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The Aravali | A Layered Inquiry

A 10-point Recommendation

Content

Executive Summary

Protecting the Aravali demands a broad, layered governance framework aligned with the region's geological, ecological and societal needs.

This report examines the implications of recent efforts to establish a unified geological and ecological framework of the Aravali Hills and Ranges and finds that definitional clarity alone is insufficient to ensure geological integrity, ecological protection or sustainable governance. While the objective of uniformity is understandable, adopting narrow, height-based or relief-based criteria risks fragmenting a geologically continuous and ecologically critical mountain system. Such an approach overlooks the Aravali's role in groundwater recharge, desertification control, biodiversity support, and regional climate resilience, particularly in low-relief and degraded segments that remain environmentally functional.

The findings of this report are based on a detailed analysis of multiple Central Empowered Committee (CEC) reports, relevant orders and directions of the Hon'ble Supreme Court, and deliberations contained in various committee reports, including those of the five-member expert committee constituted under LIGHTS-GnY.

Drawing on the Supreme Court's directions, Central Empowered Committee reports, 9-member expert assessments, the National Mineral Policy, 2019, and other scientific evaluations, the report highlights a persistent gap between sustainability discourse and operational mechanisms. Despite repeated references to sustainable mining, existing frameworks fail to adequately distinguish between mining, distinguished building stones, and other surface-destructive activities such as stone cutting; do not classify minerals based on societal need or substitutability; and lack cumulative impact– or carrying-capacity–based regulation. Unregulated activities in DARK zones, institutional overreach, and violations within forest and other protected areas further exacerbate these gaps. Judicially mandated mining prohibitions in ecologically sensitive areas underscore the urgent need to shift policy focus from merely redefining extractive categories to enforcing restoration, compliance, and land-use control.

To address these shortcomings, the report proposes an integrated and interdisciplinary framework that brings together geology, hydrology, ecology, land use, mining practices, and institutional governance. It recommends moving from parcel- and lease-level decision-making to belt-wise and landscape-scale planning; embedding sustainable mining principles into enforceable regulatory pathways; strengthening the role of scientific institutions; and treating degraded Aravali landscapes as priorities for restoration rather than grounds for regulatory exclusion.

The report concludes that safeguarding the Aravali requires realigning law, science, and policy through an integrated governance framework that recognises the range as a living ecological system, not merely a definitional or administrative construct.

Fig 1: Unregulated quarrying has changed the relief and forest cover of the Aravali.
The visual, shot on the Delhi-Jaipur Highway near Shahpura, clearly shows a hillock cut in half by quarrying.
Photo Courtesy: Dr Rasik Ravindra

Introduction

The Aravali debate is not new. From encroachment to illegal mining, the Aravali has been suffering on various counts. An assessment of successive judgments, orders, and committee reports reveals a fundamental misalignment between the nature of the problem and the regulatory responses so far. This misalignment reached a critical juncture with the Supreme Court's November order[1], which for the first time attempted a formal definition of the *Aravali Hills* and *Aravali Range* by prescribing that only landforms exhibiting a minimum local relief of 100 metres would qualify as Aravali Hills, and that two or more such hills located within 500 metres of each other would constitute an Aravali Range. This serves as a tipping point, mandating a relook at the genesis and progressive distortion of scientific understanding through legal-administrative interpretation of the issues surrounding the ancient mountains. We analyse four documents and some of their annexures, and related judgments over the years.

The documents referenced for the analysis include:

1. Central Empowered Committee (CEC), *Report on Issues Relating to the Aravali Hills and Ranges*, dated 26 June 2018[2].
2. CEC, *Report No. 03 of 2024 on the Definition of Aravali Hills and Ranges*[3].
3. Nine-member Committee Report (2025) on *Uniform Definitions of Aravali Hills and Ranges*[4]
4. Supreme Court of India, *In re: Issue Relating to Definition of Aravali Hills and Ranges*, Order dated 20 November 2025, W.P. (C) No. 202 of 1995[5].

A ten-pointer recommendation by a 5-member expert committee[6], constituted by LIGHTS-Geography and You, is presented below.

1. The Land-Use of Aravali Needs a Definition, not Aravali

The Aravali is already defined. It is a relic fold mountain running through Gujarat, Rajasthan, Haryana and Delhi. What we need is not a definition of the Aravali, but a definition of its land use**.** The Aravali does not consist solely of mining; it has several other interconnected issues that need to be laid, layer upon layer, to get a composite view of the go and no-go areas. This is a sensitive matter of importance, as any erroneous definition of the Aravali can create precedential ambiguity regarding all prior orders and judgments.

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[1] Supreme Court of India. (2025, November 20). *In re: Issue relating to definition of Aravalli Hills and Ranges* (Writ Petition (Civil) No. 202 of 1995; I.A. No. 105701 of 2024, CEC Report No. 03 of 2024). Supreme Court of India.

[2] Central Empowered Committee. (2018, June 26). Report on issues relating to the Aravalli Hills and Ranges. Supreme Court of India.

[3] Central Empowered Committee. (2024). Report No. 03 of 2024 on the definition of Aravalli Hills and Ranges. Supreme Court of India.

[4] Committee on Uniform Definitions of Aravalli Hills and Ranges. (2025). Report on Uniform definitions of Aravalli Hills and Ranges. Government of India / Competent Authority.

[5] Supreme Court of India. (2025, November 20). In re: Issue relating to definition of Aravalli Hills and Ranges (Writ Petition (Civil) No. 202 of 1995). Record of proceedings.

