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Biodiversity Richness of Western Ghats

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Abstract

The Western Ghats of India is one of the world's most significant biodiversity hotspots, known for its high species richness and large number of endemic plants and animals. Stretching approximately 1,600 km along the western coast of India, the region supports about 4,000– 5,000 plant species, including nearly 650 tree species, as well as diverse vertebrate groups such as amphibians, reptiles, and fishes. Many of these species are found only in this region, and more than 325 species are globally threatened, highlighting the urgent need for conservation. This review summarizes current knowledge on the patterns and drivers of biodiversity in the Western Ghats. The exceptional biological richness of the region is closely linked to its long geological history and unique environmental conditions. The Western Ghats originated from the ancient Gondwana landmass, and subsequent tectonic movements, mountain building, and intense southwest monsoon rainfall created diverse habitats that promoted species diversification. The region functions as an evolutionary transition zone where lineages of African and Asian origin overlap. In particular, the southern Western Ghats experience a relatively stable, warm, and wet climate, which has allowed both ancient species to persist and new species to evolve, resulting in high evolutionary diversity. The review also highlights the major approaches used to study biodiversity in the Western Ghats. Traditional field surveys and taxonomic studies have played a key role in documenting species across different ecosystems, including evergreen forests, grasslands, and shola habitats. Advances in remote sensing have enabled the mapping of vegetation patterns and estimation of species richness at larger spatial scales. Molecular tools such as DNA barcoding and phylogenetic analyses have improved the understanding of hidden diversity and evolutionary relationships among species. In addition, species distribution models that combine species records with climate and habitat data have been widely used to identify areas of high species richness and endemism, including regions outside protected areas. Overall, this review emphasizes that integrating multiple research approaches provides a comprehensive understanding of biodiversity patterns in the Western Ghats and supports better conservation planning and management of this globally important region.

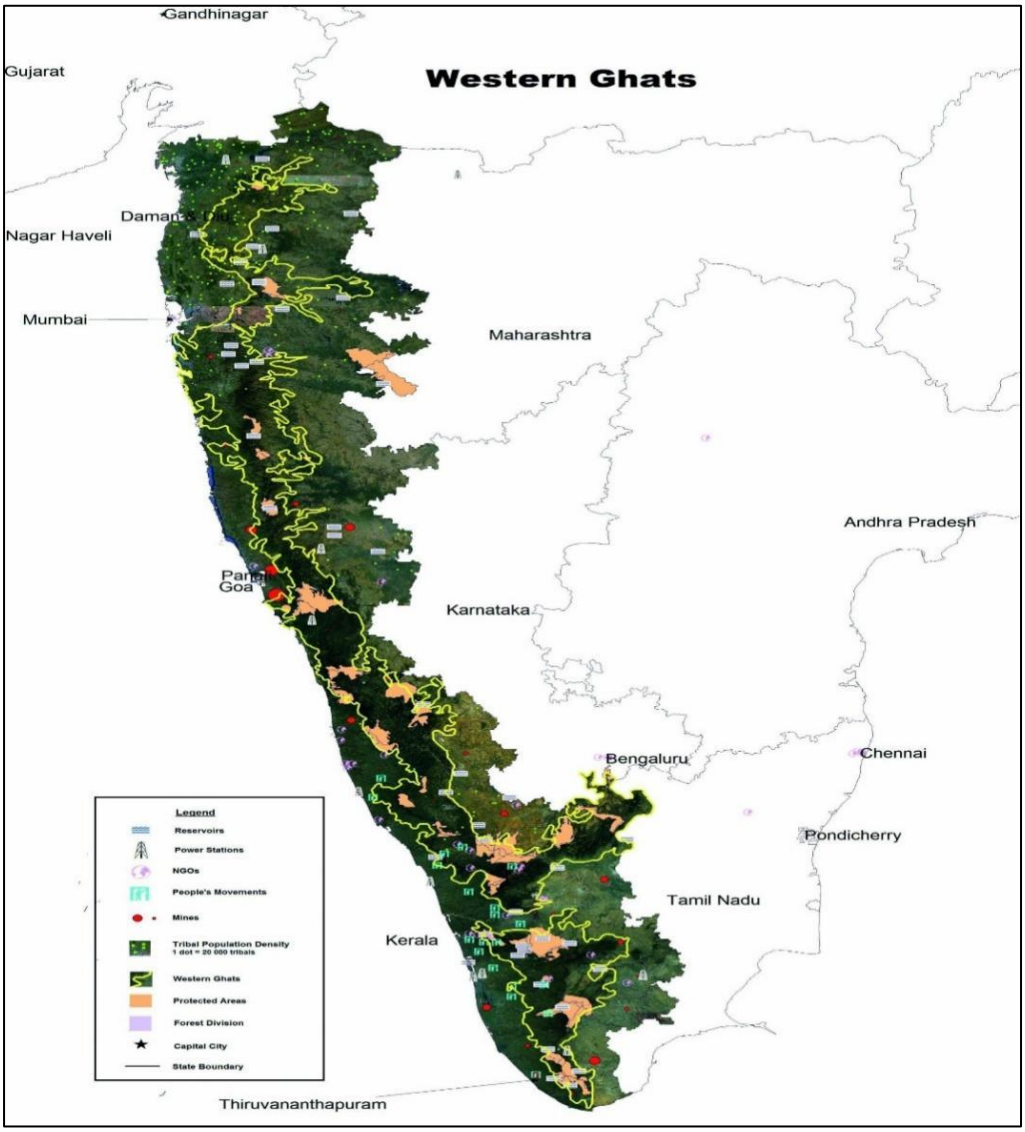
Keywords: Conservation; Ecosystem; Ecology; Endemic; Habitat

