DRA Annual International Conference On
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Ind. Jr. of Mod. Res. and Rev *PEER-REVIEWED JOURNAL* *Volume 4 [Special Issue 1] Year 2026*

Indian Journal of Modern Research and Reviews

This Journal is a member of the *'Committee on Publication Ethics'*

Online ISSN:2584-184X

Research Article

The Aravalli Range and Desert Ecology: Emerging Issues, Conservation Challenges, and Implications for Bee–Plant Interactions in Western Rajasthan

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DOI: https://doi.org/10.5281/zenodo.20199729

Abstract

The Aravalli Range, one of the oldest mountain systems in the world, plays a critical ecological role in north-western India by regulating climate, preventing desertification, facilitating groundwater recharge, and supporting diverse biological communities. Extending across Gujarat, Rajasthan, Haryana, and the National Capital Region of Delhi, the Aravallis act as a natural barrier between the Thar Desert and the Indo-Gangetic Plains. Despite their ecological importance, the range has undergone rapid degradation due to mining, urban expansion, deforestation, and weak policy enforcement. This review synthesizes available literature on the geography, vegetation, vertebrate and invertebrate fauna of the Aravalli Range, with special emphasis on pollinators—particularly bees. The paper highlights patterns of biodiversity, evaluates ecosystem services provided by the Aravallis, examines threats and legal frameworks, and proposes evidence-based conservation strategies with a strong focus on pollinator-friendly management and policy integration.

Manuscript Information

- **ISSN No:** 2584-184X
- **Received:** 01-01-2026
- **Accepted:** 29-04-2026
- **Published:** 15-05-2026
- **MRR:**4(SP1); 2026: 176-185
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- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

How to Cite this Article

Pathak P. The Aravalli Range and Desert Ecology: Emerging Issues, Conservation Challenges, and Implications for Bee–Plant Interactions in Western Rajasthan. Indian J Mod Res Rev. 2026;4(SP1):176-185.

Access this Article Online

www.mrrjournal.in

KEYWORDS: Aravalli Range, Biodiversity, Bees, Pollinators, Desertification, Conservation Policy

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1. INTRODUCTION

Mountain ecosystems are globally recognised as centres of high biodiversity and providers of critical ecosystem services, including climate regulation, water security, and habitat heterogeneity (Korner *et al*., 2017; Rahbek *et al*., 2019) [11, 26]. In India, the Aravalli Range represents an ancient geological formation that has profoundly influenced regional ecology, climate, and human settlement patterns. The Aravalli Range is an ancient mountain system in western India, extending approximately 700–800 km in a south-west to north-east direction across Gujarat, Rajasthan, Haryana, and the National Capital Territory of Delhi (Sharma, 2009; Geological Survey of India, 2012) [31, 5]. With an estimated geological age of about 2.5 billion years, it is among the oldest mountain ranges in the world (Valdiya, 2016) [42].

The Aravallis constitute a significant ecological hotspot owing to their complex geological history and physiographic heterogeneity, supporting diverse flora and fauna, including several endemic and threatened plant and animal species, as well as a rich assemblage of reptiles adapted to semi-arid and arid conditions (Rodgers *et al*., 2002; Khandelwal *et al*., 2018) [29, 10]. The range plays a crucial hydrological role by acting as a source and recharge zone for freshwater systems that sustain large parts of western India, including regions adjoining the Thar Desert, thereby limiting desert expansion and supporting agricultural and urban water demands (Valdiya, 2013; CGWB, 2017) [41, 2].

In addition to its ecological significance, the Aravalli Range is rich in mineral resources such as marble, granite, copper, zinc, lead, and mica, which have historically influenced the region's cultural, economic, and industrial development (Heron, 1953; GSI, 2012) [7, 5]. The range gives rise to several important river systems and their tributaries, notably the Banas and Sahibi rivers, which form part of the Yamuna River basin, and the Luni River, which flows westward and ultimately drains into the Rann of Kutch (Rao, 1979; MoWR, 2014) [27, 20]. Owing to its biodiversity value, water-regulating functions, and increasing vulnerability to anthropogenic degradation, the Aravalli Range has been recognized by the Government of India as an eco-sensitive region requiring priority conservation and sustainable management (MoEF&CC, 2018) [19].

The judiciary has played a decisive role in safeguarding the Aravalli Range by recognizing its ecological significance and vulnerability. In *M.C. Mehta vs. Union of India*, the Supreme Court directed State authorities to prepare comprehensive conservation plans and, based on recommendations of the Central Empowered Committee, imposed restrictions on mining and construction activities in ecologically sensitive areas of the Aravalli landscape (Supreme Court of India, 2009) [38]. In recent proceedings, the Supreme Court emphasized the need for a uniform, science-based definition of the Aravalli Range, proposing that all hill formations rising above 100 meters in elevation and areas within a 500-meter radius of such hills be treated as part of the Aravalli system for environmental protection, irrespective of revenue land classification (Supreme Court of India, 2021) [39].

