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The Degradation of Green Belts to Gray Corridors: An Analysis of the Cumulative Impact of Mining on Biodiversity Decline in Republic of India

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Abstract

The Mining activities are crucial for economy development of country. The raise in demand for raw material in industries, infrastructure development and energy sector lead to rapid expansion of mining activities in India. To meet the industrial demand over exploitation of resources due to mining has significantly altered natural landscape and posed serious threats to biodiversity. The main objective of this paper is to analyse the cumulative impact of mining on biodiversity decline, mainly focusing on its adverse effects on flora, fauna and biodiversity hotspots present in India. The study highlights that there is serious threat to endangered species due to loss of natural habitat. Deforestation, soil degradation and pollution due to mining activities have accelerated the loss of species and poses the threat of extinction. The paper further examines the environmental laws governing mining in India made by the legislature. An analysis highlights the gaps in implementation and loopholes regulatory mechanism in environmental laws. The study concludes by proposing reforms in implementation of laws and further suggest mechanisms by which impact of mining can be reduce to protect our ecosystem.

Keywords: Mining, Species, Biodiversity, Extinction.

METHODOLOGY:

In this present study which is primarily focused on the cumulative impact of mining on biodiversity decline in India. This study adopts a qualitative and analytical research methodology which is primarily based on secondary data collected from government reports, research articles, policy documents, and publications of institutions such as the Ministry of Mines, Forest Survey of India, international organizations like IUCN and appropriate laws and rules of India. The paper follows a doctrinal approach to analyse environmental laws and regulatory frameworks governing mining activities in India. The research also includes study of impact of mining on flora and fauna on major biodiversity hotspot in India.

1. INTRODUCTION

The term Environment has been derived from the term “environ”, which means “to surround”. The etymologically environment means “surrounding condition, circumstances affecting people’s life”. Environment include water, air and land and there is inter-relationship between water, air, land, human

being and all other living creatures like plants, animal, micro-organism. The study of the nature has presented many evidences to show that from the ancient time human beings are dependent on the nature directly and indirectly to fulfil their needs of livelihood like food, shelter, fire, wood, water etc.[1] Earlier human being was dependent on nature was only for fulfil their basic needs. Now the human has been exploiting natural resources for making their life more comfortable. Natural resources are integral part of ecosystem and they are for the benefit of humans but the over exploitation of resources has led to change in the ecosystem.

Mining is one of the oldest and most economically significant human activities, providing the raw materials essential for industrial civilization. India is rich in minerals and it is one of the world's largest producer of minerals. India Produces 95 minerals. Mining industry has key role in contribution to Indian economy. The mining industries has enhanced the growth of Indian economy on the other hand it has caused many irreversible harm to the environment. The extraction of minerals from the Earth's crust entails deforestation, destruction of habitats, contamination of water bodies, soil degradation, and the displacement of countless species of flora and fauna.

This paper undertakes a detailed examination of: (a) Understanding mining in India. Its contribution in economy. (b) the environmental laws applicable to mining operations in India and; (c) the specific adverse impacts of mining on flora and fauna. The analysis reveals a complex but essential tension between developmental imperatives and ecological preservation.

2. UNDERSTANDING MINING IN INDIA

Mining, in its broadest sense, refers to the extraction of naturally occurring mineral substances from the earth, whether by surface excavation, underground tunnelling, or alluvial washing. Under the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act), 'mining operations' means any operations undertaken for the purpose of winning minerals. This encompasses open-cast or open-pit mining, underground mining, placer mining, mountaintop removal, and in-situ leaching, among other methods.

India being one of the world's leading producers of key minerals, mining sector plays a pivotal role in the national economy, serving as a primary supplier of raw materials essential for industries such as steel, cement, power generation, aluminium production and infrastructure development. FY 2024-25 Annual Report of Ministry of Mines Shows that India Produces 95 minerals out of these 4 fuels, 10 metallic, 23 Non-Metallic, 3 atomic and 55 minor minerals (including building and other materials). India is self-sufficient to produce Major Minerals like Bauxite, Chromite, Iron ore, Copper conc., Lead conc., Garnet, Zinc Conc., Manganese ore, Limestone, Phosphorite and sillimanite.[2]

As per World Mineral Production, 2018-22, British Geological Survey, India's ranking in 2022 in world production in term of quantity was 2nd in steel (crude/liquid) and lead (refined), followed by 3rd in zinc (slab) and chromite ores & concentrate, 4th in iron ore and graphite; 5th in aluminium (primary); 6th in manganese ore and bauxite; 10th in copper (refined) and 16th in apatite & rock phosphate and magnesite.[3] The sector directly supports energy security, manufacturing growth, and export revenues, while indirectly fuelling downstream industries that contribute significantly to overall industrial output.

[1] Prof. Satish C. Shastri, Environmental Law, 52-70 (Eastern Book Company, 7th ed., 2022).
[2] Ministry of Mines, Gov't of India, Annual Report, 18 (2024-25), https://mines.gov.in/admin/download/67b48dd05215b1739886032.pdf (last visited: 17th March, 2026).
[3] Ministry of Mines, Gov't of India, Annual Report, 21 (2024-25), https://mines.gov.in/admin/download/67b48dd05215b1739886032.pdf (last visited: 17th March, 2026).

Global Ranking of India in the Production of key Minerals:

Mineral	Ranking of India	Global Top Ranking Country
Limestone	3RD	China
Iron Ore	4TH	Australia
Chromite	4TH	South Africa
zinc	4TH	China
Bauxite	5TH	Australia
Manganese	6TH	South Africa

3. CONTRIBUTION OF MINING IN DEVELOPMENT OF INDIA AND EXPANDING FOOTPRINT: AN OVERVIEW

3.1 Economic Contribution and GDP Share: The contribution of mining and quarrying sector (excluding atomic minerals, fuel minerals in some classifications and minor minerals) in FY 2024-25 was approximately 1.8% to 2.5% of India's Gross Domestic Product (GDP) directly. The recent data from the Ministry of Statistics and Programme Implementation (MoSPI) and other related analyses showed that in FY 2024-25 (First Advanced Estimates), the mining and quarrying sector's Gross Value Added (GVA) at current prices was around Rs. 5.4 lakh crore and it represented about 1.84% of total GVA. It stood at approximately Rs.3.47 lakh crore at constant prices (2011-12 base),, showing modest growth of approximately 2.9% over the previous year.[4] If focused over the broader estimates then the sector's linkages to industrial GDP, place its effective contribution at 10-11% of industrial GDP, as mining provides foundational inputs for steel, cement and energy sectors.