Introduction

The Western Ghats or Sahyadri Mountains, extending for about 1,600 km through Gujarat, Maharashtra, Goa, Karnataka, Kerala, and Tamil Nadu, form one of the most ancient and ecologically important mountain chains in the world. Geologically older than the Himalayas, this range has evolved over millions of years, creating a wide variety of landscapes such as dense tropical evergreen forests, moist and dry deciduous forests, montane shola–grassland ecosystems, and unique lateritic plateaus. This long evolutionary history, combined with the region's isolation and varied climate, has resulted in exceptional biodiversity, making the Western Ghats one of the world's eight "hottest" biodiversity hotspots.

The region supports over a third of India's plant, animal, and freshwater species, with very high endemism—many amphibians, reptiles, and plant species occur nowhere else on Earth. Ecologically, the Western Ghats play a critical role in controlling the Indian monsoon system by intercepting moisture-laden winds, causing heavy rainfall along the western slopes. They also serve as the birthplace of major rivers like the Godavari, Krishna, and Kaveri, which supply water for drinking, agriculture, and hydropower to millions of people. Despite their ecological importance, the Western Ghats face significant threats from deforestation, unregulated development, mining, plantation expansion, and climate change, all of which are rapidly degrading habitats and disrupting ecological balance. For these reasons, the conservation of the Western Ghats is not only important for protecting biodiversity but also vital for maintaining regional climate stability, water security, and the overall environmental health of peninsular India.

Map of the Western Ghats
Source: Reddy, S. C. (2016). Location map of Western Ghats. ResearchGate



Map of the Western Ghats showing major biodiversity zones and protected areas
Source: ResearchGate (2018). Map of the study area – The Western Ghats of Maharashtra (Protected Area)

Objectives

- To collect and summarize all available research on the biodiversity richness of the Western Ghats.
- To understand how biodiversity is distributed across plants, animals, and different habitats in the Western Ghats.
- To explain what factors, influence this biodiversity, such as geology, climate, rainfall, and elevation.
- To review the different scientific methods used to study biodiversity, including field surveys, remote sensing, molecular tools, and species distribution models.
- To identify major threats and research gaps and suggest ways to improve conservation and protect the biodiversity of the Western Ghats.