Statutory institutions complement these judicial interventions. The Ministry of Environment, Forest and Climate Change (MoEF&CC) formulates conservation and regulatory frameworks under the Environment (Protection) Act, 1986 and the Forest (Conservation) Act, 1980, while the National Green Tribunal (NGT) has repeatedly ordered the cessation of illegal mining and unauthorized construction in the Aravalli region (NGT, 2015; MoEF&CC, 2018) [22, 19]. The National Biodiversity Authority (NBA), established under the Biological Diversity Act, 2002, promotes biodiversity conservation and sustainable use of biological resources, while the National Mission for Clean Ganga (NMCG) supports catchment restoration initiatives for rivers originating in the Aravallis (NBA, 2014; NMCG, 2017) [21, 23]. Collectively, these legal and institutional mechanisms form the foundation for Aravalli conservation, although effective enforcement and inter-state coordination remain key policy challenges.

2. Geographical, Geological, and Climatic Overview of the Aravalli Range

The Aravalli Range extends for approximately 670–800 km in a south-west to north-east orientation, stretching from northeastern Gujarat through Rajasthan and Haryana to the National Capital Territory of Delhi (Sharma, 2009; GSI, 2012) [31, 5]. Geologically, the range originated during the Proterozoic era and represents one of the oldest fold mountain systems on Earth, with an estimated age of over 2.5 billion years (Valdiya, 2016) [42]. Prolonged denudation and tectonic stability over geological timescales have resulted in extensive weathering, reducing the Aravallis to low, discontinuous hills and ridges, in stark contrast to the geologically younger and tectonically active Himalayan mountain system (Valdiya, 2013) [41].

Climatically, the Aravalli Range experiences a predominantly subtropical to semi-arid climate, characterized by high seasonal variability. Summer temperatures frequently exceed 45 °C, while winter temperatures may fall below 5 °C in elevated and inland regions (IMD, 2018) [8]. Rainfall exhibits pronounced spatial variation, with comparatively higher precipitation on the south-western slopes due to the influence of the southwest monsoon, and progressively drier conditions toward the north-eastern and leeward sections of the range (Rao, 1979; Valdiya, 2013) [27, 41]. This climatic heterogeneity, combined with altitudinal and edaphic variation, generates a mosaic of microhabitats that support diverse plant and animal communities across the Aravalli landscape (Rodgers *et al*., 2002) [29].

Rajasthan displays marked climatic heterogeneity, ranging from arid and hyper-arid conditions in the western Thar Desert to semi-arid, sub-humid, and locally humid climates in the eastern and south-eastern parts of the state. These gradients exert a strong influence on the distribution, structure, and composition of forest vegetation (Sharma & Tiagi, 1979; Rodgers & Panwar, 1988) [35, 28]. Annual rainfall varies widely, from less than 100

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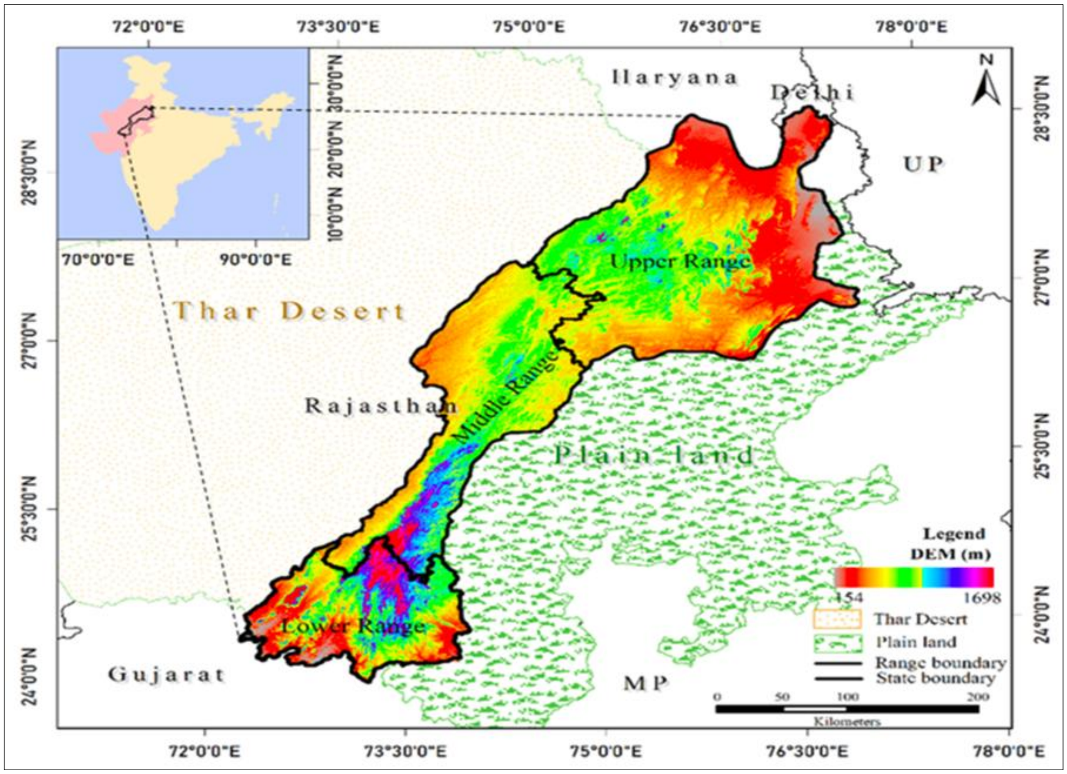
mm in western Rajasthan to more than 800 mm in the south-eastern districts, accompanied by extreme temperature fluctuations and high rates of evapotranspiration (IMD, 2018; Singh *et al*., 2017) [8, 37].

