low grade ore and rejects and recovery of associated minerals.*
- *All mining shall be undertaken within the parameters of a comprehensive Sustainable Development Framework which includes guiding principles for a miner to leave the mining area in a better ecological condition after mining*

National Mineral Exploration Policy, 2016

The policy provides for an action plan to ensure comprehensive exploration of mineral resources (non-fuel and non-coal) in the country (ENVIS, 2016). In brief the policy:

- Addresses the gaps of data consolidation and states, so that pre-competitive baseline data (to understand geology, structure, etc.) will be made available by the government free-of-charge and calls for the establishment of a National Geo-scientific Data Repository (NGDR) -- a repository that will assemble all mineral baseline and exploration data.
- Puts special impetus to explore deep seated mineral deposits.
- Invites the private sector to carry out exploration work in the identified blocks and lays out further provisions with regards to sharing of revenue and other compensatory measures if the private agency fails to discover any mineral reserves in the respective areas.
- Provides for the establishment of a National Centre for Mineral Targeting (NCMT) dedicated to increasing the discovery rate in mineral exploration and the quality of discoveries (without relying on substantial increase in exploration expenditure.

Overview of Other Policies, Acts, Rules and Regulations

S.No.	Act/Policy/Rule/Regulation	Description
1.	Mines Act, 1952	This Act regulates the working conditions of workers in mines, and their safety measures. It also oversees regulations for carrying out mining operations and management.
2.	The Mines Rules, 1955	These rules outlined the framework for the basic health examination of persons employed in mines, and sanitation provisions and welfare facilities for miners and their families.
3.	Mines Concession Rules, 1960 Amended on 2012	As per provisions of Section 13 of MMDR Act 1957 these rules define the process of grant of mineral concessions with regards to reconnaissance permits, prospecting licences and mining leases which are granted by state government. These rules were further amended in 2012.
4.	Oilfields (Regulation and Development) Act, 1948	This Act regulates the grant of licences for exploration of oilfields by the Central Government.
5.	Petroleum and Natural Gas Rules, 1959 Amendments in 2013	This Act regulates the grant of exploration licences and mining leases in respect of petroleum and natural gas.
6.	Coal Bearing Areas (Acquisition and Development) Act, 1957	This Act establishes public control over the coal mining industry and its development by providing for acquisition by the State of unworked land containing or likely to contain coal deposits.
7.	The Coal Mines (Nationalisation) Act, 1973	This Act regulates the acquisition and transfer of the right, title and interest of the owners in respect of the coal mines specified in the Schedule.
8.	Coal Mines (Conservation & Development) Act, 1974	This Act aims to provide for conservation of coal and development of coal mines and for matters connected therewith or incidental thereto.
9.	Coal Mining (Nationalisation)	This Act was amended to allow private

S.No.	Act/Policy/Rule/Regulation	Description
	Amendment Act, 1993 Amended in 1986	coal mining for captive consumption for generation of power, washing of coal obtained from a mine and other end users to be notified by Government from time to time in addition to the existing provisions.
10.	Colliery Control Rules 2004	These rules specify the role of the coal Controller, who will be responsible for overseeing and regulating the compliance of mandatory requirements for the colliery owners.
11.	Granite Conservation and Development Rules, 1999	These rules were framed for conservation and systematic development and scientific mining to conserve the granite resources and to prescribe a uniform framework with regard to exploitation of granite throughout the country.
12.	Marble Development and Conservation Rules, 2002	These rules were framed for systematic prospecting and quarrying or mining of marble and to provide a uniform framework with regard to scientific exploitation of marble.
13.	The Offshore Areas Mineral (Development and Regulation) Act 2002	This Act regulates the development of mineral resources in territorial waters, continental shelf, exclusive economic zone and other maritime zones of India.
14.	The Offshore Areas Mineral Concession Rules, 2006	The rules lay down the process for grant and renewal of reconnaissance permits, exploration licences and production leases as per provisions of Section 35 of the Offshore Areas Mineral (Development and Regulation) Act, 2002. The rules prescribe for measures for protecting the marine environment and safety measures to be followed in the leased area. The rules also define the operational guidelines for each concession granted under the Act.
15.	Minerals (Evidence of Mineral Contents) Rules, 2015	This provides the set of rules that set the procedures to be followed for conducting any exploration to determine the mineral content and to take up the mineral blocks

S.No.	Act/Policy/Rule/Regulation	Description
		for auction and mineral concessions.
16.	Mineral (Non-exclusive Reconnaissance Permits) Rules, 2015	It laid down the process to be followed for grant of Non-exclusive Reconnaissance Permit - any operation undertaken for preliminary prospecting of a mineral through regional, aerial, geophysics, or geochemical surveys and geological mapping, but does not include pitting, trenching, drilling, or sub-surface excavation.
17.	Mineral Conservation and Development Rules, 1988 Amended on 2011 Mineral Conservation and Development Rules, 2017	As per the provisions of sections 18 of MMDR Act 1957 these rules prescribes guidelines for conservation and development of minerals to ensure scientific management of the mining process.
18.	National Mineral Exploration Trust Rules, 2015	Under Section 9C (1) of MMRD 2015, the Central Government established a Trust, called the National Mineral Exploration Trust, which is a non-profit organisation. The object of the Trust is to use funds accrued to the Trust for the purposes of regional and detailed exploration in such manner as may be prescribed by the Central Government.
19.	Mineral (Auction) Rules, 2015	The rules specify auctioning mechanisms with regards to value of estimated resources for auction of block; value of mineral dispatched; sale price of mineral (grade wise and state wise); Reserve Price; Auction prerequisites; Bidding Process; Upfront Payment; Performance Security; and Mine Development and Production Agreement (MDPA).
20.	Atomic Minerals Concession Rules, 2016	The rules prescribe the procedures for regulating the grant of reconnaissance permits, prospecting licences and mining leases in respect of Atomic minerals and for purposes connected therewith.

Sources: Information extracted from (Randive, Jawadand, & Raut, 2017); (Ministry of Mines, 2016a); (Ministry of Mines, 2016b) and official government documents with the links embedded in the title

3. Environmentally Sustainable Mining: A Sectoral Overview of its Legal and Regulatory Framework

Impact of Mining Activities on the Environment

The mining sector is perceived as a major contributor to environmental degradation throughout the world. It is often tagged as a 'polluting industry' with substantial amount of environmental footprint which is also under of claws of illegal mining activities that exacerbates ecological degradation. Even though minerals are core constituents for many manufacturing and industrial sectors, their extraction and processing creates considerable negative environmental and social effects. In sum, mining leads to destruction of flora and fauna, clearance of large tracts of land, air-water-soil pollution and can even disrupt local ecological balance or wipe out local biodiversity. This heavily impacts both the environment and the people. Social impacts of developing a mining facility majorly involves relocation of tribal people or communities dwelling in mineral rich areas which are often met by social resistance and disagreements around issues such as resettlement, compensation and land rights of the indigenous people.