Literature Review

Concept and global framing of hotspots

The biodiversity hotspot framework, pioneered by Myers and later expanded by Mittermeier and colleagues, identifies regions that combine exceptional concentrations of endemics with high levels of threat. The Western Ghats consistently ranks among the world's highest-priority conservation hotspots under this framework (Myers et al., 2000; Mittermeier et al., 2011).

Foundational work on Western Ghats vegetation established essential insights into floristic composition and ecological processes. Pascal (1988) documented wet evergreen forest structure, successional patterns, and species composition, while Ramesh and Pascal (1997) mapped plant endemism centres, revealing fine-scale hotspots aligned with topographic and rainfall gradients (Pascal, 1988; Ramesh & Pascal, 1997). Macroecological analyses show a clear latitudinal increase in species richness and endemism from the northern to the southern Western Ghats, accompanied by strong elevational turnover. Davidar et al. (2007) linked tree diversity patterns to climatic gradients, topography, and disturbance regimes. Multiple syntheses highlight the concentration of paleo- and neo-endemic taxa in the climatically stable southern Ghats (Davidar et al., 2007; Mittermeier et al., 2011).

Herpetofaunal endemism and "sky-islands"

Western Ghats amphibians show exceptionally high local endemism, often restricted to isolated massifs or valleys. Regional overviews emphasize the role of shola–grassland "sky-island" complexes in driving isolation and diversification (Gunawardene et al., 2007). Furthermore, molecular tools such as DNA barcoding have accelerated the discovery of cryptic amphibian species (Gunawardene et al., 2007; Hebert et al., 2003).

Freshwater fish diversity and hydrological controls

Freshwater fish communities display high basin-level endemism driven by steep, short west-flowing rivers and historical hydrological isolation. Conservation studies highlight the sensitivity of endemic fishes to flow modification and water extraction (Gunawardene et al., 2007; Bawa et al., 2007).

Remote sensing and landscape change

Remote sensing and GIS have transformed the ability to detect vegetation patterns, quantify forest fragmentation, and monitor land-use change at landscape scales. These tools are essential for connectivity planning and long-term ecological monitoring (Körner & Spehn, 2002; Davidar et al., 2007). DNA barcoding and phylogenetic analyses have clarified species boundaries, revealed cryptic lineages, and helped reconstruct diversification histories—insights important for recognizing evolutionarily significant units (Hebert et al., 2003; Mittermeier et al., 2011).