[6] Ravindra, R., Chairman, Research Advisory Committee, NCPOR; former Deputy Director General, Geological Survey of India,Chattopadhyay, S., Secretary General, LIGHTS, Pant, N. C., Visiting Honorary Scientist, NCPOR; Former Professor of Geology, University of Delhi, Sinha, S., Former Professor, Jawaharlal Nehru University, Prasad, N., Parliamentary Advisor to Hon'ble Speaker, Arunachal Pradesh. Personal communications.

The inconsistency sharpens when the definition is viewed against the Forest Survey of India (FSI)'s own methodology, evolved pursuant to judicial directions. In compliance with the Hon'ble Supreme Court's order dated 19.02.2010 (I.A. No. 828 and connected matters), the FSI submitted its methodology on 25.10.2010, laying down three cumulative parameters for delineating the Aravali hills using 20 m contour intervals: *(i)* areas at and above 115 metres from Mean Sea Level (MSL), *(ii)* terrain having a slope of 3 degrees or more, and *(iii)* the inclusion of a uniform 100-metre buffer on the downslope side to account for contour variability and geomorphic continuity. However, recent administrative and committee-led exercises - including the Committee Report dated 03.10.2025 on the "Uniform Definition of Aravali Hills and Ranges" - have discarded or diluted all three of these parameters without providing a scientifically comparable alternative. The elevation benchmark of 115 m MSL, the 3-degree slope threshold, and the 100-m protective buffer—which together operationalised the Supreme Court's conservation intent—stand buried under a shift towards relative, ground-level–based interpretations. This departure is not merely technical; it represents a substantive rollback of a court-mandated, nationally consistent framework, replacing it with criteria that are vulnerable to land-use pressures such as mining and real estate development. In effect, what was once a geomorphologically defensible delineation has been transformed into an administrative abstraction, undermining both environmental governance and inter-state spatial consistency.

Complexities in measuring 100m

The height of 100 m for a hill and that of a distance of 500 m between them, for contiguous hills, is a first definition of its kind[7]. It needs to be placed in the context of how such a criterion will be interpreted by the layers that have not been taken into account, from watershed management to real estate development. Academic landform schemes (e.g., Murphy's relief-based classification) should not be used to decide land-use eligibility for mining or real estate, as they ignore regional ecological and geological context.[8] As outlined in the CEC Report (03/2024), a representative photograph of the Aravali is presented with a red line drawn at a height of 100 m, where the FSI and Geological Survey of India (GSI) have disagreed with Rajasthan's Murphy classification, remarking that "the restriction will apply on the whole landscape"[9].

Fig: A representative example from the CEC (03/24) report of the Aravali hill range, which, as per the red line, can be used to identify the height of 100m above ground level.

The Aravali Range is a continuous geographical and structural extent, with surface and subsurface presence of Aravali–Delhi Supergroup rocks, the regional NE–SW alignment, and litho-structural continuity. Subsurface

[7] CEC Report 07 March 2024 stated "As the task of delineation of the hill's boundary was first of its kind"

[8] Rajendran, C. P. (2025). *Aravali at risk: How a height-based redefinition threatens India's oldest mountains*. LeftWord/LeftViews.

[9] Central Empowered Committee. (2024). Report No. 03 of 2024 on the definition of Aravalli Hills and Ranges. Supreme Court of India.(pg 71, pt. 29)

evidence (GSI drilling, metro and seismic studies) confirms continuity beyond exposed hills, including the Delhi–Haridwar underground ridge[10].

Second, an assessment of whether the ground/surface level is a better measure of a mountain's height than the average mean sea level (ASML) reveals that the latter is, in fact, more accurate. The 3-10-2025 Committee Report on "Uniform Definition of Aravali Hills and Ranges"[11]submits that as there is "the wide variability of the elevation from ASML of Aravali Hills and Ranges", and because the "elevation with reference to local relief, as already being followed by state of Rajasthan and agreed by other states, [it] may be more appropriate and objective criteria for conservation and management of aravali hills and ranges".

This approach raises serious concerns about scientific consistency and spatial comparability when applied to a regionally extensive, geologically continuous mountain system such as the Aravali. Elevation referenced to ASML is a globally accepted geodetic standard because it provides an externally referenced datum that allows consistency across space, jurisdictions, and time. In contrast, defining landforms relative to local or average ground level introduces inherent variability: ground level itself is neither fixed nor uniform and is often altered by erosion, mining, urbanisation, and land modification. As a result, two geologically identical ridges may be classified differently solely because of differences in surrounding terrain or anthropogenic alteration, leading to the arbitrary inclusion or exclusion of continuous Aravali segments.

Moreover, the Aravali Range is an ancient Proterozoic fold belt that has undergone differential denudation over geological time. Its northward reduction in relief—from high elevations at Guru Shikhar to subdued or near-surface expressions in Delhi—reflects erosional history, lithological and structural control rather than geological termination[12]. Using local relief as the primary reference, therefore, risks converting geomorphic degradation into a basis for regulatory exclusion, thereby penalising the most ecologically fragile and anthropogenically stressed portions of the range.