As a consequence of these climatic and physiographic gradients, Rajasthan supports a diverse array of forest vegetation types. These include tropical thorn forests and desert scrub in arid regions, dry deciduous forests in semi-arid and sub-humid zones, mixed deciduous forests in eastern Rajasthan, and dry teak forests in the south-eastern plateau regions, particularly in the Hadoti and Mewar areas (Champion & Seth, 1968; Meena & Sharma, 2015) [3, 15]. These vegetation types exhibit pronounced ecological adaptations to moisture availability, soil depth, and thermal stress, and play a critical role in biodiversity conservation, soil stabilization, hydrological regulation, and climate moderation in the ecologically fragile landscapes of Rajasthan (Singh *et al*., 2017; Rodgers *et al*., 2002) [37, 29].

Fig 1: Landscape view of the Aravalli Range, India. Source: TarunIAS, *"Aravalli Range: Geography, Ecology, Threats, Conservation & Significance"*. Used for academic purposes.



Source: Adapted from Tarun IAS (Amit Kumar, 2025).

Fig 2: Location and physiographic extent of the Aravalli Range in India.

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3. Floral Diversity of the Aravalli Range

The vegetation of the Aravalli Range is predominantly classified as tropical dry deciduous forest and tropical thorn forest, interspersed with scrublands, grasslands, rocky hill vegetation, and riparian plant communities along seasonal streams and river courses (Champion & Seth, 1968; Rodgers & Panwar, 1988) [3, 28]. This vegetation structure reflects long-term adaptation to semi-arid to arid climatic conditions, shallow soils, and high temperature stress. Dominant tree species commonly recorded from the Aravalli landscape include *Anogeissus pendula* (Dhok), *Acacia nilotica* (Babul), *Boswellia serrata* (Salai), *Butea monosperma* (Palash), *Ziziphus mauritiana* (Ber), *Prosopis cineraria* (Khejri), and *Tecomella undulata* (Rohida), which form the ecological backbone of these dry forest systems (Sharma *et al*., 2013; Mathur, 2015) [30, 4].

Botanical surveys conducted across Rajasthan, Haryana, Delhi, and Gujarat have documented considerable floral richness within the Aravalli Range, with estimates ranging from approximately 3,000 to 3,200 plant species, including trees, shrubs, herbs, grasses, and climbers (Champion & Seth, 1968; Sharma & Tiagi, 1979; Singh & Pandey, 1989) [35, 3, 36]. Studies from Rajasthan alone report more than 25 tree species and over 100 species of herbs, shrubs, and grasses distributed across different Aravalli habitats, highlighting the region's role as an important floristic reservoir in north-western India (Sharma *et al*., 2013; Meena & Sharma, 2015) [30, 15].

The floristic composition of the Aravalli Range is dominated by angiosperms, which constitute the major structural and functional components of the region's dry deciduous forests, thorn forests, grasslands, and scrub ecosystems (Champion & Seth, 1968; Singh & Pandey, 1989) [3, 36]. Commonly recorded angiosperm taxa include Dhau, Khair (*Acacia catechu*), Neem (*Azadirachta indica*), Peepal (*Ficus religiosa*), Banyan (*Ficus benghalensis*), Amla (*Phyllanthus emblica*), Arjun (*Terminalia arjuna*), Bael (*Aegle marmelos*), Gugal (*Commiphora wightii*), Hingot (*Balanites aegyptiaca*), Kair (*Capparis decidua*), Safed Siris (*Albizia procera*), Kaner (*Nerium oleander*), Lasora (*Cordia dichotoma*), Kachnar (*Bauhinia variegata*), and Seesam (*Dalbergia sissoo*), along with ecologically important grasses such as Moonj (*Saccharum munja*), Sewan (*Lasiurus sindicus*), Anjan (*Cenchrus ciliaris*), and Doob (*Cynodon dactylon*) (Sharma *et al*., 2013; Mathur, 2015) [30, 4].

In contrast, gymnosperms are sparsely represented in the Aravalli Range due to prevailing warm and dry climatic conditions and are largely confined to isolated natural occurrences or plantation areas. Species such as *Pinus roxburghii*, *Cupressus* spp., and *Juniperus* spp. are occasionally reported from higher elevations, protected forest tracts, or managed landscapes rather than forming natural forest stands (Rodgers & Panwar, 1988; Singh *et al*., 2017) [28, 37].

