A Guide to India's Grasslands and other Open Natural Ecosystems



Ministry of Environment, Forest and Climate Change

ATREE

IUCN



A Guide to India's Grasslands and other Open Natural Ecosystems



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Developed by the Ashoka Trust for Research in Ecology and the Environment (ATREE), in collaboration with the International Union for Conservation of Nature (IUCN), under the aegis of the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India.

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About This Guide

This Guide synthesises published scientific literature, government and institutional datasets, and field observations made over decades. The ENVIS Bulletin on 'Ecology and Management of Grassland Habitats in India', Volume 17, published by the ENVIS Centre at the Wildlife Institute of India, has been an important reference informing our understanding of some of the ecosystems covered in this Guide. Its opening chapter, 'Grassland Vegetation of India: An Update' by Manoj Chandran, has guided the structuring of the ecosystem chapters.

Each ecosystem chapter has been reviewed for accuracy by subject specialists in that ecosystem. The information in each ecosystem chapter is introductory and foundational: largely reflecting long-standing understanding drawn from the wider literature on these ecosystems. Specific studies and findings are attributed to their authors or sources in the text.

The writing in this Guide also draws considerably on articles published in Down to Earth, Mongabay India, RoundGlass Sustain, Sanctuary Asia, and Conservation India, by subject matter experts and researchers, environmental journalists, and science writers. Relevant chapters from NCERT textbooks have also been referred to, especially for the sections on geography and key ecological features and processes.

Rainfall data are drawn from the India Meteorological Department (IMD) website, from reports by research institutes and other government departments and ministries at the Central and State levels, and from published research drawing on IMD data.

The maps for each ecosystem chapter are schematic. Ecosystem extents and boundaries shown are indicative rather than exact. The maps are intended to convey the broad distribution of each ecosystem rather than precise boundaries. Some of the maps illustrated in the guide have been derived from Madhusudan, Vanak & Koulgi (2024), Map of Open Natural Ecosystems (ONE) of India (ATREE Eco-Informatics Lab or EIL), based on Madhusudan & Vanak (2023), with active support from the EIL. It is worth noting that ecosystem boundaries are rarely sharp on the ground.

Generative Artificial Intelligence models such as Claude and ChatGPT have been used for grammatically accurate reconstruction of original text as and when needed. In some cases, they have also been used to check for accuracy and cross-verification or create a broader content canvass which was then edited to meet the requirements of this Guide.

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FOREWORD

India's relationship with nature is as ancient as its civilisation and as diverse as its landscapes. Across generations, our traditions and lived experience have recognised that the health of our ecosystems is inseparable from the wellbeing of our people. It is in this spirit that I commend this guide to India's open natural ecosystems, a landmark publication that brings long-overdue attention to a vital part of our natural heritage.

Grasslands, savannas, meadows, scrublands, and other open ecosystems extend across much of our country. They support extraordinary biodiversity, sustain the livelihoods of millions of pastoralists, farmers, and local communities, regulate water, conserve soils, and contribute to climate resilience through carbon storage. These landscapes have also been shaped over millennia by the people who have lived and worked within them. Yet, despite their ecological and cultural significance, they have often remained under-recognised in conservation and public policy.

This guide is an important first step in addressing this gap. By documenting twenty-four distinct open natural ecosystem types, from the Trans-Himalayan cold deserts and the Banni grasslands to the extensive savanna grasslands of the Deccan plateau, the floating phumdi grasslands of Manipur, and the red sand dunes of Tamil Nadu, it provides an authoritative reference for understanding the remarkable diversity of these landscapes. It will serve as an important resource for researchers, policymakers, practitioners, educators, students, and all those interested in India's rich natural heritage.

The declaration of 2026 as the International Year of Rangelands and Pastoralists offers an important opportunity to recognise the invaluable contributions of pastoral communities and to strengthen global attention towards these landscapes. India welcomes this initiative and remains committed to advancing science-based conservation that respects traditional knowledge and promotes sustainable land stewardship.

(Bhupender Yadav)

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MESSAGE

India's natural heritage extends across an extraordinary diversity of landscapes, each contributing in its own way to the ecological security and prosperity of our nation. Alongside our forests, India's grasslands, savannas, scrublands, alpine meadows, coastal grasslands, and other open natural ecosystems support remarkable biodiversity, sustain pastoral and agricultural livelihoods, and provide invaluable ecosystem services that strengthen resilience to climate change.

The Government of India has consistently recognised the importance of conserving ecosystems in all their diversity as part of our commitment to sustainable development and environmental stewardship. As we advance our national programmes on ecosystem restoration, biodiversity conservation, and climate resilience, a sound understanding of these landscapes becomes increasingly important.

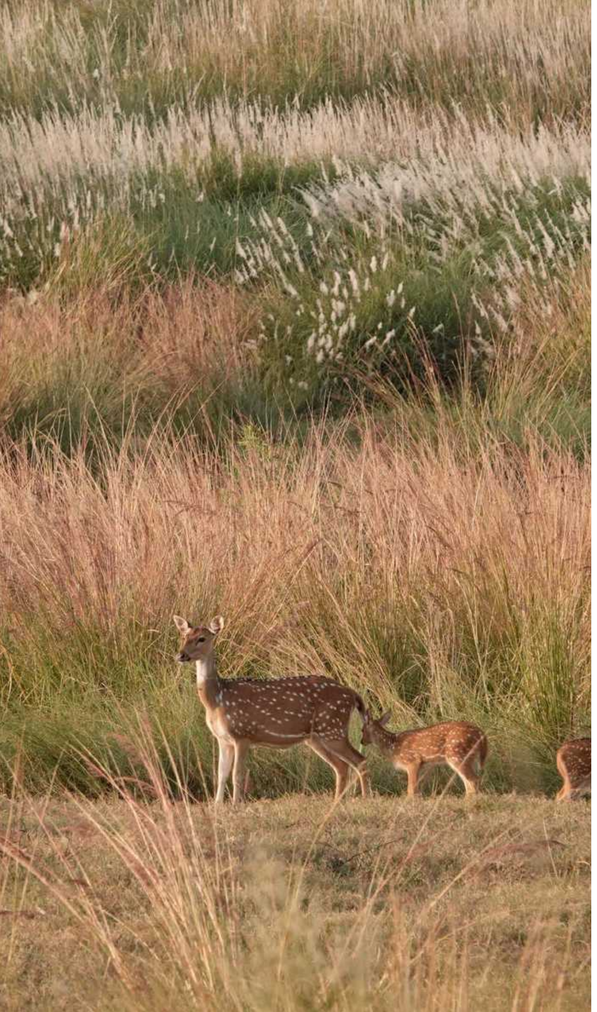
This guide to India's Grasslands and other Open Natural Ecosystems is therefore both timely and significant. Bringing together scientific knowledge from across the country, it documents twenty-four distinct ecosystem types and provides an accessible reference for administrators, forest officers, researchers, students, and conservation practitioners. It will strengthen our collective ability to plan restoration, conserve biodiversity, and support sustainable livelihoods through informed decision-making.

The declaration of 2026 as the International Year of Rangelands and Pastoralists further highlights the global importance of these landscapes and the communities who have stewarded them for generations. India has an opportunity to demonstrate how scientific knowledge and traditional wisdom can work together to promote sustainable land management and ecological resilience.

I congratulate the authors, scientists, institutions, and field practitioners who have contributed to this important publication. I am confident that this guide will encourage greater appreciation of India's open natural ecosystems and serve as a valuable resource for conservation, education, and policy for years to come.

(Kirti Vardhan Singh)

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AND CLIMATE CHANGE



PREFACE

India's environmental future depends upon our ability to understand, conserve, and restore the full diversity of its ecosystems. Sound policy is founded upon sound science, and effective conservation requires accurate knowledge of the landscapes we seek to manage.

The publication of this guide marks an important step in how India understands and administers its open natural ecosystems. By documenting the diversity, ecological characteristics, and distribution of India's open natural ecosystems, it provides an authoritative knowledge base that will support planning, research, restoration, and informed decision-making across sectors. It arrives at an important moment, as ecosystem restoration, climate adaptation, biodiversity conservation, and sustainable land management become increasingly integrated within national and state-level planning.

The Ministry has been strengthening efforts to promote landscape-based conservation approaches that recognise ecological processes alongside the needs of local communities. Open natural ecosystems play an important role within this broader framework, supporting biodiversity, regulating hydrological systems, storing carbon, and sustaining millions of people whose livelihoods remain closely connected with these landscapes.

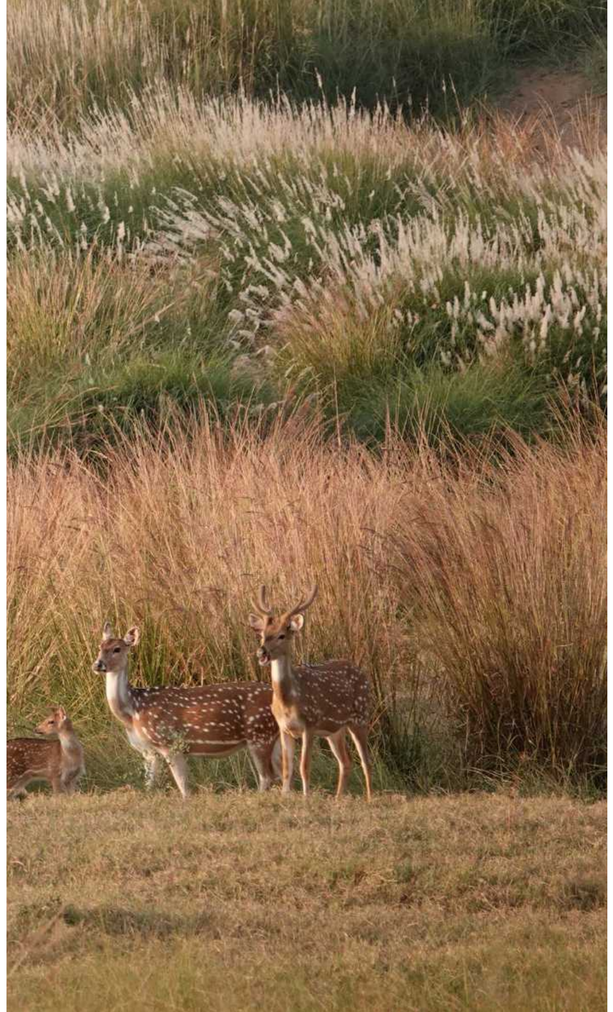
As India advances its commitments under the Convention on Biological Diversity, the United Nations Convention to Combat Desertification, and the Paris Agreement, reliable scientific references such as this guide will become increasingly valuable for governments, researchers, educational institutions, and practitioners working across disciplines.

I congratulate the authors and collaborating institutions for producing a publication of exceptional scientific quality and practical relevance. I hope it becomes an enduring reference that promotes greater understanding and supports effective conservation and restoration of India's remarkable open natural ecosystems.

11/8/26
(Tanmay Kumar)

Place: New Delhi
Dated: August 11, 2026

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MESSAGE

The conservation of India's natural heritage increasingly calls for an integrated landscape approach that recognises the diversity of ecosystems across the country. Along with forests, India's grasslands, savannas, scrublands, alpine meadows, and other naturally open ecosystems make indispensable contributions to biodiversity conservation, watershed protection, climate resilience, and sustainable livelihoods.

Forest departments across the country are engaged in protecting, restoring, and managing landscapes that often include these ecosystems alongside forests and wetlands. Scientific guidance that improves our understanding of their ecological character is therefore essential for informed management and long-term conservation. This publication offers the Indian Forest Service, state forest departments, and allied institutions a clear, science-based account of twenty-four distinct ecosystem types, from the high-altitude meadows of the Himalaya to the coastal grasslands of the peninsula. It is the kind of reference document our field officers need when making decisions about restoration, protection, and sustainable use.

The publication also reflects the growing importance of science-based conservation in achieving India's national and international environmental commitments. It demonstrates how robust ecological knowledge can support better management decisions while strengthening the conservation of biodiversity and the ecosystem services upon which people depend.

I commend the authors, researchers, and institutions whose dedicated efforts have produced this landmark reference. I am confident that it will serve as an important resource for the forestry and conservation community and contribute meaningfully to the stewardship of India's open natural ecosystems.

(Sushil Kumar Awasthi)

Place: New Delhi
Date: 11th August , 2026

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AND CLIMATE CHANGE



MESSAGE

India is a country defined in the popular imagination by the richness and density of its forests. Yet some of the most ancient, ecologically complex, and biologically distinctive landscapes on the subcontinent deserve recognition for their uniqueness. They are naturally open ecosystems: vast grasslands stretching to the horizon in the arid northwest, montane meadows rolling between peaks in the Himalayas, rocky plateaus rising from the Deccan, and the tall grasslands that fringe alluvial floodplains of the Ganges and Brahmaputra river systems. These are among the most significant, and most underappreciated, components of the country's natural heritage.

This guide is the first comprehensive documentation of the full range of India's grassland and open natural ecosystem types. It covers twenty-four distinct ecosystem types that are ecologically unique, harbouring biodiversity that is found nowhere else, and nurturing the communities that have lived within and depended upon it across centuries. In doing so, it fills a significant gap in our understanding of the country's ecological diversity.

The Ministry of Environment, Forest and Climate Change is pleased to commend this publication and to recognise the work that has gone into its preparation. India's commitments under the Convention on Biological Diversity, the United Nations Convention to Combat Desertification, and the Paris Agreement all require that we understand, document, and protect the full range of our ecological systems. Open natural ecosystems, which support a substantial proportion of India's threatened and endemic species, and sustain the pastoral and agricultural livelihoods of millions of people, whilst also performing critical ecosystem services including carbon sequestration, groundwater recharge, and the regulation of dust and wind erosion, must be central to that effort.

This guide appears at a moment of particular relevance. The United Nations has declared 2026 the International Year of Rangelands and Pastoralists, recognising globally what those who work in India's open landscapes have long understood: that grasslands and the communities that manage them are indispensable to ecological and human wellbeing alike. India, as one of the world's great grassland nations, has both the opportunity and the responsibility to demonstrate in policy, in law, in land use planning, and in the support extended to the pastoral and farming communities whose knowledge and practice have maintained these landscapes for generations.

The chapters that follow describe landscapes of extraordinary variety and beauty. It is our hope that this guide contributes to greater understanding, and that it serves as a resource for researchers, conservation practitioners, educators, policymakers, and all those who share a commitment to the full breadth of India's ecological inheritance.

We extend our appreciation to the authors, scientists, ecologists, and field researchers whose work underpins every chapter of this guide, and to the pastoral and indigenous communities whose generations of knowledge and stewardship have ensured that these landscapes survive to be documented at all.

(Ramesh Pandey)

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Government of India
Ministry of Environment, Forest & Climate Change
National Afforestation & Eco-Development Board



MESSAGE

Grasslands and open natural ecosystems are among the landscapes I have returned to most often across my years in the forest service, and it is a pleasure to see them documented with the depth and care this guide brings to them. It gives field officers, researchers, and planners a shared, scientifically grounded vocabulary for landscapes that are as ecologically significant as any forest we manage.

The twenty-four ecosystem types catalogued here, from arid scrublands to montane meadows, are technically demanding to characterise, and the effort that has gone into documenting them accurately is considerable. At the National Afforestation and Eco-Development Board, our restoration work extends across degraded lands adjoining national parks, sanctuaries, and other protected areas, and grasslands and open ecosystems form a vital part of that protective network. They serve as buffers and corridors around core wildlife habitats, sustain the grazing and fodder needs of communities living alongside protected areas, and anchor the ecological continuity that makes conservation landscapes function as connected systems rather than isolated islands.

Having ecosystem-specific reference material of this quality strengthens our ability to plan restoration that responds to what a landscape actually is, whether grassland, scrub, or savanna, and to support it accordingly. This is precisely the kind of scientific grounding that helps eco-development and afforestation programs work in harmony with the landscapes they are meant to protect and restore.

The publication also arrives during the International Year of Rangelands and Pastoralists, highlighting the close relationship between biodiversity conservation and the communities whose stewardship has shaped these landscapes over generations. Strengthening this partnership between science, conservation practice, and local knowledge will be central to the long-term resilience of these ecosystems.

I commend the authors and researchers for this work and hope it becomes a working tool and an essential reference text for those of us tasked with the eco-restoration of India's open landscapes.

(Dr. Clement Ben)

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A Scientific and Industrial Research Organization, recognised by the Department of Scientific & Industrial Research, Ministry of Science and Technology, Govt. of India

Anita Arjundas



Message from Executive Director, ATREE

Open natural ecosystems (ONEs) in India are socio-ecologically rich landscapes and constitute an integral part of India's natural heritage. They support a remarkable range of unique biodiversity, provide forage, sustain pastoralist and agricultural livelihoods supporting rural economies, influence water and nutrient cycles, conserve soils and contribute to the resilience of both landscapes and communities. Additionally, these landscapes are integral to India's climate resilience and carbon sequestration capabilities.

ATREE has been at the forefront of working on these important ecosystems. ATREE produced India's first ever high-resolution map on Open Natural Ecosystems in India in 2023, and since then developed conservation prioritization methods, ecological restoration protocols, and policy briefs with recommendations for their holistic management.

At ATREE, we believe that effective environmental stewardship must be grounded in sound science while remaining attentive to the knowledge and experiences of the communities who depend upon these landscapes. This guide brings these perspectives together by documenting the extraordinary diversity of India's open natural ecosystems.

It has been our honour to collaborate with the Ministry of Environment, Forests, and Climate Change and the International Union for the Conservation of Nature (IUCN)-India towards the development of this important guide. I extend my sincere appreciation to the scientists, ecologists, researchers, practitioners, reviewers, photographers and community members whose contributions have made this publication possible. I would also like to extend my gratitude to ATREE's supporters, and in particular to WestBridge Capital for recognising the importance of these diverse open ecosystems and supporting the development and design of this guide.

May this guidebook help ensure that India's grasslands and other open natural ecosystems are recognised, valued and sustained as an essential part of our shared natural heritage.



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Introduction

Punjab, Sindh, Gujarat, Maratha, Dravida, Utkal, Banga, Vindhya, Himachal, Yamuna, Ganga, Ucchala Jaladhi Taranga

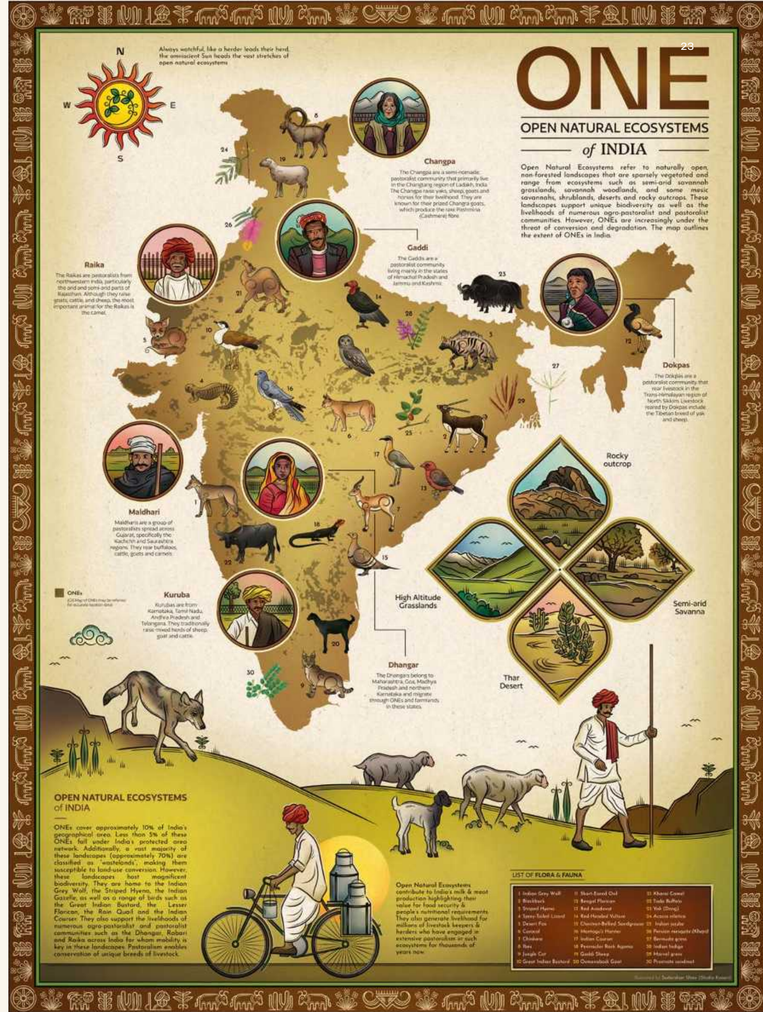
When invoking these geographical references in our national anthem, little would Guru Rabindranath Tagore have realised that inadvertently he was also tracing the arc of the grasslands of India. The grazing commons and scrublands of Punjab and Sindh; the vast dryland ecosystems and salt desert margins of Gujarat; the plateau savannas and rocky outcrops of the Maratha country; the dry plains, red sand dunes, and palm savannas of the Dravida south; the sal-edge meadows and seasonal wetlands of Utkal and Banga in the east; the ancient ridgelines and ravine grasslands of the Vindhyas at the heart of the subcontinent; the alpine meadows, temperate pastures, and cold desert mosaics of the Himalayan ranges in the north; and threading through it all, the floodplain grasslands and riparian corridors of the Yamuna and the Ganga, their voices finally dissolving into the tidal and coastal grasslands at the edge of the sea. This arc traces, with remarkable fidelity, the distribution of some of the most ecologically significant and least understood landscapes in the country. These are India's open natural ecosystems: grasslands, meadows, savannas, scrublands, rocky outcrops, and desert systems that together cover a substantial portion of the country's land surface, support a distinctive and in many cases irreplaceable complement of biodiversity, and have sustained human communities, pastoral traditions, and agricultural economies for millennia. They have been shaped by a unique combination of geology, climate, fire, and land use history. Each has its own ecological origin, species assemblages, and an interwoven relationship with the people who have lived within it. And each, in its own way, has been hiding in plain sight.



This illustrated guide profiles twenty-four distinct open natural ecosystem (ONE) types across India, describing their geography, climate, ecology, biodiversity, and the pressures they face. It is addressed to naturalists, students, conservation practitioners, and anyone with a serious interest in India's ecological heritage who wishes to understand these landscapes on their own terms. The ecosystems covered here span an extraordinary range of environmental conditions, altitudinal zones, biogeographic affinities, and anthropogenic influence. But what is common to all of them is their openness: a structural character defined not by the absence of trees but by the presence of grass, rock, sand, or sky in proportions that create conditions quite unlike those of closed forest, and that have given rise, over long timescales, to biological communities found nowhere else, and of human and their companion animal communities that co-developed to adapt to their largesse and scarcity in equal terms.