There are several phases in a mining project – site exploration; development (construction of access roads, site preparation and clearing); active mining (open cast mining, placer mining, underground mining, reworking of inactive or abandoned mines and tailings); disposal of overburden and waste rock; ore extraction and transportation; beneficiation (including milling); tailings disposal; and site reclamation and closure. These eight stages are further segregated into different process having a specific environmental footprint which has been delineated in the Table 4.

Table 4: Environmental Footprints of a Mining Process

S.No.	Process	Environmental Implication
1.	Exploration	Involves clearing of vegetation, and removal of top soil thereby leading to loss of flora and fauna.
2.	Development	Once minerals have been discovered and profiled in a certain region, the next step is to develop access to the region by building access roads in order to transport heavy machines for drilling and excavating the region. Construction activities not only lead to waste generation but also destroy the flora and fauna particularly if activities are conducted in an ecologically sensitive site.
3.	Active mining	This is one of the most environmentally damaging activities in the mining process. Open pit mining, placer mining, and underground mining involve drilling and blasting activities that is detrimental to vegetation and leads to dust cloud formation,

S.No.	Process	Environmental Implication
		release of particulate matter causing severe respiratory health issues, acid rain due exposure of sulfide ores to environment, release of toxic gases in the atmosphere, and noise pollution.
4.	Disposal of overburden and waste rock	The mining process creates overburden and waste rock while extraction of mineral content from the excavated reserve (typically the strip ratio of overburden to actual mineral reserve is very high). As a result, huge piles of overburden/waste dump is collected near mining sites and contains significant levels of toxic substances and also creates dust clouds with fumes od other toxic gases thereby leading to air pollution and water pollution as a result of runoff during monsoon season.
5.	Ore extraction and transportation	In this stage the raw metal ores are extracted using various kinds of heavy machinery and then transported to the processing units using haul roads. This activity creates a unique set of environmental impacts, such as emissions of fugitive dust from haul roads. Furthermore, if the extracted ores are uncovered during transportation stage, huge amounts of fine dust is dispersed in environment and tends to stay in air for long period of time.
6.	Mineral processing through beneficiation	Beneficiation is used to separate core minerals from the metal ore through beneficiation processes such as gravity concentration, magnetic separation, electrostatic separation, flotation, solvent extraction, electro-winning, leaching, precipitation, and amalgamation, etc resulting in creation of high-volumes of tailings (toxic mining waste material) containing harmful metal contaminants (like arsenic, lead, cyanide, sulfuric acid, cadmium, etc) resulting in water, soil and air pollution.
7.	Tailings disposal	In most of the cases wet and/or dry tailing are disposed by mining companies in nearby rivers or small streams or dumped in open areas. Unscientific and untreated disposal of tailing water into the river is highly destructive for river ecology, leads to surface and groundwater contamination with high-levels of toxic contaminants that are fatal for the people who encounter the water, and the entire ecological

S.No.	Process	Environmental Implication
		chain.
8.	Site reclamation and closure	If a mining operation is not reclaimed and closed using scientific interventions it can prove to be extremely hazardous to humans and the environment for decades and even centuries after.

Source: (ELAWS, 2010); and (ISID, 2012)

Legal and Regulatory Framework for Environmentally Sustainable Mining in India

Since mining is one of the most controversial economic activities, leaving detrimental imprints in the environment and the society, a majority of countries throughout the world have established legal and regulatory framework to control its socio-environmental impacts. India too has a laid down an array of policies, laws, rules and regulations (mostly based on international best practices) for ensuring sustainability in the mining sector. The Ministry of Environment, Forest and Climate Change (MoEFCC) is the apex organisation that has laid down a set of policies, acts, rules and regulation to combat environmental conflicts that might arise due to different mining activities. The policy framework under the MoEFCC is generic for the entire industrial sector -- Environment Protection Act (EPA) 1986 with the recent amendments-Environment Protection (Amendment) Act (EPA 2006) and the Forest (Conservation) Act, 1980 (FCA 1980) as the two main policies that have specific clauses for monitoring mining activities for the protection of the environment.

Forest (Conservation) Act (FCA 1980) has been amended over the years with the most recent amendments in 2014. The Act empowers the Central Government to take all measures as deemed necessary for protecting the environment, and preventing, controlling, and abating pollution. EPA 1986 lays down standards for discharge of effluents, national ambient air quality standards, ambient air quality standards, and the requirements of the Environmental Impact Assessment (EIA) that will lead to environmental clearance. Under EPA 2006, EIA is most important environmental requirement for a mining operation which was started in 1994 and is being continued with refinements since that date. Furthermore, under the aegis of MoEFCC, Central Pollution Control Board (CPCB) is the main regulatory agency that plays an advisory role to MoEFCC on any matter concerning prevention and control of water and air pollution from industrial activities. In order to curtail the impacts of mining processes on the environment, CPCB has laid down the Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act, 1981 and the Coastal Zone Regulation, 2011.

Apart from the central regulatory bodies, in conjunction with the central institutions, laws and regulations, respective state governments have set-up dedicated departments for controlling and regulating the mineral sector of their states. At the state level, the key institutions include the Department for Mining (DoM), the Department of Forest

(DoF) and State Pollution Control Boards (SPCB). DoM mainly deals with discovery, development and administration of mineral resources in the State and mainly looks at providing mineral concessions, supervising mineral operations and is also a repository of state specific mineral data. DoF mainly deals with forest clearance mechanisms required to be obtained for a mining operation and also lays down areas which are protected and where mining or any industrial activity is prohibited. SPCBs are state level regulatory bodies that ensure mining operations are complying with the rules and regulations for water and air protection (Khanna, 2013).

MoM has also laid down specific rules and regulations in order to ensure environmental integrity in mining operations. MMRD, 1957 has been amended over the years to incorporate clauses concerning environmental sustainability. Under MMRD 2015, MoM has also issued the Mineral Conservation and Development Rules (MCDR) 1988 (amended in 2011) which prescribes detailed procedures and practices to be followed by the holders of reconnaissance permits, prospecting licences and mining leases in order to ensure safe and scientific mining, systematic development of mineral deposits, conservation of minerals and protection of the mines-environment. These rules mandates to follow practices mentioned in Sustainable Development Framework (SDF) that prescribes a detailed mining standards (specifically with regards to be adopted of scientific and environmental friendly mining, addressing social impacts of mining, adoption of scientific means of mine reclamation and closure, and so on) by mining companies and accordingly the ministry would rate (1 to 5 star rating) the mining companies in terms of their operation and compliance to SDF (Ministry of Mines, 2016a).