Seasonal flowering phenology is a defining ecological feature of Aravalli flora and plays a crucial role in sustaining insect communities, particularly pollinators. Several woody and shrub species flower during the dry summer and pre-monsoon periods, providing vital nectar and pollen resources when floral availability is otherwise limited in semi-arid environments (Sharma *et al*., 2013; Gaur & Parveen, 2025) [30, 4]. This temporal availability of floral resources makes the Aravalli vegetation especially important for the survival and persistence of native bee populations and other pollinating insects in north-western India. Collectively, the diverse and stress-adapted flora of the Aravalli Range contributes significantly to biodiversity conservation, soil stabilization, hydrological regulation, and mitigation of desertification processes in this ecologically fragile landscape (Singh *et al*., 2017; Gaur & Parveen, 2025) [37, 4].

4. Faunal Diversity of the Aravalli Range and Its Ecological Significance

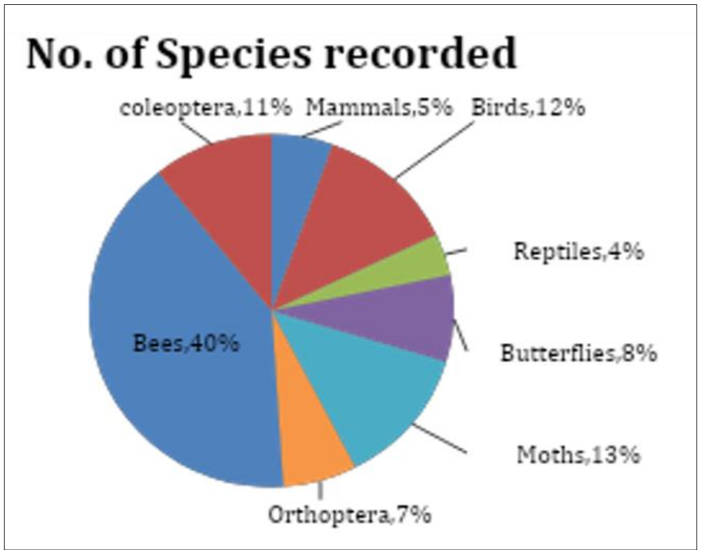

Fig 1: No of species recorded

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Table 1: Vertebrate and Invertebrate Diversity Recorded from the Aravalli Range

Taxonomic Group	No. of Species recorded	Ecological significance in the Aravli ecosystem
Mammals	24	Top predators and herbivores regulate trophic structure, seed dispersal, and ecosystem balance
Birds	55	Pollination, seed dispersal, scavenging, and indicators of habitat quality
Reptiles	17	Prey–predator regulation and adaptation to rocky, arid habitats
Butterflies	35	Pollinators and sensitive bioindicators of climate and vegetation change
Moths	56	Nocturnal pollination, herbivory, and key food resources for birds and bats
Orthoptera	29	Nutrient cycling, herbivory, and primary prey base for higher vertebrates
Bees	178	Keystone pollinators supporting plant reproduction, forest regeneration, and agro-ecosystems
coleoptera	47	Decomposition, soil health, nutrient recycling, and ecosystem functioning

4.1 Vertebrate Fauna

The Aravalli Range supports a diverse assemblage of vertebrate fauna, including mammals, birds, reptiles, and amphibians, reflecting its role as a critical ecological refuge in north-western India (Rodgers & Panwar, 1988; Mathur, 2015) [28, 4]. Notable mammalian species recorded from the region include the leopard (*Panthera pardus*), striped hyena (*Hyaena hyaena*), Indian wolf (*Canis lupus*), sloth bear (*Melursus ursinus*), chinkara (*Gazella bennettii*), and nilgai (*Boselaphus tragocamelus*), many of which are adapted to dry deciduous and semi-arid habitats (Prater, 1993; Menon, 2014) [25, 17].

Several important protected areas lie within or adjacent to the Aravalli hills, including Sariska Tiger Reserve, Mount Abu Wildlife Sanctuary, Kumbhalgarh Wildlife Sanctuary, and Jhalana Leopard Reserve. These protected landscapes play a crucial role in conserving remnant forest habitats and sustaining viable populations of large and medium-sized vertebrates (Rodgers *et al*., 2002; Mathur, 2015) [29, 4]. Overall, the vertebrate fauna of the Aravalli Range comprises approximately 96 recorded species, including about 24 mammals, 55 bird species, and 17 reptile species, underscoring the conservation significance of this ancient mountain system as a stronghold for higher vertebrates in an otherwise semi-arid to arid region (Sharma *et al*., 2013; Singh *et al*., 2017) [30, 37].

