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Aravalli's conservation: a geographical perspective from pre-cambrian to present

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Abstract:
The Aravalli Range, recognized as one of the oldest fold mountain systems in the world, holds a profound geographical, geological, and ecological significance in the Indian subcontinent. Originating over 2.5 billion years ago, the Aravalli Craton's evolutionary history provides critical insights into the Archean-Paleoproterozoic transition and early plate tectonic mechanisms. Beyond its staggering geological antiquity, the Aravalli acts as a vital climatic barrier against advancing desertification and serves as a rich, albeit fragile, repository of biodiversity. However, in the modern era, rapid anthropogenic interventions including illegal mining, unchecked urbanization, and systemic deforestation, have catalysed severe environmental degradation. This multifaceted crisis is historically rooted in "wasteland governmentality," a colonial paradigm that arbitrarily classified these rugged hills as uncultivable wastes, rendering them systematically vulnerable to state-led land enclosures, arboreal bio politics, and modern real-estate speculation. This paper explores the Aravalli Range tracing its history from the Pre-Cambrian era, through indigenous sacred grove protection, to present-day ecological challenges. Drawing exclusively from scholarly assessments, it highlights the pressing necessity for sustainable land-use, rigorous ecosystem service valuation, "restorative commoning," and a paradigm-shifting revival of indigenous eco-conscious traditions to safeguard this irreplaceable ecosystem.

Keywords: Aravalli Range, Pre-Cambrian Geology, Wasteland Governmentality, Ecosystem Services, Sacred Groves, Restorative Commoning.

1. Introduction

The Aravalli Range stretches for an impressive 800 kilometers diagonally across northwestern India. Specifically, it extends continuously from Palanpur in the semi-arid eastern regions of Gujarat, cutting through the geographical heart of Rajasthan and southern Haryana, and finally terminating in the scattered, highly urbanized ridges of Delhi. This monumental geographical feature stands as India's oldest and arguably most heavily degraded fold mountain system, with a deep geological history dating back roughly 2.5 to 3 billion years (Tanwar, 2025). The range acts as a critical climatic and hydrological barrier for the entire subcontinent. Geographically, it serves as the primary watershed divide separating the drainage basins of the Bay of Bengal (via the Banas and Chambal rivers) from the Arabian Sea (via the Luni and Sabarmati rivers). Even more crucially, by standing as an elevated, rugged barricade, the Aravalli actively prevents the Thar Desert's aggressive eastward expansion into the highly fertile,

densely populated agricultural plains of the Indo-Gangetic basin. Furthermore, it effectively regulates the region's broader monsoonal cycles by physically checking the dry, moisture-stripping westerly winds from Central Asia, while simultaneously capturing and directing monsoon clouds moving inland from the Arabian Sea toward the foothills of the Himalayas (Tanwar, 2025; Nagendra & Mundoli, 2019).

Historically and culturally, the Aravallis have been an inseparable part of India's civilizational narrative, serving as natural fortresses for Rajput kingdoms like Mewar, and inspiring deep ecological reverence in marginalized tribal societies that have historically cohabited its harsh terrains. However, looking at it through a purely extractive lens, the mountains have also been historically dubbed a "museum of minerals."

Today, the Aravalli is actively eroding beneath the weight of rapid industrialization. Its immense resource wealth such as quartzite, marble, silica, and copper, has precipitated widespread soil erosion, aggressive habitat fragmentation, and severe aquifer depletion. This unmanaged depletion now poses an existential threat to the water survival of the entire Delhi National Capital Region (NCR) (Kumari, 2025a).

This rapid ecological collapse is deeply rooted in historical policy. Colonial and post-colonial authorities systematically classified much of this rugged, semi-arid domain as *gair mumkin pahar* (uncultivable hills) or revenue wastelands. This bureaucratic classification catalysed the structural separation of local pastoral and agrarian communities from their ancestral commons, turning biologically rich habitats into "waiting lands" ripe for exploitation (Bathla, 2024; Di Palma, 2014). The sharp dichotomy between the Aravalli's rich, billion-year geological heritage and its present ecologically precarious state under late-stage capitalism demands a critical geographic and socio-ecological analysis.

Ancient regional history provides grim precedents of total ecological collapse caused by anthropogenic oversight in specialized semi-arid climates. As Dasgupta and Chattopadhyay (2004) note, the mighty Indus Valley civilization which historically flourished merely hundreds of kilometres away along similar climatic latitudes, ultimately perished largely due to anthropogenic deforestation, massive overgrazing, and intensive river-flow manipulation. These actions catalysed subsequent desiccation, increased soil salinity, and dramatic agricultural fertility loss, leading to systemic societal collapse (Wheeler, 1960). Modern northwestern India now faces a strikingly similar existential paradox. The Aravalli ecosystem, which has quietly sustained millions of people for millennia, is rapidly disintegrating underneath the modern developmental pressures characteristic of a relentless, concrete-driven "urban revolution" (Lefebvre, 2003 [1970]).