In 2017, MCDR was further amended and the star rating of mines was made a mandatory requirement. Further, it laid down strict pecuniary penalties for defaulters. As per the latest amendment if any mining operation fails to adhere to scientific and efficient mining operations as mentioned in the SDF and does not achieve at least four star rating within a period of two years from the date of notification of these rules or two years from the date of commencement of mining operation, the MoM will suspend the licence of such defaulting companies and seize their operations.

MoM has vested the responsibility of monitoring the proper enforcement of the rules under MCDR and SDF on the IBM. MCDR puts an obligation on the mine operators to follow the best practices prescribed for scientific mining and submit various prescribed plans, schemes and reports to the authorised officials of IBM and in some cases, the concerned state governments. IBM scrutinises these reports and in some cases like the mining plans, schemes of mining, and mine closure plans, provides the required approvals and then monitors their implementation. IBM officials also undertake field inspections/studies for the enforcement of the provisions of MCDR 1988. During inspection, IBM officials ensure that various elements of scientific mining are followed in the mines operations and sometimes they also provide guidance to the mines operators and officials in the areas of scientific mining including protection of the mines environment (ISID, 2012)

Table 5: Indian Mining Sector Environmental Protection Policies, Rules and Regulations

S.No.	Policy, act, rule, regulation	Description
1.	EIA under Environment Protection (Amendment) Act 2006	EIA 2006 regulates the construction, expansion and modernisation of developmental projects that have a potential threat to the environment in different parts of India. This law mandates prior environmental clearance to be obtained for a listed project before starting any operation. It is obtained through a series of steps that includes screening of the project, scoping (preparation of detailed terms of reference), engagement with project-affected communities through public hearings, preparation of the EIA report and an appraisal of project documents by a group of experts. As per 2006 notification, EIA is required for projects listed in category A and B1 project. In the case of mining sector more than 50 hectares of mining lease area in respect of non-coal mine lease and 150 hectares of lease area in respect of coalmine lease are included in Category 'A', along with offshore and onshore, oil and gas exploration and development. Category 'B' projects cover mining lease area between 5-150 hectares in respect of coal and 5-50 hectares in respect of other minerals. Mineral prospecting, however, is excluded from prior environment clearance.
2.	Sustainable Development Framework (SDF) under MMRD 2015	SDF makes it mandatory for every mining company to follow SDF standards in order to achieve five star ratings which are based on mining operation performance on techno, socio-economic and environmental parameters The star rating is initially done for mines of 'major minerals' and ratings are based on the following parameters: (i) The management of impact by carrying out scientific and efficient mining; ii) Addressing social impacts of resettlement and rehabilitation requirements from mining activities; (iii) Local community engagements and welfare programmes; (iv) Steps taken for progressive and final mine closure; and (v) Adoption of international standards. The star rating of mines is based on self-certification which is verified by the Apex committee constituted under the aegis of the IBM.
3.	The Forest (Conservation) Act, 1980 Forest Conservation	The Act put a mandate on the state government to have consultation and approval before declaring any forest as 'Non-Forest' zone which has been specifically reserved as 'Forest Zone'. The power to

S.No.	Policy, act, rule, regulation	Description
	Amendments Rules, 2014	make rules under the Act has been delegated to the Central Government.
4.	Coastal Zone Regulation, 2011	The regulation strictly controls the setting up and expansion of any industry, operations or processes and manufacture or handling or storage or disposal of hazardous substances as specified in the Hazardous Substances (Handling, Management and Transboundary Movement) Rules, 2009 within a strip of 520 metres from the shore in coastal areas.
5.	The Water (Prevention and Control of Pollution) Act, 1974 Amended in 1988	The Act provides for the prevention and control of water pollution and the maintenance or restoration of wholesome quality of water. For this purpose, it vests power in the State Pollution Control Boards (SPCB) to lay down and enforce effluent standards for 'trade effluents' i.e. any liquid, gaseous or solid substance discharged by industrial establishments including mines and processing plants.
6.	Water (Prevention and Control of Pollution) Cess Act 1977	The Act provides for the levy and collection of a cess on water consumed both by persons carrying on certain industries and by local authorities to augment resources for the pollution control boards. Mining is one the industries included within the ambit of the Act and accordingly a cess is charged per kilolitre water used for activities such as industrial cooling, spraying in mining pits, etc. Industries and operations which have installed mechanisms to keep water pollution under control are given a rebate in the cess charged.
7.	The Air (Prevention and Control of Pollution) Act, 1981 Amended in 1987	Under this Act, all industries (including mines) operating with in designated air pollution control areas must obtain permits (consent) from SPCBs. The state boards lay down the standards of emission of air pollutants in to the atmosphere from industries (including mines) and vehicles after consulting the central board and noting its ambient air quality standards.
8.	Sustainable Sand Mining Guidelines, 2016	These guidelines specify sustainable mining practices and environment friendly management practices required in order to maintain and restore the ecology of river and other sand sources.

Source: (ISID, 2012); (Ministry of Mines, 2016a); (Khanna, 2013)

4. Mining Technologies and the Indian Mining Sector

With regards to worldwide mineral production, India ranks 3rd in coal and zinc production and contributes to about 8.1 percent of total coal and lignite while 5.5% of total zinc production in the world. The country ranks 4th in Bauxite, Chromite and Iron ore production, respectively contributing 8.5%, 7.2% and 3.8% of total world production (Ministry of Mines, 2016a). Even though, on a global scale, India is a leading mineral producing country in various mineral categories but looking at the performances of countries like USA, China and Australia, the country lags behind in optimal resource utilization due to sub-optimal technology penetration in the planning and operation stage. The need for technology penetration is further necessitated by issues concerning unfavourable geological mines characteristics (frequent faults in terms of a planar fracture or discontinuity in a volume of rock, shallow and thick ore deposits, etc.), degrading quality of mineral ores, increased volatility in commodity prices coupled with chaotic regulatory mechanisms and governance impediments. Moreover, since the country's total mineral production has been consistently falling from 2011-12 there is a need to consider technological solutions (global standards of high capacity technology) to revamp production capacity in all types of mineral category, mainly targeting fuel and metallic minerals.

Mining Processes and Related Technologies: Examples from Coal Mining in India

There are two main mining techniques used worldwide – surface/opencast and underground mining. Being cheaper in terms of operational cost but more pressurising on the environment, surface mining is commonly used for production of most of the metallic ores and minerals (excluding petroleum and natural gas) in India while underground mining has rare usages which are just limited to certain mineral by few prominent mining companies, specifically the coal industry. This is largely due to a combination of factor including the need for huge initial capital, high labor costs, long gestation periods as well as limited or non-availability of local equipment.