4.2 Insect Diversity

Recent entomological studies have highlighted the remarkable insect diversity of the Aravalli Range, particularly within forest reserves and protected landscapes such as Jhalana and Galta (Jaipur) and the Ajmer Aravalli hills (Sharma *et al*., 2019; Meena *et al*., 2021) [33, 16]. Surveys of Lepidoptera have documented a rich butterfly fauna, with 35 species belonging to five families, of which Pieridae and Nymphalidae are dominant, reflecting adaptation to open dry forests and scrub habitats (Kunte, 2000; Sharma *et al*., 2019) [12, 33]. Moth diversity is comparatively higher, with 56 species representing 41 families reported from the Ajmer Aravalli region, indicating substantial nocturnal insect richness in semi-arid ecosystems (Sharma & Singh, 2020) [32].

Orthopteran diversity in the Aravalli Range is represented by at least 29 species belonging to six families, with Acrididae emerging as the dominant family, consistent with grassland and open scrub habitats prevalent across the region (Ingrisch & Shishodia, 2000; Meena *et al*., 2021) [9, 16]. The present study provides the first comprehensive account of coleopteran diversity from the Jhalana Reserve Forest and Galta Forest of the Aravalli Range, Jaipur, India. A total of 1,171 individuals representing 47 species, 41 genera, 31 subfamilies, and 14 families under the suborders Adephaga and Polyphaga were recorded. Coleopterans play a vital role in terrestrial ecosystems owing to their high species richness, polyphagous feeding habits, and multifunctional ecological roles, including decomposition, herbivory, predation, and nutrient cycling (Lawrence & Britton, 1994; Triplehorn & Johnson, 2005) [13, 43].

The order Hymenoptera constitutes a cornerstone of insect biodiversity in the Aravalli Range and ranks as the second most diverse insect group in the region, with over 208 documented species across seven major families (Goulet & Huber, 1993; Sharma *et al*., 2022) [6, 34]. Members of this order function as pollinators, herbivores, parasitoids, predators, and prey for higher trophic levels, making them critical to ecosystem stability and resilience (Michener, 2007; Potts *et al*., 2016) [18, 24].

The diversity of the superfamily Apoidea (bees) recorded from Rajasthan, India, is documented here for the first time in a comprehensive manner. A total of 178 bee species belonging to 34 genera across five families Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae have been recorded from the state. Notably, the family Melittidae has not yet been reported from Rajasthan (Michener, 2007; Ascher & Pickering, 2020) [18, 1]. Among the recorded families, Megachilidae exhibits the highest species richness (68 species), followed by Halictidae (52 species) and Apidae (48 species), whereas Colletidae and Andrenidae are represented by fewer species, with six and four species, respectively. This pattern reflects the dominance of solitary, ground- and cavity-nesting bees adapted to arid and semi-arid ecosystems, highlighting the ecological importance of the Aravalli Range in sustaining native bee diversity in north-western India (Potts *et al*., 2016; Sharma *et al*., 2022) [24, 34].

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Apis florea Fabricius, 1783 on *Verbesina enselioides*

Apis dorsata Fabricius, 1787on *Echinops echinatus*

5. Major Threats to the Aravalli Range

Despite its immense ecological, hydrological, and climatic significance, the Aravalli Range is under severe pressure from multiple anthropogenic and environmental threats. Rapid development activities, coupled with weak enforcement of environmental regulations, have accelerated ecosystem degradation across the region.

5.1 Illegal and Unregulated Mining

Illegal mining of marble, limestone, quartzite, and other minerals is one of the most severe threats to the Aravalli ecosystem. Mining activities lead to large-scale deforestation, habitat fragmentation, soil erosion, and the destruction of hillside structures. Blasting and excavation disrupt natural drainage systems, reduce groundwater recharge, increase dust pollution, and permanently alter the landscape's geomorphology, making ecological restoration extremely challenging.

Fig 2: Mining-affected landscape in the Aravalli Hills, India, highlighting anthropogenic degradation of the region. *Source: The Indian Express (Express Photo), November 22, 2025.*

5.2 Deforestation and Loss of Biodiversity

Extensive deforestation driven by mining, agricultural expansion, fuelwood collection, and infrastructure development has led to a drastic decline in native flora and fauna. The loss of vegetation cover reduces habitat availability for wildlife, disrupts pollination networks, and accelerates soil erosion and desertification. Several plant and animal species dependent on the Aravalli forests now face population decline and local extinctions.

5.3 Human–Wildlife Conflict

The expansion of human settlements, agriculture, and industrial areas into forested regions has increased human–wildlife interactions. Wildlife such as leopards, hyenas, nilgai, and wild boars increasingly venture into human-dominated landscapes in search of food and water, leading to crop damage, livestock predation, and occasional human casualties. These conflicts often result in retaliatory killings and further threaten wildlife populations.

5.4 Unplanned Urbanization and Infrastructure Development

Rapid and unplanned urban expansion, particularly around cities like Delhi, Gurugram, Faridabad, Jaipur, and Udaipur, has severely degraded Aravalli landscapes. Construction activities fragment habitats, block wildlife corridors, and increase pollution loads. Road networks, real estate projects, and tourism

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infrastructure have reduced forest cover and disrupted ecological connectivity across the range.