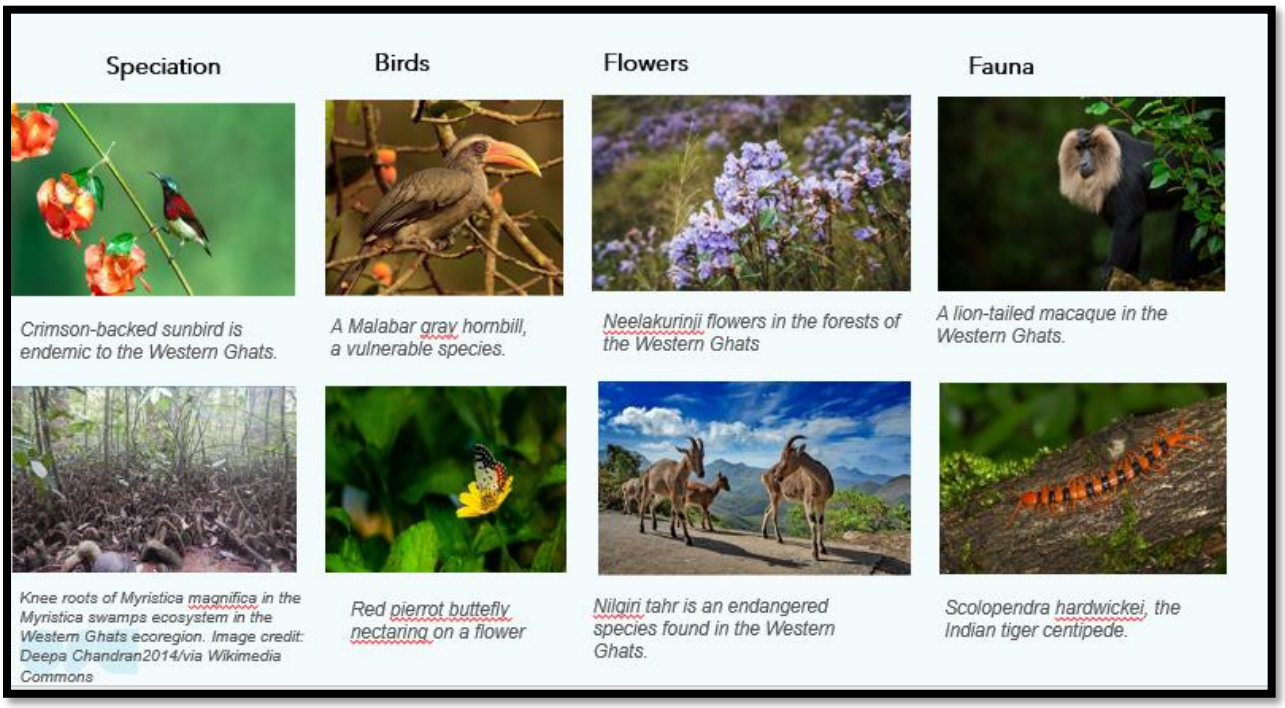
SDMs, which integrate species records with climatic and habitat data, are widely used to identify biodiversity hotspots, refugia, and potential range shifts under climate change. In the Western Ghats, SDMs complement field surveys by identifying suitable habitats beyond protected-area boundaries (Guisan & Zimmermann, 2000; Davidar et al., 2007). Literature consistently identifies habitat loss, fragmentation, hydrological alteration, invasive species, and climate change as major threats. Case studies from human-dominated landscapes in India emphasize integrating community livelihoods and governance strategies, including recognizing Other Effective Area-based Conservation Measures (OECMs) beyond traditional protected areas (Karanth & DeFries, 2010; Bawa et al., 2007). Across disciplines, studies agree that long-term geological history, monsoon-driven climate gradients, and steep topographic complexity shape the Western Ghats' exceptional biodiversity. Key research gaps include micro-scale climate and hydrology datasets for "sky-island" ecosystems, phylogenomics for resolving rapid radiations, cumulative impact models for land-use and climate pressures, and long-term socio-ecological monitoring (Mittermeier et al., 2011; Guisan & Zimmermann, 2000). Research consistently identifies the Western Ghats as a globally important biodiversity hotspot, supporting more than 30% of India's plant and animal species despite covering only 140,000–164,280 km² (Myers et al., 2000; Gunawardene et al., 2007).

Floral studies document over 7,402 flowering plant species, including more than 1,270 endemics, enabled by diverse microhabitats and steep environmental gradients (Pascal, 1988; Ramesh & Pascal, 1997). Faunal analyses show high