Recommendation: *A uniform, science-based definition of the land-use of the Aravali Hills and Ranges should not rely solely on elevation relative to local ground level. A fine-meshed matrix of critical information encompassing all protection needs of the Aravali mountain mass should be overlaid to identify sensitive and no-go zones beyond the present interpretation by the 9-member committee. While local relief may serve as a supplementary tool for site-level management, the primary reference framework should be anchored to a fixed geodetic datum - such as ASML - combined with geological criteria including lithology, structural continuity, and tectonic origin. This hybrid approach would ensure global consistency, spatial comparability, and protection of geologically continuous but low-relief segments of the Aravali system, thereby preventing artificial discontinuities created by erosion or human modification.*

2. Mapping to Mining in Aravali by Identifying OGP

[10] Manglik, A., Suresh, M., Nagarjuna, D., Pavankumar, G., Demudu Babu, M., Chakravarthi, N. N., & Kandregula, R. S. (2022). *Subsurface expressions of the Aravalli–Delhi Fold Belt in the Western Ganga Basin by magnetotellurics*. **Journal of the Geological Society of India, 98**(12), 1721–1727. [The Geological Society of India, along with other geoscientific institutions, has documented the subsurface expression of the Aravalli–Delhi Fold Belt. This buried continuation beneath Quaternary alluvium is commonly referred to as the Delhi–Haridwar Ridge (DHR)]

[11] Committee on Uniform Definitions of Aravalli Hills and Ranges. (2025). Report on Uniform definitions of Aravalli Hills and Ranges. Government of India / Competent Authority.

[12] Sharma, K. (2025, December 22). *History of Aravalli Hills: Formation, tectonic evolution, and significance of the world's oldest fold mountains*. *Jagran Josh*.

On 10 January 2024, in Writ Petition(s) (Civil No. 202/1995) Hon'ble court directed CEC "to take on board the experts from Geology before finalising its report[13]" in a period of 8 weeks. This emphasis on securing geological information changed in the 9-member Committee, which was comprised of the bureaucrats from the Minister of State for Environment, Forest and Climate Change (MoEF&CC) from the centre and the states of Delhi, Haryana, Rajasthan and Gujarat and FSI; with a sole representative from GSI, apart from a member from CEC[14]. This resulted in a subjective bias, with substantial attention devoted to operational landform/topographical definitions for mining regulation, whereas the CEC Report (03 of 2024), led by geology experts, avoids defining the Aravali Hills and Ranges, leaving their geological identity undefined.

As per the CEC Report (03 of 2024), the GSI identified the morphological aspects, details of mining and exploration of minerals[15], along with Obvious Geological Potential (OGP-2020). The GSI has identified approximately 6.88 lakh sq km, largely within India's hard-rock terrain, as priority areas for systematic mineral exploration. The Aravali–Delhi Fold Belt constitutes one of the country's most significant repositories of base metals (lead–zinc–copper), precious metals (gold, and associated mineralisation), industrial minerals and building stone etc. An extensive mapping of the OGP in the Aravali is therefore the next coherent step in identifying new mining areas and bolstering existing ones, particularly for rare earth, atomic, and strategic minerals, in addition to traditional mineral exploration and consequent exploitation. Despite this, the subsequent reports and regulatory deliberations do not take the cue from the CEC or the committee reports. They neither identify mineral-specific zones nor direct GSI to evaluate the OGP for an Aravali belt-wide mining zonation assessment.

Recommendation: *A geology-first approach to the Aravali, grounded in its Proterozoic origin and structural continuity, must precede any classification. The geological origin, tectonic continuity of the Aravali–Delhi Supergroup, and mining potential must be assessed and designated first. A belt-wise Mining Suitability and Exclusion Assessment must be carried out, integrating: lithology and structural integrity; watershed-aquifer vulnerability and mining zones; buffer zone, degraded land, forests, ecosystem sensitivity; wildlife corridors; cumulative impact thresholds; encroachment/built-up areas; and more.*

3. Distinguish Between Mining and Rock Cutting (major and minor minerals)

Through the reports and judgements[16] regulatory frameworks have largely treated all extractive activities under the generic category of "mining," while overlooking distinct practices such as rock cutting, hill slicing, quarrying and ridge levelling, which often result in equal or greater geomorphological and ecological damage. The CEC Report (03 of 2024) itself recognises that the Aravali Range has substantial potential for critical and strategic minerals such as tin, graphite, molybdenum, and rare earth elements, alongside significant reserves of minor minerals used as building materials[17], predominantly extracted by surface cutting rather than conventional mining. Despite this clear distinction, the reports led to an SC judgment that does not differentiate between subsurface mineral extraction and surface-level rock cutting. This conflation obscures the vastly different environmental impacts, regulatory requirements, and economic implications of these activities. A mandate to reduce the consumption of rock facades

[13] Shri Alok Chauhan, Director(G), GSI, Jaipur; Officials from Directorate of geology and mines and Forest Departments both from Rajasthan and Haryana; controller Indian Bureau of Mines, Udaipur etc were part of this CEC Report, putting emphasis on the geological requirement of Aravalli's mining land use.

[14] Committee on Uniform Definitions of Aravalli Hills and Ranges. (2025). Report on Uniform definitions of Aravalli Hills and Ranges. Government of India / Competent Authority.

[15] Annexure R-3 (colly). Central Empowered Committee. (2024). Report No. 03 of 2024 on the definition of Aravalli Hills and Ranges. Supreme Court of India.

[16] (CEC 2024). Report No. 03 of 2024 on the definition of Aravalli Hills and Ranges. Supreme Court of India. & The Supreme Court of India (2025, November 20). *In re: Issue relating to definition of Aravalli Hills and Ranges)*

[17] CEC 07-03-2024 report stated "Minor minerals mean building stones, gravel, ordinary clay etc., used for prescribed purposes, and any other mineral which in exercise of the powers conferred by clause (e) section 3 of the mines and minerals (Development and Regulation Act) 1957"

excavated from the Aravali, as also the mandated use of aggregates recycled from *malba* or building debris, needs to be popularised in mission mode. It is imperative to introduce legally binding requirements in Aravali districts and the National Capital Region (NCR) for the use of manufactured sand (M-sand), recycled aggregates, and blended cements in all public and private construction projects. This would directly curb demand for hill-derived stone and limestone. Accelerating the establishment of C&D waste recycling facilities across Aravali districts and NCR towns, with mandatory procurement of recycled aggregates for road sub-bases, embankments, and non-structural concrete, would pave the way towards a concerted Aravali conservation effort. Urban local bodies should integrate recycled materials into the standard Schedule of Rates (SoRs).