The following important processes are the steps required in mining (India Infrastructure Limited, 2016a):

Exploration

In order to get systematic views of the geology, mineral exploration at depth is vital. This requires physical property studies, geological studies, 2D and 3D surveys, and downhole measurements. In this preliminary stage, the mass move towards mechanized drilling technologies has already begun in India. Capacity enhancing technologies like 2D and 3D seismic surveys are being accepted widely in India. The government has recently initiated the National Mineral Exploration Policy, 2016 in order to enhance participation of the private sector and accelerate exploration.

As part of the policy, the Ministry of Mines proposes to provide world-standard baseline geo-scientific data in the public domain via public-private partnerships to promote research. The ministry has also noted that it will take initiatives for finding deep-seated, concealed deposits, and will undertake aero-geophysical surveys of the country. Therefore, it is expected that the demand for advanced exploration equipment will also be enhanced.

Production

Surface mining techniques

Surface mining has several advantages over underground mining methods. It is a blast-free method, does not require multiple operations, requires less labour, offers improved operations and works better for selective mining. Surface miners can additionally reduce the cost of transportation of minerals by belt conveyors/dumpers. They can also utilise inbuilt water spraying system to suppress dust pollution from coal cutting. In addition, a significant consideration is that there are very low chances of fire in the coal face.

Opencast or surface mining consist of three different methods: strip mining, open-pit mining, and mountain top blasting. The soil on the surface is broken up, and rocks are broken down using explosives and then removing debris until the coal seams are exposed. Drills and other equipment are then necessary in order to extract the coal. As previously mentioned, this allows for more comprehensive extraction.

However, surface mining is typically a method which causes large scale environmental degradation. It destroys large areas of land, and natural habitat. For instance, mountaintop removal uses explosives to breakdown the surface of mountain tops in order to reach coal seams deep inside the earth, up to 400 feet below surface. The use of surface miners is gaining widespread acceptance in opencast mines of India. For mines where drilling and blasting is either prohibited or uneconomical this can be a boon. At the Gevra coal mine in Korba district of Chhattisgarh, for example, 66 per cent of the coal production is through surface miners and 34 per cent using the conventional drilling/blasting method. It is the largest opencast mine in Asia, and a good example of the advantages of the usage of surface miners.

Underground Mining Techniques

The share of underground mines in other major coal producing countries other than India, such as China, United States and Australia are 95 per cent, 30 per cent and 25 per cent respectively. In India, efforts are under way to step up production from underground mines by introducing mass production techniques like Longwall/Highwall/Shortwall mining as these techniques have greater mineral extraction capacity as compared to surface mining.

In India, Longwall and continuous miner technologies are being seen as important technology for coal extraction in India. Longwall mining involves the full extraction of coal from a section of the seam or face using mechanical shearers. The coal seam can vary in length from 100 metres to 350 metres. Self-advancing and hydraulically powered supports hold up the roof temporarily while the coal is extracted. When the coal has been fully extracted from the area, the roof is allowed to collapse.

Longwall mining, after having witnessed failure in a number of projects, is now receiving interest from the industry, given successful projects like the Adriyala mines. Given the state of mining in India, it is wise to prepare for future extraction from deeper locations up to 600 metres, from 300 metres in the wall face. This can only be achieved through the use of longwall technology.

Case Study 1

Coal India Limited Future Perspective in Technology Development and Mechanisation

In order to reach a coal production capacity of 1 billion tonne by 2019-20, Coal India Limited (CIL) has put forward a roadmap for incorporating technology upgradation.

For opencast mining the company plans to:

- use Hydrostatic Drilling to achieve higher efficiency;
- more use of geophysical loggers;
- optimisation of number of coring boreholes based on the complexity of geology of the block;
- extensive use of planning software for opencast mines like MINEX;
- use of Laser Survey Technology for output measurement along with presently used Theodolite technology;
- use of high capacity dumper-shovel equipments and size draglines along with undertaking operation for overburden (OB) crushing which is not being done presently;
- more use of surface miners for the purpose of selective mining and using Ripper Dozer in removing OB near the villages;
- extensive use of high capacity motor – graders and vibratory road rollers and ripper dozer for establishment and maintenance of haul roads and use of cement in haul roads construction;
- in coal transportation stage, increase use of in-pit crushing and conveying System, angle conveyors including high angle conveyors, skip conveyors, tube conveyors, flexible conveyors;
- deploying technological options for redesigning open cut mines to reduce haul distances and elevations & dump schedules; and
- use of high speed drivage equipment with advanced technology for drivage of shafts, inclines/drifts.

With regards to underground (UG) mining, CIL looks forward to use latest planning software for underground mines apart from the presently used Auto-cad software; increased application of longwall/shortwall technology; highwall technology; hydraulic mining by replacing hand held drills with hydraulic and jumbo drills

For mine safety CIL plans for development of sensors and use of modern on-line network system; development of hidden slip and geo-logical disturbance detectors; integration of strata monitoring with support; and use of directional drilling and seismic survey technology for water danger management (Coal India Limited, 2015).

As mentioned in the Annual Report 2016-17 of Ministry of Coal has an in-house Science & Technology as well as Research & Development Programme which has come up with several useful innovations for better and more environmentally sustainable mining.

In the year 2015-16, some of the technologies produced by CIL include (Ministry of Coal, 2017):

1. Development of tele robotics and remote operation technology for underground coal mines: CIL's R&D division has conducted field trial of a tele-robot at Khottadih mine of Eastern Coalfield Limited (ECL). It is capable of monitoring environmental parameters particularly air pollutants like CO2, CH4, O2 and also humidity & temperature. The real time graphical-user-interphase (GUI) based navigational camera is capable of providing a 3D representation of the environment in the underground mines from sensor data.
2. Development of indigenous catalyst through pilot scale studies of Coal-to-Liquid (CTL) conversion technology: A fully integrated Coal-to-Liquid Pilot plant consisting of coal gasification, gas cleaning, shift reaction, CO2 scrubbing, liquefaction and liquid collection has been completed at the Central Institute of Mining and Field Research (CIMFR), Dhanbad.
3. Blast design and fragmentation control: Field trials have been carried out at Nigahi, Kusmunda, Samleshwari, and Sonepur Bazari opencast mines. Software was used to study the effect of blasting on three parameters: rock fragmentation, distribution pattern and scattering effect.
4. Design and development of truck mounted mobile coal sampler for instant coal ash & moisture analyser at site from railway wagon/ truck: This project was completed in 2 Phases with successful field trials. Phase-I established the feasibility of nuclear technique method with dual gamma-ray transmission for analysis of ash and moisture content in coal. Phase –II developed a truck mounted mobile coal sampler for field trials at Ramagundam area of SCCL. The efficiency improvement from this project comes from the fact that the samples could be optimized for consistency in product yield and ash of various coal samples with size fraction of 100-75 mm, 100-50 mm and 75-50 mm collected from different mines of Western Coalfield Limited.
5. Design, development and show-casing demonstrative trials at Khottadih Colliery, ECL of safe liquidation method for thick seams of Raniganj Coalfield: Field trials were completed successfully. Sub-panels (B-2A & B-2B) of B-2 panel was extracted safely in a low-incubation coal seam. As part of safety instrument, during the depillaring operation, a number of geotechnical instruments were installed to monitor the stress and deformation of the strata. No significant observations of stress and deformation at the time of extraction were noted.