3.2 Expanding Footprint: Recent Trends (2023-2025): India has significantly noticed a remarkable expansion in its operational reach in recent years, in mining sector, particularly from 2023 onward, as the country ramps up efforts to meet rising domestic needs for infrastructure, steel, energy and materials vital for the shift to clean energy technologies.[5] This broadening footprint stems from sustained reforms to mining laws, accelerated auctions of mineral blocks, intensified geological exploration and targeted initiatives to secure supplies of critical and strategic minerals.

The sector has pushed into new territories through a series of mineral block auctions, where hundreds of blocks covering both traditional commodities and emerging critical resources have been offered and awarded across multiple states.[6] These auctions have extended activities into previously less-explored or restricted areas, including deep-seated deposits and offshore zones in India's Exclusive Economic Zone. There is an increased focus that has shifted toward minerals essential for batteries, electronics, renewables and defence. Dozens of blocks have been successfully allocated in recent tranches, tapping into resources like graphite, rare earth elements, lithium-related associations and others across diverse regions from eastern and central India to southern and island territories.

[4] Press release, Ministry of Statistics & Programme Implementation (MoSPI), "Press Note on Provisional Estimates of Annual Gross Domestic Product for 2024-25 and Quarterly Estimates of Gross Domestic Product for the Fourth Quarter (January- March) of 2024", (May 30, 2025), https://mospi.gov.in/sites/default/files/press_release/NAD_PR_30may2025.pdf .
[5] Press release, Ministry of Mines, "Record Production in Mining in FY 2024-25" (May 5, 2025), https://pib.gov.in/PressReleasePage.aspx?PRID=2126960 .
[6] Press release, Ministry of Mines, Ten Critical and Strategic Mineral Blocks Auctioned in Tranche V, Including 2 Potash Blocks for the First Time in India, (May 27, 2025), https://www.pib.gov.in/PressReleasePage.aspx?PRID=2131723 .

Additionally, the launch of the National Critical Mineral Mission in early 2025 has further accelerated the spread of mining and exploration efforts. This comprehensive program which is backed by substantial government and public-sector funding, aims to boost domestic discovery and production of around 30 prioritized critical minerals over the coming years. It focuses on large-scale exploration projects, in which hundreds of projects undertaken annually by agencies like the Geological Survey of India along with incentives for processing, recycling, stockpiling and overseas asset pursuits. These measures have encouraged private participation, deeper drilling and entry into frontier areas, gradually broadening the physical and operational scope of mining operations nationwide.[7]

This expanding footprint is evident in production trends, highlighting the key minerals achieving record or near-record outputs in recent fiscal years, driven by heightened demand from manufacturing, power generation and infrastructure projects. The surge in activity has resulted in more mines reporting operations, expanded leasing in mineral-rich belts and associated infrastructure development such as transport corridors and processing facilities that extend industrial influence into forested, hilly and ecologically sensitive landscapes.[8]While this progressive expansion of mining areas has contributed to economic self-reliance and industrial growth, it has also accelerated the transformation of natural green belts into fragmented, industrialized gray corridors. This, in turn, has intensified cumulative pressures on biodiversity in vulnerable regions.

4. MINING LANDSCAPES IN INDIA: AN OVERVIEW

India's geographical landscape is rich in minerals like coal, bauxite, chromite, iron ore, and limestone etc. India has a total geographical land area of 328.73 million hectares.[9] As per the report of Ministry of Mines based on National Mining Ministers' Conference 2025 on Sustainable mining of Vikasit Bharat, Total number of working mines in India are 1,206. Geological Survey of India (GSI) has shown that India has about 6.88 lakh sq. km area as obvious Geological Potential (OGP) area.[10]

The Major Mineral Producing States of India and state wise working mines are:

Sr. No.	State	Operational Mines
1	Madhya Pradesh	302
2	Gujarat	153
3	Karnataka	105
4	Andhra Pradesh	101
5	Rajasthan	98
6	Odisha	96
7	Chhattisgarh	89
8	Maharashtra	73

[7] Ministry of Mines, National Critical Mineral Mission (NCMM) (Jan 10, 2026), https://mines.gov.in/admin/storage/ckeditor/NCMM'_1768030756.pdf (last visited: 17th March, 2026).
[8] Press release, Ministry of Mines, Mineral and non-ferrous metal production on growth track in FY 2025-26 (June 4, 2025), https://mines.gov.in/admin/storage/ckeditor/Press_Release_Press_Information_Bureau_1750740163.pdf .
[9] Indian Bureau of Mines, Ministry of Mines, Government of India, Bulletin of Mining Leases & Prospecting Licences, 2020 (Excluding Atomic Minerals, Coal, Lignite, Petroleum, Natural Gas and Minor Minerals), 1 (2020), https://www.ibm.gov.in/writereaddata/files/11292021122720BMLPL_2020.pdf (last visited: 17th March, 2026).
[10] Ministry of Mines, Government of India, Overview of Mining Sector in India (Presentation at National Mining Ministers' Conference 2025, 20 January 2025), https://mines.gov.in/admin/storage/ckeditor/DAY_1_PPT_2_1737541727.pdf (last visited: 17th March, 2026).

9	Tamil Nadu	63
10	Telangana	36
11	Jharkhand	29
12	Himachal Pradesh	26
13	Meghalaya	15
14	Jammu and Kashmir	8
15	Assam	4
16	Uttar Pradesh	3
17	Uttarakhand	2
18	Bihar	1
19	Goa	1
20	Kerala	1

5. BIODIVERSITY HOTSPOTS AND FRAGILE ECOSYSTEM IN INDIA

Mining activities cause significant noise, vibration, pollution and environmental disturbances which affect the wildlife and biodiversity of that particular area. While mining disturbance causes animals to move from one place to another in search of habitat. Many plant species also get affected while clearing areas for mining. This disturbance affects the many ecological processes also like predator prey relation, pollination and seep dispersal.[11] There are areas in India which are rich in biodiversity and many a times mining activities take place in those areas which lead to threat of loss of endangered species. Endangered species may face serious danger due to this disturbance. This disturbance directly affects the population of endangered species.