While the CEC (03 of 2024) report provides an extensive classification of minerals found in the Aravali region—ranging from major and minor minerals to metallic, non-metallic, critical minerals, green marble, and other building materials—this categorisation remains largely descriptive and extractive. The distinction between major and minor minerals, though administratively useful, does not by itself advance the objectives of sustainable mining unless it is accompanied by a clear assessment of mineral criticality, substitutability, and long-term necessity. Materials such as green marble[18] and other building stones/construction minerals are treated alongside economically and strategically critical minerals, without differentiation based on societal need, environmental costs, or the availability of viable alternatives. In the context of sustainable mining, classification alone is insufficient; it must be complemented by a framework that identifies which minerals are essential and which can be substituted. Without such need-based categorisation and replacement pathways, the distinction between major and minor minerals does little to guide policy towards sustainability, resource efficiency, or ecological conservation, particularly in environmentally sensitive regions like the Aravalis.

Recommendation: *Legal and regulatory frameworks must explicitly distinguish between mining and rock cutting, define and assess them separately in terms of their methods, extent, and damage, and subject surface-destructive extraction to controls, particularly in ecologically and hydrologically sensitive segments of the Aravali landscape. A concerted effort to recycle building debris and to reduce the consumption of hill-derived stones must be mandated by the Supreme Court*.

4. Enforce the Management Plan for Sustainable Mining (MPSM) through the Ministry of Mines

The CEC, in its 03/2024 report, noted that the principle of the National Mineral Policy, 2019 (for non-fuel and non-coal minerals), explicitly places sustainable development at the centre of mineral governance. The Policy envisages mining that is socially responsible, environmentally and scientifically sound, and governed by a long-term perspective. It further mandates the establishment of benchmarks for sustainable mining and the intensity of mining activities. The Supreme Court subsequently introduced and extensively employed the term “MPSM” in its recent judgment[19], and recommended the preparation of MPSMs in consultation with the Indian Council of Forestry Research and Education (ICFRE), across 34 districts forming part of the Aravali range, recognising that fragmented, lease-by-lease clearances have failed to address cumulative environmental impacts.

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[18] Central Empowered Committee. (2024). *Report No. 3 of 2024 in W.P. (C) No. 202 of 1995: Regarding Aravalli Hills and Ranges in the State of Rajasthan and Haryana* (Vols. I–II). Supreme Court of India. (Pg. 75)

[19] Supreme Court of India. (2025, November 20). *Order in In re: Issue relating to definition of Aravalli Hills and Ranges, I.A. No. 105701 of 2024 in Writ Petition (Civil) No. 202 of 1995 (T.N. Godavarman Thirumulpad v. Union of India & Ors.)*.

However, despite the formal acknowledgement of the MPSM concept, the Supreme Court further directed that "until the MPSM is finalised by the MoEF&CC through ICFRE, no new mining leases should be granted[20]." There is no clear direction regarding its scope, mandatory contents, institutional responsibility, timelines for preparation, or its legal status vis-à-vis mining approvals. Also, the judgment does not explain why responsibility for preparing the mining sector plan has been vested in MoEF&CC and ICFRE, rather than with the Ministry of Mines or another statutory authority with domain expertise over minerals and planning. This gap undermines both the intent of the NMP 2019 and the CEC's own recognition that sustainability in the Aravalis cannot be achieved through piecemeal, project-level decision-making.

Recommendation: *An explicit and binding judicial direction mandating the preparation, adoption, and enforcement of a belt-wise MPSM for all identified Aravali districts. No mining lease - whether new, renewed, or expanded - should be granted unless it is demonstrably consistent with an approved MPSM, and integrated into the ILSM. The Court should further require that the MPSM be prepared by independent, multidisciplinary expert institutions headed by the Ministry of Mines, specifying enforceable standards for pollution control, resource use, and mine closure.*

5. Shift Lead Custodianship of Aravali from MoEF&CC and FSI to the Ministry of Mines and GSI

It is observed that judicial orders concerning mining in the Aravali region adopted a multi-institutional oversight framework, recognising that mining impacts extend beyond forestry and require expertise in environmental, engineering, and hydrological fields. As reflected in the Supreme Court's orders dated 16.12.2002 and 03.05.2007, and subsequent compliance submissions placed before the Hon'ble Court on 12.09.2007, regulatory decision-making relied on reports and inputs from institutions such as the National Environmental Engineering Research Institute (NEERI), Haryana State Pollution Control Board (HSPCB), Central Public Works Department (CPWD), Central Ground Water Board (CGWB), Environmental Pollution (Prevention and Control) Authority (EPCA), and the CEC itself. These bodies were tasked not merely with advisory roles but with inspection, monitoring, and recommending conditional recommencement of mining in individual cases, thereby embedding technical plurality and cross-sectoral checks into the governance framework.

In contrast, recent CEC reports (3/2024) and the 9-member committee report do not include representatives from these specialised institutions as members of the decision-making framework. This omission of watershed and environmental engineering experts exposes a structural flaw in the delineation exercise. Although the task of delineating the Aravali hill boundary was assigned to the FSI, the CEC (3/2024) records that the process involved "scientific literature review, in-house discussions and hit and trials," underscoring that the exercise was exploratory rather than determinative. Such an approach may be understandable where an institution is operating outside its core domain of expertise. FSI's institutional mandate and technical strength lie primarily in forest cover assessment, vegetation mapping, and ecological classification—not in geological interpretation, litho-structural continuity, or the evolution of ancient fold mountain systems. The need to rely on trial-and-error methods reflects this limitation and raises a foundational question: why was an institution without geological specialisation placed at the core of a task that is fundamentally geological?