At one end of the altitudinal and climatic spectrum are the Himalayan montane grasslands, addressed in the opening section of this guide. From the subtropical grasslands of the foothills through the temperate meadows and alpine pastures of the higher ranges to the cold desert mosaic of the trans-Himalayan zone and the riparian valley wetlands that thread through it, these are among the highest-altitude open ecosystems in the world. They are structured by temperature, snowmelt, and the dynamics of high-altitude grazing, and they support assemblages of wildlife found nowhere else in the subcontinent: snow leopard, Himalayan ibex, woolly hare, black-necked crane, and a flora adapted to conditions of extreme cold, low oxygen, and intense ultraviolet radiation. The sub-Himalayan Terai-Bhabar belt that runs along the foothills forms a distinct transition zone between the mountains and the plains, combining alluvial grassland savanna, forest edge, and seasonal wetland in a mosaic that historically supported some of the highest densities of large mammals in Asia. The hill grasslands and savannas of the north-east and the floating *phumdi* grass islands or mats of Loktak Lake in Manipur represent further variants of this broader Himalayan periphery, each shaped by a distinct combination of rainfall, terrain, and land use history.

At the other end of the climatic spectrum are the hot hyper-arid systems of western India. The Thar desert, the Rann of Kachchh, the Banni grasslands, and the Kachchh and Saurashtra grasslands together constitute the most extensive dryland open ecosystem complex in the country. These landscapes are defined by low and erratic rainfall, extreme temperatures, and soils ranging from mobile sand to crystalline salt flat. They are also, in many cases, among the most culturally layered landscapes in India: the Banni alone, spread across approximately 2,600 square kilometres of Kachchh district, has been tended for centuries by twenty-one Maldhari pastoral communities whose knowledge of its ecological rhythms is inseparable from the functioning of the landscape itself.





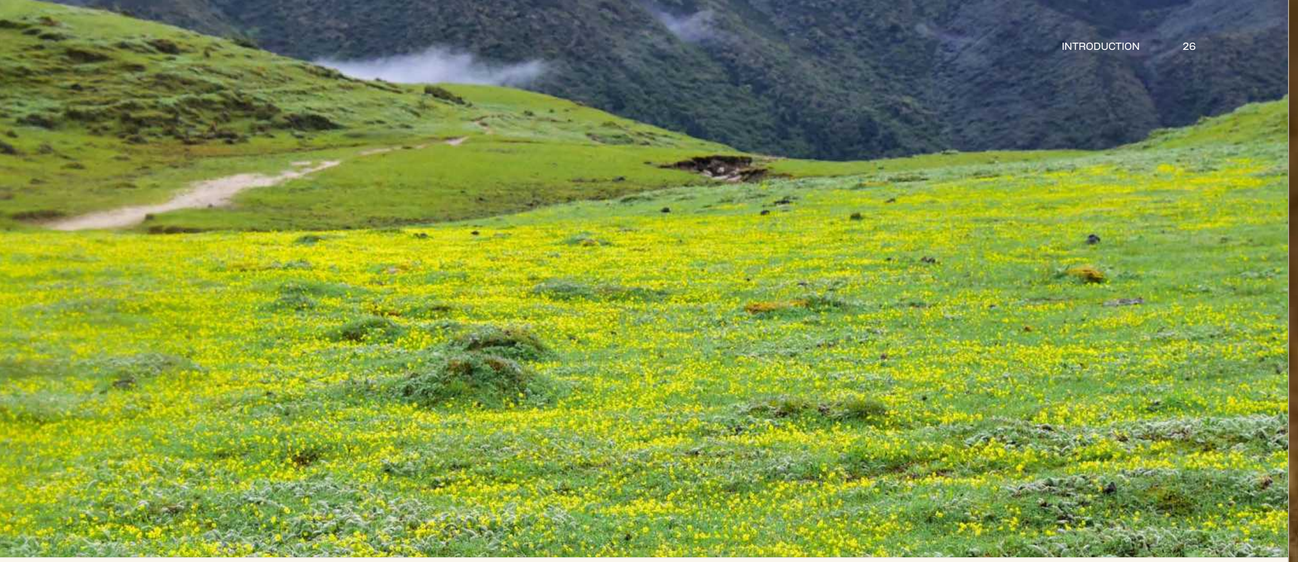
Between these extremes lies a wide range of plateau, slope, peninsular, and coastal grassland types. The Aravalli scrublands of Rajasthan, the central Indian highlands grasslands and savannas, the ravine lands of the Yamuna-Chambal zone, the Deccan plateau grassland and scrubland mosaic, the granite inselbergs that rise from it, the rocky plateaus of the northern Western Ghats, each represent distinct geological and ecological systems, their open character maintained by a combination of soil type, drainage, fire history, and centuries of land use. The *shola*-grassland mosaic of the southern Western Ghats uplands is among the most ecologically distinctive landscapes in India, of montane evergreen forest and open rolling grassland at elevations above 1,500 metres that supports a high degree of endemism in both flora and fauna. The open natural ecosystems of Tamil Nadu, addressed in a dedicated section of this guide, include the interior dry plains of Tirunelveli and Thoothukudi, the rain-shadow grasslands of the Western Tamil Nadu or Kangayam belt, and the extraordinary red sand dune landscapes of the *theri kaadu*, each with its own ecology and suite of specialist species. The guide also covers the central Nicobar grasslands, one of the least-documented open ecosystem types in the country.

The core of the guide consists of chapters that describe a grassland or ONE: its geographical extent and boundaries and general topography, climate, key ecological features and processes, the communities and livelihoods associated with it, its conservation status, the threats it faces, and a representative selection of its flora and fauna. The guide does not claim to be exhaustive. The ecological literature on Indian grasslands and other open landscapes remains relatively sparse, and significant gaps in documentation persist across most of the landscapes covered here. Where data are limited or contested, this is noted. Across all of these landscapes, a set of common themes recurs. Open natural ecosystems are structurally maintained by a combination of abiotic factors, including soil depth, chemistry, and drainage, alongside fire, grazing, and climate. They are far more stable and ecologically ancient than they are commonly assumed to be, and many have existed in their current form for hundreds of thousands of years. In a significant number of cases they have been actively shaped by pastoral and agricultural communities whose land use practices are inseparable from the ecology of the landscape. The biodiversity they support is both distinctive and, in many cases, poorly inventoried relative to forest ecosystems. A significant proportion of India's threatened and endemic species are grassland-dependent, among them the great Indian bustard, the lesser florican, the Bengal florican, the Indian wolf, the blackbuck, and the sociable lapwing, and their conservation is contingent on the recognition and active management of the open habitats they require.

Four cross-cutting themes are of sufficient complexity and policy relevance that they are addressed in dedicated chapters at the close of this guide, extending beyond the ecosystem profiles that form its core.

Fire is perhaps the most misunderstood ecological process in the Indian grassland context. Across ecosystems as different as the shola margins of the Nilgiris, the scrub savannas of the Deccan, and the meadow complexes of central Indian tiger reserves, fire has shaped vegetation structure, suppressed woody encroachment, and maintained the open character of these landscapes over millennia. The chapter examines the ecology of grassland burning, the consequences of blanket fire suppression policies, and what a science-based approach to fire management in open natural ecosystems should look like.





Pastoralism is the other great shaping force of India's grasslands. From the Maldhari of the Banni and the Rabari of the Thar to the Van Gujjar of the Himalayan foothills and the Toda of the Nilgiri plateau, India's pastoral traditions represent millennia of accumulated ecological knowledge embedded in practice. The chapter examines the relationship between mobile livestock keeping and grassland ecology, the consequences of sedentarisation and the loss of common grazing lands, and the policy frameworks needed to recognise pastoral communities as active partners in grassland conservation.

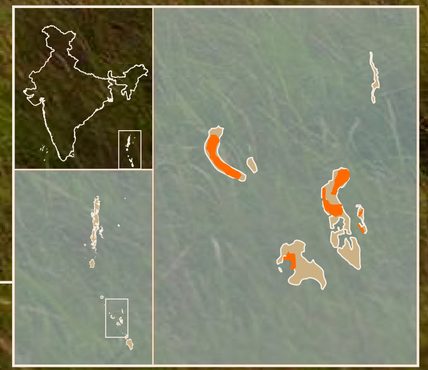
The carbon sequestration chapter addresses one of the most consistently undervalued dimensions of open ecosystem ecology. While forests have dominated the national conversation on carbon and climate, grassland soils, particularly in arid and semi-arid systems, store substantial quantities of carbon below ground in forms that are stable and resistant to release. The chapter examines what is currently known about carbon stocks across India's major grassland types and makes the case that the conversion of grassland to plantation forestry for carbon credit purposes is both ecologically counterproductive and climatically counterintuitive.

The final chapter addresses the contribution of open natural ecosystems to Land Degradation Neutrality, the global framework under the UNCCD by which countries commit to ensuring that productive land remains stable or improves over time. India has committed to restoring 26 million hectares of degraded land by 2030. The chapter argues that grasslands must be central to how that commitment is implemented, as productive, biodiverse, and climatically significant systems whose restoration suit their local ecological requirements.

Despite their immense ecological and socio-economic importance however, India's grasslands and other open natural ecosystems remain among the country's most threatened and least protected biomes. Historically perceived as degraded forests or "wastelands," many have been converted to agriculture, industrial and urban development, plantations, mining, and infrastructure. Others have been degraded by the disruption of natural ecological processes such as grazing, fire, and hydrological regimes, leading to woody encroachment, invasive alien species, and declining biodiversity. Although several iconic grassland species are protected within India's network of national parks and wildlife sanctuaries, most grasslands occur outside protected areas, embedded within multi-use landscapes that support pastoralism, livestock production, and other livelihoods. As a result, many grassland-dependent species continue to decline despite formal protection. Securing the future of India's open natural ecosystems will therefore require moving towards landscape-scale conservation that recognises these ecosystems as distinct biomes, supports traditional land-use systems, restores natural ecological processes, and integrates biodiversity conservation with sustainable livelihoods.

The guide is illustrated with stunning visuals of the landscapes, and a small selection of the representative biodiversity within each of these sites. Also mentioned are the people who inhabit these landscapes and their cultural and socio-economic ties. The intention is to provide a reliable and accessible reference that reflects the current state of knowledge, and to make the case, through the accumulation of ecological and cultural detail, that these landscapes deserve sustained and serious attention.

Central Nicobar Grasslands



Geography

Deep in the humid tropics, a mere eight degrees north of the equator, a distinctive set of grasslands occur in the central Nicobar Islands, in the southern part of the Andaman and Nicobar archipelago. Set in rolling, hilly terrain towards the interiors of the islands, these patchily-distributed grasslands account for up to 40 percent of the vegetation cover in these islands. Because they occur alongside tropical wet forests, the dominant and expected vegetation type in this region of high annual rainfall (>2400 mm), these grasslands were erroneously assumed to be anthropogenically derived habitats, carved out by the clearing of tropical forests.

However, it is now established these grasslands are edaphically determined, occurring on ultramafic serpentine soils that limit tree growth. Such edaphic grasslands occur across tropical South-east Asia, in an arc from the Arakan range in Myanmar to Papua New Guinea in the far east, and are thought to have evolved during the arid conditions of the Last Glacial Maximum more than 20,000 years ago. The biogeographic affinities of the dominant *Poaceae* and *Cyperaceae* species in the central Nicobar grasslands with those of Sundaland (consisting of Singapore, Brunei, Malaysia, western Indonesia, and parts of Thailand) suggest that these grasslands are indeed part of this Greater Sundaic arc.

Climate

Rainfall

MAY TO DECEMBER

~2400 mm
Average annual rainfall, Drier months (Jan–Apr) receive measurable rainfall

EQUABLE TROPICAL CLIMATE
Nearly uniform temperatures perennially

<20°C
Minimum Temperature

>35°C
Maximum Temperature

Key Ecological Features and Processes

Ultramafic serpentine soils

Serpentine soils are soils that form from the weathering of ultramafic rocks (that are very low in silica and very rich in magnesium and iron). The most common parent rock is peridotite, which often gets partly altered into a rock called serpentinite, hence the name of the derived soils is serpentine.

The soils derived from these rocks have high concentrations of heavy metals that are toxic to plants. They also tend to be low in the major nutrients plants need (nitrogen, phosphorus, potassium), and are often shallow, rocky, and don't hold water well.

Therefore, trees struggle to establish themselves even in high-rainfall regions. This is why serpentine areas frequently support open, stunted, or grassy vegetation surrounded by forests that stops abruptly at the soil boundary. Due to the harsh soil conditions, serpentine outcrops tend to evolve specialised plants, giving them unusually high endemism.

Conservation Status

These grasslands have no specific recognition or protection as a conservation priority. They have long been perceived as anthropogenic formations, which has influenced their conservation and management.



People and Livelihoods

Nicobar islanders

The Nicobar grasslands are part of the commons of the local Nicobar islander community, who refer to grasslands in two Nicobari languages as *Kuisen* (Kamorta, Nancowry, Trinket & Katchal) or *Kufo* (Chowra, Terassa, Bompoka) "the place of grass". Their use by the community has been guided by community elders, as per well-defined social norms that govern the harvest of natural resources from the sea, forest, mangroves and grasslands, all of which are traditionally treated as the community commons. While the grasses are harvested post-monsoon for the thatched roofs of traditional Nicobari round-huts, pre-monsoon controlled fires facilitated renewal of fresh grass for harvest the next year as well as an occasion to hunt the wild pig.

Biodiversity

Flora

Sensitive Plant *(Mimosa pudica)*
Conservation status: Least Concern

Tall-stilt Mangrove *(Rhizophora apiculata)*
Conservation status: Least Concern

Nicobar Islands Breadfruit *(Pandanus leram)*
Conservation status: Data Deficient

Forked Fern *(Dichranopteris pedata)*
Conservation status: Not Evaluated



Cogon Grass (*Imperata cylindrica)*
Conservation status: Least Concern



Fragrant Screwpine *(Pandanus odoratissimus)*
Conservation status: Not Evaluated



Nypa Palm *(Nypa fruticans)*
Conservation status: Not Evaluated



Sumatran Scleria (*Scleria sumatrensis)*
Conservation status: Least Concern



Cantor's Pit Viper *(Trimeresurus cantori)*
Conservation status: Endangered



Nicobar Gliding Gecko (*Gekko nicobarensis)*
Conservation status: Endangered



Slaty-breasted Rail *(Lewinia striata)*
Conservation status: Least Concern



Zitting Cisticola *(Cisticola juncidi)*
Conservation status: Least Concern

Fauna

Mammals

Andaman Wild Pig *(Sus scrofa andamanica)*
Conservation status: Least Concern

Feral Water Buffalo *(Bubalus bubalis)*
Conservation status: Not Evaluated

Trinket Cattle (Feral) *(Bos indicus)*
Conservation status: Not Evaluated

Birds

Asian Blue Quail *(Synoicus chinensis)*
Conservation status: Least Concern

White-rumped Munia *(Lonchura striata)*
Conservation status: Least Concern

Yellow-legged Buttonquail *(Turnix tanki)*
Conservation status: Least Concern

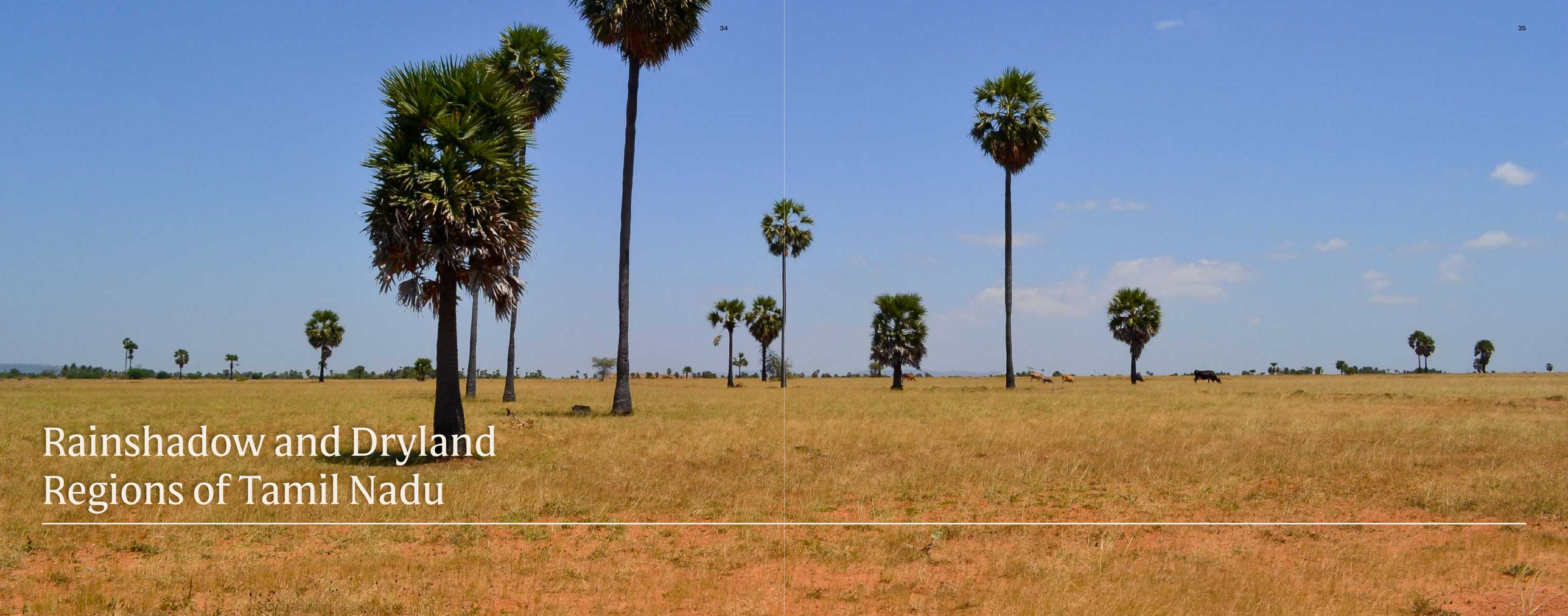
Birds like swiftlets, drongos, and flycatchers use the airspace above grasslands as feeding sites.

Reptiles

Central Nicobar Pit Viper *(Trimeresurus mutablis)*
Conservation status: Endangered

Nicobar Long-tailed Lizard *(Bronchocela rubrigularis)*
Conservation status: Data Deficient





Rainshadow and Dryland Regions of Tamil Nadu



The Eastern and Western Ghats converge at the Nilgiris, forming a physiographic divide that separates the Deccan Plateau from the plains of Tamil Nadu to the south. These plains extend across a substantial area, bounded to the west by the southern Western Ghats, to the north and northwest by the Ghats convergence corridor, and to the east by the Bay of Bengal. Tapering progressively southward, the plains terminate at Kanyakumari, the southernmost point of the Indian peninsula. These plains support savanna grasslands that are ecologically and structurally distinct from those of the Deccan Plateau.

The grasslands and savannas that historically dominated large portions of the Tamil Nadu plains now persist as highly discontinuous and fragmented remnants within an agricultural and built-up matrix. Three broad regions retain meaningful concentrations of these ONEs:

The rainshadow zone of the Western Ghats in western Tamil Nadu — Adjoining the Palakkad Gap and encompassing the northwestern and western districts of Coimbatore, Tiruppur, Erode, Namakkal, Karur, and Dindigul; this region is bisected by the floodplains of the River Kaveri.

The dryland complex of southern and southeastern Tamil Nadu — bounded to the north and east by the Kaveri delta, to the west by the Western Ghats, and to the south by the irrigated wetland ecosystems of Kanyakumari — constitutes a broad interior belt of open, semi-arid landscapes. The Tamirabarani river corridor, tank and canal irrigation command areas, and sections of the lower Vaigai system represent localised exceptions to the prevailing dryland conditions. Across this mosaic, ONEs take the form of grasslands, savannas, thorn scrub, open woodlands, and rocky slopes of hills and outcrops.

Notable concentrations within this zone include:

- Tirunelveli and Thoothukudi districts: Remnant grasslands and savannas of formerly extensive coverage, and the Theri or Teri Kaadu — a characteristic red sand landscape of significant ecological and geomorphological interest.
- Ramanathapuram district: Waterbody-associated open habitats, primarily within the Vaigai river basin and its tributaries, alongside a distinct belt of reed-dominated vegetation in the district's southern reaches.

Beyond these principal zones, several other ONE types occur across Tamil Nadu. Coastal sand dune grasslands occupy active, mobile foredune systems along the present shoreline — structurally and ecologically distinct from the relict inland Theri dunes — and are characterised by herbaceous communities dominated by *Spinifex littoreus* and *Ipomoea pes-caprae*. Marshy coastal wet grasslands, seasonally inundated and spanning a freshwater-to-brackish gradient, occur at localities such as Point Calimere and Kaliveli. Saline grasslands fringe lagoon and swamp margins, dominated by halophytic grasses and herbs. Finally, grasslands and savannas of Eastern Ghats affinity, maintained by fire and grazing, occur on the lower slopes and plateau margins of the Shevaroy, Javadi, and Sirumalai Hills from approximately 700 metres above mean sea level — the hills themselves rising considerably higher — and are characterised by high spatial discontinuity and patch-level isolation.

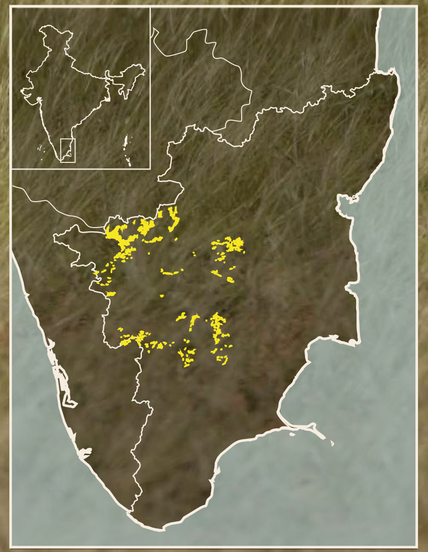
The districts of Coimbatore, Erode, Karur, and Tiruppur are a part of the Kangayam region located in the rain shadow of the southern Western Ghats in Tamil Nadu which also includes Dindigul, and Namakkal. The three districts were documented to have around 3,841 square kilometres of grasslands in 2011 according to an IGFRI study.