This paper systematically untangles this paradox. It evaluates the Aravalli Range starting from its deep Paleoarchean foundational geology, traverses through its profound biodiversity, and critically maps the modern anthropogenic assault driven by wasteland governmentality. Finally, it outlines urgent contemporary perspectives on conservation, demanding a shift from extractive capitalism towards restorative commoning and indigenous ecological respect.

2. Geological Antiquity: The Pre-Cambrian Foundation

The Indian subcontinent hosts five major Archean cratonic nuclei, and the Aravalli Craton is among its most consequential and intensely studied fragments (Mazumder, De, & Raju, 2018). The Aravalli Banded Gneissic Complex (BGC), which forms the foundational basement of this range, represents highly metamorphosed Tonalite-Trondhjemite-Granodiorite (TTG) gneisses dating between 3.3 to 2.9 Ga. These rocks serve as the rigid, stabilized basement over which the diverse metasedimentary and

metavolcanic rocks of the subsequent Aravalli and Delhi Super groups were deposited during early rifting events (Todarwal, 2022; Gupta et al., 1997).

The Archean BGC is unconformably overlain by the Paleoproterozoic Aravalli Super group. Its stratigraphy is globally significant, featuring extensive dolomitic limestones, paleosols, and stromatolitic phosphorites, the latter providing evidence of early cyanobacterial life and playing a dominant role in India's current commercial phosphate reserves (Mazumder, De, & Raju, 2018).

To the eastern fringe of this monumental orogenic belt lies the enigmatic Hindoli Group. Previously confused with Archean secondary greenstones and heavily debated due to its low metamorphic grade, advanced U-Pb zircon geochronology has firmly placed the Hindoli felsic volcanics at 1854 ± 7 Ma. This confirms them as a Proterozoic supracrustal cover that is broadly synchronous with Aravalli sedimentation, closing a long-standing stratigraphic controversy (Deb, Thorpe, & Krstic, 2002; Bose & Sharma, 1992). Geographically, as the Aravalli system extends northeastward into Haryana toward Delhi, the basement rocks plunge, and the exposed hills are predominantly hard quartzite (metamorphosed sandstone) resting upon the ancient Gneiss (Tanwar, 2025; Heron, 1917).

3. Biodiversity and Geographical Significance

Despite its harsh, semi-arid character, the unique topography of the Aravalli Range intercepts varied climatic zones, supporting a highly specialized and dynamic confluence of Saharan, Ethiopian, Peninsular, Oriental, and Malayan ecologies that survive in micro-habitats (Tanwar, 2025). This diversity stands out starkly when contrasted against the highly concretized and intensely polluted environments surrounding the mega-cities in the region (Nagendra, 2016).

Flora: The Aravalli's ecosystem primarily constitutes tropical dry deciduous and semi-arid scrub forests. Dominant native canopy species are uniquely adapted to withstand extreme summer temperatures and prolonged droughts. These include the climax species *Dhok* (Anogeissus pendula), which aggressively colonizes steep rocky slopes, *Salai* (Boswellia serrata), *Palash* (Butea monosperma), and various Acacia species (Todarwal, 2022). The region is critically rich in floral diversity, particularly concerning medicinal plants such as Kadaya, Gugal, Amla, Moosli, and Khair, which have been utilized for centuries by local traditional healers (Todarwal, 2022).

Modern grassroots initiatives like the Aravalli Biodiversity Park (ABDP) in Gurugram function as a living arboretum and nursery for rare regional plants, successfully raising and propagating over 300 native species mapped carefully to the rugged, water-scarce terrain (Tanwar, 2025; Bathla, 2024; Krishen, 2006).

Fauna: Avian and mammalian biodiversity remains surprisingly rich despite accelerating habitat fragmentation. Extensive wildlife surveys utilizing camera traps and drone mapping have documented apex predators and major mammals such as leopards, striped hyenas, golden jackals, nilgai (blue bulls), palm civets, wild pigs, and Indian crested porcupines (Tanwar, 2025). Hydrological features situated within the range, such as Kotla Lake, Badkhal, and Surajkund, have historically acted as major oases and halting points for migratory birds such as the Eurasian Wryneck and Himalayan Griffon Vulture, navigating the Central Asian Flyway (Yadav & Yadav, 2012; Rangarajan, 2018).