Looking at the R&D success of CIL, the state-of-art technologies developed by this company could successfully be deployed in the overall coal mining segment of India in order to make mining safer, more environmentally sustainable, and more efficient in the near-future.

Case Study 2

Longwall Mining in Adriyala by Singareni Collieries Company Ltd & Impacts of Longwall Mining on the Environment in New South Wales, Australia

Initially, as a testing site, a single high capacity longwall project with an annual capacity of 2.817 MTPA was commissioned with state of art equipment at Adriyala Longwall Project (ALP). A number of new (although tested in other countries) technologies were introduced at the project for the first time:

- *Punch entry (Direct access to coal from Opencast highwall)*
- *11 KV power transmission to UG (for less voltage drop)*
- *Pre tensioned Cable bolting (for effective roof support)*
- *Automation systems (for sequence control/less manual intervention)*
- *400 KW high capacity fan (to supply more air with high water gauge)*
- *Diesel transport vehicles (FBL) (for flexible, speedy & safe equipment transportation)*
- *Floor Concreting in underground (for Diesel vehicle movement with heavy equipment); VFD controlled un-manned Belt conveyor system (for soft starts and power conservation); and Mine cruiser (for faster and safe transport)*

After seeing the performance of Adriyala Longwall Project, Singareni Collieries Company Ltd is planning to introduce more longwall mines in the future. But it is important to consider the environmental footprint of this technology and learn from the experience from countries like Australia where longwall mining has been practiced since last decade and its environmental effects have been analyzed in detail (Total Environment Centre, 2007).

1. **Subsidence and fracturing:** After the mining is complete, when the gaps in the mine are allowed to collapse in, impacts can manifest in the form of fracturing of rivers and rock benches, rock falls and slumping. Cracking may occur in other parts of the landscape but these are often hidden by soil and vegetation. This sort of stress may even lead to rock falls or cliff falls as seen in places like the Newnes Plateau.
2. **Water Loss:** Subsidence may further lead to loss of water to near-surface groundwater flows. If the water body is located in an area where the coal seam is less than approximately 100 metres below the surface, longwall mining can cause the water body to lose flow permanently, changing the ecology of the area entirely.
3. **Water Quality:** The cracking and subsequent sedimentation of rocks and ground from mining will lead to water interacting with various new compounds, not all of which are neutral. For example, iron oxides are a typical material in many New South Wales creeks from mining.
4. **Gas:** Fracturing of rock strata may result in gas release. This gas is associated with near surface geology and not the coal seam being mined. The gases are mostly carbon based (C4 and C6) and frequently methane. Impacts may include localised alterations to water chemistry, soil heating, and death of local vegetation.
5. **Wastewater:** Large amounts of water are used in both underground and above

ground longwall mining operations. Additionally, runoff from the colliery and washery sites may include coal dust, oils and other harmful products. Unfortunately, while wastewater from mining cannot be entirely eliminated at the present time, longwall mining can be particularly expensive in this regard.

It is evident that longwall mining is the future for coal mining in India and has been widely adopted in developed nations as well. But like every other resource extraction activity, this engineering technique has its own limitations. Therefore, it is important to devise high-tech mechanisms/technologies that can balance out the environmental footprint of longwall mining and make it more sustainable.

Case Study 3

Analysing Trends on Mining Technology by India Infrastructure Ltd.

India Infrastructure Ltd. has studied the trends of technology deployment in the country's mining sector with regards to the scope of automation in the Indian mining sector. The analysis points out that due to frequent fluctuation in the commodity price of minerals in the global market coupled with challenges posed by climate change concerning carbon emissions, it is important for large-scale Indian mining to look for technology options that are cost-efficient and environment-friendly. As a result of sluggish growth in prices of the worldwide mining and its macro-economic impacts on India, various large mining enterprises in India are considering cost cutting in operation and planning stage of mining through the deployment of advanced technology option (India Infrastrucutre Limited, 2016b)

- The analysis points out an increasing practice of surface or opencast mining in India being cost effective and less labour intensive.
- Given limitation on degrading quality of mineral reserves and in order to achieve resource efficiency, the Indian mining sector is already looking forward to adopt advanced mine surveying and exploration technologies (using geophysics applications using 2D and 3D seismic surveys) along with the usage of software solutions by utilizing 3D software packages (like Micromine, Gemcom Minex, Surpac, CAE Mining Datamin and Vulcan) in the mine planning and design stage.
- Apart from the usage of small-mining equipments, major mining operations are moving towards the deployment of large equipment for achieving economies of scale as it improves loading and haulage efficiency. In the opencast mining fragment, the enterprises are increasingly using large equipments like 70 tonne dumpers (trucks used for removal of over-burden material in opencast mines) and 10 m^3 shovels, and also to an extent 110 tonne capacity dumpers with 20 m^3 shovels. Most mining operations have been using 35 tonne dumpers with 4.6 m^3 shovels but in order to increase productivity, save fuel and cost, Indian coal mining companies have been using large excavating equipments with some enterprises seen using 240 tonne dumpers with 30 m^3 shovels.
- Furthermore, large-scale Indian mining operators like Coal India Limited (CIL), Tata Steel Limited, Hindustan Zinc Limited, et al are seen moving towards

increased adoption of automation in mining technologies through in-house capacity building initiatives by their respective R&D departments.

- Mining enterprises are moving towards deploying environment-friendly and energy efficient technologies and processes for enhancing their operational sustainability. Availability of fossil fuel additives, like FuelSpec Combustion Catalysts from Efficient Fuel Solution LLC (USA) (which enhances combustion efficiency (by 6-8 per cent) and reduces fuel consumption) shows promising energy efficiency returns and should be adopted by more mining operations in India. Coal India Limited (CIL) is also in advanced stages of implementing clean coal technologies such as underground coal gasification (UCG) and the extraction of cleaner fuels such as coal bed methane.
- Considering the issues of lower grades mines and environmental degradation due to open-cast mining, prominent Indian mining operation like CIL are moving towards environment-friendly technologies like longwall mining which has been recently implemented to produce 2.34 million tonnes per annum of coal at Singareni Collieries Company Limited’s Adriyala mine.
- Mine operators are also seen using technology solutions like geotagging of vehicles/manpower which accrue benefits such as alerts for zone violation, tracking machine health, movement of machines and materials from source to destination, monitoring mis-dumps, cycle time and perimeter breaches, etc.