These ancient, grass-dominated systems, are home to blackbucks, Indian foxes, coursers and larks, fan-throated lizards, jungle cats, sandgrouse, and star tortoises: species that depend on the open plains. The Kangayam grasslands region is well-known for its Korangadu silvipasture, a centuries-old paddock system of pasture dominated by *Cenchrus* grass, scattered *Vachellia leucophloea* and fodder trees and live fences of *Commiphora berryi*, that sustains the Kangayam cattle breed and remains a genuinely instructive model of drought-resilient, community-governed land use. However, Korangadu is a silvipasture system within this open ecosystem mosaic rather than its entirety — alongside the managed pastures lie relict patches of natural thorn scrub and savanna dominated by *Vachellia planifrons*.



Vachellia leucophloea

Rainshadow Zone of Western Tamil Nadu





Kozhukkottai/Birdwood Grass *(Cenchrus setigerus)*
Conservation status: Least Concern



Kiluvai/Indian Balm of Gilead
(Commiphora berryi)
Conservation status: Least Concern



Oil Cake Tree *(Albizia amara)*
Conservation status: Not Evaluated



Indian Bean *(Vigna trilobata* var. *pusilla)*
Conservation status: Not Evaluated



Kuruthu Pillu/Swollen Fingergrass
(Chloris barbata)
Conservation status: Not Evaluated



Arugampul/Bermuda grass *(Cynodon dactylon)*
Conservation status: Not Evaluated



Birdsville Indigo/Seppunerinji/Nine-leaved Indigo
(Indigofera tsiangiana)
Conservation status: Not Evaluated



Nathaichuri/Shaggy Buttonweed
(Spermacoce hispida)
Conservation status: Not Evaluated

Biodiversity

Flora

- Annual Bristle Grass/Broom Grass *(Aristida setacea)*
  Conservation status: Least Concern
- Buffalo Grass *(Cenchrus ciliaris)*
  Conservation status: Least Concern
- Indian Gum Arabic Tree *(Vachellia nilotica)*
  Conservation status: Least Concern
- White Bark Acacia *(Vachellia leucophloea)*
  Conservation status: Least Concern
- Blumea *(Blumea sp.)*
- Bristly Foxtail Grass *(Setaria verticillata)*
  Conservation status: Not Evaluated
- Reddish-yellow Beardgrass/Red False Beard Grass *(Chrysopogon fulvus)*
  Conservation status: Not Evaluated
- Poonapudukukodi/Spherical Rattlepod *(Crotalaria globosa)*
  Conservation status: Not Evaluated
- Umbrella Thorn *(Vachellia planifrons)*
  Conservation status: Not Evaluated
- Vennampul/Indian Rough-Grass *(Trachys muricata)*
  Conservation status: Not Evaluated

IUCN RED LIST

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NE	DD	LC	NT	VU	EN	CR	EW	EX



Black-winged Kite *(Elanus caeruleus)*
Conservation status: Least Concern



Indian Hare/Black-naped Hare *(Lepus nigricollis)*
Conservation status: Least Concern



Indian Fox *(Vulpes bengalensis)*
Conservation status: Least Concern



Indian Grey Mongoose *(Urva edwardsii)*
Conservation status: Least Concern



Grey Francolin *(Ortygornis pondicerianus)*
Conservation status: Least Concern



Indian Silverbill *(Euodice malabarica)*
Conservation status: Least Concern



Leschenault's Snake-eye *(Ophisops leschenaultii)*
Conservation status: Least Concern

Fauna

Mammals

- Madras Hedgehog *(Paraechinus nudiventris)*
  Conservation status: Least Concern
- Golden Jackal *(Canis aureus indicus)*
  Conservation status: Least Concern
- Indian Gerbil *(Tatera indica)*
  Conservation status: Least Concern
- Jungle Cat *(Felis chaus)*
  Conservation status: Least Concern

Birds

- Ashy-crowned Sparrow-lark *(Eremopterix griseus)*
  Conservation status: Least Concern
- Chestnut-bellied Sandgrouse *(Pterocles exustus)*
  Conservation status: Least Concern
- Blackbuck *(Antilope cervicapra)*
  Conservation status: Least Concern
- Indian Courser *(Cursorius coromandelicus)*
  Conservation status: Least Concern
- Indian Thick-knee *(Burhinus indicus)*
  Conservation status: Least Concern
- Jerdon's Bushlark *(Plocealauda affinis)*
  Conservation status: Least Concern
- Large Grey Babbler *(Argya malcolmi)*
  Conservation status: Least Concern
- Montagu's Harrier *(Circus pygargus)*
  Conservation status: Least Concern
- Oriental Skylark *(Alauda gulgula)*
  Conservation status: Least Concern
- Rosy Starling *(Pastor roseus)*
  Conservation status: Least Concern
- Yellow-wattled Lapwing *(Vanellus malabaricus)*
  Conservation status: Least Concern

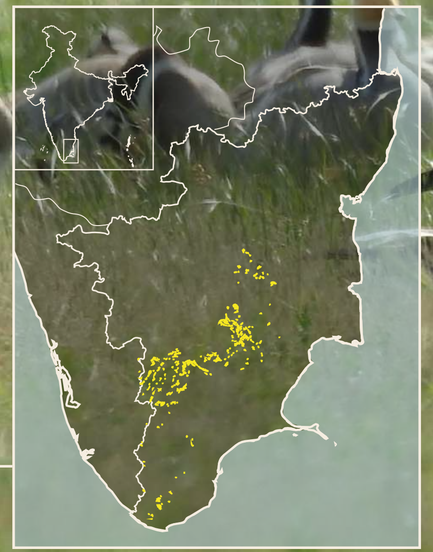
Reptiles

- Bengal Monitor Lizard *(Varanus bengalensis)*
  Conservation status: Least Concern
- Fan-throated Lizard *(Sitana sp.)*

IUCN RED LIST

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NE	DD	LC	NT	VU	EN	CR	EW	EX

Dryland Complex of Southern and Southeastern Tamil Nadu



Geography

From the foothills of the Western Ghats stretching east all the way to the Bay of Bengal, the vast rolling plains of southern Tamil Nadu comprise dry grasslands and shrublands. Known locally as *Mullai* and described in Sangam literature, these landscapes once extended across parts of present-day Tirunelveli and Thoothukudi districts but have declined substantially in extent over the past several decades. The semi-arid grassland-scub-savanna landscape of this region extends from south of Madurai all the way to Radhapuram district, close to the southern tip of the peninsula. Highly fragmented due to conversion to farmlands for decades, the open spaces exist mostly as discontinuous patches.

Climate

Rainfall

JUNE TO DECEMBER

~800–900 mm
Average annual rainfall

Winter

JANUARY TO MARCH

February
Peak

~16-18°C
Minimum Temperature

Summer

MARCH TO MAY

May
Peak

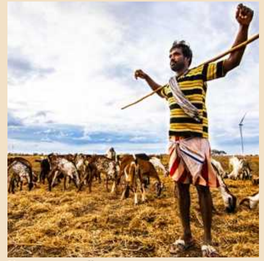
~42°C
Maximum Temperature



Conservation Status

Vallanadu Blackbuck Sanctuary in Thoothukudi district is a protected area around which remnant scrub tracts of this southern Tropical thorn forest are found in pockets.

People and Livelihoods



Konar pastoralist

Konar or Ediyar

A community of traditional sheep herders who straddle between Tirunelveli and Thoothukudi districts in search of pasture for their *nadu chembari* and *pottu* (local breeds) sheep in this semi-arid land. Typically the sheep feed on grasses and uvai (harvested paddy stalks in farm fallows), on temple commons and *meichal perompoke* (grazing land). The Konar synchronise sheep husbandry with farmland activities in the traditional rainfed cropping system of the region.

Their migration between various locations in the two districts is very important for farmlands in the landscape too, since during the day sheep graze and defecate in the paddy fallows which enrich the soil and reduce the usage of chemical fertilizers for cultivation.



Lindernia minima
Conservation status: Endangered



Cyanotis papilionacea
Conservation status: Not Evaluated



Mvunganjati *(Catunaregam spinosa)*
Conservation status: Not Evaluated



Biophytum nervifolium
Conservation status: Not Evaluated



Karai *(Canthium coromandelicum)*
Conservation status: Not Evaluated



Umbrella Thorn *(Vachellia planifrons)*
Conservation status: Not Evaluated



Poonapudukukodi/Spherical Rattlepod
(Crotalaria globosa)
Conservation status: Not Evaluated



Theriophonum sivaganganum
Conservation status: Not Evaluated

Biodiversity

Flora

- *Dalbergia coromandeliana*
  Conservation status: Near Threatened
- *Gmelina asiatica*
  Conservation status: Least Concern
- Kiluvai/Indian Balm of Gilead
  (Commiphora berryi)
  Conservation status: Least Concern
- Robber Thorn *(Vachellia horrida)*
  Conservation status: Least Concern
- *Caralluma bhupinderiana*
  Conservation status: Not Evaluated
- *Chloris wightiana*
  Conservation status: Not Evaluated
- *Jatropha maheshwarii*
  Conservation status: Not Evaluated
- *Lepidagathis barberi*
  Conservation status: Not Evaluated
- *Lepidagathis pungens*
  Conservation status: Not Evaluated
- *Micragereia wightii*
  Conservation status: Not Evaluated
- *Theriophonum fischeri*
  Conservation status: Not Evaluated
- *Theriophonum sivaganganum*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Serrated Fan-throated Lizard *(Sitana marudhamneydhal)*
Conservation status: Endangered



Indian Pangolin *(Manis crassicaudata)*
Conservation status: Endangered



Madras Hedgehog *(Paraechinus nudiventris)*
Conservation status: Least Concern



Pallid Harrier *(Circus macrourus)*
Conservation status: Near Threatened



Rock Eagle-owl *(Bubo bengalensis)*
Conservation status: Least Concern



Schneider's Toad *(Duttaphrynus scaber)*
Conservation status: Least Concern



Peregrine Falcon *(Falco peregrinus)*
Conservation status: Least Concern

Fauna

Mammals

- Blackbuck *(Antilope cervicapra)*
  Conservation status: Least Concern
- Indian Fox *(Vulpes bengalensis)*
  Conservation status: Least Concern
- Indian Gerbil *(Tatera indica)*
  Conservation status: Least Concern
- Jungle Cat *(Felis chaus)*
  Conservation status: Least Concern

Birds

- Ashy-crowned Sparrow-lark *(Eremopterix griseus)*
  Conservation status: Least Concern
- Greater Short-toed Lark *(Calandrella brachydactyla)*
  Conservation status: Least Concern
- Indian Courser *(Cursorius coromandelicus)*
  Conservation status: Least Concern
- Montagu's Harrier *(Circus pygargus)*
  Conservation status: Least Concern
- Pied Harrier *(Circus melanoleucos)*
  Conservation status: Least Concern
- Short-toed Snake Eagle *(Circaetus gallicus)*
  Conservation status: Least Concern
- Western Marsh Harrier *(Circus aeruginosus)*
  Conservation status: Least Concern
- Yellow-wattled Lapwing *(Vanellus malabaricus)*
  Conservation status: Least Concern

Reptiles

- Scaly Gecko *(Hemidactylus scabriceps)*
  Conservation status: Endangered
- Red Sand Boa *(Eryx johnii)*
  Conservation status: Endangered
- Common Dotted Garden Skink *(Riopa punctata)*
  Conservation status: Least Concern
- Saw-scaled Viper *(Echis carinatus)*
  Conservation status: Least Concern
- Dakota's Leaf-toed Gecko/Termite Hill Gecko *(Hemidactylus triedrus)*
  Conservation status: Least Concern
- Daudin's Bronzeback *(Dendrelaphis tristis)*
  Conservation status: Least Concern
- Pondichéry Fan-throated Lizard *(Sitana ponticeriana)*
  Conservation status: Least Concern

Amphibians

- Marbled Globular Frog *(Uperodon systoma)*
  Conservation status: Least Concern
- Roland's Burrowing Frog *(Sphaerotheca rolandae)*
  Conservation status: Least Concern

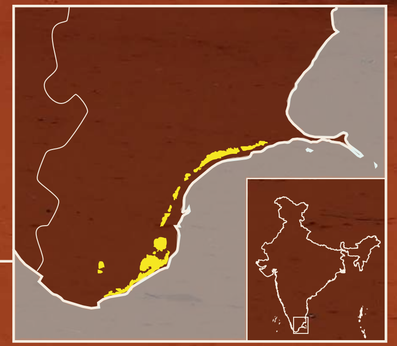
Invertebrates

- Lemon Pansy *(Junonia lemonias)*
  Conservation status: Not Evaluated
- Tawny Coster *(Acraea terpsicore)*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Theri Kaadu: Red Sands of Southern Tamil Nadu



Geography

The *Theri* sands are deposited over an area of 500 square kilometres, largely in Thoothukudi and Tirunelveli districts along the southeast coastal belt of Tamil Nadu. The coastal red sand deposits occur along the shoreline and are the most dynamic, while the near-shoreline ones show moderate movement, extending up to about 15 km inland from the coast. Both these are of aeolian origin or shaped by wind. The sand occurs as rolling dunes forming a gently undulating terrain and are sometimes topped with vegetation. Along the coast, two shore-parallel dune lines occur: the first runs along the sea shore and the second lies parallel to it, 100–500 m inland. The maximum thickness of the red sand deposits observed is over 10 metres. On the other hand, along the foothills of the Western Ghats, the inland *Theri* sand deposits are thought to be fluvial in origin and are relatively more stable than their coastal counterparts. The Theri sands are thought to have started being deposited about 15,000 years ago and the bulk of the sands were deposited roughly by 11 thousand years ago, followed by a later, near-shoreline phase. Each of these represent distinct depositional environments and sedimentological characteristics reflecting their formational processes.

Climate

The fluvial *Theri* deposits are found in the rainshadow zone of the Western Ghats and receives about 700 mm average annual rainfall while the coastal aeolian *Theri* deposit belt receives over 1000 mm rainfall. Rain is received mainly from the northeast (winter) monsoon, and a lesser amount from the summer monsoon. This strong, seasonally reversing wind regime is critical for the *Theri* ecosystem, as it actively mobilises sand and shapes dune morphology.

Key Ecological Features and Processes

The **distinctive red coloration** of these sands is a defining characteristic which is attributed to iron oxide formed from the weathering of heavy minerals like garnet, ilmenite, magnetite, and hypersthene, oxidised under a fluctuating arid–humid climate. The iron oxide, or hematite, is carried on kaolinite clay formed from the weathering of feldspar, which coats the quartz grains and stains the matrix between them.

Sunai springs

Freshwater springs known locally as *sunai* emerge through the porous sands, sustaining plants, birds, insects and small animals.



Conservation Status

Two reserved forests (RF) in Tiruchendur taluk, Thoothukudi district, protect a small part of the belt: Kuthiraimozhi Theri RF (~23.9 km²) and Sathankulam RF (~9 km²). The rest lies outside formal protection.



Woody-fruit Jujube *(Ziziphus xylopyrus)*
Conservation status: Least Concern



Purple Hop Bush/Hopseed Bush *(Dodonaea viscosa)*
Conservation status: Least Concern



Rubber Thorn *(Vachellia horrida)*
Conservation status: Least Concern



Mvunganjati *(Catunaregam spinosa)*
Conservation status: Least Concern



Governors Plum *(Flacourtia indica)*
Conservation status: Least Concern



Indian Mulberry *(Morinda coreia)*
Conservation status: Least Concern

Biodiversity

Flora

- Anjan *(Hardwickia binata)*
  Conservation status: Least Concern
- Asian Palmyra Palm *(Borassus flabellifer)*
  Conservation status: Least Concern
- Chanda Katta *(Dalbergia spinosa)*
  Conservation status: Least Concern
- Kiluvai/Indian Balm of Gilead *(Commiphora berryi)*
  Conservation status: Least Concern
- Coromandel Boxwood *(Canthium coromandelicum)*
  Conservation status: Not Evaluated
- Umbrella Thorn *(Vachellia planifrons)*
  Conservation status: Not Evaluated

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Madras Hedgehog *(Paraechinus nudiventris)*
Conservation status: Least Concern



Rough-tailed Sand Boa *(Eryx conicus)*
Conservation status: Near Threatened



Red-headed Falcon *(Falco chicquera)*
Conservation status: Near Threatened



Indian Roller *(Coracias benghalensis)*
Conservation status: Near Threatened



Scaly Gecko *(Hemidactylus scabriceps)*
Conservation status: Endangered



Giant Red Velvet Mite *(Trombidium grandissimum)*
Conservation status: Not Evaluated



Common Kestrel *(Falco tinnunculus)*
Conservation status: Least Concern

Fauna

Mammals

- Indian Pangolin *(Manis crassicaudata)* — Conservation status: Endangered
- Indian Fox *(Vulpes bengalensis)* — Conservation status: Least Concern
- Indian Gerbil *(Tatera indica)* — Conservation status: Least Concern
- Indian Hare *(Lepus nigricollis)* — Conservation status: Least Concern
- Common Indian Field Mouse *(Mus booduga)* — Conservation status: Least Concern

Birds

- Asian Green Bee-eater *(Merops orientalis)* — Conservation status: Least Concern
- Blue-faced Malkoha *(Phaenicophaeus viridirostris)* — Conservation status: Least Concern
- Chestnut-bellied Sandgrouse *(Pterocles exustus)* — Conservation status: Least Concern
- Common Iora *(Aegithina tiphia)* — Conservation status: Least Concern
- Grey Francolin *(Ortygornis pondicerianus)* — Conservation status: Least Concern
- Rosy Starling *(Pastor roseus (Sturnus roseus))* — Conservation status: Least Concern
- White-eyed Buzzard *(Butastur teesa)* — Conservation status: Least Concern

Reptiles

- Bibron's Skink *(Eutropis bibronii)* — Conservation status: Near Threatened
- Red Sand Boa *(Eryx johnii)* — Conservation status: Near Threatened
- Keeled Indian Mabuya *(Eutropis carinata)* — Conservation status: Least Concern
- Saw-scaled Viper *(Echis carinatus)* — Conservation status: Least Concern
- Pondichéry Fan Throated Lizard *(Sitana ponticeriana)* — Conservation status: Least Concern
- Fan-throated Lizards *(Sitana spp.)* — Conservation status: Not Evaluated

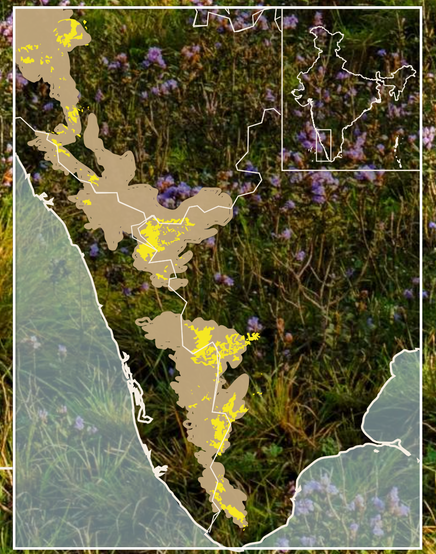
Invertebrates

- Scarlet Tip *(Colotis anae)* — Conservation status: Least Concern
- Plain Tiger *(Danaus chrysippus)* — Conservation status: Least Concern

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Shola Grasslands Mosaic



Geography

At elevations typically over 1400–1500 metres above mean sea level in the southern Western Ghats in Tamil Nadu, Karnataka and Keralam, a very unique mosaic of two very different ecosystems with sharp boundaries can be seen. These are montane grasslands on the rolling hills, interspersed with sholas, which are stunted evergreen tropical montane evergreen forests in the valleys. The bi-phasic mosaics are estimated to have existed for over 20,000 years and are called 'shola sky islands' since they are found isolated only at higher elevations in the mountain ranges.

Climate

Rainfall

APRIL TO DECEMBER

>1500 mm
Average Annual Rainfall

January to March
Measurable rainfall even in drier months

Winter

NOVEMBER TO FEBRUARY

December and January
Peak

Below-freezing
Minimum Temperature (in higher elevations)

Summer

MARCH TO JUNE

April-May
Peak

22-23°C
Maximum Temperature

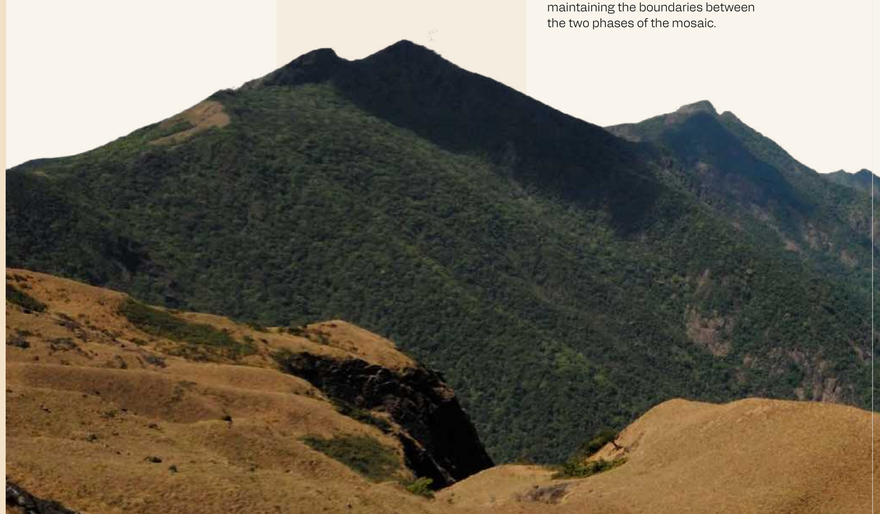
Key Ecological Features and Processes

Persistent cloud cover and misty conditions

Although these ecosystems are at low, tropical latitudes, their high elevations result in weather that is cool with relatively little seasonal temperature variations. Summers are mild and pleasant while winter nights can witness lows below-freezing point. These areas therefore maintain relatively high atmospheric humidity year-round, enabling persistent cloud cover and misty conditions.

Frost

The sharp boundaries between the two ecosystems, shola forests and grasslands, and the fact that both co-exist in the same elevation range and climate is uncommon. At higher elevations (>1800 metres above sea level), frost that is more dominant in the open grasslands than in the warmer forests, might be the key factor in maintaining the sharp boundaries and preventing the forests from taking over the grasslands. This is evidenced by the high mortality rate under frost conditions of the native tree seedlings in the sholas. At the lower elevations (1400-1800 metres asl), fire and herbivory may be important in maintaining the boundaries between the two phases of the mosaic.