5.5 Depletion of Water Resources
Unchecked development, excessive groundwater extraction, and destruction of natural recharge zones have led to severe depletion of water resources in the Aravalli region. The degradation of hill slopes and forest cover reduces rainwater infiltration, affecting aquifers and drying up seasonal streams, lakes, and wetlands. This water stress impacts both biodiversity and human livelihoods in the surrounding areas.

5.6 Geological Instability and Increased Natural Hazards
Ancient and fragile geological formations with multiple faults and fractures characterize the Aravalli Range. Large-scale mining and construction activities exacerbate geological instability, increasing the risk of landslides, slope failures, and seismic vulnerability in certain areas. These disturbances also weaken the natural resilience of the hills against erosion and climatic extremes.

5.7 Climate Change and Extreme Weather Events
Rising temperatures, erratic rainfall, prolonged droughts, and increased frequency of extreme weather events are intensifying stress on the Aravalli ecosystem. Climate change affects flowering phenology, pollinator activity, water availability, and species distributions, further destabilizing already fragile habitats.

5.8 Invasive Alien Species
The spread of invasive plant species such as *Prosopis juliflora* has altered native vegetation structure and reduced biodiversity in many parts of the Aravalli Range. These species outcompete native flora, reduce habitat quality, and disrupt ecological interactions.

5.9 Pollution and Waste Dumping
Industrial emissions, vehicular pollution, construction debris, and unregulated waste dumping contribute to air, soil, and water pollution in the Aravalli region. Pollution degrades habitat quality and poses serious health risks to wildlife and local communities.

5.10 Weak Governance and Enforcement Gaps
Despite legal protection measures, weak enforcement of environmental laws, encroachments, and a lack of coordinated management across states have allowed continued degradation of the Aravalli Range. Policy inconsistencies and delayed conservation actions further compound ecological decline.

6. Ecological Role of Bees in the Aravalli Landscape

Pollinators are central to maintaining plant reproductive success and ecosystem resilience. While butterflies and moths are relatively well-documented in the Aravalli Range, systematic studies on bees are notably scarce. Within this, the families Apidae and Halictidae exhibit the highest species richness, serving as the primary drivers of pollination services for both native flora and surrounding agro-ecosystems. Field observations in key protected areas like the Sariska Tiger Reserve and Mount Abu highlight the prominence of the Giant Honey Bee (*Apis dorsata*) and the Little Bee (*Apis florea*), which show significant seasonal colonization patterns tied to the flowering cycles of dominant trees like *Anogeissus pendula*. Furthermore, the diversity extends to various solitary bees, carpenter bees (*Xylocopa* spp.), and wasps, which together maintain a complex ecological network. This Hymenopteran abundance is particularly critical in the central Aravalli districts like Ajmer, where they facilitate the production of essential seed spices and sustain the genetic health of the dry deciduous forest landscape. Nevertheless, the diversity of flowering plants and the presence of rich Lepidopteran assemblages strongly suggest the existence of diverse native bee communities, including solitary bees, carpenter bees, leafcutter bees, and bumblebees in higher elevations. Bees play a more efficient pollination role than most other insects due to their foraging behavior, pollen-carrying structures, and floral fidelity. In the Aravalli landscape, bees likely contribute significantly to the pollination of wild plants as well as adjacent crops such as mustard, pulses, and vegetables. Habitat degradation, loss of native flora, pesticide use, and climate extremes pose serious threats to these pollinator communities.

7. Conservation Strategies with Special Reference to Bees
Bees play a crucial role in protecting and sustaining biodiversity in the Aravalli Range by acting as primary pollinators of wild and cultivated angiosperm species across its arid to semi-arid landscapes. Through effective pollination, bees enhance plant reproductive success, genetic diversity, and seed set, which are essential for the regeneration of dry deciduous forests, tropical thorn forests, grasslands, and scrub vegetation characteristic of the Aravalli ecosystem (Klein *et al*., 2007; Potts *et al*., 2010) [24]. Many keystone and native plant species of the Aravallis, such as Khejri, Rohida, Palash, and various grasses and herbs, depend on bee-mediated pollination for population stability and habitat continuity, indirectly supporting higher trophic levels including birds, mammals, and other insects (Ollerton *et al*., 2011). By maintaining floral diversity and ecosystem resilience, bees contribute to soil stabilization, prevention of desertification, and restoration of degraded habitats, thereby playing a vital role in conserving the fragile biodiversity of the Aravalli Range under increasing anthropogenic and climatic pressures (IPBES, 2016; Singh *et al*., 2017) [37].