A departure from the earlier jurisprudential approach is observed, which treated mining in the Aravalis as a composite environmental–engineering–geological issue rather than a narrowly forest-centric one. The exclusion of institutions with demonstrated domain expertise in pollution control, hydrogeology, and infrastructure assessment

[20] Supreme Court of India. (2025, December 29). *In re: Definition of Aravalli Hills and Ranges and ancillary issues* (SuO Moto Writ Petition (Civil) No. 10/2025). Record of Proceedings.

has narrowed the analytical lens, weakened inter-agency accountability, and further accentuated the institutional imbalance wherein land-use and mining determinations are undertaken without the participation of either the nodal mining authorities or the technical regulators historically relied upon by the Court. This position is consistent with the GSI's earlier stance. As early as 2003, the GSI refused to accept the Rajasthan Government's approach[21] of defining the Aravali Hills solely on the basis of '100 metres from ground level', cautioning that such a criterion would lead to slope instability and arbitrariness in boundary delineation.

Recommendation: *Institutions such as GSI should be vested with the final authority over what constitutes the Aravali Hill and Ranges (surface and subsurface), while MoEF&CC should regulate their protection, and the Ministry of Mines should determine where and under what conditions mineral extraction is permissible. This separation mirrors best practices in mineral governance and avoids institutional overreach. Moreover, any future adjudication or order, committee constitution, or regulatory framework concerning mining in the Aravali Hills or Range must mandatorily involve the Ministry of Mines (for mineral policy, lease frameworks, and enforcement), as nodal authority for mining leases, mineral policy, and enforcement, and GSI as the authoritative body for defining the geological extent, origin, continuity and mineral potential of the Aravali–Delhi Fold Belt.*

6. Adoption of Global Best Practices in Environmentally Responsible Mining and Use of AI

India's mining governance in the Aravali region must move beyond minimum compliance and adopt internationally proven best practices that demonstrably reduce environmental harm. This imperative is reinforced by the presence of the Alwar Quartzite in the Aravali - one of the most prominent lithological units of the Delhi Supergroup, extensively exposed across Rajasthan, Haryana, and Delhi - which has been recognised by the International Union of Geological Sciences (IUGS) as a Global Heritage Stone Resource. Several global examples illustrate how mining impacts can be substantially mitigated when ecological safeguards are treated as integral rather than optional. For instance, in Chile, mining operations in arid regions increasingly rely on desalination plants to supply processed water, significantly reducing pressure on local freshwater aquifers. In Ghana, mercury-free gold mining techniques have been implemented to curb soil and water contamination, directly addressing long-term public health and ecological risks. Following the 2014 tailings breach at the Mount Polley mine in Canada, large-scale remediation efforts—including the planting of over 600,000 trees and shrubs and the creation of new fish habitats enabled the recovery of local rainbow trout populations, demonstrating that ecological restoration is achievable when mandated and enforced. Without this shift, mining will continue to externalise ecological costs onto already fragile landscapes, accelerating desertification and long-term environmental insecurity.

Recommendation: *A global understanding of new technologies and their synergies is needed to regulate mining. Around the world, mining companies and industry associations are increasingly leveraging artificial intelligence (AI), autonomous systems, and digital technologies to enhance sustainability and safety in mining operations. None of the reports or judgments talk about the technological needs of sustainable mining. For instance, autonomous mining trucks and equipment not only improve safety by removing workers from hazardous conditions but also reduce fuel consumption and operational costs[22]. AI and digital analytics are being used to optimise energy and water use, as seen in Chile, copper operations, where substantial water and energy savings have been realised, demonstrating how technology can directly reduce environmental impact[23]. Smart systems such as autonomous haulage and sensor networks further support efficient decision-making, lower emissions, and enhance workplace*

[21] CEC Report (03 of 2024). GSI, Western Region vide letter no. 8615/96/TC/EQ/WR/2001 dated 14 August 2003 (Annexure R-69)
[22] Tomorrow's World Today. (2022). *Sustainable mining around the world*.
[23] BHP. (2024). *Artificial intelligence is unearthing a smarter future*.

safety[24]. In Canada, the integration of digital systems under sustainability frameworks has enabled the launch of fully electric mines that eliminate diesel use, reinforcing that technology and regulatory practice must evolve together to truly achieve sustainable mining[25].

7. A Layered Approach to an Aravali Ecosystem

The Aravali supports an interconnected ecosystem comprising forests, wildlife, airsheds, watersheds, aquifers, and degraded lands. Consequently, the geographic and aerial extent of the range is far more critical than its present-day topographical manifestations, such as elevation alone[26]. Mining in the Aravali hills has long been a source of environmental concern, as highlighted in successive CEC reports, though the ecological implications of such activities have often remained inadequately elaborated.

The CEC, in its *Report No. 03 of 2024*, reiterates and builds upon earlier findings by stating that *"the hill range, whether having green cover or not, is the curtain barrier for the spread of desertification; green cover is a value-added barrier."* The same report quantified the Aravali's hydrogeological role, estimating an average groundwater recharge potential of approximately two million litres per hectare, attributable to the highly fractured, jointed, and weathered nature of its rocks[27]. The 9-member Committee Report observed that the Aravali range historically acted as a physical barrier against desertification, checking the eastward spread of the Thar Desert into eastern Rajasthan, the Gangetic plains, Haryana, Delhi, and western Uttar Pradesh. These observations underscore that removing, flattening, or excluding low-relief or sparsely vegetated Aravali formations from protection directly undermines their role in desertification control and aquifer recharge, impacts that cannot be compensated merely through afforestation or green-wall initiatives.