Conservation Status

Several protected areas, mainly in the states of Keralam and Tamil Nadu along with a few in Karnataka, aim to conserve this ecosystem mosaic.

They include Eravikulam National Park (NP), Anamudi Shola NP, Pampadum Shola NP, Mathikettan Shola NP, Silent Valley NP, Kurinjimala Sanctuary, and Chinnar Wildlife Sanctuary (WLS) in Keralam (most of which lie in the Anamalai sub-cluster around Munnar/ Idukki), and Mukurthi NP in the Nilgiris, along with Grass Hills NP within the Anamalai (Indira Gandhi) Tiger Reserve and WLS in Tamil Nadu.

The protected areas in Karnataka sit at the northern edge of this mosaic's range. They include Kudremukh NP, and the upper elevations of Pushpagiri, Someshwara, Talacauvery and Brahmagiri WLS.

People and Livelihoods



Toda pastoralists

Toda

Toda, an indigenous pastoralist community of the upper Nilgiris, keepers of the Toda buffalo breed.





Nilakurinji *(Strobilanthes kunthiana)*
Conservation status: Vulnerable



Nilgiri Champa *(Magnolia nilagirica)*
Conservation status: Vulnerable



Indian Wild Cherry *(Prunus ceylanica)*
Conservation status: Endangered



Ladies'-tresses *(Spiranthes sp.)*
Conservation status:



Whorled Hedyotis *(Hedyotis verticillaris)*
Conservation status: Not Evaluated



Indian Persea *(Persea macrantha)*
Conservation status: Not Evaluated



Shield Sundew *(Drosera peltata)*
Conservation status: Least Concern



Garden Balsam *(Impatiens balsamina)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Nilgiri Memecylon *(Memecylon sisparense)*
  Conservation status: Critically Endangered
- White Cedar *(Dysoxylum malabaricum)*
  Conservation status: Endangered
- Jangli Almond/Marotti *(Hydnocarpus pentandrus)*
  Conservation status: Vulnerable
- Kulanjamun *(Syzygium travancoricum)*
  Conservation status: Vulnerable
- White Vitex *(Vepris bilocularisr)*
  Conservation status: Vulnerable
- Chestnutleaf Top-Fruit Tree *(Nothopegia castaneifolia)*
  Conservation status: Near Threatened
- Pavadakkambu *(Psychotria nilgiriensis)*
  Conservation status: Near Threatened
- Jamun/Black Plum *(Syzygium cumini)*
  Conservation status: Least Concern
- Malabar Ironwood *(Hopea parviflora)*
  Conservation status: Least Concern
- Analivegam *(Pittosporum neelgherrense)*
  Conservation status: Not Evaluated
- *Andropogon polyptychos*
  Conservation status: Not Evaluated
- *Discospermum sphaerocarpum*
  Conservation status: Not Evaluated
- Nepal Satyrium *(Satyrium nepalense)*
  Conservation status: Not Evaluated
- Nilgiri Rhododendron *(Rhododendron arboreum nilagiricum)*
  Conservation status: Not Evaluated
- Pearly Everlasting *(Anaphalis neelgerryana)*
  Conservation status: Not Evaluated
- Spotted Balsam/ Spotted Jewelweed *(Impatiens maculata)*
  Conservation status: Not Evaluated

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Nilgiri Pipit *(Anthus nilghiriensis Sharpe)*
Conservation status: Vulnerable



Nilgiri Tahr (Nilgiritragus hylocrius)
Conservation status: Endangered



Leopard (*Panthera pardus)*
Conservation status: Vulnerable



Gaur/Indian Bison (*Bos gaurus)*
Conservation status: Vulnerable



Anaimalai Spiny Lizard *(Salea anamallayana)*
Conservation Status: Least Concern



Nilgiri Flycatcher (*Eumyias albicaudatus)*
Conservation status: Least Concern



Broad-tailed Grassbird (*Schoenicola platyurus)*
Conservation status: Near Threatened

Fauna

Mammals

Dhole/Asiatic Wild Dog *(Cuon alpinus)*
Conservation status: Endangered

Tiger *(Panthera tigris)*
Conservation status: Endangered

Nilgiri Marten *(Martes gwatkinsii)*
Conservation status: Vulnerable

Birds

Nilgiri Sholakili *(Sholicola major)*
Conservation status: Near Threatened

Black Eagle *(Ictinaetus malaiensis)*
Conservation status: Least Concern

Reptiles

Sispara Day Gecko *(Cnemaspis sisparensis)*
Conservation status: Near Threatened

Horseshoe Pit Viper *(Craspedocephalus strigatus)*
Conservation status: Least Concern

Anamalai Wood Snake *(Xylophis mosaicus)*
Conservation status: Not Evaluated

Large-scaled Pit Viper *(Craspedocephalus macrolepis)*
Conservation status: Not Evaluated

Amphibians

Indigo Bush Frog *(Raorchestes indigo)*
Conservation status: Vulnerable

Invertebrates

Colour Sergeant *(Athyma nefte)*
Conservation status: Not Evaluated

Ground-dwelling Spider *(Oedignatha carli)*
Conservation status: Not Evaluated

Heavy Jumping Spider *(Hyllus diardi)*
Conservation status: Not Evaluated

Nilgiri Clouded Yellow *(Colias nilagiriensis)*
Conservation status: Not Evaluated

Red-disc Bushbrown *(Mycalesis oculus)*
Conservation status: Not Evaluated

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Rocky Plateaus of the Northern Western Ghats and the Konkan Coast

Geography

Rocky outcrops are areas with over 50% of exposed rocks. In the Western Ghats, they can be seen in the form of ferricretes across the states of Maharashtra, Goa, Karnataka and Keralam, or in the form of basaltic mesas in Maharashtra. Together they occur over large parts of the Western Ghats, from the sea coast to the foothills, mid-altitude and crestline of the northern Western Ghats. Vast expanses of these outcrops form plateaus, more extensively in the northern Western Ghats, with typically very shallow soil and little tree cover. The porous lateritic crust of these plateaus is formed by the weathering of the parent rock basalt, in the northern Western Ghats. Kaas plateau and Panchgani tableland are well-known examples.

These plateaus are culturally significant, lived-in landscapes: local communities rely on their biodiversity for ritual and festival practices, as well as for essential resources such as fodder and water.

Climate

The crestline of the Western Ghats and the windward western slopes that meet the coast receive high annual rainfall, over 3000 mm, mostly between June and September through the south-western monsoon for the northern and central portions of the Ghats.

The dry season along the western coast starts after the monsoon recedes. The temperature and humidity drop in the winter months with minimum temperatures around 20°C, episodically dropping below that. After peak winter in December-January, the temperatures gradually start rising along with humidity, with maximum temperatures reaching the upper 30s, rarely crossing 40°C in the peak summer.

On the other hand, the crestline, owing to the elevation and distance from the coast, experiences lower temperatures and humidity. After the retreat of monsoon, the temperatures begin to drop with single digit lows in winter and highs in the mid-20°C. Post winter temperatures increase to the mid-30°C in the peak summer months of April and May. In recent years, however, higher than average maximum temperatures in the range of upper 30s have been recorded during intense pre-monsoon heat waves. These extreme climatic fluctuations, together with the diversity of rocky microhabitats, create unique and highly ephemeral microclimatic conditions across the plateaus.

Key Ecological Features and Processes

Ephemeral and endemic floral diversity

Thin soils, high heat exposure in the summer, and heavy rainfall in the wet season make these rocky plateaus a harsh and inhospitable environment for many species that may thrive in the adjacent valley and slope forest habitats. This highly variable environment has resulted in the evolution of some unique flora that are highly seasonal, growing typically towards the tailend of the monsoon.

A majority of the flora are endemic to this habitat. Along with unique fauna, they form 'habitat islands' in these areas.

Rocky microhabitats

After the arrival of the monsoon, small water bodies with deep bowl-like depressions and small ephemeral pools (with shallower depressions) are formed as water accumulates during the rains. In case of lateritic plateaus, the porous rock itself acts like a sponge, retaining water and slowly releasing it to the small streams that originate here. Apart from the water-associated microhabitats, loose rocks, boulders, moss, lichen and grass root mats create a large number of unique microhabitats that are inhabited by endemic and threatened flora and fauna.

Boulder and rock microhabitats

Boulders and rocks on the plateau have been shown to support a range of species and contribute to the ecological functioning of these systems.

Conservation Status

Kaas Plateau in Satara district of Maharashtra is a protected biodiversity reserve spread over 10 square kilometres and has been designated a World Heritage Nature Site by UNESCO.

Several lateritic plateaus in Satara district have been designated as Conservation Zones under the Regional Plan prepared under the framework of The Maharashtra Regional and Town Planning (MRTP) Act of 1966, which regulates urban development and land use across Maharashtra. There are some promising community-led conservation initiatives, such as the proposal for designation of Ambolgad Plateau in Ratnagiri district as a Biodiversity Heritage Site.

While some scattered portions of high-elevation plateaus fall within the protected area network, almost all low-elevation plateaus or *sadas* are currently unprotected, with many areas classified as 'wasteland'.

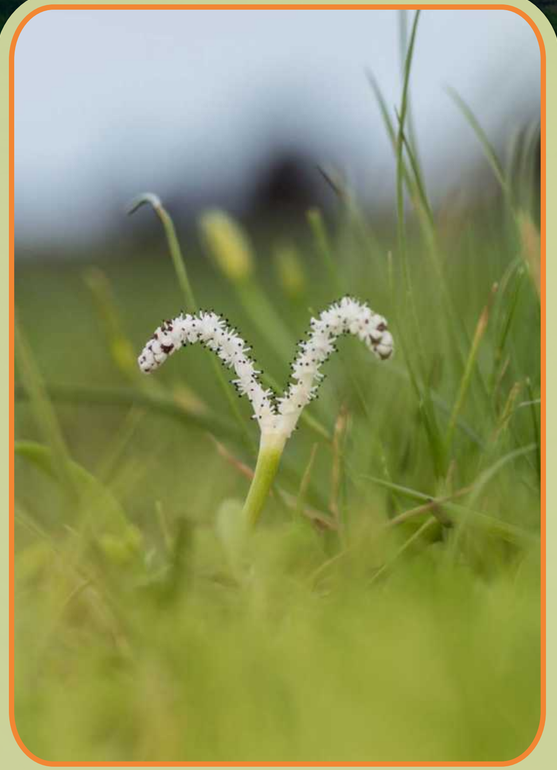
Human History



A geoglyph at Rundhe Tali, Ratnagiri district

The coastal laterite plateaus (locally called *sadas*) of the Konkan region have over a thousand geoglyphs, some perhaps 12,000 years old, carved by prehistoric communities, depicting fauna, including various terrestrial ones like elephant, tiger, monkey, buffalo, rabbit, boar, rhino, hippopotamus, aquatic animals like sharks, tortoise, fishes, sting rays, and birds like peacock, human figures, and abstract shapes and motifs including some complex labyrinths. Interestingly, many of the depicted animals have not been observed in this ecosystem for centuries. As of now nine sites are in the UNESCO Tentative World Heritage List.





Satara Aponogeton *(Aponogeton satarensis)*
Conservation Status: Endangered



Iphigenia ratnagirica
Conservation status: Endangered



Khandala Spurge *(Euphorbia panchganiensis)*
Conservation status: Not Evaluated



Konkan Dipcadi *(Dipcadi concanense)*
Conservation status: Endangered



Jaini Ceropegia *(Ceropegia jainii)*
Conservation status: Endangered



Indian Paddy-grass *(Wiesneria triandra)*
Conservation status: Least Concern



Panchgani Aamri *(Habenaria suaveolens)*
Conservation status: Not Evaluated



Tiny Bladderwort *(Utricularia praeterita)*
Conservation status: Near Threatened

Biodiversity

Flora

- *Eriocaulon ratnagiricum*
  Conservation status: Critically Endangered
- Sahyadri Rotala *(Rotala ritchiei)*
  Conservation status: Endangered
- *Cryptocoryne cognata*
  Conservation status: Vulnerable
- Purple-spike Lace Plant *(Aponogeton bruggenii)*
  Conservation status: Vulnerable
- Double Paired Smithia *(Smithia bigemina)*
  Conservation status: Least Concern
- Yellow Bane//Diskhead Knob-Bush *(Blumea lutea)*
  Conservation status: Least Concern
- *Amorphophallus konkanensis*
  Conservation status: Not Evaluated
- *Dimeria woodrowii*
  Conservation status: Not Evaluated
- *Jansenella neglecta*
  Conservation status: Not Evaluated
- *Dichanthium panchganiensis*
  Conservation status: Not Evaluated
- Pink Chaff Flower *(Achyranthes coynei)*
  Conservation status: Not Evaluated
- Shrirang Eulalia Grass *(Eulalia shrirangii)*
  Conservation status: Not Evaluated

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Superb Large Fan-throated Lizard *(Sarada superba)*
Conservation status: Critically Endangered



Hottentotta vinchu
Conservation status: Not Evaluated



White-striped Viper Gecko
(Hemidactylus albofasciatus)
Conservation status: Vulnerable



Satara Gecko *(Hemidactylus sataraensis)*
Conservation status: Critically Endangered



Long-legged Cricket Frog
(Minervarya syhadrensis)
Conservation status: Least Concern



Amboli Lateritic Toad *(Beduka amboli)*
Conservation status: Endangered



Pallid Harrier *(Circus macrourus)*
Conservation status: Endangered

Fauna

Mammals

- Dhole/Asiatic Wild Dog *(Cuon alpinus)*
  Conservation status: Endangered
- Bonnet Macaque *(Macaca radiata)*
  Conservation status: Vulnerable
- Gaur/ Indian Bison *(Bos gaurus)*
  Conservation status: Vulnerable
- Leopard *(Panthera pardus)*
  Conservation status: Vulnerable
- Sambar *(Rusa unicolor)*
  Conservation status: Vulnerable
- Sloth Bear *(Melursus ursinus)*
  Conservation status: Vulnerable
- Smooth-coated Otter *(Lutrogale perspicillata)*
  Conservation status: Vulnerable
- Indian Crested Porcupine *(Hystrix indica)*
  Conservation status: Least Concern
- Wild Boar *(Sus scrofa)*
  Conservation status: Least Concern

Birds

- Great Hornbill *(Buceros bicornis)*
  Conservation status: Vulnerable
- Black-backed Dwarf-kingfisher *(Ceyx erithaca)*
  Conservation status: Near Threatened
- Indian Courser *(Cursorius coromandelicus)*
  Conservation status: Near Threatened
- Malabar Lark *(Galerida malabarica)*
  Conservation status: Least Concern

Reptiles

- Bengal Monitor Lizard *(Varanus bengalensis)*
  Conservation status: Near Threatened
- Saw-Scaled Viper *(Echis carinatus)*
  Conservation status: Least Concern

Amphibians

- Koyna Toad *(Beduka koynayensis)*
  Conservation status: Endangered
- Humbarli Caecilian *(Indotyphlus maharashtraensis)*
  Conservation status: Data Deficient
- Amboli Bush Frog *(Pseudophilautus amboli)*
  Conservation status: Least Concern
- Seshachari's Caecilian *(Gegeneophis seshachari)*
  Conservation status: Least Concern

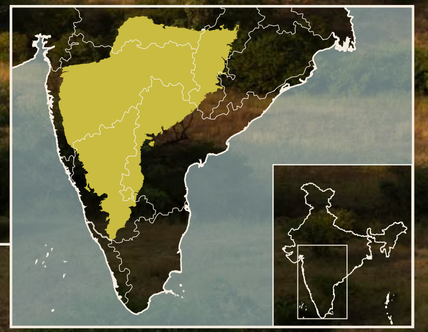
Invertebrates

- *Ghatiana rathbunae*
  Conservation status: Not Evaluated
- Hooded Grasshopper *(Teratodes monticollis)*
  Conservation status: Not Evaluated
- Konkan Rock Dweller *(Bradinopyga konkanensis)*
  Conservation status: Not Evaluated

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Deccan Plateau Mosaic: Grasslands, Savannas, and Thorn Scrub



Geography

The Deccan Plateau forms the central triangular region of peninsular India. It is bounded in the south by the conjunction of the Western and Eastern Ghats, which also marks its western and eastern boundaries respectively. The Vindhya and Satpura ranges form the Northern boundary. The plateau spans across the states of Maharashtra, Karnataka, Telangana, and interior and western parts of Andhra Pradesh with parts extending into northwestern Tamil Nadu. The overall terrain is hilly and gently undulating, with rocky outcrops (mesas and inselbergs).

Geologically, the northern Deccan Plateau is formed of the Deccan Volcanic Province made of the rock basalt which started forming around 66 million years ago. The majority of the southern part of the Deccan plateau is underlain by Dharwar craton, formed of one of the oldest rocks on the subcontinent, and at the eastern fringe is the Cuddapah basin which has largely sedimentary rocks.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~700 mm
Average annual rainfall

<500 mm to >1000 mm
Annual rainfall range

Winter

OCTOBER TO FEBRUARY

December–January
Peak

<5°C
Minimum Temperature

Summer

MARCH TO JUNE

April–May
Peak

>45°C
Maximum Temperature

Key Ecological Features and Processes

The tropical semi-arid savanna character

The Deccan savannas represent ancient open natural ecosystems with distinct ecological and evolutionary histories. They are maintained by complex interactions between factors such as rainfall, topography, geology, herbivory, fire, and human activities. This balance is what gives the plateau its distinctive savanna mosaic of open grassland with scattered trees and scrub.

Fire ecology

Fire is a defining process in the Deccan grasslands, and a powerful engine of nutrient cycling and renewal. Many endemic grassland species also possess adaptations linked to historical fire and grazing regimes, including below-ground bud banks and fire-stimulated germination, suggesting that these processes have played a key role in maintaining endemic diversity. The dominant grasses, *Sehima* and *Dichanthium* species, for example, are fire-adapted.

Fully suppressing seasonal fires may in fact reduce biodiversity by allowing woody encroachment to threaten the open habitat on which grassland species depend. What matters, however, is the fire regime: the timing, frequency, and intensity of burns. Unseasonal or uncontrolled fires, particularly during the breeding season of birds, can be as damaging as fire suppression: ground-nesting birds like the great indian bustard are acutely vulnerable to poorly timed burns.

Herbivory and agropastoralism

The Deccan savannas support herbivores like the blackbuck and Indian gazelle which are the prey of predators like the Indian wolf. Grazing and browsing by these herbivores as well as livestock such as goats and sheep actively shape vegetation structures. Traditional grazing practices, including seasonal migration, are an integral part of this ecosystem.

Water-efficient, below-ground carbon storage

The grasslands and savannas of the Deccan Plateau are important carbon sinks, capable of storing substantial carbon below ground within extensive root systems that are comparatively less vulnerable to seasonal fires. Unlike forests, where carbon is largely stored in above-ground woody biomass, Deccan grasslands retain a significant proportion of carbon below ground, enhancing long-term stability and resilience.

Soil-topography-vegetation gradient: Conditions for grassland, savanna, or scrub development

A combination of factors like soil depth and moisture, and slope of the land determines whether a patch of land becomes grassland or thorny scrubland. Shallow, rocky soils on slopes favour grasses that can handle drought and poor nutrients, while deeper soils in valleys and gentler terrain accumulate more moisture and organic matter, allowing shrubs and small trees to establish and persist.



Diversity and endemism of grasses, herbs, and forbs

Savannas and grasslands of the Deccan region support a highly diverse and structurally complex herbaceous layer characterized by remarkable local-scale species packing. Studies like the 2023 study by Nerlekar et al., explore this in detail. Undisturbed, baseline communities maintain an average native richness of 12 species/m^2 and a total native ground cover of 49% during the peak monsoon growing season. This rich floristic matrix is split into distinct functional groups, heavily dominated by non-woody plants. Specifically, the ground layer is structurally anchored by long-lived perennial C4 grasses such as *Cymbopogon martini*, *Chrysopogon fulvus*, *Sehima nervosum*, and *Heteropogon contortus*, alongside specialized annual native grasses like *Melanocenchris jacquemontii* and *Oropetium thomaeum* that occupy shallower soils.

Complementing the dominant grass-like plants is an extremely diverse suite of seasonal native forbs and herbs that comprise the vast majority of the plant community's total species richness. This flora is characterised by specialized open-habitat indicators such as *Cyanotis fasciculata*, *C. tuberosa* and *Vigna indica*. Evolutionary adaptation to open sunny habitats, highly seasonal rainfall, and frequent grass-fueled surface fires as well as herbivory - which are known as disturbance regimes - has driven high habitat specialization within this regional species pool. The unique ecological value of this herbaceous layer is underscored by its distinct composition: out of 175 total species documented in the region's reference old-growth savannas, 65 native ground-layer specialists are completely restricted to these intact ecosystems and are entirely missing from human-modified or degraded landscapes.

Conservation Status

There are several protected areas in this region like the Great Indian Bustard Sanctuary (also known as Jawaharlal Nehru Bustard Sanctuary) at Nannaj in Maharashtra, Rollapadu Wildlife Sanctuary (WLS) in Andhra Pradesh, Ranibennur Blackbuck Sanctuary in Karnataka, Jayamangali Blackbuck Conservation Reserve in Karnataka, and Pocharam WLS in Telangana. However, compared to the total area of this mosaic, very little falls under protected area.



People and Livelihoods



Dhangar pastoralist

Dhangar (Maharashtra)
A sheep and cattle herding group of the Maharashtra region of the Deccan, they migrate between savannas and agricultural regions seasonally, rearing the hardy, indigenous Dakhni sheep and weaving gongadi (woollen blankets) and carry a rich oral tradition of *Ovee* singing.

Kuruba / Kuruma / Kuruva (Karnataka, Telangana, Andhra Pradesh)
The principal shepherd community of the Deccan plateau, they herd sheep and goats, weave woollen blankets, and carry a rich oral tradition of *Oggu Katha* storytelling.

Golla (Telangana, Andhra Pradesh, Karnataka)
A cattle and sheep herding group, many Golla practise semi-nomadic transhumance across the plateau, providing milk, ghee, and wool for local markets.

Banjara / Lambadi / Lambada / Lamani / Gor / Sugali (across the entire Deccan)
Originally nomadic pastoralists and traders, most Banjara are today settled in tanda (settlements) across the Deccan, many maintaining cattle alongside practising agriculture.