India has a rich diversity. Out of 36 globally recognised biodiversity hotspots 4 are located in India.[12] They are:

1. The Himalayas
2. Indo-Burma
3. Sundaland
4. Western Ghats

Sr. No	Biodiversity Hotspot	States/UTs Covered
1.	The Himalayas	Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, parts of Assam and northern West Bengal

[11] Shanmukha N. T, Vinayaka M., Lokeshappa B., Shanwaj Nadaf, "Biodiversity Loss Due to Mining Activities", ResearchGate (June, 2024) https://www.researchgate.net/publication/381428628_Biodiversity_Loss_Due_to_Mining_Activities (last visited: 18th Mar, 2026).

[12] Subodh Sharm, "Biodiversity Hotspots in India: Map, Criteria & Key Features", Maps For UPSC, https://mapsforupsc.com/biodiversity-hotspots-in-india/ (last visited: 18th Mar, 2026).

2.	Indo-Burma	Meghalaya, Tripura, Mizoram, Nagaland, Manipur, Parts of Assam, and the Andaman Islands
3.	Sundaland	Nicobar Islands only (part of Andaman & Nicobar UT)
4.	Western Ghats	Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat

India only has 2% of the world's total land surface. A great wealth of biodiversity exists in the regions of India. India has over 7.5% of species of animals compared to the whole world. According to the survey of The Zoological Survey Of India (ZSI), India holds around 92,037 species of fauna out of this 61,375 are alone insect species. India also has a rich diversity of flora. India ranks 10th place in the world and 4th in Asia for the largest number of plant species. According to the data of Botanical survey of India (BSI), India has 46,000 species of plants.[13]

India is home to 350 Mammal species, 1224 Bird species, 408 Reptiles species, 197 Amphibians species and 2546 Fishes species. Due to loss of habitat and expansion of human industrial activities, over exploitation, pollution and introduction of toxic substances in rivers and forest many species are in threat of extinction and most of them are in endangered list. According to the Reports of IUCN, India contain 172 species of animal that are considered to be globally threatened. Out of 172 species 53 are mammals, 69 birds, 23 reptiles and 3 amphibians.[14] Due to destruction of forest for human urban development several plant species are facing extinction. According to data from the botanical survey of India (BSI) published in the red data book, around 1,336 plant species which are considered to be vulnerable are endangered.[15]

6. THE SILENT EXTINCTION OF ESPECIALLY ENDANGER SPECIES THROUGH HABITAT LOSS

Mining in India has become one of the most significant drivers of habitat fragmentation and eventual disappearance of the population of variety of species, leading to "silent extinction" particularly of the vulnerable and endangered species. The process of extraction of various minerals, whether open-cast coal mining in Jharkhand or iron ore mining in Goa removes the natural vegetation, alters landscapes and displaces species from their ecological niches. Habitat loss in India is the primary driver mainly due to mining, deforestation, urbanization, agriculture and infrastructure development. There are 36 biodiversity hotspots in the world. Their combined areas cover 2.3% of the earth's land surface. "Each hotspot has already lost at least 70% of its original natural vegetation," said the Botanical Survey of India. It noted that over 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to the 35 biodiversity hotspots. The CSE's report has compiled publicly available data from the 'ecosystem accounts for India' and the International Union for Conservation of Nature's (IUCN) report on endangered species. It said 12% of 1,212 animal species in India, monitored by the IUCN under its Red List monitors,

[13] Gov't of India: Know India, "Flora", https://knowindia.india.gov.in/profile/flora.php (last visited 18th Mar, 2026)
[14] Swarndeep S. Hundal, Wildlife Conservation Strategies and Management in India: An Overview, Species at Risk 2004 Pathways to Recovery Conf. Proc., 2-3 (Mar. 2–6, 2004), https://www.arlis.org/docs/vol1/69415913/hundal_edited_final_march_10.pdf (last visited 18th Mar, 2026).
[15] Gov't of India: Know India, "Flora", https://knowindia.india.gov.in/profile/flora.php (last visited 18th Mar, 2026).

are endangered.[16] Mining does not kill species overnight; it erodes their natural habitats until survival becomes impossible.

6.1 THE WESTERN GHATS: In the last two decades mining in the Western Ghats has become a very important source of raw materials such as iron ore and bauxite. To meet the growing demands for urbanization, housing and infrastructure there has also been an increase in quarrying in the region for granite, limestone and other types of stone. In India, several species of butterfly are facing extinction and in Western Ghats alone, out of the 370 butterfly species, 70 are at the brink of extinction.[17] There are over 6000 vascular plants belonging to over 2500 genera in this hotspot, of which over 3000 are endemic. The highest concentration of species in the Western Ghats is believed to be the Agasthyamalai Hills in the extreme south. The region also harbors over 450 bird species, about 140 mammalian species, 260 reptiles and 175 amphibians. Over 60% of the reptiles and amphibians are completely endemic to the hotspot. Remarkable as this diversity is, it is severely threatened today. The vegetation in this hotspot originally extended over 190,000 square kms. Today, its been reduced to just 43,000 sq. km.[18] Mining and related tourism/infrastructure have fragmented shola forests and riparian zones, causing silent extinctions among stream-breeding frogs like the Critically Endangered Nasikabatrachus sahyadrensis (purple frog). Sand mining is another threat affecting the breeding grounds of fishes, and is common in most of the rivers of the Western Ghats assessment area. In the Indrayani River of the northern Western Ghats, severe sand mining is a major threat to existing populations of Glyptothorax poonaensis (EN). Extensive sand mining in the rivers draining the Vembanad Lake, Kerala, leading to 7-15 cm lowering in the riverbed annually. Energy production and mining are identified as major ongoing threats to fishes with 6% of species (9% of threatened species) impacted, molluscs with 5% of species (43% of threatened molluscs) impacted, and plants with 4% of species (13% of threatened species) impacted.[19]