While earlier reports emphasised pollution control measures, the 9-member Committee Report, on which the Supreme Court based its November judgement, does not address safety provisions for mining operations or measures to control pollution and contamination from mining effluents, leaving a significant gap in regulatory oversight. Significantly, the Comptroller and Auditor General (CAG) Report of 2018, highlighting the "serious deficiencies and apathy towards fulfilment of environmental conditions relating to top soil, overburden dumps, plantation, air pollution control measures, noise pollution control measures, rehabilitation measures and mining in benches" were also not addressed by the 9-member committee.

Interestingly, the Supreme Court, vide its order dated 6 May 2002 in W.P. (Civil) No. 4677 of 1985 (M.C. Mehta vs. Union of India), explicitly prohibited mining activities within a 2 km radius of the Badkhal and Surajkund tourist resorts, directed that closed mines in this zone shall not be reopened, and mandated the enforcement of NEERI's recommendations by the Director of Mining and Geology and the State Pollution Control Board. These directions were rooted in the recognition of cumulative environmental degradation and the ecological sensitivity of the Aravali region. In light of these judicial prohibitions and documented regulatory failures, the continued emphasis on definitional distinctions appears incongruous. Once mining itself has been judicially restricted or banned[28] in large parts of the Aravalis, the policy discourse must shift from categorisation towards enforcement, restoration, and alternatives to extraction. Persisting with classificatory frameworks without addressing the foundational legal

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[24] S&P Global Market Intelligence. (2025). *A peek at the AI revolution in mining: Promise meets peril*.

[25] Tomorrow's World Today. (2022). *Sustainable mining around the world*.

[26] National Herald India. (2025, January 13). *The Aravallis: Defining an ecosystem with a tape measure*.

[27] Central Empowered Committee (CEC). Report on Issues Relating, the degraded or low-lying Aravali remnants must g to the Aravalli Hills and Ranges, dated 26 June 2018. & Central Empowered Committee (CEC). Report No. 03 of 2024 on the Definition of Aravalli Hills and Ranges.

[28] The Hon'ble court in the matter of W.P Civil no 4677 of 1985 stated by the order dated 29/30.10.2002 "The mining in the entire Aravalli hills was prohibited and banned".

bar on mining raises fundamental questions about the purpose and direction of such definitions in the context of sustainable development and the rule of law. However, despite the binding nature of the Supreme Court's judicial positions, the 9-member Committee Report as well as the CEC Report (3/2024) do deliberate on the operationalisation of the Supreme Court's 13.04.2006 prohibition on mining in Aravali's water-table areas[29].

The broader ecological implications of mining in the Aravali region—such as desertification, land degradation, biodiversity loss, decline in soil fertility, and falling water tables—remain underexplored in regulatory discourse. The absence of safety provisions in the Supreme Court's November judgment further compounds the vulnerability of both mine workers and surrounding communities. Therefore, there is an emerging need to protect the degraded or low-lying Aravali remnants, as they play a critical role in groundwater recharge, dust suppression, climate moderation, and biodiversity connectivity. Degradation should trigger restoration measures rather than exclusion from environmental protection.

Global experience demonstrates that treating degraded or low-relief landscapes as expendable leads to irreversible ecological and social costs. Mining, urban expansion, and vegetation removal accelerate soil erosion, reduce water-holding capacity, and prevent natural regeneration, driving desertification across dryland regions. Nearly two billion people live in such vulnerable landscapes, with up to 50 million at risk of displacement by 2030[30]. The European Commission's Joint Research Centre estimates that an area equivalent to half the European Union is degraded each year, primarily in Asia and Africa[31]. In China, large-scale construction near the Gobi Desert[32] has intensified dust storms and public-health risks, while historic gold and mercury mining in California has caused persistent river contamination and bioaccumulation of toxins[33]. These precedents demonstrate that degradation heightens environmental risk rather than negating ecological value.

Although DARK (over-exploited) groundwater zones are mentioned in several places, they are not integrated into mining decision-making. The references remain limited to a general acknowledgement that such zones have been identified by the Central Ground Water Board in areas such as Faridabad and Gurugram, without any clarification on their precise spatial extent, criteria for identification, mapping methodology, or how these zones are to be operationalised in regulatory decisions in the entirety of the Aravali. The reports provide no guidance on the location-specific treatment of DARK zones or their implications for granting, regulating, or prohibiting mining activities. There is no direction to the FSI or SoI to integrate the Dark Zones as no-go areas in the Aravali.

Land-use planning in the Aravali region should incorporate watershed boundaries alongside administrative boundaries. Eastern and western slope drainages, recharge zones, and terminal basins should be delineated as hydrological management units, with differentiated protection norms reflecting their recharge and runoff functions. There also needs to be a systematic integration of groundwater with climate policies, given Aravali's role in groundwater recharge. Mining permissions must correlate with aquifer vulnerability indices and rainfall infiltration models. Watershed-based ecological/recharge no-go zones, apart from forest zones in active recharge areas, need to be identified by scientists.

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[29] The Hon'ble Supreme Court in the matter of W.P. Civil No. 4677 of 1985 in the matter of MC Mehta vs Union of India. Para 96 of the judgement.

[30] CGIAR. (2024, December 5). Statement to UNCCD COP16 gathering.