5. Promoting Environmentally Sustainable Mining: Successful Case Studies Using Best Process Practices in India

Amendments in the MMRD 2015 and MCDR 2011 made it mandatory for mining companies to follow scientific, sustainable and efficient mining practices. Considering the latest data on number on mining leases as per the area of distribution (Table 6), the number of large scale mining leases stands at 382 (for fuels and major minerals) while small and medium scale mining leases occupies 90 percent of the total share. It has to be noted that most of the large scale mining leases is controlled/operated by large scale companies that have the technological and financial capacity to adopt safe, scientific and efficient mining technologies and processes for ensuring sustainable mining as compared to small mine operations. Small scale mine operations are mostly handled by small companies and in majority of cases these enterprises do not adhere to sustainable mining standards mainly because of chaotic regulatory hurdles, corruption, governance failure, lack of supervision coupled with financial and technological constraints. Presence of illegal mining (mining without a license; mining outside the licensed area; mining more than a permissible amount of mineral extraction; and continued mining even if a company's renewal is pending) has further exacerbated the problem of environmental degradation due to the practice of unsustainable mining practices (mining beyond the carrying capacity of mines) that are rampantly prevalent in mineral rich regions of India. Since India has untapped mineral reserves that needs optimum utilisation, it is imperative to build capacities of existing mining operations for adopting sustainable mining operations by implementing strong regulatory mechanism backed up by competent institutions having the capacity to closely oversee and monitor the mining operations. Furthermore, it is also important to take lessons from large-mining enterprises that have been adopting innovative, cost-friendly and environmental friendly mining technologies and process throughout the entire cycle of a mining operation. Therefore, this section of the paper will present a few case studies on sustainable mining practices presently being used in by various large-scale mining operation and enterprises.

Table 6: Mining Leases in India as per the Area of Distribution

S.No.	Lease Area Distribution	Fuels & Major Minerals	%	Minor Minerals	%
1.	Small Scale Mining Leases 0-50 Hectare	2874	74	57000	95
2.	Medium Scale Mining Leases 50-200 Hectares	612	16	1800	3
3.	Large Scale Mining Leases >200 Hectares	382	10	1200	2
Total		**3868**		**60000**	

Source: (Ministry of Mines, 2016a) and Federation of Mining Associations of Rajasthan (FMAR)

Case Study 4
Noamundi Iron Ore Mine under Tata Steel Ltd.

Noamundi Iron Ore mine is located in the state of Jharkhand and is being operated by Tata Steel Limited. Being India's one of the oldest mines in operation since the last 100 years, this mine has always been a pioneer in showcasing sustainable and innovation mining technologies and processes. It has been awarded with several awards and recognitions, very recent being the Bala Gulshan Tandon Excellence Award for best overall performance awarded by the Federation of Indian Mineral Industries for the year 2016-17 and 'Most Innovative Environmental Project Award' in Biodiversity category under the theme of 'GREEN makes business sense' at the 6th GreenCo Summit organised by Confederation of Indian Industries (CII).

This mining lease covers an area of 1160.06 hecatre in West Singhbhum District of Jharkhand and annually produces 10.00 million tonnes of Iron ore. This operation has been using mechanised method of open cast mining in a series of 12 metre high benches with the help of shovel-dumper combination. This operation follows a comprehensive safe, sustainable and environment friendly mining process using latest innovative technologies.

With regards to mineral conservation for *in-situ* mineral this operation makes use of the latest SURPAC software which is utilised for preparation 3-D ore body model, pit digging, and production scheduling.

With regards to Solid Waste Management intervention includes:

- Wastes generated during the process used for road making and haul road maintenance;
- The excess quantity of over burden is stacked separately over non-mineralised area. The sub grade ore is used by blending the same with richer ore to achieve mineral conservation;
- The excess quantity is stored separately as subgrade stack while slime from the ore washing plant is separately stored in zero discharge slime dam for possible future use;
- Reclamation and rehabilitation plan has been established;

Water quality interventions includes:

- Recycle and reuse of process water generated from the wet beneficiation plant by provision of two thickeners;
- Construction of zero discharge slime dams, where the under flow from the thickeners is pumped to and decanted water from the dam is again recycled from the pond, leaving the solids there;
- The addition of chemicals for faster settling of suspended solids also binds the sludge and hence, increases life of the slime dam;
- Construction of rain water harvesting structures for use of rain water and augmentation of ground water table;
- Construction of series of check dams across the water courses those enable retention of suspended solids and allow flow of clear water during rainy season;

- Stabilisation of waste dump slopes by timely vegetation with native species to prevent wash offs during rain;
- Waste dumps are provided with toe walls and garland drains, that arrest washed off solids from the dumps and prevents the outside water source from pollution;
- Oil & Grease traps in the equipment workshop provided to trap oil & grease from the workshop effluent for further reuse;
- Actiflo clarifier (micro sand ballasted technology) with pressure sand filter has been installed for treatment mine water to make it suitable for drinking and this filtered water is supplied to the inhabitants of the colony;
- Mining operation is limited on hill slopes and above the ground water table and there is no depletion of water table occurs because of our mining operation; and
- The beneficiation process does not use any chemicals and hence there is no likelihood of any chemical contamination of water bodies due to the mining activities. (Indian Bureau of Mines , 2014); (Tata, 2017)

Case Study 5
Rampura Agucha Zinc Mine under Hindusthan Zinc Ltd.

Hindusthan Zinc Limited is a subsidiary of Vedanta Limited-one of the largest mining companies in the world. This zinc mine is located in Rampura Agucha in Rajasthan and is also the largest zinc mine in the world. On an average this mining operating has an ore production capacity of 6.15 metric tonne per annum and in 2015 around 6.98 metric tonne of mined metal was produced through this mine (which included 6.4 metric tonne of contained zinc and 57 metric tonne of contained lead.

This mining operation uses open pit and underground mining practices using state of the art technology. The open pit operation includes drilling, blasting, loading, and hauling. Underground mining is carried out using Long Hole Open Stoping with Paste Fill method with mined out stopes backfilled with cemented rock and with cemented tailing in paste form.

For extracting zinc and lead concentrates from the excavated ores, this mining facility uses highly efficient rod mill-ball mill combination in stream I; Semi-Autogenous Grinding (SAG) mill-ball mill combination in stream II, III & IV; and flotation methods to produce zinc and lead concentrates.