6.2 INDO-BURMA: India and its neighbours have lost together 90% of their original natural vegetation, particularly in the country's four biodiversity hotspots with the biggest one, Indo-Burma hotspot, being the worst hit, reporting loss of nearly 95% of natural vegetation from originally estimated area of 2.3 million sq., these figures were highlighted by Centre for Science and Environment (CSE) in its 2021 annual statistical compendium on the state of India's environment and ongoing fragmentation pushes narrow-endemic species toward oblivion. Noting that the four biodiversity hotspots have been reduced to less than 10% of their original extent, CSE in its report also flagged that 25 plant species have gone extinct in these hotspots.[20] This region is home to several primate species such as monkeys, langurs and gibbons with populations numbering only in the hundreds. Many of the species, especially some freshwater turtle species, are endemic. Almost 1,300 bird species exist in this region including the

[16] Vishwa Mohan, "90% of Green cover lost under 4 biodiversity hotspots: CSE", TOI (Jun. 9, 202, 06:18 IST) https://timesofindia.indiatimes.com/india/90-of-green-cover-lost-under-4-biodiversity-hotspots-cse/articleshow/83357648.cms (last visited 18th Mar, 2026).
[17] A.J. Thatheyus, "Threats to Indian Biodiversity, National Biodiversity Authority of India, http://nbaindia.org/uploaded/docs/ncb_jan_06_15.pdf (last visited Mar. 18, 2026).
[18] Gaurav Moghe, "Biodiversity hotspots in India", Biodiversity of India: A Wiki Resource for Indian Biodiversity (Oct. 7, 2011), https://www.biodiversityofindia.org/index.php?title=Biodiversity_hotspots_in_India (last visited Mar. 18, 2026).
[19] S. Molur, K.G. Smith, B.A. Daniel & W.R.T. Darwall (compilers), "The Status and Distribution of Freshwater Biodiversity in the Western Ghats, India", IUCN, 8 (2011), https://portals.iucn.org/library/sites/library/files/documents/rl-540-001.pdf (last visited Mar. 18, 2026).
[20] Vishwa Mohan, "90% of Green cover lost under 4 biodiversity hotspots: CSE", TOI (Jun. 9, 202, 06:18 IST) https://timesofindia.indiatimes.com/india/90-of-green-cover-lost-under-4-biodiversity-hotspots-cse/articleshow/83357648.cms (last visited 18th Mar, 2026).

threatened white-eared night-heron, the grey-crowned crocias, and the orange-necked partridge. It is estimated that there are about 13,500 plant species in this hotspot, with over half of them endemic.[21] India is one of the 17 mega-diverse countries, covering 2.4% of global land but hosting 6.7% of animal species and 9.13% of floral diversity. Meghalaya, part of the Indo-Burma biodiversity hotspot (ranked 34th globally), has high species diversity and nine BirdLife International sites in the Khasi Hills, including Nohkalikai and Nohsngithiang Falls.[22] Coal mining in Meghalaya and Assam has degraded karst caves and rainforests, home to EN species like the lesser horseshoe bat (Rhinolophus hipposideros) and hoolock gibbons. Rat-hole mining fragments cave networks, displacing roosting colonies and leading to a population drop.[23]

6.3 THE EASTERN HIMALAYAS: The Eastern Himalayas in India are home to many unique and endangered species found nowhere else on Earth. This region supports iconic animals like the red panda and snow leopard (both Endangered), which live in high-altitude bamboo forests and rocky slopes.[24] The Eastern Himalayan hotspot has nearly 163 globally threatened species including the One-horned Rhinoceros (Rhinoceros unicornis), the Wild Asian Water buffalo (Bubalus bubalis (Arnee)) and in all 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrate and 36 plant species The Relict Dragonfly (Epiophlebia laidlawi) is an endangered species found here with the only other species in the genus being found in Japan. There are an estimated 10,000 species of plants in the Himalayas, of which one-third are endemic and found nowhere else in the world. Five families - Tetracentraceae, Hamamelidaceae, Circaesteraceae, Butomaceae and Stachyuraceae - are completely endemic to this region. Many plant species are found even in the highest reaches of the Himalayan mountains. For example, a plant species Ermania himalayensis was found at an altitude of 6300 metres in northwestern Himalayas. A few threatened endemic bird species such as the Himalayan Quail, Cheer pheasant, Western tragopan are found here, along with some of Asia's largest and most endangered birds such as the Himalayan vulture and White-bellied heron.[25] Mining for coal, limestone, and dolomite clears forests, creates landslides, and fragments habitats, pushing these species toward silent extinction because most of them have very small natural ranges and cannot easily move to new areas.

6.4 SUNDALAND: Sundaland is a region in South-East Asia that covers the western part of the Indo-Malayan archipelago. It includes Thailand, Malaysia, Singapore, Brunei and Indonesia. India is represented by the Nicobar Islands. The United Nations declared the islands a World Biosphere Reserve in 2013. The islands have a rich terrestrial and marine ecosystem that includes mangroves, coral reefs and sea grass beds. The marine biodiversity includes several species such as whales, dolphins, dugong, turtles, crocodiles, fishes, prawns, lobsters, corals and sea shells. The primary threat to this biodiversity comes from over exploitation of marine resources. In addition, the forests on the

[21] Gaurav Moghe, "Biodiversity hotspots in India", Biodiversity of India: A Wiki Resource for Indian Biodiversity (Oct. 7, 2011), https://www.biodiversityofindia.org/index.php?title=Biodiversity_hotspots_in_India (last visited Mar. 18, 2026).
[22] M.Z.M. Nomani et al., "Environmental Impact of Rat-Hole Coal Mines on the Biodiversity of Meghalaya, India", 18 Asian Journal of Water, Environment and Pollution 77, 78 (2021),https://api-journal.accscience.com/journal/article/preview?doi=10.3233/AJW210010 (last visited Mar. 18, 2026).
[23] Uttam Saikia & Manuel Ruedi, "Beauties Beneath: The Cave Bats of Meghalaya", 26 Resonance 829, (2021), https://www.ias.ac.in/public/Volumes/reso/026/06/0829-0840a.pdf.
[24] World Wildlife Fund, "The Eastern Himalayas", WWF, https://www.worldwildlife.org/places/eastern-himalayas/ (last visited 18th Mar, 2026).
[25] Gaurav Moghe, "Biodiversity hotspots in India", Biodiversity of India: A Wiki Resource for Indian Biodiversity (Oct. 7, 2011), https://www.biodiversityofindia.org/index.php?title=Biodiversity_hotspots_in_India (last visited Mar. 18, 2026).

island also need to be protected from mining. Due to the islands' small size and isolation, these species have nowhere to move, making them extremely vulnerable to silent extinction from mining activities.