[31] Nunez, C. (2019, May 31). Desertification, explained. National Geographic.

[32] Srinivas, H. (2022, October). Cities and desertification: The long arm of urban areas. Global Development Research Center (GDRC).

[33] U.S. Geological Survey. (2024, April 2). New maps identify legacy mercury contamination. U.S. Department of the Interior.

Recommendations: *In view of the CGWB's recognition of DARK (over-exploited) groundwater zones as ecologically unsustainable for extractive activities.[34] The Supreme Court needs to direct the competent authorities, including the CGWB/State Ground Water Boards and relevant State agencies, to systematically identify, map, and notify DARK (over-exploited) zones within the Aravali region. Mining and quarrying activities within such identified DARK zones should be expressly prohibited or subjected to the most stringent restrictions, with groundwater stress treated as a decisive regulatory criterion rather than a peripheral consideration. Overall, there should be strict enforcement of environmental conditions for mining operations, requiring compliance with topsoil preservation, overburden management, and pollution control norms in well-demarcated watershed boundaries. The degraded and low-relief areas of the Aravalis must therefore be protected and restored, not excluded from environmental safeguards.*

8. Correct the Protected Area Fallacy

Despite extensive discussion on protected areas, less than ~4% (approximately 3.55%) of the Aravali landscape is currently under formal protection[35]. Notably, this figure emerges from studies and assessments conducted by the MoEF&CC itself, which acknowledge that only a small fraction of the Aravali forest and ecologically significant areas fall within notified protected categories. This stark mismatch between the scale of ecological concern and the extent of statutory protection underscores the inadequacy of relying solely on protected area designations for conserving the Aravali system. The 9-member committee report, although headed by the MoEF&CC, which incidentally also heads the Green wall project in the Aravali, has not found it pertinent to highlight the extent of protected areas in the Aravali region.

Recommendation: *In light of the MoEF&CC'S own assessments of a minuscule area under formal protection in the Aravali, conservation frameworks must move beyond a protected-area-centric approach. Ecologically functional Aravali features—including ridges, slopes, inter-hill valleys, recharge zones, and degraded forest lands outside notified protected areas—should be brought under statutory conservation and regulatory safeguards, with eco-sensitive/eco-strategic zones mapped. This should be a multi-institutional effort, highlighting layers such as desertification prevention, watershed understanding, and more. Protection of the Aravalis must therefore adopt a landscape-level approach commensurate with the ecological significance of the range, rather than relying solely on the limited extent of existing protected areas.*

9. Explicitly Address Urbanisation and Real Estate Issues

Notably, urbanisation, encroachment and real estate development - the original trigger of the Aravali dispute - remain largely unaddressed in the current regulatory discourse. This omission persists despite the CEC's earlier report[36], which explicitly recognised encroachment as a serious concern and recommended that mining leases or permits be cancelled where the extent of encroachment exceeds 10% of the lease area. While this recommendation acknowledged the direct link between encroachment, land conversion, and regulatory failure, subsequent deliberations have not extended this logic to address real estate–driven degradation across the wider Aravali landscape. Speculative markets with a 100 m definition for mining may open vast, high-value areas in Faridabad and Gurgaon[37], as well as elsewhere, depending on how the Aravali is interpreted by law. It is essential to

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[34] Press Information Bureau. (2013, August 29). Dark zones (Press release). Government of India, Ministry of Water Resources.
[35] Ministry of Environment, Forest and Climate Change, Government of India. (2025). *Aravali landscape restoration and creation of the green wall* [PDF].

[36] Central Empowered Committee. (2016, June 26). *Report on issues relating to protection of the Aravalli Hills and regulation of mining activities* (Submitted to the Supreme Court of India in Writ Petition (Civil) No. 202 of 1995, T.N. Godavarman Thirumulpad v. Union of India & Ors.). Supreme Court of India.
[37] Indian Express. (2025, November 22). *New Aravalli definition may open low hills to mining: Activists*. *The Indian Express*.

delineate the urban extent of the Aravali and create a no-go zone not only for mining but also for real estate/institutional development.

Recommendation: *Regulatory frameworks for the Aravali region should explicitly incorporate controls on urbanisation and real estate/ institutional development in eco-strategic locations, including strict action against encroachment, land-use conversion, and unauthorised construction on ridges, slopes, and inter-hill valleys. Measures addressing mining impacts must be complemented by equally robust mechanisms to regulate urban expansion, failing which the root cause of Aravali degradation will remain unresolved.*

10. Effective System of Community Participation in Decision Making

On 15.01.2016, the MoEF issued a notification amending the EIA notification, 2006, which revealed a dilution of community participation in mining-related decision-making. Under the Environmental Impact Assessment (EIA) Notification, this amendment permitted mining projects in the 5–25 hectare category to also proceed without public consultation, as 0-5 hectares can, effectively excluding affected communities from decisions with direct environmental and social consequences. This exemption was questioned by the National Green Tribunal (NGT)[38], which held that dispensing with public consultation for areas between 5 and 25 hectares, including in cluster situations, amounted to a dilution of the EIA process and was inconsistent with the principles laid down in earlier judicial precedents. The NGT's intervention marked a critical course correction by reaffirming that community participation is not an administrative formality but a substantive safeguard against environmental harm and regulatory capture. Local communities need to be informed about the basic elements of mining proposals in order to limit and manage ecological/environmental damage. Community-driven approval models exist nationally (tribal areas in northeastern Indian states e.g. Meghalaya and Nagaland) and globally (Maori community in New Zealand engaged in biobanking, genomic research[39]; Canadian Arctic[40]). Therefore, mining activities in the 0–5 hectare category need to be integrated in the mandatory public consultation, as such projects—particularly when occurring in clusters or ecologically sensitive landscapes like the Aravalis—can cumulatively result in serious environmental degradation. The continued exclusion of local communities from decision-making at this scale undermines the precautionary principle and ignores the lived knowledge of those most directly affected by land degradation, groundwater depletion, dust pollution, and ecosystem fragmentation.