Indian Spurge Tree *(Euphorbia neriifolia)*
Conservation status: Least Concern



Anjan *(Hardwickia binata)*
Conservation status: Least Concern



Khair/Black Cutch *(Senegalia catechu)*
Conservation status: Least Concern



Bor/Indian Jujube *(Ziziphus mauritiana)*
Conservation status: Least Concern

Biodiversity

Flora

- Razi's Squill *(Drimia razii)*
  Conservation status: Endangered
- Dwarf Jatropha/Kirkundi *(Jatropha nana)*
  Conservation status: Vulnerable
- Devbabhal/White Bark Acacia *(Vachellia leucophloea)*
  Conservation status: Least Concern
- Desert Date/Hingot/Hingan *(Balanites roxburghii)*
  Conservation status: Least Concern
- Indian Ash Tree *(Lannea coromandelica)*
  Conservation status: Least Concern
- Indian Frankincense/Salai *(Boswellia serrata)*
  Conservation status: Least Concern
- Roundleaf Jujube *(Ziziphus nummularia)*
  Conservation status: Least Concern
- Black Speargrass *(Heteropogon contortus)*
  Conservation status: Not Evaluated
- Caucasian Bluestem *(Bothriochloa bladhii)*
  Conservation status: Not Evaluated
- Hooked Mimosa *(Mimosa hamata)*
  Conservation status: Not Evaluated
- Kangaroo Grass *(Themeda triandra)*
  Conservation status: Not Evaluated
- Marvel Grass/Sheda Grass *(Dichanthium annulatum)*
  Conservation status: Not Evaluated
- Pitted Bluestem Grass *(Eremopogon foveolatus)*
  Conservation status: Not Evaluated
- Rat-tail Grass/White Grass *(Sehima nervosum)*
  Conservation status: Not Evaluated
- *Capparis spp.*

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Indian Wolf *(Canis lupus pallipes)*
Conservation status: Vulnerable



Lesser Florican *(Sypheotides indicus)*
Conservation status: Critically Endangered



Painted Sandgrouse *(Pterocles indicus)*
Conservation status: Least Concern



Indian Courser *(Cursorius coromandelicus)*
Conservation status: Near Threatened



Indian Fox *(Vulpes bengalensis)*
Conservation status: Least Concern



Yellow-wattled Lapwing *(Vanellus malabaricus)*
Conservation status: Least Concern



Saw-scaled Viper *(Echis carinatus)*
Conservation status: Least Concern

Fauna

Mammals

- Indian Pangolin *(Manis crassicaudata)*
  Conservation status: Endangered
- Striped Hyena *(Hyaena hyaena)*
  Conservation status: Near Threatened
- Blackbuck *(Antilope cervicapra)*
  Conservation status: Least Concern
- Chinkara/Indian Gazelle *(Gazella bennettii)*
  Conservation status: Least Concern
- Golden Jackal *(Canis aureus indicus)*
  Conservation status: Least Concern
- Indian Hare *(Lepus nigricollis)*
  Conservation status: Least Concern

Birds

- Great Indian Bustard *(Ardeotis nigriceps)*
  Conservation status: Critically Endangered
- Jerdon's Courser *(Rhinoptilus bitorquatus)*
  Conservation status: Critically Endangered
- Pallid Harrier *(Circus macrourus)*
  Conservation status: Near Threatened
- Ashy-crowned Sparrow-lark *(Eremopterix grisea)*
  Conservation status: Least Concern
- Chestnut-bellied Sandgrouse *(Pterocles exustus)*
  Conservation status: Least Concern
- Indian Bushlark *(Mirafra erythroptera)*
  Conservation status: Least Concern
- Montagu's Harrier *(Circus pygargus)*
  Conservation status: Least Concern
- Rock Bush Quail *(Perdicula argoondah)*
  Conservation status: Least Concern
- Sykes's Crested Lark *(Galerida deva)*
  Conservation status: Least Concern

Reptiles

- Indian Star Tortoise *(Geochelone elegans)*
  Conservation status: Vulnerable
- Indian Monitor Lizard *(Varanus bengalensis)*
  Conservation status: Near Threatened
- Deccan Fan-throated Lizard *(Sarada deccanensis)*
  Conservation status: Least Concern
- Indian Cobra *(Naja naja)*
  Conservation status: Least Concern
- Russell's Viper *(Daboia russelii)*
  Conservation status: Least Concern

Invertebrates

- Assassin Bug *(Rhaphidosoma atkinsoni)*
  Conservation status: Not Evaluated
- Jumping Spider *(Mogrus pune)*
  Conservation status: Not Evaluated

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NE	DD	LC	NT	VU	EN	CR	EW	EX

Scattered across the Deccan Plateau of peninsular India, isolated rocky hillocks rise abruptly from the surrounding plains in a landform known as inselbergs, from the German *Inselberg*, meaning island mountain. Their elevations vary considerably, from modest hills of around 250 metres, such as the Gingee Hills in Viluppuram district, Tamil Nadu, to massifs approaching 1,500 metres, such as Nandi Hills in Chikkaballapur district, Karnataka. Structurally, these outcrops occur in several forms, dome-shaped monoliths, exposed rock sheets, and tors, the latter characterised by stacked or loosely aggregated boulder formations. In certain areas they occur not in isolation but as spatially clustered groupings across the landscape.

Geologically, these outcrops are of considerable antiquity and scientific significance. They belong to two major Precambrian geological provinces: the Dharwar Craton and the Southern Granulite Terrain, both of which predate the volcanic basalt formations of the northern Deccan Plateau. The granitoid gneiss of the Dharwar Craton ranks among the oldest exposed rock in India. The regional geology is dominated by hard igneous and metamorphic lithologies — granite, granitic gneiss, charnockite, and khondalite.

Soils on these hillocks are extremely thin where present at all, and the vegetation reflects this constraint. Dry scrub dominates, with tree cover sparse and discontinuous. Rocky cliff faces provide nesting substrate for cliff-dependent birds including vultures and owls, while boulder fields and cave systems offer denning, resting, and shelter habitat for a diverse assemblage of native fauna. Large carnivores and megafauna — leopard, sloth bear, striped hyena, and Indian wolf — are among the species that rely on these structural features, alongside a suite of mesocarnivores including the golden jackal, jungle cat, and Indian fox. At finer scales, moisture retained within rock crevices sustains discrete microhabitats that support invertebrates, reptiles, and specialised plant communities including mosses and ferns.



Ephemeral Rock Pool

Deccan Rocky Outcrops:
Inland Hills, Hillocks, and Inselbergs

Biodiversity

Flora

- Beddome's Cycad/Peritha *(Cycas beddomei)*
  Conservation status: Endangered
- Swallow-root *(Decalepis hamiltonii)*
  Conservation status: Endangered
- Malaipuvarasu *(Hildegardia populifolia)*
  Conservation status: Near Threatened
- Anjan/Indian Blackwood *(Hardwickia binata)*
  Conservation status: Least Concern
- Indian Spurge Tree *(Euphorbia neriifolia)*
  Conservation status: Least Concern
- Jackal Jujube *(Ziziphus oenoplia)*
  Conservation status: Least Concern
- Num-num *(Carissa spinarum)*
  Conservation status: Least Concern
- Soft Fig/Donkey Banyan *(Ficus mollis)*
  Conservation status: Least Concern
- Teak *(Tectona grandis)*
  Conservation status: Least Concern
- Woolly-leaved Fire-brand Teak *(Premna tomentosa)*
  Conservation status: Least Concern
- Andhra Spider Star *(Ceropegia pullaiahii)*
  Conservation status: Data Deficient
- *Euphorbia deccanensis*
  Conservation status: Not Evaluated



Krishna Siris *(Albizia amara)*
Conservation status: Least Concern



Kolar Leaf-nosed Bat *(Hipposideros hypophyllus)*
Conservation status: Critically Endangered



Painted Spurfowl *(Galloperdix lunulata)*
Conservation status: Least Concern





Yellow-throated Bulbul *(Pycnonotus xantholaemus)*
Conservation status: Least Concern

Fauna

Mammals

- Grey Slender Loris *(Loris lydekkerianus)*
  Conservation status: Near Threatened
- Madras Treeshrew *(Anathana ellioti)*
  Conservation status: Least Concern

Birds

- Jerdon's Courser *(Rhinoptilus bitorquatus)*
  Conservation status: Critically Endangered
- White-naped Tit *(Machlolophus nuchalis)*
  Conservation status: Near Threatened

Reptiles

- Deccan Fan-throated Lizard *(Sarada deccanensis)*
  Conservation status: Least Concern
- Indian Golden Gecko *(Calodactylodes aureus)*
  Conservation status: Least Concern
- Gokak Fan-throated Lizard *(Sitana gokakensis)*
  Conservation status: Data Deficient
- Malabar Toad *(Firouzophrynus hololius)*
  Conservation status: Data Deficient
- Deccan Wolf Snake *(Lycodon deccanensis)*
  Conservation status: Not Evaluated
- Mahony's Rock Gecko *(Hemidactylus mahonyi)*
  Conservation status: Not Evaluated
- Srikanthan's Rock Gecko *(Hemidactylus srikanthan)*
  Conservation status: Not Evaluated

The Central Indian Highlands are amongst the most important wildlife habitats in India. Surrounded by the Indo-Gangetic Plains to the north and east, the Deccan Plateau to the south, and the Aravalli range to the northwest, and transitioning into Chota Nagpur Plateau in the east through the Rajmahal Hills. The 'spine' of the Highlands comprises of two mountain ranges — the Vindhya (northern) and the Satpura (southern) — separated by the Narmada river valley. The eastern part of the Satpuras range, called the Maikal hills, and a southern spur of the Vindhyas meet at Amarkantak plateau, where the river Narmada originates. The highlands slope towards the north and northeastern directions.

Called 'highlands' due to average elevation ranging between 700 to 1000 metres above the mean sea level, the region has an overall slope towards the north-northeastern direction. Many rivers originating here (like Ken, Betwa) are tributaries of Yamuna, which is a tributary of Ganga. The Narmada, however, is a notable exception — it flows westward through a pre-existing east-west tectonic trough or rift valley (a geological feature), which guides its course toward the Arabian Sea. The Son river, meanwhile, flows northeastward to join the Ganga.

This highly forested region receives most of its monsoonal rainfall between June and September, ranging from 900 mm to 1,600 mm (increasing generally from the west to the east), followed by a cool, dry winter and a hot summer. The Central Highlands are a mosaic of forested and open canopied areas with transition gradients, rather than abrupt boundaries (like the shola-grassland system of the southern Western Ghats), the open natural ecosystems (ONEs) in these areas are formed mainly due to factors such as slopes and soil thickness, and human alterations. The slopes and plateaus of the Vindhya and the Satpura ranges host extensive grasslands. Some areas are covered by scrublands and many by woodland / wooded savannas. Large areas of these woodland savannas have traditionally been described and categorised as dry deciduous forests.

There are also human-maintained meadow patches, especially in the tiger reserves, where ungulates such as chital deer thrive and help maintain the population of tigers. Many of these patches would see woodland growth if not maintained artificially.

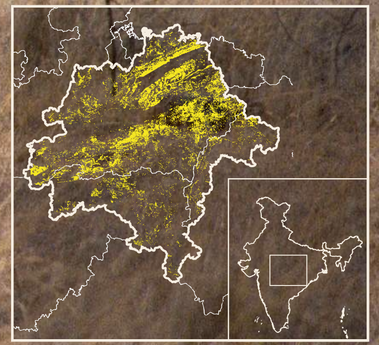
However, large parts of the Central Highlands region have been converted to agriculture or other human land-uses and the natural ecosystems such as forests and ONEs are reduced to a limited area compared to their original extent, with corridors between patches becoming increasingly vulnerable.

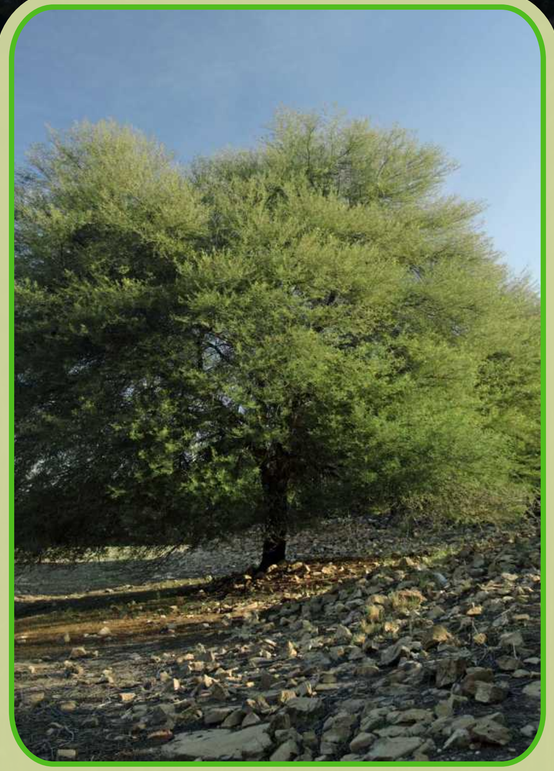
Conservation Status

The Central Highlands host most of the Tiger Reserves (TR) in India: Kanha, Pench, Bandhavgarh, Satpura, Panna, Sanjay-Dubri, the recently notified Veerangana Durgavati (formed largely from the Nauradehi Sanctuary), and Madhav in the state of In Madhya Pradesh, and Melghat, Tadoba-Andhari, Bor, and Nawegaon-Nagzira in Maharashtra. Chhattisgarh hosts Achanakmar, and, on the eastern fringe, Udanti-Sitanadi and Indravati TRs. Tadoba is Maharashtra's oldest and largest national park and one of India's largest Project Tiger reserves.

There are numerous Wildlife Sanctuaries (WLS) such as Bori, Pachmarhi, Phen, Ratapani, Singhori, Ken Gharial, Karera, and Bagdara, many of which act as corridors. These corridors provide critical connectivity between key reserves like Tadoba, Pench, Bor, and Nagzira. Many of these corridors are formally recognised by the National Tiger Conservation Authority or Wildlife Institute of India, such as Kanha–Pench, Pench–Satpura, Satpura–Melghat and Kanha–Achanakmar, and their functionality for tiger dispersal is supported by landscape-genetic and connectivity studies in Central India.

Savannas within the Central Highlands Mosaic





Babul/Indian Gum Arabic Tree *(Vachellia nilotica)*
Conservation status: Least Concern



Malabar Melastome *(Melastoma malabathricum)*
Conservation status: Not Evaluated



Chinese Hat Plant *(Holmskioldia sanguinea)*
Conservation status: Not Evaluated



Lance-leaved Blumea *(Blumea lanceolaria)*
Conservation status: Not Evaluated



Orange Jasmine *(Murraya paniculata)*
Conservation status: Not Evaluated



Black Speargrass *(Heteropogon contortus)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Short Beardgrass *(Schizachyrium brevifolium)*
  Conservation status: Least Concern
- Dimeria Grass *(Dimeria connivens)*
  Conservation status: Not Evaluated
- Interrupted Sophora *(Sophora interrupta)*
  Conservation status: Not Evaluated
- Jacquemont's Tripogon *(Tripogon jacquemontii)*
  Conservation status: Not Evaluated
- Kangaroo Grass *(Themeda triandra)*
  Conservation status: Not Evaluated
- Scented Bluestem *(Bothriochloa odorata)*
  Conservation status: Not Evaluated

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	NE	DD	LC	NT	VU	EN	CR	EW	EX



Tiger *(Panthera tigris)*
Conservation status: Endangered



Barasingha/Swamp Deer
(Rucervus duvaucelii branderi)
Conservation status: Vulnerable



Dhole/Asiatic Wild Dog *(Cuon alpinus)*
Conservation status: Endangered



Rough-scaled/Common Sand Boa *(Eryx conicus)*
Conservation status: Near Threatened



Gaur/Indian Bison *(Bos gaurus)*
Conservation status: Vulnerable



Chital/Spotted Deer *(Axis axis)*
Conservation status: Least Concern



Red Sand Boa *(Eryx johnii)*
Conservation status: Near Threatened

Fauna

Mammals

- Asian Elephant *(Elephas maximus)* — Conservation status: Endangered
- Indian Pangolin *(Manis crassicaudata)* — Conservation status: Endangered
- Four-horned Antelope/Chousingha *(Tetracerus quadricornis)* — Conservation status: Vulnerable
- Leopard *(Panthera pardus)* — Conservation status: Vulnerable
- Sambar *(Rusa unicolor)* — Conservation status: Vulnerable
- Madras Treeshrew *(Anathana ellioti)* — Conservation status: Least Concern
- Nilgai *(Boselaphus tragocamelus)* — Conservation status: Least Concern

Birds

- Pallid Harrier *(Circus macrourus)* — Conservation status: Near Threatened
- Ashy-crowned Sparrow-lark *(Eremopterix griseus)* — Conservation status: Least Concern
- Crested Bunting *(Emberiza lathami)* — Conservation status: Least Concern
- Crested Goshawk *(Accipiter trivirgatus)* — Conservation status: Least Concern
- Indian Pitta *(Pitta brachyura)* — Conservation status: Least Concern
- Painted Francolin *(Francolinus pictus)* — Conservation status: Least Concern
- Painted Spurfowl *(Galloperdix lunulata)* — Conservation status: Least Concern
- Scaly-breasted Munia *(Lonchura punctulata)* — Conservation status: Least Concern
- Skyke's Lark *(Galerida deva)* — Conservation status: Least Concern
- Yellow-eyed Babbler *(Chrysomma sinense)* — Conservation status: Least Concern

Reptiles

- Banded Racer *(Argyrogena fasciolata)* — Conservation status: Least Concern
- Central Indian Leaf-toed Gecko *(Hemidactylus chipkali)* — Conservation status: Least Concern
- Common Krait *(Bungarus caeruleus)* — Conservation status: Least Concern
- Common Kukri Snake *(Bungarus caeruleus)* — Conservation status: Least Concern
- Indian Cobra *(Naja naja)* — Conservation status: Least Concern
- Indian Rat Snake *(Ptyas mucosa)* — Conservation status: Least Concern
- Russell's Viper *(Daboia russelii)* — Conservation status: Least Concern
- Satpura Eyelid Gecko *(Eublepharis satpuraensis)* — Conservation status: Least Concern

IUCN RED LIST

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When Project Tiger was launched in 1973, the reserves that were established enclosed villages, seasonal fields, common grazing grounds, and the open lands that came with them. As communities were relocated out of core zones over the following decades, these cleared and cultivated areas did not revert to forest. They quickly became grasslands and meadows, attracting herbivores, and becoming productive wildlife habitat in the reserve. In many reserves they were formally designated as managed grazing grounds brought under periodic controlled burning, mowing, and water management. What emerged over decades were the *maidans*, *dhanis*, and *chaurs* that are today among the most wildlife-rich patches in any reserve in India.

The form these arrested successional grasslands take varies considerably by reserve and landscape. In Kanha Tiger Reserve in Madhya Pradesh, the meadows occupy the sites of former villages relocated after the reserve's establishment, sitting on fertile black cotton soils in the valley floor of the Halon and Banjar rivers. Managed through controlled burns in February and March and periodic invasive and brush removal, they support *Dichanthium-dominated* short-grass communities of exceptional palatability, and hold the world's only viable population of the hard-ground barasingha (*Rucervus duvaucelii branderi*), a subspecies recovered from fewer than 100 individuals in the early 1970s to over 800 today through targeted grassland management alone. In Ranthambore in Rajasthan, the meadows take a different form: they are lake-margin grasslands fringing the seasonal waterbodies of Padam Talao, Malik Talao, and Raj Bagh, occupying former agricultural land within what is now a predominantly Tropical dry thorn forest and scrub savanna landscape. Here the combination of open grazing ground and reliable dry-season water creates conditions of extraordinary wildlife density, sustaining the chital, sambar, and nilgai populations that underpin one of India's most celebrated tiger populations. In Tadoba-Andhari in Maharashtra, open glades punctuate the teak forest across the sites of former village settlements in the core zone, their black cotton soils supporting Dichanthium grassland interspersed with seasonal wetlands that concentrate chital and gaur in numbers that sustain one of Maharashtra's highest tiger densities. In Nagarahole in Karnataka, the clearings are known as *hadlu*, a Kannada term for the former paddy fields of communities relocated after the reserve's establishment. Embedded within the moist deciduous and semi-evergreen forest matrix of the Western Ghats foothills, these *hadlu* are open glades of exceptional ecological value in an otherwise densely canopied landscape, their former paddy soils sustaining lush, palatable grass growth that draws the highest densities of chital, sambar, gaur, and elephant in the reserve, and concentrating tiger and leopard activity to a degree rare in southern India.

The rationale for maintaining all of these landscapes is ultimately one of prey biomass. Tigers are, despite their forest association in popular imagination, animals of the forest-grassland ecotone. They hunt in grasslands, rest at forest margins, and depend on the mosaic of open and closed habitat. Beyond tigers, these anthropogenic meadows support a disproportionate share of their reserves' biodiversity. The *hadlu* of Nagarahole, the lake-margin grasslands of Ranthambore, the village-site meadows of Tadoba, and the managed maidans of Kanha and Bandhavgarh all function as focal points of ecological activity, places where predator and prey interact at high densities, where open-country birds find habitat within a forested landscape, and where the invertebrate communities of short grass thrive absent from the surrounding canopy.

Left to natural succession, all of these clearings would transition toward scrub and closed canopy within decades. Their persistence depends on controlled burning, mechanical woody removal, invasive weed management, particularly against *Lantana camara*, which now occupies large tracts within Bandhavgarh, Kanha, Tadoba, and Nagarahole. The maintenance of these grasslands is an integral part of management of the reserve and a proud showcase of wildlife habitat development within these protected areas.

Grasslands and Meadows of the Tiger Reserves of India

Ravine Lands of Central India: Yamuna Chambal Zone

Geography

Ravine lands are landscapes with a high density network of gullies or narrow channels formed by the erosive action of water on the soils or rocks it passes through. Ravine lands comprise severely eroded soils with sparse vegetation, and an uneven terrain that makes them highly unsuitable for agriculture. While ravine lands are found along many rivers in India, four major zones have been recognised: Yamuna-Chambal zone, Gujarat zone, Shiwalik Foothills zone, and the Chhota Nagpur plateau zone. Other than these, some notable ravine formations are the Erra Matti Dibbalu (coastal red-sand) in Andhra Pradesh, Adula-Mahalungi located along the banks of two tributaries of River Pravara in Godavari basin, and the Lamayuru Palaeolake gully formation(also known as Lamayuru Moonland) in the Ladakh Himalayas, which is the highest altitude ravine landscape in India.