7. DELETERIOUS EFFECT OF MINING ON FLORA & FAUNA

7.1 FLORA

Deforestation and Vegetation Loss: The most immediate and visible impact of mining on flora is the wholesale destruction of vegetation cover. Open-cast mining requires the physical removal of all surface vegetation trees, shrubs, grasses, ground flora over vast areas. In India's coal belt regions of Jharkhand, Chhattisgarh, and Odisha, millions of trees have been felled to facilitate coal extraction, destroying not only individual plants but entire ecosystems. Tropical forests, which harbour the greatest biodiversity of flora on Earth, are disproportionately targeted for mining due to the geological concentration of minerals in these regions. A study published in the journal Science found that mining activities between 2000 and 2019 caused forest loss across approximately 3,264 square kilometres of protected areas globally. Many endemic plant species those found nowhere else on Earth have been driven to extinction or near-extinction by mining-induced deforestation. The Niyamgiri Hills of Odisha, home to rare medicinal plants and the sacred forest of the Dongria Kondh tribe, was the subject of fierce legal battles over proposed bauxite mining precisely because of the irreplaceable botanical wealth at stake.

Soil Degradation and Loss of Seed Banks: Mining operations destroy the soil profile, removing the topsoil that contains seeds, spores, root systems, and the microbial communities essential for plant growth. The topsoil — the product of centuries or millennia of organic decomposition is often stripped away and discarded in overburden dumps. Without this living soil, natural regeneration of plant communities is essentially impossible on the timescale of human lifetimes. The soil seed bank the reservoir of dormant seeds in the soil is completely destroyed, eliminating the capacity for natural revegetation. Overburden dumps the mounds of waste rock and soil material removed to access ore cover large areas and are typically devoid of vegetation, subject to severe wind and water erosion, and prone to leaching of toxic materials into surrounding soils. The compaction of soil by heavy mining machinery destroys soil structure, eliminates pore spaces, and creates anaerobic conditions inimical to plant life. Revegetation of mined-out areas, even with deliberate replanting efforts, frequently results in impoverished plant communities dominated by invasive species rather than native flora.

Water Table Disruption and Aquatic Flora: Deep mining operations frequently disrupt the groundwater table, causing the drying up of streams, wetlands, and other water bodies that support rich communities of aquatic and riparian flora. Mangroves, water lilies, reeds, and other wetland vegetation are devastated when mine dewatering operations draw down water tables. Conversely, the subsidence of land above underground mines can create waterlogged conditions that drown existing vegetation. The Goa mining region has witnessed widespread destruction of khazan lands low-lying lands with unique saline-freshwater interface ecosystems due to mining effluent discharge.

Chemical Pollution and Phytotoxicity Mining releases a cocktail of toxic substances heavy metals such as lead, cadmium, arsenic, mercury, and chromium; cyanide used in gold processing; sulphuric acid from acid mine drainage into soils and water bodies. These substances are directly phytotoxic: they inhibit seed germination, stunt growth, disrupt photosynthesis, damage root systems, and ultimately kill plants. The bioaccumulation of heavy metals in plant tissues also makes any vegetation that does survive toxic to herbivores, thereby cascading the harmful effects up the food chain. The red mud lakes of aluminium

smelting zones and the fly-ash ponds of coal-based power plants adjacent to mines present extreme examples of phytotoxic environments where virtually no native vegetation can survive.

7.2 FAUNA

Habitat Destruction and Fragmentation: The destruction of forest and grassland habitats by mining is the most profound threat to fauna. Animals lose their nesting sites, breeding grounds, foraging areas, and movement corridors. Large-scale habitat loss forces wildlife into increasingly small patches of remaining habitat, reducing population size, genetic diversity, and the viability of wildlife populations. Habitat fragmentation the breaking up of continuous habitats into isolated islands is often more ecologically damaging than outright destruction, because it traps populations in small fragments, prevents migration, disrupts predator-prey dynamics, and increases the risk of local extinction. In the Eastern Ghats of India, open-cast bauxite and iron ore mining has severely fragmented the forest habitat of elephants, tigers, leopards, sloth bears, and numerous endemic reptile and amphibian species. The Hasdeo Arand forests of Chhattisgarh among India's most ecologically sensitive coal-bearing forests support wild elephants, wolves, and rare bird species. Mining proposals in this region have been fiercely contested in courts and on the ground by tribal communities and environmentalists precisely because of the irreversible wildlife consequences.

Water Pollution and Aquatic Fauna: Mine effluents laden with suspended solids, heavy metals, acids, and processing chemicals devastate aquatic ecosystems. Fish kills are a common and well-documented consequence of mine drainage entering rivers and streams. Heavy metals bioaccumulate through the aquatic food chain: algae absorb them from water, invertebrates accumulate higher concentrations, fish bioaccumulate still higher concentrations, and apex predators including birds, otters, and humans suffer the most severe effects. The Subarnarekha river in Jharkhand has been severely polluted by coal mine drainage, leading to dramatic declines in fish populations and threatening the livelihood of riparian communities. The gharial India's critically endangered freshwater crocodilian faces existential threat from mining-induced siltation and pollution of its Chambal River habitat.

Noise and Vibration: Acoustic Pollution Mining generates intense and persistent noise from blasting, drilling, crushing, and heavy machinery. This acoustic pollution disrupts the behavioural ecology of wildlife in profound ways. Many species rely on acoustic communication for mating, predator avoidance, and territorial defence. Mining noise masks these signals, reducing breeding success and increasing predation risk. Migratory birds that navigate by acoustic landmarks are particularly vulnerable. Vibrations from blasting can collapse underground burrows, killing burrowing owls, porcupines, pangolins, and other burrowing species. The physiological stress response triggered by chronic noise exposure suppresses immune function and reproductive hormones, reducing the fitness and survival of affected animal populations.

Indirect Effects: Roads, Poaching, and Invasive Species Mining operations bring with them a cascade of indirect environmental impacts on fauna. The construction of access roads into previously remote forests opens up these areas to hunting, poaching, timber extraction, and agricultural encroachment. Mining workers, living in large camps in forest areas, create demand for bushmeat, driving hunting of deer, wild pigs, primates, and birds. Mining vehicles are responsible for large numbers of wildlife road kills. The introduction of invasive plant species through soil disturbance and imported machinery alters habitat quality for native fauna. The alteration of drainage patterns creates new breeding sites for mosquitoes, spreading malaria and other vectorborne diseases to both wildlife and human communities.