Concerning the disposal and reuse of tailing after beneficiation process, this facility has adopted highly efficient and environment-friendly way of storing the tailings in specially constructed tailing dam whose base fully sealed by the application of a layer of impervious soil at bottom. After settling, the tailings water gets recycled and is fully utilised in the plant for various purposes, thereby ensuring zero waste discharge.

With regards to waste disposal, specifically disposal of overburden this operation has adopted an innovative technique to stabilise the overburden dumping sites by undertaking systematic multilayer disposal of dump and then rehabilitating the site by use of geo-textile mats/geo-soil savers (made from organic coconut husk) and plantation of Vetiver grass over them.

Since zinc smelters use a considerable amount of water, HZL has introduced water saving technologies like Adiabatic Cooling Towers (water consumption for acid plant cooling tower has reduced from 22,000 m^3 to 800 m^3 per month and for gas cleaning plant from 15,000 m^3 to 200 m^3 per month, resulting in a total saving of 36,000 m^3 per month) and Air Cooled Condenser (resulting in a water saving of 700 m^3 per day) Air cooled condenser reduces water consumption by up to 95% as compared to water cooled condenser.

Since processing of zinc through smelting process results in release of poisonous sulphur dioxide gas (SO_2) in the atmosphere, this operation has introduced some state of art technologies. For reducing the impact of SO_2 emissions, HZL with the help of Mitsubishi Corporation of Japan developed a special technology that uses zinc oxide solution to react with SO_2 to produce zinc sulphate which is recycled back to hydrometallurgical plant for recovery of zinc, thereby resulting in no sludge production. HZL is also undertaking extensive research in the gainful utilisation of Jarosite (byproduct during the purification and refining of zinc mainly found in acid mine drainage of a zinc plant) in cement industry (Hindustan Zinc Limited, 2017).

Case Study 6
Sankhali Iron Ore Mine under Sesa Sterlite Ltd.

Iron ore, manganese and bauxite are major minerals of economic importance and important iron ore deposits are located in the Goa in the region of Bicholim, Sanguem and Satari whereas manganese ore deposits are confined to Sanguem region. The entire mineral belt of Goa has been leased to private mine operator. Unlike Odisha and Jharkhand and other mineral-rich states, all the mines in Goa are concentrated in a small area comprising four *talukas* — Bicholim, Sattari, Sanguem and Quepem.

Sanquelin mine of Sesa Strelite (Vendat group subsidiary) is a model mine in terms of sustainability, particularly the post-closure plans (site reclamation and closure). Traditionally 'waste dumps' of mines are stabilised using laterite cover, garland drain, etc., and then brought under plantation of handy plants without taking into consideration of the region's biodiversity and community use. To become a pioneer in scientific reclamation of mining site, Sesa Strelite used innovative techniques for waste dump management by following systematic and scientific multilayer dumping and then using Geo-textiles and Vetiver grass to stabilise the dump sites.

The measures taken for rehabilitation of mined out/degraded land on 106 out of 203 hectares of Sesa Goa's Sanquelin mine is exemplary. The company has made efficient use of biotechnology for reclaiming the mine site. Initially, fast-growing species like acacia were planted in order to stabilise the degraded land quickly and create a green cover. Afterwards taking the region's biodiversity and community needs into consideration, Acacia was promoted with cashew plantation through a mixed approach.

Further on, after 1998, with improvement in reclamation technology, there was greater support for native species to be planted, which are better able to support the biodiversity. Native plants were supported at the nursery stage with bio-fertilisers like

Rhizotria and Azactbacter and then the plants were planted in bigger pits with organic manures, top soil and mine spoil. Aftercare is provided for three to four years in order to support the plants.

For reclaimed mine pits, the company made a Pisciculture pond in collaboration with National Institute of Oceanography in 1990. Pisciculture pit was scientifically created in a way to promote afforestation and then treated mine water was transferred in this pit and finally aquatic fingerlings of Rahu, Mrugal and Carp were released in this pond. Presently, this pond is full of fish.

In 2016, this mining enterprise has also received the prestigious 'Environmental Leadership Award' under the Environmental Sustainability category presented by Responsible Business Awards for their efforts for scientific site closure and reclamation efforts of Sankhali Mine (ISID, 2012); (Sesa Strelite, 2015)

6. Conclusion

India's mining industry has a tremendous growth potential which has been exhibited by its dominance on being one of the world leading producers of minerals like iron, coal, zinc, bauxite and so on. Even though India ranks amongst the top ten world producers of several fuel, metallic, non-metallic and industrial minerals but its output contribution to worldwide production is not very encouraging. Therefore, it is imperative to conjoin effective implementation institutional and regulatory mechanisms along with technological and process solutions to make this sector more efficient and sustainable.

The Indian mining sector is highly regulated with strong legal and regulatory mechanisms with the government introducing cum revamping several acts, policies, rules at the central and state levels. Since mining sector is a highly polluting industry causing severe environmental and social problems, India has been quite progressive in establishing institutions and regulatory framework in order to counter balance the negative externalities caused by this sector. But unfortunately the governance system has been stymied by political and administrative hurdles that need immediate attention to act upon. From the regulatory point of view, the most urgent necessity is to ensure effective, efficient and purposive administration of the existing mining and environmental laws.

For promoting environmentally and socially sustainable mining it is important that the Indian government devise governance mechanism that can be effectively adopted by the small mining operators. In this regards the government should give more impetus to develop business models based on consortia of small mining enterprises which should be provided with technical advisory services so that they can undertake sustainable and scientific mining practices. Also the government should promote self-regulation and adoption of ethical business practices by mining enterprises for achieving sustainable mineral development.

Currently, demand for advanced technology is already present in India. In order to achieve resource efficiency, the Indian mining sector is already looking forward to adopt advanced mine surveying and exploration technologies (using geophysics applications using 2D and 3D seismic surveys) along with the usage of software solutions by utilizing 3D software packages (like Micromine, Gemcom Minex, Surpac, CAE Mining Datamin and Vulcan) in the mine planning and design stage.

With regards to active mining processes, underground mining (longwall mining in case of coal extraction) and resource-efficient surface drilling technologies (usage of large equipments for dumpers and excavators for improving loading and haulage, hydraulic mining by replacing hand held drills with hydraulic and jumbo drills, etc) are increasingly being adopted by large-mining operations apart from the traditional open-cast mining techniques.

Furthermore, large-scale Indian mining operators like Coal India Limited (CIL), Tata Steel Limited, Hindustan Zinc Limited, et al are seen moving towards increased adoption of automation in mining technologies through in-house capacity building initiatives by their respective R&D departments.