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Table 2: Ecological Link between Aravalli Biodiversity and Bee Conservation

Componant	Role	Impact on bees
Native plants	Flowering nectar & pollen supply	Direct food sources
Forest patches	Nesting habitats	Shelter & reproduction
Grassland & scrub	Floral continuity	Seasonal survival
Water bodies	Microclimate continuity	Seasonal survival

7.1 Habitat-Level Conservation

Protection of native forest patches, scrublands, and grasslands is critical for sustaining bee populations. Unlike managed honeybees, native bees depend on undisturbed soil, dead wood, rock crevices, and plant stems for nesting. Preventing further fragmentation of the Aravalli landscape will ensure the continuity of foraging and nesting habitats essential for wild bees.

7.2 Floral Resource Management

Conservation efforts must prioritize native flowering plant diversity, particularly species that flower during dry and lean seasons. Restoration programs should use indigenous plant species such as *Anogeissus*, *Butea*, *Acacia*, and *Ziziphus*, which are known to provide critical nectar and pollen resources. Maintaining year-round floral availability directly enhances bee survival and reproductive success.

7.3 Pollinator-Friendly Land Use

Agricultural fields adjacent to the Aravalli Range should adopt pollinator-friendly practices, including:

- Reduced pesticide and herbicide usage
- Organic or low-input farming
- Preservation of field margins with flowering weeds

Such practices create buffer zones that connect natural habitats with farmlands, strengthening pollination networks.

7.4 Mining and Infrastructure Regulation

Mining and construction activities cause irreversible damage to bee habitats by destroying nesting substrates and altering microclimates. Strict enforcement of mining bans in ecologically sensitive zones, along with mandatory pollinator impact assessments, should be incorporated into environmental clearance processes.

5. Long-Term Monitoring and Research

The absence of systematic data on bee diversity in the Aravalli Range highlights an urgent need for long-term pollinator monitoring programs. Standardized surveys, GIS-based habitat mapping, and seasonal sampling should be undertaken to document bee species richness, floral associations, and population trends.

6. Community Participation and Awareness

Local communities play a crucial role in conservation success. Awareness programs highlighting the role of bees in crop productivity, medicinal plants, and ecosystem health can encourage community-led conservation. Traditional ecological knowledge should be integrated into modern management strategies.

7. Policy-Level Interventions

Future conservation policies should:

- Recognize pollinators as key ecological components
- Integrate bee conservation into State Biodiversity Action Plans
- Establish Pollinator Conservation Zones within the Aravalli Range
- Strengthen legal definitions to prevent exploitation under ambiguous land classifications

8. Climate Change Adaptation Measures

Increasing temperature extremes and erratic rainfall pose severe threats to pollinators. Conservation planning must include climate-resilient habitats, water retention structures, and restoration of degraded hills to buffer climate impacts on bees and flowering plants.

7. Impacts of Biodiversity Loss in the Aravalli Range

The degradation of the Aravalli ecosystem has led to multiple adverse consequences, including habitat fragmentation, decline of native species, increased human–wildlife conflict, reduced groundwater availability, and loss of pollination services. The disappearance of several hill formations in Rajasthan over the past two decades illustrates the scale of ecological loss. Declining insect diversity, particularly pollinators, can trigger cascading effects on plant reproduction, food webs, and rural livelihoods.

8. Legal Status and Policy Framework

The Aravalli Range is governed by multiple legal instruments, including the Indian Forest Act, Wildlife Protection Act (1972), Forest Conservation Act (1980), and provisions under the Environment Protection Act (1986). Judicial interventions, particularly by the Supreme Court of India, have played a significant role in restricting mining activities in certain Aravalli regions. However, ambiguity in the legal definition of the Aravalli range, weak enforcement, and conflicting land-use priorities continue to undermine effective conservation.

9. Conservation Strategies with Special Reference to Bees

Effective conservation of the Aravalli biodiversity requires an integrated approach:

- Protection and restoration of native vegetation to ensure year-round floral resources for pollinators.

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- Establishment of ecological corridors linking fragmented forest patches.
- Promotion of pollinator-friendly agricultural practices in surrounding landscapes.
- Long-term monitoring of bee diversity and pollination networks.
- Community participation and awareness programs emphasizing the ecological and economic value of pollinators.

10. CONCLUSION

The Aravalli Range is a critical ecological asset for India, supporting diverse flora and fauna while providing essential ecosystem services. Protecting this ancient mountain system is vital not only for conserving biodiversity but also for ensuring water security, climate stability, and sustainable livelihoods. Bees and other pollinators must be recognized as central components of Aravalli conservation efforts. Scientifically informed policies, effective enforcement, and community engagement are essential to safeguard the ecological future of the Aravallis.