The ravine lands of the Yamuna-Chambal zone of North-central India are the most extensive and well-known ravines of the country. Chambal, the longest tributary of the Yamuna river, flows for about a thousand kilometres, originating from Janapav valley in the Vindhyan range, in the north-northeast direction through the states of Madhya Pradesh, Rajasthan, and Uttar Pradesh. The ravines along the Chambal stretch for 480 kilometres and occupy an area of almost five thousand square kilometres, with some sections as wide as 10-12 km.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

700–900 mm
Average annual rainfall

Winter

NOVEMBER TO FEBRUARY

January
Peak

5–8°C, sometimes near freezing
Winter Minimum Temperatures

Summer

MARCH TO JUNE

May and June
Peak

>45°C, sometimes beyond 48°C
Maximum Temperature

Key Ecological Features and Processes

The Yamuna-Chambal ravine lands are one of the most extensive and spectacular **erosive landscapes** of India. The common landforms observed are deep trenches, ridges with steep scarps, and hills and hillocks. The upstream rills and gullies, less than a metre deep and narrow, become wider ravines stretching across 20 m or more and deeper than 50 m, as you move downstream towards the confluence with Yamuna. These gullies and ravines form an intricate network giving the landscape a dissected and rugged appearance.

Conservation Status

The National Chambal Sanctuary is a ~1800 square kilometres protected area administered by the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh. A stretch of 625 kilometres of the Chambal River is part of the tri-state riverine sanctuary which was established between 1979 and 1983 to protect the gharial, a critically endangered species.



People and Livelihoods

Sahariya / Saharia

Classified as a Particularly Vulnerable Tribal Group (PVTG), the Sahariya are traditionally forest-dwellers, subsisting on the collection of minor forest produce such as gum, tendu leaves, honey, and medicinal herbs, alongside small-scale cultivation and wage labour.

Nishad
Kurmi
Meena
Gujjar (**Gurjar**)
Rajput (**like Tomar, Bhadauria**)
Yadav (**Ahir**)
Jatav



Flame of the Forest/Palash *(Butea monosperma)*
Conservation Status: Least Concern



Trellis-vine *(Pergularia daemia)*
Conservation status: Endangered



Harra *(Terminalia chebula)*
Conservation status: Least Concern



Balloon Vine *(Cardiospermum halicacabum)*
Conservation status: Least Concern



Karira/Bare Caper *(Capparis decidua)*
Conservation status: Least Concern



Tendu *(Diospyros melanoxylon)*
Conservation status: Not Evaluated



Broom Creeper *(Cocculus hirsutus)*
Conservation status: Not Evaluated



Indian Elm Tree *(Holoptelea integrifolia)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Babul/Indian Gum Arabic Tree *(Vachellia nilotica)*
  Conservation status: Least Concern
- Ber/Indian Jujube *(Ziziphus mauritiana)*
  Conservation status: Least Concern
- Dhok/Dhonk/Kardhai *(Anogeissus pendula)*
  Conservation status: Least Concern
- Khair/Black Cutch *(Senegalia catechu)*
  Conservation status: Least Concern
- Miswak/Meswak *(Salvadora persica)*
  Conservation status: Least Concern
- Sheesham/North Indian Rosewood *(Dalbergia sissoo)*
  Conservation status: Least Concern

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Striped Hyena *(Hyaena hyaena)*
Conservation status: Near Threatened



Sloth Bear *(Melursus ursinus)*
Conservation status: Vulnerable



Bengal Monitor Lizard *(Varanus bengalensis)*
Conservation status: Near Threatened



Sarus Crane *(Grus antigone)*
Conservation status: Vulnerable



Indian Rock Python *(Python molurus)*
Conservation status: Near Threatened



Egyptian Vulture *(Neophron percnopterus)*
Conservation status: Endangered



Black Francolin *(Francolinus francolinus)*
Conservation status: Least Concern

Fauna

Mammals

- Indian Wolf *(Canis lupus pallipes)* — Conservation status: Vulnerable
- Leopard *(Panthera pardus)* — Conservation status: Vulnerable
- Blackbuck *(Antilope cervicapra)* — Conservation status: Least Concern
- Desert Fox *(Vulpes vulpes pusilla)* — Conservation status: Least Concern
- Golden Jackal *(Canis aureus indicus)* — Conservation status: Least Concern
- Indian Gazelle/Chinkara *(Gazella bennettii)* — Conservation status: Least Concern
- Indian Long-eared Hedgehog *(Hemiechinus collaris)* — Conservation status: Least Concern
- Jungle Cat *(Felis chaus)* — Conservation status: Least Concern
- Nilgai *(Boselaphus tragocamelus)* — Conservation status: Least Concern

Birds

- Indian Vulture *(Gyps indicus)* — Conservation status: Critically Endangered
- Black-necked Stork *(Ephippiorhynchus asiaticus)* — Conservation status: Least Concern
- Bonelli's Eagle *(Aquila fasciata)* — Conservation status: Least Concern

Reptiles

- Gharial *(Gavialis gangeticus)* — Conservation status: Critically Endangered
- Red-crowned Roofed Turtle *(Batagur kachuga)* — Conservation status: Critically Endangered
- Marsh Crocodile *(Crocodylus palustris)* — Conservation status: Vulnerable
- Rough-tailed Sand Boa *(Eryx conicus)* — Conservation status: Near Threatened
- Jerdon's Snake-eye *(Ophisops jerdonii)* — Conservation status: Least Concern
- Small-scaled Lacerta *(Ophisops microlepis)* — Conservation status: Least Concern
- Russell's Kukri Snake *(Oligodon taeniolatus)* — Conservation status: Least Concern

IUCN RED LIST

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Scrub Savanna Mosaic of the Aravallis



Geography

One of the oldest mountain ranges in India and indeed the world, the Aravallis started forming at least 1.8 billion years ago and consist of rocks even older, about 2.5 billion years old. Eroded over hundreds of millions of years, they now average between 300 to 900 metres above mean sea level, with the highest peak, Guru Shikhar in Mount Abu, Rajasthan, reaching 1,722 metres — a fraction of their original height. Running in the southwest-northeastern direction for about 692 kilometres through the states of Gujarat, Rajasthan, Haryana and the union territory of Delhi, Aravallis form a natural barrier between the Thar Desert to the west and the Indo-Gangetic plains to the east.

The ranges' slopes and valleys support mosaics of open natural ecosystems that together define the Aravalli landscape: scrublands, grasslands, rocky outcrops, and seasonal salt flats and plains. Of these, the savanna shrubland — or scrub — is the most extensive, carpeting vast stretches of the hills and their foothills in a hardy, drought-adapted vegetation that is distinct from — though ecologically linked to — the more arid expanses of the Thar to the west. To the southeast, the mosaic dominated by Open Natural Ecosystems (ONEs) gradually gives way to the denser tropical dry forests of the Vindhyan highlands. However, the invasive plant species like *Neltuma juliflora* and increasingly *Lantana camara* now cover vast tracts of the Aravalli hills, replacing the native trees and scrub species that once dominated this landscape. Most of the dune landscapes are dominated by another exotic tree species, *Vachellia tortilis*, that was planted to stabilise the dunes since the 1980s.

The Aravalli hills have forests of *Boswellia serrata* and associated species on the steep rocky outcrops. Where the terrain is more contiguous, the forests are mainly of *Terminalia pendula* (locally known as dhok) almost forming a closed canopy. Some 100 tree species, 60 shrub species and 100 odd understory species are found in these forests.

The valleys within the hill system have denser vegetation as micro-climates make diverse species possible. *Mitragyna parvifolia* (kadam), *Ficus racemosa* (goolar) and other associate species are found in these valleys.

A large part of the western edge of the Aravallis landscape is sand, sandy loamy and obstruction dunes. This holds sparse vegetation and has communities of *Prosopis cineraria* (khejdi), *Capparis decidua* (kair), *Tecomella undulata* (roheda), *Salvadora oleoides* (meethi jaal), *Gymnosporia senegalensis* (kanker) and large shrub community such as *Ziziphus nummularia* (jhadber), *Leptadenia pyrotechnica* (kheemp), *Vachellia jacquemontii* (buibawal), *Clerodendron phlomides* (arni) and others. Roughly 200 species of perennial and ephemeral grasses, and forbs are found here.

The salt pans have different communities of plants such as *Salvadora persica* (khari jaal), *Sueda fruticosa*, and several salt tolerant grasses and forbs.

Climate

Rainfall

JUNE TO SEPTEMBER

~500 mm
Average Annual Rainfall

400 mm–>870 mm
Rainfall variability

Summer

MARCH TO JUNE

May and June
Peak

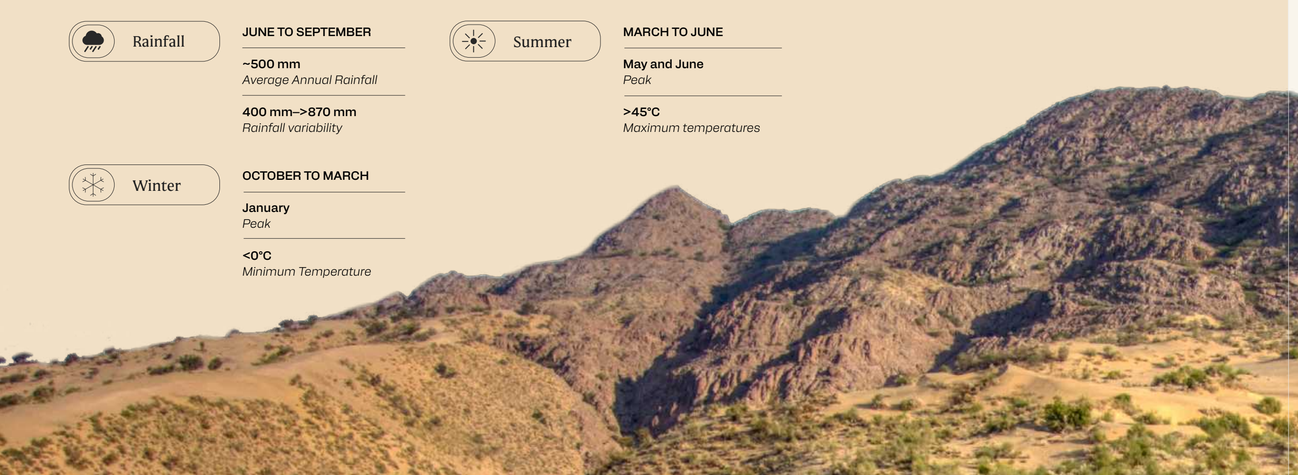
>45°C
Maximum temperatures

Winter

OCTOBER TO MARCH

January
Peak

<0°C
Minimum Temperature



Key Ecological Features and Processes

Ecological / Biological / Wildlife Corridor

The Aravalli range and its surrounding mosaic landscape harbour multiple protected areas, and facilitate wildlife movement. A notable stretch is the Northern Aravalli Leopard Corridor — from Sariska Tiger Reserve in Rajasthan to the Delhi Ridge — which supports movement of animals like leopards, striped hyenas, Indian wolves, sloth bears, and several deer species through the ecosystem mosaic and remains functionally intact despite fragmentation.

Groundwater Recharge

The Aravalli range acts as a vast groundwater recharge zone allowing seepage/percolation of rainwater through its fractured rocks

Stopover Habitat for Long-Distance Migratory Birds

The Aravalli landscape serves as a critical stopover for migratory birds like the common cuckoo, greater flamingo, bar-headed goose, Demoiselle crane and pied avocet travelling between higher northern latitudes and Africa, providing diverse habitats and food resources for birds before they cross the Thar Desert or the Arabian Sea. The Aravalli open mosaic is thus a node within global migratory networks, making it ecologically important beyond the Indian subcontinent. The **ephemeral seasonal wetlands** play a major role in supporting migratory birds.

Herbivory and Agropastoralism

Grazing and browsing by wild herbivores as well as livestock like goats and sheep actively shape vegetation structure. The ecological web is inseparable from human pastoralism. Traditional grazing practices, including seasonal migration, are an integral part of this ecosystem. Breeds like Sirohi / Ajmera goats and Nari / Sirohi cattle are well-suited for the region.





Conservation Status

Some of the protected areas in this zone include Sariska Tiger Reserve, Kumbhalgarh Wildlife Sactuary (WLS), Mount Abu WLS, Todgarh–Raoli WLS, Bhainsrodgarh WLS, Jaisamand (Dhebar) WLS, Nahargarh WLS / Biological Park, Jhalana Leopard Reserve and Jawai Leopard Conservation Reserve, all in Rajasthan. These, together with Jhir Reserve Forest in Haryana, are leopard/ tiger Aravalli habitats forming the Northern Aravalli wildlife corridor (Sariska to Delhi Ridge). So Sariska, the Haryana Aravallis and Asola Bhatti WLS in Delhi are ecologically linked even though they're administratively split across three states.

Jessore WLS or Jessore Sloth Bear Sanctuary is in Banaskantha, Gujarat.

People and Livelihoods

Mina/Meena
The Meena reside in the northern and eastern parts of the Aravalli and engage in cultivation and animal husbandry for their livelihood.

Ahir
The Ahir engage in cultivation and animal husbandry along with dairying.

Gurjar
Engaged mainly in cattle breeding and animal husbandry, and agriculture, the Gurjar mostly live in north and central Aravallis.

Rabari/Rebari
Mostly from the central and southern Aravallis, the Rabari rear sheep, camel, and cattle. Some also engage in agriculture and artisanry.

Bhil
A tribal group in the southern Aravalli region, the Bhil are engaged in agriculture and rear animals like chicken, goats, and cattle. Some members collect forest produce.

Damor/Damaria
The Damor, mainly residing in the southern Aravalli region, engage primarily in agriculture, animal husbandry, and collection of forest produce.

Sahariya
A tribal community, the Sahariya are known to be skilled at honey gathering and traditional medicine preparation.

Kathodi/Kathodia
Skilled in extracting kathha from the wood of the khair tree, the Kathodi also collect other minor forest produce.

Girasia/Garasia
A tribal community from the southern Aravalli region, the Girasia have multiple clan groups including the Bhil Garasia and Dungri Garasia. They are known for their artisanal skills.



Desert Date/Hingot *(Balanites roxburghii)*
Conservation Status: Least Concern



Indian Ash Tree/Gurjan *(Lannea coromandelica)*
Conservation status: Least Concern



Indian Plum *(Flacourtia indica)*
Conservation status: Least Concern



Red Spike-thorn/Kankera
(Gymnosporia senegalensis)
Conservation status: Least Concern



Burhia Rattlepod *(Crotalaria burhia)*
Conservation status: Not Evaluated



Choti Goondi *(Cordia obliqua)*
Conservation status: Not Evaluated



Indian Caper *(Capparis zeylanica)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Indian Bdellium-tree/Guggal *(Commiphora wightii)*
  Conservation status: Critically Endangered
- Desert Teak *(Tecomella undulata)*/Roheda
  Conservation status: Endangered
- Indian Desert Statice *(Dyerophytum indicum)*
  Conservation status: Vulnerable
- Annual Beard-grass *(Polypogon monspeliensis)*
  Conservation status: Least Concern
- Bastard Teak *(Butea monosperma)*
  Conservation status: Least Concern
- Bidi Leaf Tree *(Bauhinia racemosa)*
  Conservation status: Least Concern
- Birdwood Grass *(Cenchrus setigerus)*
  Conservation status: Least Concern
- Black-honey Shrub *(Phyllanthus reticulatus)*
  Conservation status: Least Concern
- Bombay Ebony *(Diospyros montana)*
  Conservation status: Least Concern
- Buffalo Grass *(Cenchrus ciliaris)*
  Conservation status: Least Concern
- Canne Dauvage *(Saccharum spontaneum)*
  Conservation status: Least Concern
- Chinese Lantern Tree *(Dichrostachys cinerea)*
  Conservation status: Least Concern
- Dhok/Buttontree *(Terminalia pendula)*
  Conservation status: Least Concern
- Garlic Pear Tree *(Crateva adansonii subsp. odora)*
  Conservation status: Least Concern
- Hairy Crossberry *(Grewia villosa)*
  Conservation status: Least Concern
- Indian Olibanum/Salar *(Boswellia serrata)*
  Conservation status: Least Concern
- Indian Senna *(Senna alexandrina)*
  Conservation status: Least Concern
- Indian Gum Tragacanth (Kadaya) *(Sterculia urens)*
  Conservation status: Least Concern
- Long-leaf Cordia/Goondi *(Cordia sinensis)*
  Conservation status: Least Concern
- Oriental Fountain Grass *(Cenchrus orientalis)*
  Conservation status: Least Concern
- Roundleaf Jujube/Ber *(Ziziphus nummularia)*
  Conservation status: Least Concern
- Tanner's Cassia *(Senna auriculata)*
  Conservation status: Least Concern
- True Kadamb *(Mitragyna parvifolia)*
  Conservation status: Least Concern
- White Bark Acacia *(Vachellia leucophloea)*
  Conservation status: Least Concern
- White Crossberry *(Grewia tenax)*
  Conservation status: Least Concern
- Large Toothbrush Tree/Meethi Jaal *(Salvadora oleoides)*
  Conservation status: Data Deficient
- Apluda Grass *(Apluda mutica)*
  Conservation status: Not Evaluated
- Bristle Grass *(Pennisetum divisum)*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Indian Spiny Succulent *(Euphorbia caducifolia)*
Conservation status: Not Evaluated



Indian Sumac *(Searsia mysorensis)*
Conservation status: Not Evaluated



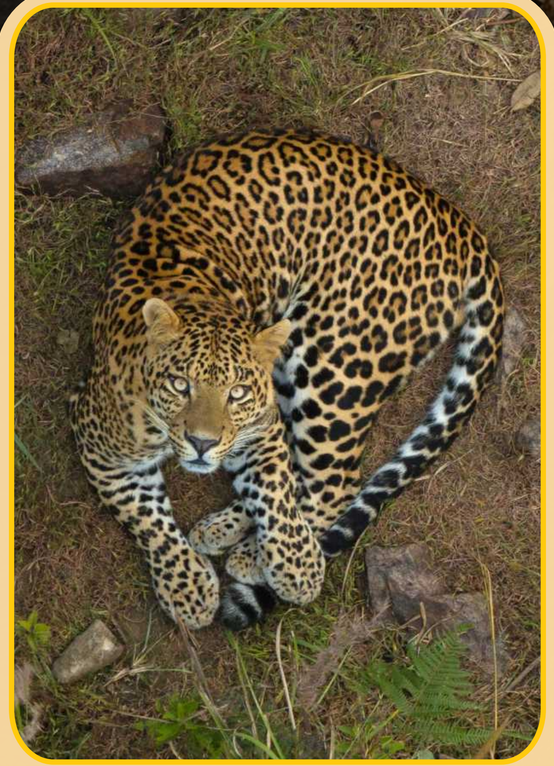
Rat-tail Grass *(Sehima nervosum)*
Conservation status: Not Evaluated

Flora

- Bristly Tephrosia *(Tephrosia strigosa)*
  Conservation status: Not Evaluated
- Brown Lily *(Dipcadi erythraeum)*
  Conservation status: Not Evaluated
- Chariot Tree *(Ougeinia oojeinense)*
  Conservation status: Not Evaluated
- Date Palm *(Phoenix sylvestris)*
  Conservation status: Not Evaluated
- Desert Grass *(Panicum turgidum)*
  Conservation status: Not Evaluated
- Egyptian Sage *(Salvia aegyptiaca)*
  Conservation status: Not Evaluated
- Grasslike Zornia *(Zornia gibbosa)*
  Conservation status: Not Evaluated
- Grey Sour Grass *(Enneapogon cenchroides)*
  Conservation status: Not Evaluated
- Gum Arabic Tree *(Senegalia senegalensis)*
  Conservation status: Not Evaluated
- Indian Bluegrass *(Bothriochloa pertusa)*
  Conservation status: Not Evaluated
- Indian Box Thorn *(Lycium edgeworthii)*
  Conservation status: Not Evaluated
- Indian Squill *(Drimia indica)*
  Conservation status: Not Evaluated
- Iwarancusa Grass *(Cymbopogon jwarancusa)*
  Conservation status: Not Evaluated
- Khejri *(Prosopis cineraria)*
  Conservation status: Not Evaluated
- Leafless East-Indian Vine *(Cynanchum acidum)*
  Conservation status: Not Evaluated
- Marvel Grass *(Dichanthium annulatum)*
  Conservation status: Not Evaluated
- Mountain Knotgrass *(Ouret lanata)*
  Conservation status: Not Evaluated
- Munj Sweetcane *(Tripidium bengalense)*
  Conservation status: Not Evaluated
- Needle-flower Jasmine *(Jasminum auriculata)*
  Conservation status: Not Evaluated
- Palmarosa Grass *(Cymbopogon martinii)*
  Conservation status: Not Evaluated
- Reddish-Yellow Beardgrass *(Chrysopogon fulvus)*
  Conservation status: Not Evaluated
- Sabai Grass *(Eulaliopsis binata)*
  Conservation status: Not Evaluated
- Sewan Grass *(Lasiurus scindicus)*
  Conservation status: Not Evaluated
- Telosma Vine *(Telosma pallida)*
  Conservation status: Not Evaluated
- Thread-leaved Three-awn *(Aristida setacea)*
  Conservation status: Not Evaluated
- Wire Grass *(Ochthochloa compressa)*
  Conservation status: Not Evaluated

IUCN RED LIST

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NE	DD	LC	NT	VU	EN	CR	EW	EX



Indian Leopard *(Panthera pardus)*
Conservation status: Vulnerable



Four-horned Antelope/ Chousingha
(Tetracerus quadricornis)
Conservation status: Vulnerable



Rusty-spotted Cat *(Prionailurus rubiginosus)*
Conservation status: Near Threatened



Caracal *(Caracal caracal)*
Conservation status: Least Concern



Indian Vulture *(Gyps indicus)*
Conservation status: Critically Endangered



White-naped Tit/ White-winged Tit
(Machlolophus nuchalis)
Conservation status: Near Threatened



Jumping Spider *(Vailimia ajmerensis)*
Conservation status: Not Evaluated

Fauna

Mammals

- Indian Pangolin *(Manis crassicaudata)* — Conservation status: Endangered
- Tiger *(Panthera tigris)* — Conservation status: Endangered
- Indian Wolf *(Canis lupus)* — Conservation status: Vulnerable
- Sambar *(Rusa unicolor)* — Conservation status: Vulnerable
- Black-naped Hare *(Lepus nigricollis)* — Conservation status: Least Concern
- Chital/Spotted Deer *(Axis axis)* — Conservation status: Least Concern
- Golden Jackal *(Canis aureus indicus)* — Conservation status: Least Concern
- Honey Badger *(Mellivora capensis)* — Conservation status: Least Concern
- Indian Desert Cat *(Felis lybica)* — Conservation status: Least Concern
- Indian Desert Gerbil *(Meriones hurrianae)* — Conservation status: Least Concern
- Indian Fox *(Vulpes bengalensis)* — Conservation status: Least Concern
- Nilgai *(Boselaphus tragocamelus)* — Conservation status: Least Concern

Birds

- Lesser Florican *(Sypheotides indicus)* — Conservation status: Critically Endangered
- Sindh Saw-scaled Viper *(Echis carinatus)* — Conservation status: Least Concern

Reptiles

- Pushkar Snake-eyed Lizard *(Ophisops pushkarensis)* — Conservation status: Endangered
- Delhi Rock Gecko *(Cyrtopodion aravallensis)* — Conservation status: Vulnerable
- Indian Rock Python *(Python molurus)* — Conservation status: Near Threatened
- Indian Cobra *(Naja naja)* — Conservation status: Least Concern
- Indian/ Western Russell's Viper *(Daboia russelii)* — Conservation status: Least Concern
- Aravalli Leaf-toed Gecko *(Hemidactylus aravalliensis)* — Conservation status: Not Evaluated
- *Cyrtodactylus madarensis* — Conservation status: Not specified

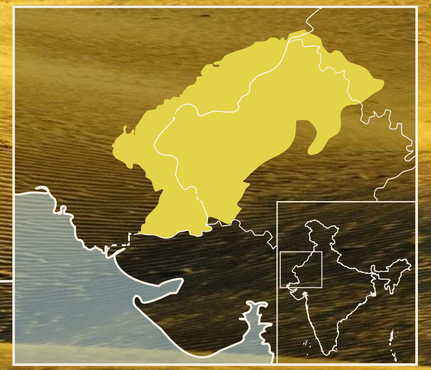
Invertebrates

- Ground-dwelling Jumping Spider *(Langelurillus udaipurensis)* — Conservation status: Not Evaluated

IUCN RED LIST

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NE	DD	LC	NT	VU	EN	CR	EW	EX

Thar Desert



Geography

Stretching across northwestern India and eastern Pakistan, the Thar or Great Indian Desert, ranks ninth largest among the world's major subtropical deserts. Natural boundaries define its edges on all sides: the ancient Aravalli ranges to the east, the Sutlej river to the northwest, the Rann of Kachchh to the south, and the broad plains of the Indus to the west.