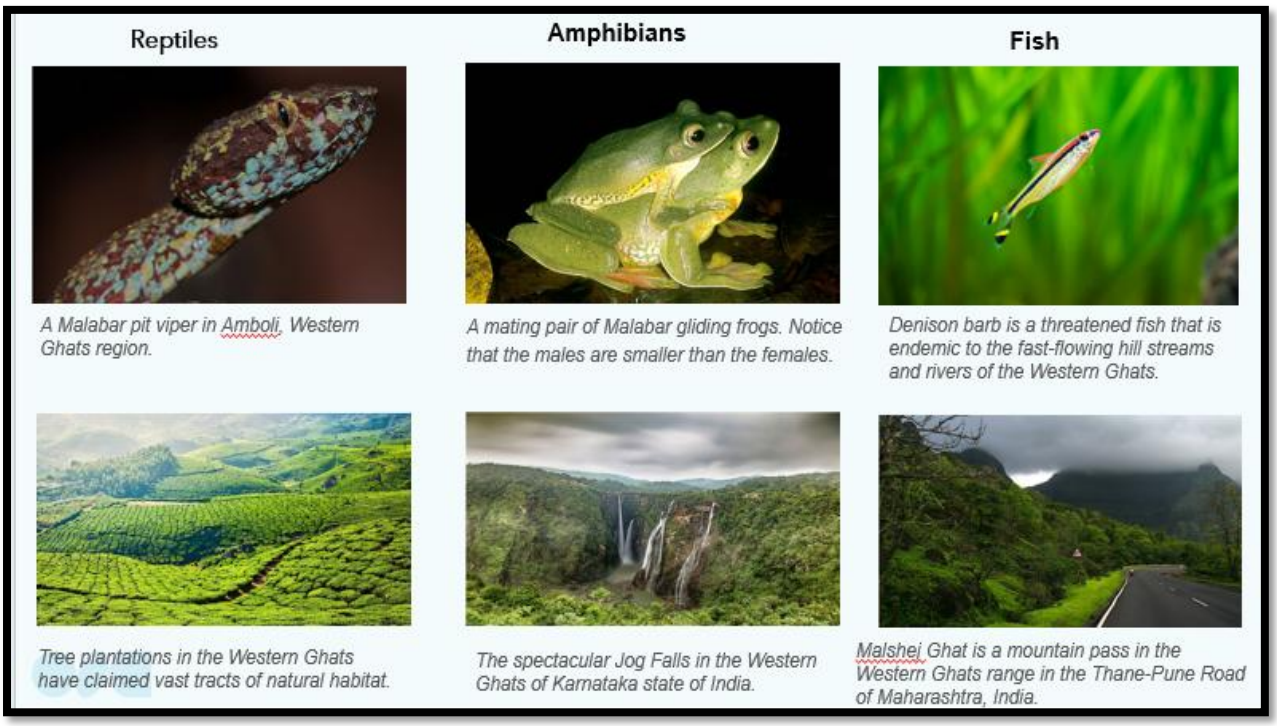
endemism in amphibians and freshwater fishes shaped by rainfall patterns, elevation, and geographic barriers such as the Palghat Gap (Gunawardene et al., 2007).

Geological history and monsoon-driven climate patterns support ancient evolutionary lineages as well as rapid diversification, with molecular tools enhancing species discovery (Hebert et al., 2003; Mittermeier et al., 2011). The region also functions as a major watershed for rivers such as the Godavari, Krishna, and Kaveri, supporting millions of people (Bawa et al., 2007). Recent studies document significant threats including deforestation, mining, infrastructure expansion, and a 9% decline in dense forest cover from 2000–2024 (Karanth & DeFries, 2010). These patterns highlight the need for integrated conservation strategies and improved long-term biodiversity monitoring (Mittermeier et al., 2011; Bawa et al., 2007).

Glimpse of Western Ghats Biodiversity



(Sources: World Atlas (2025, November 5) Western Ghats biodiversity hotspot*)*



(Sources: World Atlas (2025, November 5) Western Ghats biodiversity hotspot*)*

Biodiversity Patterns

Western Ghats have a huge variety of plants, with around 4,000 to 5,000 species in total and about 650 kinds of trees. Many animals especially frogs, reptiles, and freshwater fish are found only in this region. As you move from the northern to the southern Western Ghats, both the number of species and the number of unique species increase. Species also change a lot with height, and the high mountain "sky-island" areas have many species that do not exist anywhere else. The freshwater fish in the region are highly unique because the west-flowing rivers are short, steep, and separated from each other, which has kept fish populations isolated over time.

Drivers (Geological, Climatic, Evolutionary)

The Western Ghats were shaped by ancient geological events, including the breakup of Gondwana, land uplift, and volcanic activity. These processes created a landscape full of mountains, deep valleys, and isolated high plateaus. The mountains block the southwest monsoon winds, causing sharp differences in rainfall and forming different habitats such as evergreen forests, shola–grassland areas, and dry seasonal forests. The southern part of the Western Ghats has had stable climate conditions for a long time, allowing very old species to survive along with newer ones. This has led to high evolutionary diversity and created a region where species with both African and Asian origins can be found together.