8. LEGISLATIVE FRAMEWORK: KEY ENVIRONMENTAL LAWS GOVERNING MINING

Mining plays a crucial role in economic growth of a country. It is important for industrial development as well as infrastructural development. It provides employment to large number of people by creating job opportunities. It is backbone of several manufacturing industries and provide raw material in various industrial like steel, cement, energy, manufacturing and electronics. Apart from a lot of pros of mining sectors, it also carries a several concerning issues related to environment. The damage and impact of mining on environment is irreversible. The over exploitation of resources led to significant environmental degradation, soil pollution, water pollution, deforestation, biodiversity loss and disruption of ecological balance. [26] Even though mining is done in particular area of greater landmass, its impacts on environment extend to much greater area on the environment not only on public health, but also to all the flora and fauna of that greater area. Mining is the prolonged process and in the whole process, great threat is involved to the environment at each step. Due to Lack of proper planning, negligence of regulations and improper implementation of laws in mining sector leading to irreparable and irreversible damage to environment and biodiversity. Mining activities in forest land is one of the main reasons for loss of flora and fauna. The biggest threat of mining in forest land is to the endangered and endemic species. Mining led to loss of natural habitat of endangered species and due to this many endangered species of flora and fauna are at the point of extinction.[27] The recent reports of World Resources Institute (WRI) shows that there is growing threat of mining on forests, especially in tropical primary rainforests and protected areas that are critical for biodiversity and climate regulation. From 2001 to 2020, globally due to mining activities were loss of about 1.4 million hectares of forest land. out of this loss about 1,50,000 hectares of loss took place in protected areas.[28] The threat of loss of biodiversity is not only because of legal mining operations. The emergence of illegal mining operations is point of concerns because to full fill their own greed they do not think about damage occurring to environment. Such unsustainable practices are leading to the long term and irreversible harm to environment.

Indian legislature has made laws and regulatory frame work to carry out mining activities in sustainable and environmentally friendly methods. Laws governing mining and environmental activities in India are as follow:

8.1 Mines and Mineral (Development and Regulation) Act, 1957

The MMDR Act is the primary legislative instrument regulating mineral extraction in India. Substantially amended in 2015 and again in 2021, it provides for the grant of prospecting licences, mining leases, and composite licences. The 2015 Amendment introduced the concept of District Mineral Foundations (DMFs) to benefit communities affected by mining, and the National Mineral Exploration Trust (NMET). Mining leases are now granted through competitive e-auction rather than discretionary allotment. Section 17-A empowers the Central Government to undertake reconnaissance, prospecting, or mining operations in any area not held under any existing concession. Critically, the MMDR Act mandates the preparation of a

[26] Dr. Alok Kumar, "Mining and the Quest for Sustainability in India: Policy, Law, and Ecological Responsibility", The Law Blog (Aug. 4, 2025) https://thelawblog.in/2025/08/04/mining-and-the-quest-for-sustainability-in-india-policy-law-and-ecological-responsibility/ (last visited 19th Mar., 2026).

[27] Aijaj Ahmed Raj et al., "Environmental Impact Assessment of Mining in India: A Review of Legal and Institutional Mechanism", ResearchGate, (Jan. 2019), https://www.researchgate.net/publication/332833151_Environmental_Impact_Assessment_of_Mining_in_India_A_Review_of_Legal_and_Institutional_Mechanism (last visited 19th Mar., 2026).

[28] IUCN National Committee of the Netherlands, "Mining's Impact on Forests: A Growing Threat to Biodiversity and Climate", IUCN NL (Nov. 7, 2024), https://www.iucn.nl/en/blog/minings-impact-on-forests-a-growing-threat-to-biodiversity-and-climate/ (last visited 19th Mar., 2026).

Mining Plan, which must include provisions for restoration and reclamation of mined-out areas, dust control measures, and afforestation. Rule 27 of the Mineral Conservation and Development Rules, 2017 (MCDR) requires the lessee to maintain a progressive mine closure plan and to protect flora and topsoil. Violations of these provisions attract penalties, cancellation of lease, and criminal prosecution.[29]

8.2 The Environment (Protection) Act, 1986 & Environmental impact Assessment (EIA) Notification, 2006

Enacted in the wake of the Bhopal Gas Tragedy, the Environment (Protection) Act, 1986 (EPA) is an umbrella legislation conferring wide powers on the Central Government to take all measures necessary for protecting and improving environmental quality. Under the EPA, the Central Government may issue notifications restricting or prohibiting activities in Eco-Sensitive Areas (ESAs) around national parks and wildlife sanctuaries. The landmark EIA Notification, 2006, issued under the EPA makes Environmental Impact Assessment (EIA) mandatory for all Category 'A' and Category 'B' mining projects before grant of Environmental Clearance (EC). The EIA process requires: (i) screening; (ii) scoping to determine the terms of reference; (iii) public hearing in the project-affected area; (iv) appraisal by the Expert Appraisal Committee (EAC); and (v) grant or refusal of Environmental Clearance by the Ministry of Environment, Forest and Climate Change (MoEFCC) or the State EIA Authority. Mining projects within 10 km of national parks or wildlife sanctuaries require additional scrutiny. The National Green Tribunal (NGT), established under the National Green Tribunal Act, 2010, has become the principal adjudicatory forum for environmental disputes arising from mining.[30]

8.3 Forest (Conservation) Act, 1980

The Forest (Conservation) Act, 1980 (FCA) is perhaps the most powerful tool for protecting forest areas from mining encroachment. Section 2 of the FCA categorically prohibits any State Government or other authority from making, except with the prior approval of the Central Government, any order directing that any reserved forest shall cease to be reserved, or that any forest land shall be used for any non-forest purpose. 'Non-forest purpose' explicitly includes mining. Thus, any mining project requiring diversion of forest land whether reserved, protected, or unclassified must obtain prior forest clearance from the Central Government under Stage I and Stage II approvals. The Forest Conservation Amendment Act, 2023 has widened the scope of 'forest land' to include all categories of forests. Compensatory afforestation the planting of equivalent forest elsewhere is mandatory upon any forest diversion. The Compensatory Afforestation Fund Management and Planning Authority (CAMPA) manages the funds collected for this purpose. Critically, forest clearance is a condition precedent to environmental clearance, so any mining activity in forested areas without both clearances is ipso facto illegal.[31]