In the front of sustainable mining practices, CIL has done pilot projects on longwall mining (which is already accepted as standard by many countries across the world) along with other eco-friendly technologies developed by their R&D branch. Sesa Strelite Limited has done remarkable work in adopting biotechnology solutions in order to recover the mine site after closure of the mines by improving the degraded land to acceptable levels. Noamundi Iron Ore Mine under Tata Steel Limited and Rampura Agucha Zinc Mine under Hindusthan Zinc Limited have adopted world-class sustainable mining interventions with regards to the disposal of mine-tailings and reuse of mine-water after beneficiation process. These operations have remarkably carried out efficient and sustainable means of solid waste and water waste disposal and reuse interventions through advanced engineering and technological adoption mechanisms.

Taking into account the growing levels of innovations worldwide, more advanced technologies like Acid Mist Suppressants, Dust Control Systems, Electrostatic Precipitators, Scrubbers, Process Ventilation Systems and Pollution Control Systems are now available for deployment to efficiently control the alarming rise of pollutants in the environment. As depicted in the case study analysis, such new advanced technologies are gradually being adopted by major mining companies but mass-scale adoption is still a long way to go for the entire India mining sector. Moreover, it is mostly the private sector entities that have progressed more in this direction as compared to the public entities. Thus, it is necessary for this industry to stop its reliance over older technologies and adopt newer technologies and processes.

There are many technologies that are being adopted in small ways by large-scale individual operators as they find themselves benefiting. But these practices are only limited to big players (public and private entities) that have the financial capabilities to adopt advanced technological solutions and alongside have also been able to incorporate sustainable mining practices.

On the whole, the key for creating a sustainable mining industry is moving from individual adoption to a large-scale adoption by the entire mining industry which has to be supported by a robust regulatory and legislative mechanism. While legislative and regulatory reforms have to an extent led to many better practices, the government and industry leaders must designs best-practices to ensure an overall profitability and sustainability of the mining sector.

With regards to this, developing affordable technologies are imperative for India so that it can be easily adopted by small-scale mining enterprises as well. This would require putting more impetus to the “Make in India” programme, increased government funding and subsidies (for carrying out R&D specifically in the exploration stage), effective implementation of National Minerals Exploration Policy 2016 (for increasing private sector participation in the exploration process), learnings from domestic and international best process practices, and a conducive regulatory and legislative environment to support India’s vital mining sector.

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Indian Chamber of Commerce (ICC) Profile

Founded in 1925, Indian Chamber of Commerce (ICC) is the leading and only National Chamber of Commerce operating from Kolkata, and one of the most pro-active and forward-looking Chambers in the country today. Its membership spans some of the most prominent and major industrial groups in India. ICC is the founder member of FICCI, the apex body of business and industry in India. ICC's forte is its ability to anticipate the needs of the future, respond to challenges, and prepare the stakeholders in the economy to benefit from these changes and opportunities. Set up by a group of pioneering industrialists led by Mr G D Birla, the Indian Chamber of Commerce was closely associated with the Indian Freedom Movement, as the first organised voice of indigenous Indian Industry. Several of the distinguished industry leaders in India, such as Mr B M Birla, Sir Ardeshir Dalal, Sir Badridas Goenka, Mr S P Jain, Lala Karam Chand Thapar, Mr Russi Mody, Mr Ashok Jain, Mr Sanjiv Goenka, have led the ICC as its President. Currently, Mr Shashwat Goenka is leading the Chamber as its President.

ICC is the only Chamber from India to win the first prize in World Chambers Competition in Quebec, Canada.

ICC's North-East Initiative has gained a new momentum and dynamism over the last few years, and the Chamber has been hugely successful in spreading awareness about the great economic potential of the North-East at national and international levels. Trade & Investment shows on North-East in countries like Singapore, Thailand and Vietnam have created new vistas of economic co-operation between the North-East of India and South-East Asia. ICC has a special focus upon India's trade & commerce relations with South & South-East Asian nations, in sync with India's 'Look East' Policy, and has played a key role in building synergies between India and her Asian neighbours like Singapore, Indonesia, Bangladesh, and Bhutan through Trade & Business Delegation Exchanges, and large Investment Summits.

ICC also has a very strong focus upon Economic Research & Policy issues - it regularly undertakes Macro-economic Surveys/Studies, prepares State Investment Climate Reports and Sector Reports, provides necessary Policy Inputs & Budget Recommendations to Governments at State & Central levels.

The Indian Chamber of Commerce headquartered in Kolkata, over the last few years has truly emerged as a national Chamber of repute, with full-fledged offices in New Delhi, Guwahati, Patna, Ranchi and Bhubaneshwar functioning efficiently, and building meaningful synergies among Industry and Government by addressing strategic issues of national significance.

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CUTS International

CUTS International Profile

CUTS International is a leading think-tank working on economic and public policy issues. It is a leading Southern voice and face of consumer empowerment through its rights-based approach and activities for influencing the process and content of inclusive growth and development. Presently, its work spans a multi-pronged agenda targeted to the realisation of CUTS' Vision of 'Consumer sovereignty' and its Mission of 'consumer sovereignty in the framework of social justice, economic equality and environmental balance, within and across borders.'

Consumer interest is the *raison d'etre* of all economic transactions. In practice, that does not happen more often than not and particularly in the developing world because consumers are either less informed about their rights and responsibilities and/or on account of the fact that consumer movements in developing countries have weakened over time. Over the last three decades, CUTS has experienced an organic and evolutionary growth – marked by a refreshing spontaneity in responding to the need of the hour, particularly those of the developing world, by addressing contemporary and emerging issues of economic governance at national, regional and international-level through cross-fertilisation of ideas and experiences of state and non-state actors.

What started as a consumer protection organisation in its traditional sense, CUTS has attained uniqueness through the realisation that the consumer needs to be economically, politically and socially empowered via diverse channels such as 'Good Governance', 'Effective Regulation' and 'Rules-based Trade', so that consumer rights (from basic needs to safety, choice, information, consumer education, redressal, representation and healthy environment including sustainable consumption) are embedded in the quest of achieving sustainable development and to make economic growth more inclusive.

Three core areas: 'Good Governance', 'Effective Regulation' and 'Rules-based Trade' – constitute the areas of specialisation of CUTS that are aligned with:

- Research (for policy as well as practice changes) involves the evaluation and analysis of primary data and secondary evidence to arrive at recommendations for furthering progress towards consumer protection and sovereignty, which are articulated in the organisation's 'Vision' and 'Mission'.
- Advocacy refers to the generation of awareness about these recommendations and dissemination of other knowledge/information relevant for the mentioned progress as well as capacity building of CUTS and its partners which are needed for understanding and pushing the implementation of those recommendations.
- Networking and Capacity Building involves the creation of frameworks through which such advocacy can be effectively conducted with inputs from Research, Advocacy, Networking, Capacity Building of state and non-state actors on our core areas and their linkages, so that consumers are better empowered to access their rights and execute their responsibilities for bettering their lives.

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