REFERENCES

1. Ascher JS, Pickering J. Discover Life Bee Species Guide and World Checklist. Discover Life; 2020.
2. Central Ground Water Board. Ground Water Scenario of Rajasthan. Ministry of Water Resources, Government of India; 2017.
3. Champion HG, Seth SK. A Revised Survey of the Forest Types of India. Government of India Press; 1968.
4. Gaur R, Parveen S. Floral diversity, ecosystem services, and desertification control in semi-arid landscapes of north-western India. Journal of Arid Environments. 2025;215:104980.
5. Geological Survey of India. Geology and Mineral Resources of the States of India: Rajasthan. Geological Survey of India; 2012.
6. Goulet H, Huber JT. Hymenoptera of the World: An Identification Guide to Families. Agriculture Canada; 1993.
7. Heron AM. The Geology of Central Rajputana. Geological Survey of India; 1953.
8. India Meteorological Department. Climate Profile of Rajasthan. Government of India; 2018.
9. Ingrisch S, Shishodia MS. Orthoptera diversity in semi-arid ecosystems of India. Journal of Orthoptera Research. 2000;9:123-132.
10. Khandelwal A, Sharma S, Singh R. Biodiversity and conservation issues in the Aravalli Range of Rajasthan, India. Journal of Environmental Biology. 2018;39:123-131.
11. Korner C, *et al*. Mountain ecosystems and global change. Annual Review of Environment and Resources. 2017;42:1-29.
12. Kunte K. Butterflies of Peninsular India. Universities Press; 2000.
13. Lawrence JF, Britton EB. Australian Beetles. Melbourne University Press; 1994.
14. Mathur VB. Vegetation diversity and conservation significance of the Aravalli landscape. Indian Forester. 2015;141(3):247-256.
15. Meena SL, Sharma KC. Floristic composition and forest vegetation of Rajasthan. Indian Journal of Forestry. 2015;38(2):89-98.
16. Meena SL, Sharma KC, Singh R. Insect diversity of semi-arid forest ecosystems of Rajasthan. Journal of Insect Biodiversity. 2021;22:45-60.
17. Menon V. Indian Mammals: A Field Guide. Hachette India; 2014.
18. Michener CD. The Bees of the World. 2nd ed. Johns Hopkins University Press; 2007.
19. Ministry of Environment, Forest and Climate Change. Draft Notification on Eco-Sensitive Zones in the Aravalli Range. Government of India; 2018.
20. Ministry of Water Resources. River Basin Atlas of India. Government of India; 2014.
21. National Biodiversity Authority. India's Fifth National Report to the Convention on Biological Diversity. Government of India; 2014.
22. National Green Tribunal. Judgment on Illegal Mining in the Aravalli Range. Principal Bench, New Delhi; 2015.
23. National Mission for Clean Ganga. Catchment Area Treatment and River Rejuvenation Strategy. Government of India; 2017.
24. Potts SG, *et al*. Safeguarding pollinators and their values to human well-being. Nature. 2016;540:220-229.
25. Prater SH. The Book of Indian Animals. Bombay Natural History Society; 1993.
26. Rahbek C, *et al*. Building mountain biodiversity: Geological and evolutionary processes. Science. 2019;365:1114-1119.
27. Rao KL. India's Water Wealth. Orient Longman; 1979.
28. Rodgers WA, Panwar HS. Planning a Wildlife Protected Area Network in India. Wildlife Institute of India; 1988.
29. Rodgers WA, Panwar HS, Mathur VB. Wildlife Protected Area Network in India: A Review. Wildlife Institute of India; 2002.
30. Sharma N, Singh R, Meena SL. Floristic diversity and ecological adaptation of dry forests in the Aravalli Range, Rajasthan. Journal of Threatened Taxa. 2013;5(12):4731-4745.
31. Sharma RS. India's Ancient Geography. Oxford University Press; 2009.
32. Sharma S, Singh A. Moth diversity of the Ajmer Aravalli Hills. Indian Journal of Entomology. 2020;82:321-329.
33. Sharma S, Meena SL, Kumar A. Butterfly diversity of Jhalana Reserve Forest, Jaipur. Journal of Insect Conservation. 2019;23:875-886.
34. Sharma S, Pathak P, Kumar R. Diversity and distribution of bees (Hymenoptera: Apoidea) in Rajasthan, India. Journal of Apicultural Research. 2022;61:1-15.

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35. Sharma TC, Tiagi BL. Soils of Rajasthan. Soil Conservation Department, Government of Rajasthan; 1979.
36. Singh JS, Pandey U. Tropical dry deciduous forest ecosystems of India. Biological Conservation. 1989;49:213-231.
37. Singh S, Kumar A, Singh R. Climate variability and vegetation dynamics in Rajasthan, India. Journal of Arid Environments. 2017;145:1-10.
38. Supreme Court of India. M.C. Mehta vs. Union of India, Writ Petition (Civil) No. 4677 of 1985; 2009.
39. Supreme Court of India. Order on Protection of the Aravalli Range; 2021.
40. Todarwal R. Flora of the Aravalli Hills: Traditional Knowledge and Biodiversity. Scientific Publishers; 2022.
41. Valdiya KS. The Aravalli mountains and the Thar Desert: A geological and environmental perspective. Current Science. 2013;104(9):109-115.
42. Valdiya KS. The Making of India: Geodynamic Evolution. Springer; 2016.
43. Triplehorn CA, Johnson NF. Borror and DeLong's Introduction to the Study of Insects. 7th ed. Thomson Brooks/Cole; 2005.

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