4. Anthropogenic Degradation: The Modern Crisis

To understand the crisis in the Aravallis, it is essential to map the historical transition from indigenous,

community-managed ecosystems to a state-controlled, heavily mined wasteland network leading directly to the modern ecological crisis.

4.1. The Trajectory of Mining and Quarrying

Intensive, mechanized mining operates as the absolute primary catalyst for environmental degradation in the Aravallis. Over **25%** of the Aravalli hills in Rajasthan alone have been physically obliterated, leveled to their foundations due to extensive quarrying operations extracting limestone, marble, silica sand, and rock phosphate (Kumari, 2025a; Yadav & Yadav, 2012). Waste dumping, marble slurry disposal, and unregulated stone-crushing operations have left massive scars and gullies across foothills, completely eradicating deep soil covers that took millennia to form (Yadav & Yadav, 2012).

Deep-pit excavation, routinely surpassing subterranean aquifer depths, has severely altered natural ancient drainage pathways. In many instances, the relentless pumping of water from deep mines has desiccated surrounding village wells and seasonal lakes, catastrophically disrupting the delicate hydrological cycle in the entire National Capital Region (NCR) (Tanwar, 2025). This destruction aligns directly with broader theories regarding humanity's overpowering capacity to physically alter planetary landscapes in the Anthropocene (Chakrabarty, 2021).

4.2. Wasteland Governmentality and the Developer Nexus

Beyond direct physical mining, the Aravallis are suffering from a highly politicized legislative paradigm termed **"wasteland governmentality."** This is a systemic, bureaucratic process where the state arbitrarily classifies these complex, functional ecologies as barren, unproductive "wastes", thereby legally opening them up for massive real-estate speculation, luxury tourism setups, and infrastructure corridors (Bathla, 2024; Baka, 2013). This ideological framing of "wasteland aesthetics" ensures the land is morally and legally prepared for future capitalist gentrification, erasing centuries of communal pastoral use (Gandy, 2013). In the NCR specifically, the rapid "great acceleration" of neoliberal urbanization post-1990s formally converted these ecological "wastelands" into sites of massive surplus value accumulation, resulting in a fundamentally "fractured forest" network (Krishnan, 2020; Crowley, 2020; Ghertner, 2015).

Simultaneously, the Aravalli region has been subjected to destructive "arboreal biopolitics." Native forest species, perfectly adapted to the local climate, are aggressively replaced by the invasive *Prosopis juliflora* (Mesquite) in misguided, statistically driven state greening drives. This policy originated from flawed colonial forestry logic that prioritized fast-growing fuel wood over complex ecosystem health (Bathla, 2024; Davis & Robbins, 2018; Guha, 1983; Sivaramakrishnan, 1999).

5. Perspectives on Conservation

5.1. Sacred Groves: Indigenous Resistance and Elite Co-optation

Awareness of environmental interdependency is not a novel concept imported from the West; it has ancient, deeply culturally embedded roots in the Aravalli demographic (Berkes, 2017). Historically, indigenous tribal customs meticulously preserved vital ecological patches as sacred groves locally known as *orans* or *dev bani*, enforcing strict folk penalties for felling trees (Ramakrishnan, 1996; Sinha & Maikhuri, 1998). A comprehensive survey in Udaipur recorded 89 distinct sacred sites strictly protected by local faith. Primarily devoted to Lord Shiva and specialized native goddesses, these untamed pockets of flora act as crucial, undisturbed biodiversity refuges and vital groundwater recharge zones (Kumar & Koli, 2023).

Today, grassroots organizations deploy the "sacred" concept actively as a modern socio-political tool to resist vast state expropriation. By re-emphasizing the spiritual and communal value of *orans*, agrarian communities successfully defend native climax species, like the *Dhok* tree, against aggressive wasteland-clearing and mining initiatives, showing a deep local enchantment with nature that defies capitalist logics (Bathla, 2024; Bennett, 2016; Kumari, 2025b).

This sacred concept is increasingly vulnerable to sophisticated co-optation. In industrialized peri-urban areas, elite middle-class environmentalists and capitalized temple trusts have legally absorbed former *orans*. Rather than preserving the ecosystems, they clear-cut the native underbrush to build "faux-sacred" monuments, sprawling concrete complexes adorned with artificial "Disney-divinity" fiberglass animals and manicured lawns, which completely obliterate the original socio-ecological purpose of the grove under the guise of religious tourism (Bathla, 2024; Srivastava, 2009; Baviskar, 2011; Jain, 2021).