8.4 Wildlife (Protection) Act, 1972

The Wildlife Protection Act, 1972 (WLPA) creates a comprehensive system for the protection of wildlife and their habitats. It establishes National Parks, Wildlife Sanctuaries, Conservation Reserves, and Community Reserves, within which mining is absolutely prohibited. Section 29 prohibits any destruction, exploitation, or removal of any wildlife from a sanctuary without the prior permission of the Chief Wildlife Warden. The Act also prohibits hunting of any wild animal specified in Schedules I through IV. Mining operations invariably disturb habitat, displace animals, and often result in indirect hunting and poaching by mining workers, all of which engage the prohibitions of the WLPA. The National Board for Wildlife

[29] Mines and Minerals (Development and Regulation) Act, 1957 (as amended 2015, 2021).
[30] Environment (Protection) Act, 1986.
[31] Forest (Conservation) Act, 1980 (as amended 2023).

(NBWL), chaired by the Prime Minister, is the apex body for wildlife conservation policy. Mining projects within or near Protected Areas require clearance from the NBWL's Standing Committee. The Supreme Court has repeatedly emphasized that NBWL clearance must involve genuine application of mind and cannot be a rubber-stamp formality.[32]

8.5 Water (Prevention and control of pollution) Act, 1974 & Air (Prevention and Control of Pollution) Act, 1981

Mining operations are major sources of both water and air pollution. The Water Act, 1974 prohibits the discharge of pollutants into water bodies beyond prescribed standards and requires mining companies to obtain consent to establish and consent to operate from the State Pollution Control Board (SPCB). Acid mine drainage the flow of acidic water from mines containing heavy metals is a particularly severe form of water pollution regulated under this Act. The Air Act, 1981 similarly requires mining companies to control dust and emissions from blasting, crushing, and ore transportation. Both Acts provide for closure orders and criminal prosecution for persistent violators.[33] [34]

The Environment (Protection) Act, 1986 defines environment as "environment includes water, air and land and the interrelationship which exists among and between air, water and land and human beings, other living creatures, plants, micro-organism and property". The Constitution of India also specifically provides the provision for the protection of environment through the prism of Article 21, 47, 48(A) and 51 A (g).

- **Article 21:** According to Article 21 of the constitution, "no person shall be deprived of his life or personal liberty except according to procedure established by law." "Protections not only the human rights but also casts an obligation on human beings to protect and preserve a species becoming extinct, conservation and protection of environment is an inseparable part of right to life." Thus we as a human being have a pious duty to prevent the species who are on the verge of extinction and must implement effectively "species protection regime". The ambit of Article 21 also includes Right to healthy Environment, free of danger disease and infection is inherent in it.
- **Article 47:** It provides that the State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties. The improvement of public health also includes the protection and improvement of environment without which public health cannot be assured.
- **Article 48 – A:** It says that "the state shall endeavor to protect and improve the environment and to safeguard the forests and wild life of the country".
- **Article 51-A (g):** It says that "It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wild life and to have compassion for living creatures."[35]

9. BEYOND PLANTING TREES: FRAMEWORK FOR MIGRATION AND RESTORATION

9.1 IMPLEMENTATION AND OVERSIGHT OF MINING LAWS

[32] Wildlife Protection Act, 1972.
[33] Water (Prevention and Control of Pollution) Act, 1974.
[34] Air (Prevention and Control of Pollution) Act, 1981.
[35] Press Info. Bureau, Gov't of India, "Environment Protection under Constitutional Framework of India", PIB (June 4, 2014), https://www.pib.gov.in/newsite/printrelease.aspx?relid=105411&reg=3&lang=2.

All the above mention laws are made by Government of India to protect the environment and for sustainable development. The statutory framework is very strong and also contain provisions like fine and imprisonment to polluter but weak enforcement, corruption and political interference often undermine the effectiveness of statutes.[36] Enforcement and proper implementation of mining laws are vital for ensuring legal compliance and environment protection. Strict implementation of laws by the regulating agencies and authorities are require for proper monitoring, inspection and enforcement of legal standards of mining. Routine inspection and proper maintained reports will help to detect unauthorized mining activities and it will prevent the over exploitation of resources. Strict implementation of legal penalties like fines, termination of license and imprisonment will help in ensuring legal compliance with rules and regulation. Transparency and accountability in legal process for obtaining permission for mining and offenders of mining laws will help to successful implementation of laws.[37] There should be strict implementation of legal principles like Polluter pay principle and precautionary principle to punish the polluters and to check whether development is sustainable or not.

9.2 "NO-GO" ZONE

NO-GO Mining Zones are areas where mining is explicitly prohibited to protect sensitive ecosystems and biodiversity. This concept was First introduced by the International Council on Mining and Metals in 2003 as a voluntary commitment to avoid mining in World Heritage Sites. Government should focus more on these areas and make strict rule and regulations for on the NO-GO mining Zone. This will help to avoid serious adverse impact on the forest and wildlife.[38] As per recent reports of Press Information Bureau India government has been successful in reducing the no – go zone area by 99% which is almost 10 lakh sq km for oil and gas exploration. Cut of area at such large size will directly cause harm to flora and fauna. Government should take strict action on it in order to prevent harm to species of plants and animals and to save the environment from exploitation.[39]

9.3 BIODIVERSITY OFFSETS POLICY

This policy was made by International Union for conservation of Nature and Natural Resources (IUCN). The purpose of this policy is to provide a framework to guide the design, implementation and governance of biodiversity offset schemes and projects. A biodiversity offset is a measurable conservation action designed to compensate for the unavoidable loss of biodiversity caused by development activities. This policy come into force only after if all the previous steps to mitigation the effect of development have be considered and there are no alternatives are available to compensate for the loss. This policy work on the principle "No net loss of biodiversity and preferably a Net Gain of biodiversity". India government should also adopt this policy in order to protect and compensate to