The greater share of the Thar, roughly 85 percent, falls within India, concentrated in western Rajasthan and spilling into the northern reaches of Gujarat and the southern fringes of Punjab and Haryana. Across this expanse, the landscape shifts between rolling sand dunes, open sandy plains, and low bare hills. Rocky outcrops punctuate the terrain in the east, clustering near the Aravallis, around Jodhpur, along the limestone areas of Jaisalmer, and into Barmer.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~250 mm
Average annual rainfall

<50 mm to ~500 mm
Annual rainfall range

Winter

OCTOBER TO MARCH

January
Peak

-2°C
Minimum Temperature

Summer

MARCH TO JUNE

May–June
Peak

>50°C
Maximum Temperature

Key Ecological Features and Processes

Sand Dunes and Sandy Plains

Active, shifting sand dunes are more common in the western parts of the Thar in India while the northeastern part of the desert has older, more stabilised dunes. They range from small mobile *barchans* (crescent-shaped dunes) a few metres high to compound longitudinal ridges exceeding 50 metres in the Sam region of Jaisalmer district, shaped and shifted by the prevailing southwest monsoon and dry northwest winds. Locally called *tibba* or *dhora* or *dhoran*, these can move several metres annually, while older dunes stabilised by grass and scrub vegetation form a more fixed sandy terrain. The dunes in the south rise higher, though seldom more than 80 metres whereas the northern dunes are smaller, rising 16-20 metres above the surrounding area.

Saline Lakes or Playas

Shallow and ephemeral saline lakes or playas, defined as dry, flat depressions without outlets in which watercourses (like streams and rivers) drain, are scattered throughout the Thar. Well-known playas include Didwana, Pachpadra, and Lunkaransar, with Sambhar being the largest. Evaporite products, such as salt (halite) and gypsum are extracted from the playas. Lake Sambhar, India's largest inland saltwater lake, supports an extraordinary bird diversity and is renowned as one of the most significant flamingo congregation sites in the subcontinent. It also attracts diverse migratory species from Central Asia and Siberia.



Jawai riverbed

Ephemeral Rivers and Streams

The Luni is the Thar's principal river, though like most watercourses in the region it is seasonal or ephemeral, flowing briefly after rain before losing itself to the desert sand. The Jawai, Sukri, Jojri, and Bandi follow similar patterns, draining intermittently across the landscape before disappearing. Yet even in their dry state, the riverbeds of the Luni and Jawai are ecologically significant. Their channels support linear corridors of tall scrub, dominated by salt-tolerant species such as *Salvadora persica* and *Tamarix*, with grasses including *Aeluropus lagopides* and *Desmostachya bipinnata* binding the sandy margins. This dense, sheltered riparian scrub functions as an important refuge for the Indian wolf (*Canis lupus pallipes*), one of the subcontinent's most threatened large predators.

Where the Luni holds water through the dry season, the character of the landscape shifts. Perennial stretches such as Guda Vishnonian and Dhawa-Doli attract blackbuck (*Antelope cervicapra*), drawing these open-landscape antelope to the river for water and forage.

Rocky Outcrops

Rocky outcrops and gravel plains form a significant part of the Thar landscape, particularly across Barmer, Jaisalmer, and Jodhpur. The diversity of rocks found here, from sedimentary rocks like sandstone and limestone to igneous rocks like rhyolite and granite hold the key to the distant past of the region, right from the pre-Cambrian period to the Cenozoic era.



Jaisalmer limestone with fossils

Dust Storms

Sandstorms are a defining seasonal feature of the Thar, reaching peak intensity between April and June, when intense heat and north-western winds lift the fine sand and dust hundreds of metres into the air. In this desert ecosystem, they function as a key ecological disturbance — resisting dune stabilisation and continuously reshaping dune morphology.

Rohi/Roee

Typical open shrublands of the Thar desert, Rohi refers to flat or undulating stabilised sandy habitats dominated by *Aerva tomentosa*, *Crotalaria burhia*, *Leptadenia pyrotechnica*, *Calligonum polygonoides*, and scattered Khejri (*Prosopis cineraria*) trees. Along with hardy perennial bunch grasses like *Lasiurus scindicus* and *Panicum turgidum*, they form the characteristic open ecosystem of the sandy parts of the region. These ecosystems are ecologically critical as the primary habitat of the Great Indian Bustard and other desert-adapted wildlife species.

Conservation Status

The Desert National Park (spread over 3162 km^2) in Jaisalmer and Barmer districts is one of the largest protected areas in India, and is a critical habitat for the Great Indian Bustard and other desert fauna and flora.

People and Livelihoods



Raika pastoralists

Bishnoi
They are an agrarian community, well-known for practising environmental conservation and wildlife protection.

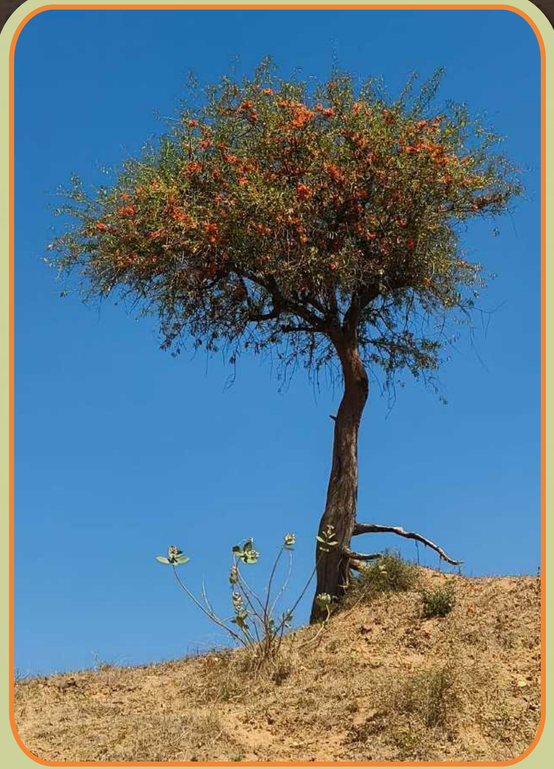
Raika
They are a traditional pastoralist community who primarily herd camels.

Meghwal
A farming and cattle-herding community known for their art and crafts, especially weaving and embroidery and Ralli (patchwork quilt)-making.

Jat
An agro-pastoralist community.

Sindhi Muslim
An agro-pastoralist community traditionally engaged in farming and herding.

Gadiya/Gaduliya Lohaar
Traditionally occupied as blacksmiths, their nomadic routes traverse the Thar region.



Rohida/Roheda/Desert Teak *(Tecomella undulata)*
Conservation status: Endangered



Khejri *(Prosopis cineraria)*
Conservation status: Not Evaluated



Indian Bdellium-tree/Guggal *(Commiphora wightii)*
Conservation status: Critically Endangered



Kheemp *(Leptadenia pyrotechnica)*
Conservation status: Least Concern



Meethi Jaal *(Salvadora oleoides)*
Conservation status: Data Deficient



Bui/ Desert Cotton *(Aerva javanica)*
Conservation status: Not Evaluated



Phog *(Calligonum polygonoides)*
Conservation status: Not Evaluated



Sewan Grass *(Lasiurus scindicus)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Ber/Indian Jujube *(Ziziyphus mauritiana)*
  Conservation status: Least Concern
- Bordi /Roundleaf Jujube *(Ziziphus nummularia)*
  Conservation status: Least Concern
- Common Needle Grass/Annual Bristle Grass *(Aristida adscensionis)*
  Conservation status: Least Concern
- Kair/Karira/Bare Caper *(Capparis decidua)*
  Conservation status: Least Concern
- Kumatiya/Kummath/Gum Arabic *(Senegalia senegal)*
  Conservation status: Least Concern
- Khari Jaal *(Salvadora persica)*
  Conservation status: Least Concern
- Stunted Babul *(Vachellia nilotica)*
  Conservation status: Least Concern
- Desert Cotton/Safed Bui *(Aerva tomentosa)*
  Conservation status: Not Evaluated
- Murat *(Panicum turgidum)*
  Conservation status: Not Evaluated
- Thor *(Euphorbia caducifolia)*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Great Indian Bustard *(Ardeotis nigriceps)*
Conservation status: Critically Endangered



Baluchistan Gerbil *(Gerbillus nanus)*
Conservation status: Least Concern



Desert Fox *(Vulpes vulpes pusilla)*
Conservation status: Not Evaluated



Indian Spiny-tailed Lizard *(Saara hardwickii)*
Conservation status: Vulnerable



Dune Cricket *(Schizodactylus monstrosus)*
Conservation status: Not Evaluated



Toad-headed Agama *(Phrynocephalus mystaceus)*
Conservation status: Least Concern



Cinereous Vulture *(Aegypius monachus)*
Conservation status: Near Threatened

Fauna

Mammals

- Indian Wolf *(Canis lupus pallipes)*
  Conservation status: Vulnerable
- Blackbuck *(Antilope cervicapra)*
  Conservation status: Least Concern
- Chinkara/Indian Gazelle *(Gazella bennettii)*
  Conservation status: Least Concern
- Indian Desert Cat/Asiatic Wildcat *(Felis lybica ornata or Felis silvestris ornata)*
  Conservation status: Least Concern
- Indian Desert Jird/Indian Desert Gerbil *(Meriones hurrianae)*
  Conservation status: Least Concern
- Lesser Mouse-tailed Bat *(Rhinopoma hardwickii)*
  Conservation status: Least Concern
- Trident Leaf-nosed Bat *(Asellia tridens)*
  Conservation status: Least Concern
- Asiatic Caracal *(Caracal caracal schmitzi)*
  Conservation status: Not Evaluated

Birds

- Indian Vulture *(Gyps indicus)*
  Conservation status: Critically Endangered
- Red-headed Vulture *(Sarcogyps calvus)*
  Conservation status: Critically Endangered
- White-rumped Vulture *(Gyps Bengalensis)*
  Conservation status: Critically Endangered
- Steppe Eagle *(Aquila nipalensis)*
  Conservation status: Endangered
- Laggar Falcon *(Falco jugger)*
  Conservation status: Near Threatened
- Black Eagle *(Ictinaetus malaiensis)*
  Conservation status: Least Concern
- Demoiselle Crane *(Anthropoides virgo)*
  Conservation status: Least Concern
- Griffon Vulture *(Gyps fulvus)*
  Conservation status: Least Concern
- Long-legged Buzzard *(Buteo rufinus)*
  Conservation status: Least Concern

Reptiles

- Red Sand Boa *(Eryx johnii)*
  Conservation status: Near Threatened
- Desert Monitor *(Varanus griseus)*
  Conservation status: Least Concern
- Sand Gecko/ Micro Gecko/ Persian Gecko *(Tropiocolotes persicus euphorbiacola)*
  Conservation status: Least Concern
- Sind Krait *(Bungarus sindanus)*
  Conservation status: Least Concern
- Sind Sand Gecko *(Crossobamon orientalis)*
  Conservation status: Least Concern
- Sindh Awl-headed Snake *(Lytorhynchus paradoxus)*
  Conservation status: Least Concern
- Sochureki's Saw-scaled Viper *(Echis carinatus sochureki)*
  Conservation status: Not Evaluated
- Wall Spider *(Oecobius thar)*
  Conservation status: Not Evaluated

IUCN RED LIST

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NE	DD	LC	NT	VU	EN	CR	EW	EX

Rann of Kachchh



Geography

The Rann of Kachchh (or Kutch) is a low-lying salt marsh system in the Kachchh district of western Gujarat. Salt marshes are a type of coastal wetland that are seasonally flooded and drained by seawater brought in by tides. The Great Rann lies between Gujarat and Sindh province in Pakistan, and the international border passes through its northern edge. It is connected with the Little Rann near its southeastern boundary. The Little Rann of Kachchh begins at the junction of the Kachchh mainland, the Gulf of Kachchh, and the arid inland districts of Gujarat.

The Rann of Kachchh formed from the slow retreat of the sea and the uplift of land that was once a shallow part of the Arabian Sea. During the Holocene (~11,700 years ago), this area remained a gulf openly linked to the sea. Over time, movement along the Kachchh faults, the inflow of sediment from mainland rivers, and the forward growth of the shoreline cut it off from open marine waters. Today, the basin survives as two tracts, the larger Great Rann and the smaller Little Rann. Repeated cycles of seawater entry and evaporation laid down thick layers of clay and salt, building up the flat, saline mudflat seen today. It is this geological evolution that makes the Rann a unique ecosystem. It supports large numbers of waterbirds, and is home to several unique species, including the only population of the Indian wild ass found in the country.

The Rann of Kachchh covers an area between 20,000 to 26,000 square kilometres (depending on how the boundaries are defined), of which the Little Rann accounts for 3,570 to 5,100 square kilometres and the Great Rann covers the rest, almost all of it falling in India. It is one of the largest seasonal saline wetlands in the world. The standing water is a mix of monsoon rainfall, river runoff, and seawater.

The Rann of Kachchh is an ecotonal zone, where distinct ecological communities meet. In this case, it sits at the junction of the Kachchh mainland, the Thar Desert, the Gulf of Kachchh, and the inland districts of Gujarat. The wider regional setting includes Pakistan to the north and northwest, Rajasthan to the northeast, the Gulf of Kachchh to the south, and the Arabian Sea to the west and the southwest. Eastward, the area transitions towards the northern plains of Gujarat.

The Rann itself is a flat saline basin of mudflats, clayey depressions, seasonal marshes, and salt-encrusted playas.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~380 mm
Average Annual Rainfall

July and August
Wettest months

100 mm to >750 mm
High rainfall variability, leading to drought or drought-like conditions

Winter

OCTOBER TO FEBRUARY/MARCH

December and January
Peak

12°C
Winter minimum temperature, sometimes below freezing

Summer

MARCH TO JUNE

May and June
Peak

44–45°C
Maximum temperatures; occasionally 48–50°C

Key Ecological Features and Processes

Seasonal Wetland

Ecologically, the Rann is a seasonally flooded wetland whose defining process is the annual transition between wet monsoon conditions and dry hypersaline conditions. Freshwater enters the Rann through rivers such as the Banas and Luni, along with seasonal streams and runoff, while seawater enters through creek systems, mainly Kori Creek in the Great Rann and creeks connected to the Gulf of Kachchh in the Little Rann. This creates a highly variable ecotonal environment of saline mudflats, marshes, scrublands, grasslands, and brackish habitats.

Only Wild-Ass Habitat

The Rann of Kachchh is the only place where the Indian wild ass , a subspecies of the Asiatic wild ass, still survives in the wild, with the Little Rann as its historic stronghold. Its core range is the Little and Great Rann, protected at its centre by the Wild Ass Sanctuary established in 1973, though growing numbers have begun spilling beyond the Rann colonising the Great Rann and extending into farmlands in the surrounding areas well outside the sanctuary itself. As a desert-adapted herbivore, it depends on the bets and the vegetated margins of the Rann for forage and refuge. It is also the flagship species and dominant native herbivore of the system, sharing the range with nilgai, chinkara, and other ungulates. The subspecies exemplifies a marked conservation recovery, having risen from a low of about 362 individuals in 1967 to an estimated 7,672 in 2024.

Bets

The Rann has scattered elevated islands known as *bets* (pronounced 'bayt's). These bets provide the main topographic variation in an otherwise open plain. In the Little Rann, 74 bets are recorded, with Pung bet the largest and Mardak bet the highest at about 55 metres above mean sea level. In the Great Rann, a few large bets form an east-west chain of islands: Pachchham, Khadir, Bela, and Chorar, that rose along a fault line and now stand as highlands above the salt flats. These are also higher than the Little Rann's bets. Khadir spans around 200 square kilometres and is where the Harappan city of Dholavira is situated, while Kala Dungar on Pachchham is the highest point in the region, at ~458 metres. The landscape remains open and dynamic because it is shaped by seasonal hydrology: monsoon flooding, river runoff, saline intrusion, sediment movement, and intense dry-season evaporation.

Salt-tolerant Vegetation

Plant life across the Rann is sparse and dominated by species that can tolerate high salinity and long dry spells. Common plants include *Salvadora*, *Suaeda*, and a range of salt-tolerant grasses and shrubs found mainly on and around the bets. Plant growth is low overall and arrives in short pulses that follow the monsoon rather than continuing steadily through the year. This thin, seasonal plant cover sets the limit for grazing animals and the broader food web.



Key Ecological Features and Processes

Flamingo and Waterbird Hub

The Rann is one of the most important breeding and wintering grounds for waterbirds in western India. It ranks among the foremost flamingo sites in Asia, its centrepiece being Flamingo City in the Great Rann. This low mudflat island is one of the largest greater flamingo breeding colonies in the world and the only regular breeding ground for greater flamingos in South Asia. Here, the birds raise conical mud-mound nests and breed only when the flats are inundated, deserting the colony if the water and food fail. Both greater and lesser flamingos nest, often in mixed colonies, across the eastern Great Rann and the Little Rann, and in peak years the wider Rann draws flamingos in spectacular numbers: counts have run to over a million birds. The Little Rann and the Gulf of Kachchh fringes also serve as major feeding and wintering grounds, alongside large numbers of pelicans, cranes, ducks, and migratory shorebirds moving along the Central Asian Flyway. This bird life is fuelled by blooms of algae and small invertebrates in the brackish floodwaters. The lesser flamingos consume algae such as Spirulina and Diatoms, while the greater flamingos feed on brine shrimp and other invertebrates.

Chir Batti

Literally known as “flickering lamp”. It is a ghostly light phenomenon seen at night over the wetlands and mudflats of the Banni grasslands and the Great Rann of Kachchh. It is believed to be caused by the spontaneous ignition of gases like phosphine and methane produced by anaerobic decomposition of organic matter in the waterlogged, anoxic soils of the Rann. The pale, dancing flames hover low over the ground, drift without an apparent source, and vanish quickly. To the Maldhari pastoralists who have shared this landscape and its nights for centuries, these wandering lights are djinn, spirits haunting the boundary between the inhabited grassland and the vast salt wilderness beyond.

Conservation Status

Kutch Desert Wildlife Sanctuary in the Great Rann, declared in 1986 and covering 7,506 square kilometres, is the largest wildlife sanctuary in India, encompassing a large part of the Great Rann. The water dries up by October-November, and the whole area turns into a salt flat. Flamingo City, one of the subcontinent’s great breeding grounds for greater and lesser flamingos out in the mudflats, is a part of this Sanctuary.

The Little Rann of Kachchh carries a high level of formal protection. Its core was designated the **Indian Wild Ass Sanctuary** in 1973 under the Wildlife (Protection) Act, 1972, covering about 4,954 square kilometres, making it one of the largest wildlife sanctuaries in India. The wider landscape forms part of the Kachchh Biosphere Reserve, declared in 2008, and BirdLife International also recognises the Rann as an Important Bird and Biodiversity Area (IBA).

People and Livelihoods



Agariya salt farmers

Agariya

The traditional seasonal salt workers, mainly from the Little Rann; over 12,000 Agariya families migrate annually into the Rann for salt production. About 61% of the Agariya identify salt production as their main source of income, while many depend on off-season wage labour and a smaller proportion on cultivation.

Miyana Muslim

The Miyana Muslim community practices ginger prawn fishing mainly around Surajbari Creek and the southern margin of the Little Rann.

Koli

The Koli community practices ginger prawn fishing mainly around Surajbari Creek and the southern margin of the Little Rann.

Ahir

A Maldhari group, the Ahir agro-pastoralists are a settled community of the bets, including Khadir Bet (the Dholavira island). They are well-known for distinctive embroidery.