5.2. Restorative Commoning and Grassroots Movements

In response to the overwhelming threats of state and private expropriation, leading urban environmentalists have conceptualized models of "anti-wasteland politics" and "restorative commoning," demanding a move towards equitable urban commons rather than exclusive, elite gated parks (Baviskar, 2019). The Aravalli Biodiversity Park (Gurugram) stands as an exemplary flagship model globally for restorative commoning. Here, citizen groups forged completely new communities of care, organizing volunteers, schoolchildren, and local corporations to painstakingly restore a severely degraded, barren mining site into a thriving 380-acre native deciduous forest (Bathla, 2024; Tanwar, 2025).

Yet, even unequivocally successful rewilding efforts continuously face severe state infrastructure threats. This precariousness was violently demonstrated in the autumn of 2018 when thousands of citizens had to physically protest to block the National Highways Authority of India (NHAI) from driving a major highway corridor directly through the heart of the successfully established urban forest (Bathla, 2024; Pant, 2018; Ahlawat, 2019).

6. Ecosystem Services and Economic Valuation

To effectively combat the financial allure of mining and real estate, macroeconomists advocate for the rigorous valuation of the Aravalli range's ecosystem services (Costanza et al., 1997; Mitchell & Carson, 1989). As demonstrated in comparative Himalayan studies, calculating the "Willingness To Pay" (WTP) by local and distant stakeholders solidifies abstract religious reverence into tangible preservation incentives (Sinha & Mishra, 2015).

The myriad ecological operations of the Aravalli Range are classified into four major domains. Table 1. below details the specific ecosystem services provided by the Aravallis to the adjoining regions:

Table 1. The Aravalli Buffer: Ecological Services and Economic Valuation			
Category of Service	**Specific Service**	**Direct Benefit to the Region**	**Economic Valuation / Real-World Impact**
Regulating	Groundwater Recharge	Primary hydrological sponge for the Delhi-NCR. Mitigates ambient temperatures.	Projects like the Aravalli Biodiversity Park recharge over 320 million litres of water annually, averting deep aquifer collapse (Tanwar, 2025).
Provisioning	Medicinal Plants, Fodder	Supplies nutritious foliage (*Dhok*) for livestock and medicines (Gugal) for health grids.	Sustains the socio-economic backbone of marginalized pastoral communities like the Gujjars (Bathla, 2024).
Cultural	Sacred Groves (*Orans*)	Spiritual identity, recreational spaces, and venues for major socio-religious festivals.	High local Willingness To Pay (WTP) for temple upkeeps and strong resistance to expropriation (Sinha & Mishra, 2015; Kumar & Koli, 2023).
Supporting	Desertification Barrier	Checks the eastward movement of the Thar Desert and supports soil nutrient cycling.	Averts catastrophic losses equivalent to millions of dollars in agricultural output (Yadav & Yadav, 2012).

7. Legal Frameworks and Judicial Interventions

Legally, the struggle over the Aravallis is marked by a labyrinth of judicial interventions and oscillating regulatory protections. Since the early 1900s, acts like the Punjab Land Preservation Act (PLPA) were instituted technically to prevent soil erosion, but essentially legally enclosed the forest commons, locking out local tribes (Bathla, 2024).

In modern India, the judiciary has frequently stepped into the regulatory vacuum left by state governments. Landmark public interest litigations spurred the Supreme Court and the National Green Tribunal (NGT) to enact sweeping bans on unauthorized mining in the eco-sensitive zones of Faridabad and Gurugram (Tanwar, 2025). Despite directives and the Ministry of Environment, Forests and Climate Change (MoEF&CC) issuing protective notifications, enforcement remains heavily fragmented. Frequent state-level attempts to dilute the PLPA (to unfreeze thousands of acres for real-estate development) highlight the persistent political vulnerability of the Aravallis despite high-profile judicial mandates.

8. Conclusion

The Aravalli Range is a geomorphological monolith, an unparalleled physical archive tying India's deep Pre-Cambrian past to its immediate future ecological survival. The ideological shift from an indigenous philosophy of "harmony with nature", exemplified by sprawling, communally managed sacred groves and nature-centric theology to a modern era poisoned by wasteland governmentality and rampant commercial exploitation has severely distressed the region's structural integrity. While decisive Supreme Court rulings and community-driven "restorative commoning" projects demonstrate encouraging momentum, safeguarding the Aravallis requires an immediate, total halt to illicit mining, the widespread application of stringent ecosystem service valuations, and an absolute end to arbitrary real-estate expropriation under the bureaucratic guise of clearing "wastelands." Promoting true "intergenerational equity" must rapidly become the core national paradigm to ensure that the ancient Aravalli continues to serve as the vital ecological lungs for Northwestern India for millennia to come.

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