[36] Dr. Alok Kumar, "Mining and the Quest for Sustainability in India: Policy, Law, and Ecological Responsibility", The Law Blog (Aug. 4, 2025) https://thelawblog.in/2025/08/04/mining-and-the-quest-for-sustainability-in-india-policy-law-and-ecological-responsibility/ (last visited 19th Mar., 2026).
[37] Legivio, "Understanding the Legal Framework Governing Mining in Protected Areas", (Aug. 16, 2024), https://legivio.com/mining-in-protected-areas-laws/ (last visited 19th Mar., 2026).
[38] The European Council for an Energy Efficient Economy, 'No-Go' Mining Zones Can Protect Nature as Renewable Energy Surges, eceee (Nov. 27, 2024), https://www.eceee.org/all-news/news/news-2024/no-go-mining-zones-can-protect-nature-as-renewable-energy-surges/ (last visited 19th Mar., 2026).
[39] Press Release, Ministry of Petroleum & Natural Gas, "India's 4-plank energy security strategy is based on diversifying supplies, increasing E&P, alternate energy sources and energy transition through a gas-based economy, Green Hydrogen etc." (Jan 10, 2023), https://www.pib.gov.in/PressReleasePage.aspx?PRID=1889967&reg=3&lang=2.

the loss that has occur due to development activities it will help to protest endangered species of flora and fauna.[40]

9.4 STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

It is a systematic process under which a proper analysis of effect of proposed plan taken into consideration and then planning on strategic actions taken place in order to mitigate the effect of development on environment and thereafter they reach to final decision. India has the process of Environmental impact Assessment (EIA) but if with this Strategic Environmental Assessment should come into force it will help to make strategy to prevent and reduce the impact on environment and species based on the assessment report.[41]

9.5 INSPECTION / MONITORING OF MINING ACTIVITIES

The Assistant Mining officer (AMO), District Mining officer (DMO), Mining inspectors (MI) and constables are responsible for inspection of Mines and quarries. They are required to conduct regular inspection after particular interval of time at all major and minor mining sites to check,

a) whether the sign boards showing lease details were placed
b) whether leased areas were properly demarcated,
c) Whether mining activity is carried in between the permitted area or not?
d) Whether there is proper identify boards or boundaries to separate allocated area from non – allocated area of mining?
e) He should maintain record of availability of mineral, quantity excavated and dispatched/ stocked to avoid over exploitation of minerals
f) Whether the people are compliances to the environment and safety norms, etc. or not?

9.6 GPS BASED VEHICLE TRACKING SYSTEM

GPS tracking of vehicles can be used to track the movement of vehicles used during mining. It will help to keep check on the movement of vehicles within forest and it will help to curb the movement to vehicles beyond permitted area for mining and also help to curb illegal mining. It will help the department to monitor the movement of vehicles and minerals.

9.7 STRENGTHENING MONITORING MECHANISMS / DRONE SURVEY

Leveraging digital tools for real-time environmental compliance checks. For real-time surveillance of mining operations and environmental compliance help of drones can be taken to supervise the mining activity withing the forest and protected areas. It will help to keep check on mining activity and mapping of area can be done easily. It will help to curb the mining operations in protected areas and it will prevent the harm which can cause to flora and fauna due to mining.[42] It will also help to prevent impact on biodiversity due to illegal mining.

9.8 MITIGATION MEASURES

Mining operations should take place with proper planning and technique. Planning should be done in a way that it contains all the best ways to minimise or eliminate environmental impacts. This may

[40] International Union for Conservation of Nature, "IUCN Policy on Biodiversity Offsets" (Jan. 29, 2016) https://iucn.org/sites/default/files/2022-06/iucn_biodiversity_offsets_policy_jan_29_2016_0.pdf (last visited 19th Mar., 2026).
[41] United Nations Economic Commission for Europe, "Introduction to Strategic Environmental Assessment (SEA)", UNECE, https://unece.org/sites/default/files/2024-02/1%20Intro%20to%20SEA%20.pdf (last visited 19th Mar., 2026).
[42] Comptroller & Auditor Gen. of India, "Report of the Comptroller and Auditor General of India on Performance Audit of Mining of Minor Minerals with Emphasis on Illegal Mining Operations, Government of Chhattisgarh", Report No. 03 of 2023 (2023), https://cag.gov.in/webroot/uploads/download_audit_report/2023/Consolidated-Report-Mining-064ba5a4f7981a5.33847644.pdf (last visited 19th Mar., 2026).

involve measures like dust suppression techniques, wastewater treatment systems, and wildlife habitat restoration initiatives.

9.9 POST MINING REHABILITATION AND RESTORATIONS

The Main aim of this technique is returning to pre-mining ecological condition or creating sustainable environment compatible with conservation goals. It is vital component to minimize environmental impact and restore ecological balance post mining. Mining operations have long term environmental damage. Leaving Mining area barren after mining leads to loss of biodiversity and also disturb ecological balance. With the technique of Rehabilitation and restoration we can use the techniques like backfilling pits, re-grading land, planting vegetation and habitat reconstruction. It will help to control soil erosion and restoring soil health. [43]

10. CONCLUSION AND WAY FORWARD

The foregoing analysis reveals a sobering truth: despite a robust and evolving body of environmental law, mining continues to inflict devastating and frequently irreversible damage upon the flora and fauna of India and the world. The legislative architecture spanning the MMDR Act, the Environment Protection Act, the Forest Conservation Act, the Wildlife Protection Act, the Water and Air Pollution Acts, and the Forest Rights Act is, on paper, comprehensive. Yet implementation remains the Achilles heel of Indian environmental governance.

The path forward demands action on several fronts. First, the EIA process must be genuinely reformed to ensure independent, rigorous, and seasonal biodiversity surveys that capture the full range of flora and fauna potentially impacted by mining. The current practice of consultants paid by project proponents conducting the EIA creates an irresolvable conflict of interest. Second, the cumulative environmental impact of multiple mining projects in a single ecological landscape such as a river basin or a forest block must be assessed, rather than evaluating each project in isolation. Third, post-mining reclamation standards must be enforced with the same vigour as pre-mining clearances: mined-out areas must be genuinely restored to functioning ecosystems, not merely planted with monocultures of fast-growing exotic species. Fourth, serious investment is needed in environmental monitoring and enforcement: satellite-based detection of illegal mining, real-time water quality monitoring in mining-affected rivers, and adequately funded and staffed pollution control boards are the institutional prerequisites for effective environmental governance.

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