Category-wise Diversity

Table 1. Species richness and endemism across major taxonomic groups in the Western Ghats.

Taxonomic Group	Approx. total species	Approx. endemism (%)	Notes
Flowering plants	4,000–5,000	~40	High local endemism; many narrow-range taxa
Trees	~650	~50	Richness structured by rainfall, elevation, and disturbance
Amphibians	~180	~75–85	Many sky-island endemics; cryptic diversity common
Reptiles	~250	~60	High turnover across elevations and basins
Freshwater fishes	~300	~40–60	Basin-level endemism; sensitive to flow alteration
Birds	~500	~15 (16 endemics)	Lower endemism than herpetofauna; high conservation value
Mammals	~140	~10–12 (~14 endemics)	Mix of wide-ranging and range-restricted species

Materials and Methods

Review Design and Overall Approach

This article was structured as a comprehensive narrative review aimed at integrating current scientific knowledge on biodiversity richness, ecological drivers, species distribution, and conservation issues across the Western Ghats. The review followed a systematic process that ensured broad thematic coverage across ecological, geological, climatic, and conservation-oriented research.

Literature Search Strategy

A structured literature search was conducted included combinations of:

- "Western Ghats biodiversity"
- "Endemism Western Ghats"
- "Species richness Western Ghats"
- "Floristic diversity Western Ghats"
- "Amphibian endemism India"
- "Freshwater fish Western Ghats"
- "DNA barcoding Western Ghats fauna"
- "Species distribution models Western Ghats"

Foundational works (e.g., Pascal 1988; Ramesh & Pascal 1997), hotspot frameworks (Myers et al., 2000; Mittermeier et al., 2011), and region-specific ecological studies (Davidar et al., 2007; Gunawardene et al., 2007) were prioritized for inclusion. No time restriction was imposed, allowing incorporation of both classical and contemporary research.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Peer-reviewed journal articles, books, book chapters, and authoritative reports.
- Studies explicitly focused on the Western Ghats or Western Ghats–Sri Lanka hotspot.

- Studies presenting quantitative or qualitative data on species richness, endemism, geology, climate, or ecological processes.
- Research addressing threats, conservation strategies, or modelling approaches (e.g., SDMs, remote sensing, molecular tools).

Exclusion Criteria

- Sources lacking scientific credibility or without adequate methodological transparency.
- Articles focusing only on socio-economic themes without ecological relevance.
- Duplicated datasets or derivative studies without novel information.

Data Extraction and Synthesis

Relevant data and findings were manually extracted, including:

- Total species richness per taxonomic group,
- Endemism levels across taxa,
- Spatial distribution patterns across latitudinal and elevational gradients,
- Habitat-specific species records (evergreen forests, shola–grassland, riparian systems),
- Evidence on geological and climatic drivers,
- Conservation status (based on IUCN Red List, 2023),
- Documented threats such as deforestation, fragmentation, hydrological alteration, and climate change.

Extracted information was categorized under thematic areas (floral diversity, faunal diversity, drivers, methods, threats, conservation frameworks) and synthesized through qualitative comparison to highlight patterns, consensus findings, and discrepancies across studies.

Threats to Western Ghats Biodiversity

Principal pressures include habitat loss and fragmentation driven by agriculture, plantations, linear infrastructure, and urbanization hydrological alteration via dams and abstraction invasive species that transform disturbance regimes; and climate change that shifts temperature and rainfall patterns, disproportionately affecting narrow-range montane taxa.

- **Deforestation and forest loss** due to urbanisation, agriculture, and development, including a noted decline in evergreen forest cover.
- **Mining, quarrying, and unplanned construction** that damage hillsides, destabilize land, and destroy habitats.
- **Climate change** causing extreme rainfall, floods, landslides, and shifting temperature patterns that threaten many species.
- **Infrastructure projects** such as dams, hydropower plants, roads, and railways leading to habitat fragmentation and ecological disruption.
- **Over-tourism** resulting in waste generation, disturbance to wildlife, and increased human–animal conflict.
- **Invasive species** spreading into natural forests and reducing native plant and animal diversity.
- **Conversion of native forests into monoculture plantations** like eucalyptus and acacia, lowering overall biodiversity.
- **Land degradation** caused by unsustainable land use practices, reducing ecosystem health.
- **Combined impact of human activities and climate change** significantly reducing vegetation productivity and ecological stability.