Integration of Indigenous Knowledge in Ecosystem Management related to water harvesting, forest protection, and agro-pastoral systems should be systematically built-into contemporary conservation, climate adaptation, and restoration programmes. Safeguards against displacement from mining, quarrying and large infrastructure projects within the Aravali must be subject to strict social impact assessments, ensuring prior informed consent, livelihood protection, and culturally appropriate rehabilitation for affected communities.

Indian experience demonstrates that public participation and judicial oversight can effectively halt environmentally damaging mining activities. The Supreme Court–mandated closure of mining by Kudremukh Iron Ore Company Ltd (KIOCL) within Kudremukh National Park and the nationwide mining shutdown in Goa in 2012 following judicial

[38] The National Green Tribunal (NGT) explicitly questioned and corrected the regulatory dilution relating to mining projects up to 25 hectares in its judgment dated 13.09.2018.

[39] Beaton, A., Hudson, M., Milne, M., Port, R. V., Russell, K., Smith, B., Toki, V., Uerata, L., Wilcox, P., Bartholomew, K., & Wihongi, H. (2017). Engaging Māori in biobanking and genomic research: A model for biobanks to guide culturally informed governance, operational, and community engagement activities. Genetics in Medicine, 19(3), 345–351.

[40] Ford, J. D., Stephenson, E., Cunsolo Willox, A., Edge, V., Farahbakhsh, K., Furgal, C., Harper, S., Chatwood, S., Mauro, I., Pearce, T., Austin, S., Bunce, A.,& Huet, C. (2016). Community-based adaptation research in the Canadian Arctic. Wiley Interdisciplinary Reviews: Climate Change, 7(2), 175–191.

intervention against illegal extraction highlight the role of legal enforcement in ecological protection[41]. At the local scale, public opposition in Nagpur, Maharashtra, led to the halting of official hearings for proposed coal mining projects, while activist resistance in Sandur (Ballari district, Karnataka) resulted in the temporary suspension of surveys facilitating iron ore extraction[42]. These cases underscore the need to institutionalise meaningful community participation and transparent decision-making in mining approvals, particularly in ecologically sensitive regions.

The CEC (03 of 2024) report explicitly acknowledges that mining in the Aravali region has historically contributed to employment and state revenues, and that blanket prohibitions can adversely affect communities dependent on mining-related livelihoods. At the same time, the CEC cautions that livelihood considerations cannot be viewed in isolation from ecological limits, noting that environmental degradation undermines long-term socio-economic sustainability. The Report therefore emphasises the need to explore alternative livelihood options and sustainable resource management strategies that balance employment concerns with conservation imperatives. This recognition reinforces that livelihood security in the Aravali must be addressed through planned transition, diversification, and restoration-linked employment, rather than through unregulated or environmentally destructive mining practices.

Very recently, the Indian government has taken a proactive step in prohibiting digital gaming in the interest of safeguarding the younger generation. Despite the scale of the market, the livelihoods affected, and the economic stakes involved, the prohibition compels a deeper reflection on collective consciousness and what the nation ultimately chooses to protect in the name of the public good. Why then is the Aravali - an irreplaceable geological, ecological, and hydrological asset of national importance - not accorded the same precautionary seriousness? Notably, the Supreme Court itself acknowledges that illegal and unplanned mining causes “huge irreversible damage[43]” to the environment and expressly records that the Aravali hill range “has to be protected at any cost,[44]” even to the extent that complete stoppage of mining may have to be considered where irreversible ecological impacts occur.

Recommendation: *Mining in ecologically sensitive landscapes such as the Aravalis must prioritize robust public participation and social safeguards. Public consultation should be mandatory for all mining projects, including those under 0–5 hectares, particularly in cluster areas with significant cumulative impacts. Community consent should be treated as a substantive environmental safeguard rather than a procedural formality, with prior informed consent, disclosure of project details, and integration of local ecological knowledge during appraisal. Rigorous Social Impact Assessments (SIA) must ensure protection of livelihoods, culturally appropriate rehabilitation, and safeguards against involuntary displacement. Furthermore, regulatory authorities should operationalise the precautionary principle through strict compliance monitoring and enforcement, drawing on judicial precedents that have successfully halted environmentally destructive mining in sensitive ecosystems.*

Concluding Principle

The Aravali is not merely about mining - it is about the strategic need to align geology, ecology, hydrology, urban policy, mineral governance and technology within a single coherent framework, safeguarding the future of the northern plains and the adjoining regions. Correcting the current trajectory, therefore, demands institutional

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[41] India Together. Kudremukh: Environment or mining? India Together.
[42] TNN. (2025, September 11). *Villagers halt hearing on proposed coal mine, demand safeguards. The Times of India.*
[43] Central Empowered Committee. (2024). *Report No. 3 of 2024 in W.P. (C) No. 202 of 1995: Regarding Aravalli Hills and Ranges in the State of Rajasthan and Haryana* (Vols. I–II). Supreme Court of India. (pg. 76.pt (c))
[44] Supreme Court judgement vide dated (Haryana) 18.03.2004 in WP (C) 4677 of 1985

realignment, a scientific primacy that acknowledges both the ecological functions and the irreplaceable geological heritage of the Aravali landscape.