Conservation Priorities

- Expand protected-area coverage to underrepresented habitats and recognize OECMs to buffer reserves and enhance connectivity.
- Prioritize riparian corridors and elevational linkages; restore with native species and structural complexity to maintain gene flow and track climate shifts.
- Enable community stewardship with participatory management, diversified agroforestry, and incentive mechanisms aligning livelihoods with conservation outcomes.
- Sustain long-term monitoring, remote-sensing change detection, and open data systems for adaptive management.

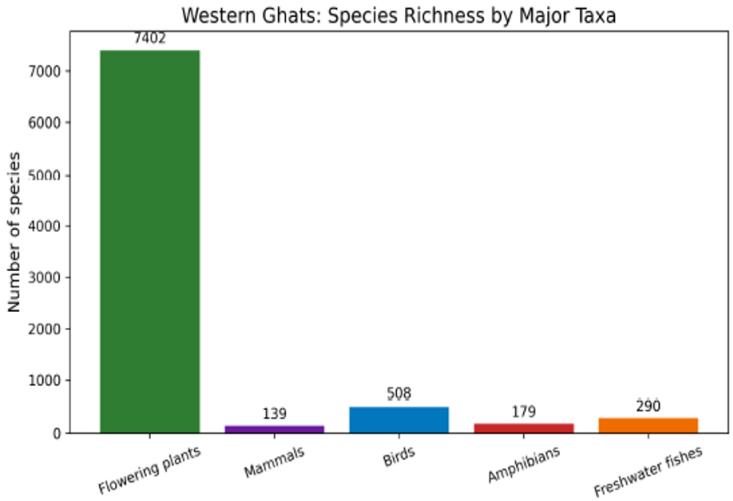


Fig. 1. Estimated number of endemic species in major taxonomic groups of the Western Ghats. (Sources: Deepu et al. 2023; Rathnamma 2018.)

Research Gap Table: Biodiversity Richness in the Western Ghats

Theme / Area	What Existing Studies Address	Identified Research Gap	Key References
Taxon-Specific Studies	Studies focus on individual groups such as trees, amphibians, and plants.	Lack of integrated, multi-taxa biodiversity richness assessments across the Western Ghats.	Davidar et al., 2007; Pascal, 1988; Bossuyt et al., 2004
Mapping Endemism	Endemic centers and localized species clusters reported.	Absence of high-resolution maps for micro-refugia and small-scale endemism hotspots.	Ramesh & Pascal, 1997; Bossuyt et al., 2004
Use of Modern Analytical Tools	Use of SDMs, molecular tools, and remote sensing mentioned conceptually.	Limited combined application of DNA barcoding + remote sensing + SDMs for richness estimation.	Hebert et al., 2003; Guisan & Zimmermann, 2000
Long-Term Monitoring	Studies document threats and static biodiversity patterns.	Lack of long-term biodiversity monitoring to detect climate-driven shifts.	Bawa et al., 2007; Karanth & DeFries, 2010
Socio-Ecological Integration	Human-dominated landscapes and conservation challenges noted.	Limited integration of community practices and land-use dynamics into biodiversity models.	Gadgil & Guha, 1992; Karanth & DeFries, 2010
Cumulative Ecological Pressures	Individual threats studied separately.	No combined models assessing multi-factor impacts on biodiversity richness.	Bawa et al., 2007; Gunawardene et al., 2007
Elevation–Climate Interactions	Climatic gradients and topography linked to diversity.	Limited modelling of joint elevation, microclimate, and soil effects on species' richness.	Davidar et al., 2007; Körner & Spehn, 2002
Data-Deficient Species	Threatened species assessments exist.	Lack of richness data for lesser-studied taxa such as insects and fungi.	IUCN, 2023
Range-Wide Comparisons	Regional studies conducted independently.	Few comparative studies covering the full Western Ghats range.	Gunawardene et al., 2007; Pascal, 1988
Linking Global & Local Frameworks	Western Ghats are recognized as a global hotspot.	Poor alignment between global hotspot models and local richness datasets.	Myers et al., 2000; Mittermeier et al., 2011

Recommendations for Future Research

- To support long-term conservation and deepen scientific understanding, future research should focus on the following areas:
    - Improve long-term biodiversity monitoring

- There is a strong need for consistent, long-term ecological data to track how species and habitats are changing due to climate change, land-use shifts, and human pressures.
    - Study poorly known groups
- Insects, fungi, freshwater invertebrates, and soil microbes remain under-studied. More research on these groups is essential to reveal hidden diversity and complete the biodiversity picture.
    - Develop high-resolution endemism and micro-refugia maps
- Fine-scale mapping will help identify small but critical habitats—especially in sky-island regions—that support rare or narrow-range species.
    - Integrate multiple scientific tools
- Future studies should combine field surveys, DNA-based methods, remote sensing, and species distribution models to improve accuracy in estimating species richness and predicting climate-driven range shifts.
    - Explore elevation–climate–soil interactions
- More detailed research is needed to understand how temperature, rainfall, and soil differences jointly influence species distributions across mountains.
    - Evaluate cumulative ecological impacts
- Most threats—deforestation, hydrological changes, climate change, and invasive species—are studied separately. Integrated models assessing their combined effects will guide better conservation planning.
    - Strengthen socio-ecological research
- Understanding how local communities use and manage landscapes, and how traditional practices can support conservation, will help design more practical and people-friendly strategies.
    - Conduct range-wide comparative studies
- Collaborative research across the entire Western Ghats range will help identify regional patterns, conservation priorities, and areas needing urgent protection.

Key Findings from Recent Studies

- High biodiversity and endemism confirmed: Over 30% of India's species and numerous narrow-range endemics occur in the Western Ghats (Gunawardene et al., 2007; Myers et al., 2000).
- Exceptional plant richness: More than 7,402 flowering plants and over 1,270 endemic species are documented (Pascal, 1988; Ramesh & Pascal, 1997).
- Amphibians and freshwater fish highly vulnerable: Endemism levels often reach 50–85% for amphibians and 40–67% for freshwater fishes (Gunawardene et al., 2007).
- Geological and climatic history drive evolution: Ancient uplift, monsoon gradients, and microclimates shape speciation patterns (Mittermeier et al., 2011; Davidar et al., 2007).
- Dense forest cover is shrinking: Dense Forest loss of around 9% (2000–2024) increases fragmentation and extinction risks (Karanth & DeFries, 2010).
- Climate change impacts intensifying: High-elevation species face increasing threats from shifting rainfall and temperatures (Körner & Spehn, 2002).
- Molecular tools reveal cryptic species: Barcoding and phylogenetics continue to uncover hidden diversity (Hebert et al., 2003).
- Need for long-term monitoring: Lack of consistent biodiversity monitoring hampers detection of ecological shifts (Bawa et al., 2007).
- Major research gaps remain: Insects, fungi, freshwater invertebrates, and high-resolution endemism maps remain under-studied (Guisan & Zimmermann, 2000).

Conclusion

The Western Ghats is one of the richest biodiversity regions in the world, shaped by millions of years of geological change, strong monsoon climates, and unique landscapes. This review shows that the region supports thousands of plant and animal species, many of which are found nowhere else. Modern research methods—such as field surveys, remote sensing, DNA barcoding, and species distribution models—have greatly improved our understanding of how species are distributed and how they evolved here. However, the Western Ghats is under increasing pressure from deforestation, development, climate change, and habitat fragmentation. To protect this global biodiversity hotspot, conservation efforts must combine scientific research, community participation, and long-term monitoring. Safeguarding the Western Ghats is essential not only for preserving its unique species but also for maintaining water resources, climate balance, and ecological stability for future generations.

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