Creek Rat-tail Grass *(Urochondra setulosa)*
Conservation status: Not Evaluated



Rudravanti *(Cressa cretica)*
Conservation status: Least Concern



Giant Milkweed *(Calotropis procera)*
Conservation status: Least Concern



Guggal/Indian Bdellium-tree
(Commiphora wightii)
Conservation status: Critically Endangered

Biodiversity

Flora

- Babul/Gum Arabic Tree *(Vachellia nilotica)*
  Conservation status: Least Concern
- Ber/Wild Jujube *(Ziziphus nummularia)*
  Conservation status: Least Concern
- Kharijaal/Peelu/Piludi *(Salvadora persica)*
  Conservation status: Least Concern
- Kerdo/Bare Caper *(Capparis decidua)*
  Conservation status: Least Concern
- Mangrove Grass/Khariyu
  (Aeluropus lagopoides)
  Conservation status: Least Concern
- Glaucous Dog-flower
  (Schweinfurthia papilionacea)
  Conservation status: Not Evaluated
- Khejri *(Prosopis cineraria)*
  Conservation status: Not Evaluated
- Panwar *(Cleome brachycarpa)*
  Conservation status: Not Evaluated
- Shrubby Seablite *(Suaeda fruticosa)*
  Conservation status: Not Evaluated
- White Milkweed *(Pentatropis spiralis)*
  Conservation status: Not Evaluated

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Indian Wild Ass *(Equus hemionus khur)*
Conservation status: Near Threatened



Greater Flamingo *(Phoenicopterus roseus)*
Conservation status: Least Concern



Indian Long-eared Hedgehog
(Hemiechinus collaris)
Conservation status: Least Concern



Black-tailed Godwit *(Limosa limosa)*
Conservation status: Near Threatened



Great White Pelican *(Pelecanus onocrotalus)*
Conservation status: Least Concern



Indian Spiny-tailed Lizard *(Saara hardwickii)*
Conservation status: Vulnerable



Saw-scaled Viper *(Echis carinatus)*
Conservation status: Least Concern

Fauna

Mammals

- Indian Wolf *(Canis lupus pallipes)*
  Conservation status: Vulnerable
- Indian Fox *(Vulpes bengalensis)*
  Conservation status: Least Concern
- Desert Fox/White-footed Fox
  (Vulpes vulpes pusilla)
  Conservation status: Least Concern

Birds

- Lesser Florican *(Sypheotides indicus)*
  Conservation status: Critically Endangered
- Lesser Flamingo *(Phoenicopterus minor)*
  Conservation status: Vulnerable
- Asian Houbara *(Chlamydotis macqueenii)*
  Conservation status: Vulnerable
- Demoiselle Crane *(Anthropoides virgo)*
  Conservation status: Least Concern
- White-browed Bushchat
  (Saxicola macrorhyncha)
  Conservation status: Vulnerable
- Painted Stork *(Mycteria leucocephala)*
  Conservation status: Least Concern

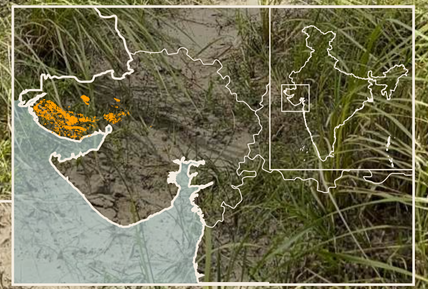
Reptiles

- Bengal Monitor Lizard *(Varanus bengalensis)*
  Conservation status: Near Threatened
- Desert Monitor *(Varanus griseus)*
  Conservation status: Least Concern
- Agamid Lizard *(Trapelus agilis)*
  Conservation status: Least Concern
- Indian Cobra *(Naja naja)*
  Conservation status: Least Concern

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Grasslands of Kachchh



Geography

The grasslands of Kachchh (also known as Kutch) occupy the westernmost district of Gujarat, one of the largest districts in India by area, spanning approximately 45,000 square kilometres of extraordinarily varied terrain. Bounded to the north by the Great Rann of Kachchh, tto the south and the west by the Gulf of Kachchh, and to the east by the Little Rann of Kachchh and the Banas river basin, the district encompasses an arc of open natural ecosystems that together constitute one of the most ecologically significant arid-zone grassland complexes in the Indian subcontinent. These grasslands occur as a mosaic across the mainland plateau, coastal margins, and the fringes of the Rann — each with its own ecological character, defined by underlying geology, soil depth, salinity, and the pattern of seasonal rainfall.

The upland plateau of mainland Kachchh, composed of ancient Deccan Trap basalts and older Jurassic and Cretaceous sedimentary formations, supports open short-grass and scrub-grassland communities on shallow, stony soils. To the northwest, the Abdasa and Lakhpat talukas hold some of the most intact remaining grassland habitat in the district, including the internationally recognised grasslands centred on Naliya — the last stronghold of the critically endangered great indian bustard and lesser florican in Gujarat and possibly the only place in India where three species of bustards are found, including the vulnerable Asian houbara *(Chlamydotis macqueeni)*. These grasslands grade southward into scrub and dry deciduous patches, and northward into the saline transition zone bordering the Rann.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~300–400 mm
Average annual rainfall (declining sharply westward)
Naliya, Abdasa receive among the lowest rainfall in Gujarat (~250–300 mm)

Highly variable rainfall between years
Frequent and prolonged droughts, particularly in the northwest

Summer

MARCH TO JUNE

April and May
Peak

>45°C in open plateaus
Maximum temperatures; with hot, desiccating winds in pre-monsoon

Winter

OCTOBER TO FEBRUARY

December and January
Peak

<5°C in open plateaus
Minimum temperatures; occasional frost

Key Ecological Features and Processes

Naliya Grasslands

The grasslands centred on Naliya in Abdasa taluka represent the most significant arid-zone grassland habitat in Gujarat, and the last viable refuge of the Great Indian Bustard in the state. It is also one of the two Important Bird Areas (Key Biodiversity Areas) of Criteria A1, identified by BirdLife International. They occupy a gently undulating basalt plateau at elevations of 50–100 metres, where thin, rocky soils and low annual rainfall combine to maintain open, short-grass communities dominated by *Cenchrus*, *Dichanthium*, and *Aristida* species, interspersed with patches of bare laterite and rocky outcrops. This open, structurally simple landscape are precisely the conditions required by the great indian bustard and lesser florican for breeding and foraging and by the Asian houbara for wintering — for these species tall vegetation and woody encroachment are existential threats. The Naliya grasslands also support one of the highest densities of raptors and open-country birds recorded anywhere in arid India during the winter months, driven by the high invertebrate productivity of the seasonally renewed grassland surface and the absence of disturbance over large areas.

Rocky Outcrops and Gravel Plains

Across the Kachchh mainland plateau, particularly in the central and eastern districts of Bhuj, Anjar, and Rapar, the grassland matrix is punctuated by rocky outcrops, low inselbergs, and expansive gravel plains. These form structurally distinct microhabitats within the broader grassland landscape. The rock faces and boulder fields provide shelter, thermoregulation sites, and denning cavities for a suite of reptiles, small mammals, and larger carnivores, most notably the Indian wolf *(Canis lupus pallipes)* and the striped hyena *(Hyaena hyaena)*, both of which use rocky terrain for denning while ranging across the surrounding grassland matrix to hunt. The spiny-tailed lizard *(Saara hardwickii)*, a characteristic species of stony arid habitats, excavates burrows in the hard gravel soils of these plains and is a significant prey item for raptors and larger carnivores.

Seasonal Drainage Lines and Ephemeral Wetlands

The plateau grasslands of Kachchh are dissected by a network of seasonal drainage lines that flow briefly during and after the monsoon before drying completely. Where these channels widen into low-lying depressions, shallow ephemeral wetlands form after good monsoon years, attracting waterbirds, waders, and wintering cranes. These wetlands are important watering points for ungulates and carnivores during the dry season and serve as focal points of biological activity in an otherwise water-scarce landscape. The riparian corridors along these drainage lines, lined with *Vachellia nilotica*, *Prosopis cineraria*, *Capparis decidua, Euphorbia caducifolia*, and *Tamarix* scrub, provide linear habitat corridors that connect isolated grassland patches and support species that require both open ground and vegetative cover.

Coastal and Saline Grasslands

Along the southern margin of the district, the Gulf of Kachchh coastline supports a distinct belt of coastal and saline grasslands occupying the zone between the intertidal and the terrestrial interior. These habitats are characterised by salt-tolerant grass communities dominated by *Aeluropus lagopoides*, *Sporobolus marginatus*, and *Urochondra setulosa*, with halophytic shrubs including *Suaeda fruticosa* and *Cressa cretica*. These coastal areas are wintering habitat for flamingos, pelicans, and shorebirds, and the creek and mudflat systems adjacent to them support significant populations of the waders and other aquatic birds. The transition between saline grassland and mangrove fringe creates an ecotonal habitat of high avian diversity.

Rann Margin Grasslands

The transitional zone between the mainland Kachchh plateau and the Great Rann supports a category of grassland distinct from both the upland plateau communities and the Banni. Here, on moderately saline soils that receive some seasonal inundation but drain more freely than the deep mudflats of the Rann interior, sparse to medium-density grass communities persist year-round, punctuated by *Salvadora* scrub and low acacia. These margins are important foraging habitat for the Indian wild ass (*Equus hemionus khur*), which ranges beyond the Little Rann and into the Kachchh grassland fringe during the monsoon and post-monsoon season. The wolf packs of Kachchh use these transition zones extensively as seasonal hunting grounds, following the movement of livestock graziers.



People and Livelihoods



Maldhari Pastoralist

Maldhari

As in the Banni, pastoralism is the defining livelihood of the Kachchh grassland landscape, and the Maldhari communities — principally Rabari, Jat, and Bharwad herders — have managed these open lands for centuries through seasonal movement of livestock. Across the plateau grasslands, herds of cattle, camels, sheep, and goats are moved in response to rainfall and grass availability, a system that historically maintained grassland openness and prevented woody encroachment. The Kharai camel *(Camelus dromedarius)* — a distinct breed adapted to swimming between coastal islands to browse mangroves — is unique to Kachchh and central to the livelihood of communities in the coastal taluka. Increasing sedentarisation, drought, and loss of traditional grazing commons to agricultural conversion and infrastructure have disrupted these pastoral systems, with significant consequences for grassland condition.

Agro-pastoral Communities

In most of the talukas in Kachchh, farming and pastoralism are practised together, with communities cultivating millet, cotton, mustard, sesame and groundnut in the brief post-monsoon growing season while maintaining livestock herds that graze fallow fields and common grasslands. This agro-pastoral mosaic historically created a patchwork of cultivated, fallow, and open land that supported high densities of open-country birds including bustards, larks, sandgrouses, and coursers. The progressive shift toward cash crops, irrigation, and enclosed private holdings has reduced the extent and connectivity of this mosaic substantially over the past three decades.

Conservation Status

The most significant protected area exists at the Kutch Bustard Sanctuary, which covers approximately 2 square kilometres of core grassland habitat around Naliya. The broader grassland matrix around it, which is ecologically essential to the population, has no formal protection status except the Eco-sensitive Zone (220 sq km) and Revised Priority Area (740 sq km) as directed by the Hon'ble Supreme Court in December 2025 for the conservation of the bustards. The Desert National Park and the Wild Ass Sanctuary (in the Little Rann) provide adjacent or nearby protection for arid and semi-arid habitats, but the majority of Kachchh's grasslands remain outside any protected designation, managed as revenue wastelands, common grazing lands, or private holdings.



Balanites aegyptiaca
Conservation status: Least Concern



Mangrove Grass *(Aeluropus lagopoides)*
Conservation status: Least Concern



Ber/Roundleaf Jujube *(Ziziphus nummularia)*
Conservation status: Least Concern



Euphorbia caducifolia
Conservation status: Not Evaluated

Biodiversity

Flora

- Athel Pine *(Tamarix aphylla)* — Conservation status: Least Concern
- Babul/Gum Arabic Tree *(Vachellia nilotica)* — Conservation status: Least Concern
- Buffalo Grass *(Cenchrus ciliaris)* — Conservation status: Least Concern
- Creek Rat-tail Grass *(Urochondra setulosa)* — Conservation status: Least Concern
- Kerdo/Bare Caper *(Capparis decidua)* — Conservation status: Least Concern
- Kharijaal/Peelu/Piludi *(Salvadora persica)* — Conservation status: Least Concern
- Khejri *(Prosopis cineraria)* — Conservation status: Least Concern
- Marvel Grass *(Dichanthium annulatum)* — Conservation status: Not Evaluated
- Palmarosa/Rusa Grass *(Cymbopogon martini)* — Conservation status: Not Evaluated
- Shrubby Seablite *(Suaeda fruticosa)* — Conservation status: Not Evaluated
- *Sporobolus marginatus* — Conservation status: Not Evaluated

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White-browed Bushchat/ Stoliczka's Bushchat *(Saxicola macrorhynchus)*
Conservation status: Vulnerable



Black Francolin *(Francolinus francolinus)*
Conservation status: Least Concern



Asian Houbara *(Chlamydotis macqueenii)*
Conservation status: Vulnerable



Bristled Grassbird *(Schoenicola striatus)*
Conservation status: Vulnerable



Striped Hyaena (Hyaena hyaena)
Conservation status: Near Threatened



Kharai Camel *(Camelus dromedarius)*
Conservation status: Not Evaluated



Indian Cobra *(Naja naja)*
Conservation status: Least Concern

Fauna

Mammals

- Indian Wild Ass *(Equus hemionus khur)*
  Conservation status: Vulnerable
- Indian Wolf *(Canis lupus pallipes)*
  Conservation status: Vulnerable
- Caracal *(Caracal caracal)*
  Conservation status: Least Concern
- Chinkara/Indian Gazelle *(Gazella bennettii)*
  Conservation status: Least Concern
- Desert Cat/Asiatic Wildcat *(Felis lybica ornata)*
  Conservation status: Least Concern
- Indian Desert Gerbil *(Meriones hurrianae)*
  Conservation status: Least Concern
- Indian Fox *(Vulpes bengalensis)*
  Conservation status: Least Concern

Birds

- Great Indian Bustard *(Ardeotis nigriceps)*
  Conservation status: Critically Endangered
- Sociable Lapwing *(Vanellus gregarius)*
  Conservation status: Critically Endangered
- Lesser Florican *(Sypheotides indicus)*
  Conservation status: Endangered
- Steppe Eagle *(Aquila nipalensis)*
  Conservation status: Endangered
- Eastern Imperial Eagle *(Aquila heliaca)*
  Conservation status: Vulnerable
- Tawny Eagle *(Aquila rapax)*
  Conservation status: Vulnerable
- Laggar Falcon *(Falco jugger)*
  Conservation status: Near Threatened
- Pallid Harrier *(Circus macrourus)*
  Conservation status: Near Threatened
- Red-headed Falcon *(Falco chicquera)*
  Conservation status: Near Threatened
- Rufous-tailed Lark *(Ammomanes phoenicura)*
  Conservation status: Near Threatened
- Common Crane *(Grus grus)*
  Conservation status: Least Concern
- Cream-coloured Courser *(Cursorius cursor)*
  Conservation status: Least Concern
- Demoiselle Crane *(Anthropoides virgo)*
  Conservation status: Least Concern
- Greater Hoopoe-lark *(Alaemon alaudipes)*
  Conservation status: Least Concern
- Montagu's Harrier *(Circus pygargus)*
  Conservation status: Least Concern
- Sykes's Nightjar *(Caprimulgus mahrattensis)*
  Conservation status: Least Concern

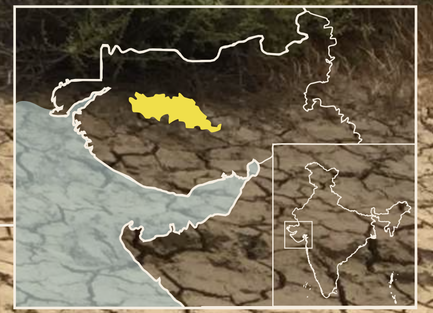
Reptiles

- Indian Spiny-tailed Lizard *(Saara hardwickii)*
  Conservation status: Vulnerable
- Brilliant Ground Agama *(Trapelus agilis)*
  Conservation status: Least Concern
- Hardwicke's Bloodsucker *(Brachysaura minor)*
  Conservation status: Least Concern
- Saw-scaled Viper *(Echis carinatus)*
  Conservation status: Least Concern

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Banni Grassland



Geography

Spread over ~ 2,600 square kilometres in Gujarat's Kachchh district, Banni grasslands is the largest contiguous stretch of grasslands in India. A largely flat area with slight undulation and low elevation (less than 20 metres above average sea level), the Banni grassland lies between the Great Rann of Kachchh to its north and mainland Kachchh to its south.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~340 mm
Average annual rainfall

Rainfall can be erratic, and droughts are common and recurrent.

Winter

OCTOBER TO MARCH

January and February
Peak

<10°C
Minimum Temperatures

Summer

MARCH TO JUNE

May and June
Peak

>45°C, can reach 50°C
Maximum Temperature

Key Ecological Features and Processes

Vast Seasonal Wetlands

The seasonal wetlands of the Banni are formed each monsoon when rainfall and sheet flooding inundate the vast flat mudflats, transforming cracked bare ground into shallow lakes stretching for kilometres. The impermeability of the salt-affected soils keeps water spread wide but shallow, creating warm, turbid, productive conditions that spawn high invertebrate diversity and density rapidly. The Maldhari community, especially the Fakirani jat, who camp here for many months with their camels, distinguish between *dhand* — deeper, more persistent wetlands that hold water for much of or almost the entire year in good monsoon years, and *chachh* — shallow, ephemeral wetlands with a lifespan of only three to four months before they dry completely. Halophytic *Suaeda* and sedges like *Cyperus* fringe the wetter margins. At the same time, the open water supports a rich fish community of cichlids, catfish, and killifish that colonise rapidly with the flood and sustain the food web through the wet season. These monsoon wetlands draw waterbirds in extraordinary numbers — flamingos, pelicans, painted storks, spoonbills, ibises, and dozens of migratory waders converge on the shrinking pools, while thousands of migratory common cranes work the drying grassland edges for bulbs and seeds.

Soil Salinity to Salt Plains

The soils of the Banni exist on a steep salinity gradient, transitioning from moderately salt-affected grassland interior soils to the hyper-saline, vegetation-free salt plains of the adjacent Great Rann. Seasonal inundation by brackish water, followed by rapid evaporation, draws salts upward through the soil and deposits them as crystalline surface crusts that few plants can tolerate. This gradient structures the vegetation mosaic: moderately saline soils support communities of salt-tolerant grasses and herbs like *Urochondrha setulosa*, *Suaeda spp.*, and *Cressa cretica*, while the most extreme outer flats grade into bare, unvegetated pans where almost nothing grows. Soil salinity also suppresses decomposition and nutrient cycling, making these soils chemically constrained and putrid.



Saline groundwater

Groundwater beneath the Banni is largely brackish to highly saline, inherited from ancient marine inundations and sustained by ongoing evaporative concentration from the surrounding salt flats. The extensive spread of the invasive plant *Neltuma juliflora* (formerly named *Prosopis juliflora* and locally called *gando baval*, meaning the mad tree) has also facilitated the increase in salinity locally.

Bets

Bets, meaning sand islands, are the slightly elevated patches of firm, sandy ground that rise above the surrounding seasonally inundated mudflats and grassland matrix of the Banni, becoming true islands when the monsoon floods the Rann around them. Their raised, well-drained soils make them ideal denning ground, favoured by wildlife such as the desert fox, Indian fox, Indian wolf, and the elusive desert cat. They are drawn to the friable, diggable soil, the elevation that keeps dens dry through the wet season, and the unobstructed sightlines across the surrounding grassland. In a landscape that floods, shifts, and offers little permanent refuge, the bets are anchors, a small and stable refuge within the vast seasonal flux of the Banni.



Conservation Status

The Banni was declared a protected forest in 1955, bringing it under the jurisdiction of the Gujarat Forest Department. Before that, the administration of Banni was under the Gujarat Revenue Department. Banni is managed by both departments owing to jurisdictional ambiguity.

Human History



Maldhari pastoralist

Maldhari

The pastoralists of Banni follow a centuries-old pastoral system and are called the "Maldhari" (*Maal* meaning livestock, and *Dhari* meaning owners), who are semi-nomadic to sedentary pastoralists migrating only during periods of drought.

The social fabric of Maldhari is made of 21 different communities which include: **Jat, Mutva, Rabari, Halepotra, Raysipotra, Hingorja, Node, Sumra, Juneja, Jiyeja, Theba, Sameja, Korad/ Korar, Khaskeli, Bambha, Pathan, Baloch, Saiyyad, Munjavar, Meghwal, Harijan Marwada, Vadha Koli, Charan, Bharwad, Sama/ Samma**.

Once supplying high quality draught animals, the Kankrej cattle, for agriculture, Banni's Maldhari today derive their primary income from the milk economy, following the increasing mechanisation of farming. Animal husbandry is now largely oriented towards dairy production, with herd compositions increasingly dominated by the drought-resistant Banni buffalo.

In addition to pastoralism, many Maldhari also engage in tourism, handicrafts, charcoal-making, sale of harvested wood, and agriculture. Income from these sources is particularly useful during drought when dairy income plummets.

The Maldhari have long navigated the water salinity constraint with remarkable ingenuity through a traditional water harvesting system of ***virdas*** — shallow wells, of eight to ten feet deep, dug into low-lying natural depressions called ***jheels*** that collect and concentrate monsoon rainwater. The walls of the virda are lined with thick layers of dry grass and wood that act as a natural filter, allowing water to seep through slowly and collect clean at the bottom. By tapping this thin upper lens of fresh monsoonal water before the saline aquifer below can contaminate it, and by siting them in jheels where rainwater accumulates, the Maldharis have engineered a system that stretches a single good monsoon into a year-round supply of drinking water.

Harijan Marwada/Meghwal

They are primarily pastoralists or engaged with pastoralism-related activities. The Meghwal have traditionally been leatherworkers, and continue to practice the craft today.



Athel Pine *(Tamarix aphylla)*
Conservation status: Least Concern



Gum Arabic *(Senegalia senegal)*
Conservation status: Least Concern



Kusha Grass/Halfa Grass *(Desmostachya bipinnata)*
Conservation status: Least Concern



Buffalo Grass *(Cenchrus ciliaris)*
Conservation status: Least Concern



Creek Rat-tail Grass *(Urochondra setulosa)*
Conservation status: Not Evaluated



Bare Caper/Kerdo *(Capparis decidua)*
Conservation status: Least Concern

Biodiversity

Flora

- Babul/Gum Arabic Tree *(Vachellia nilotica)*
  Conservation status: Least Concern
- Bada Peelu/Meethi Jaal *(Salvadora oleoides)*
  Conservation status: Data Deficient
- Dwarf Sedge *(Cyperus arenarius)*
  Conservation status: Least Concern
- Kharijaal/Peelu/Piludi *(Salvadora persica)*
  Conservation status: Least Concern
- Mangrove Grass/Khariyo *(Aeluropus lagopoides)*
  Conservation status: Least Concern
- Marvel Grass *(Dichanthium annulatum)*
  Conservation status: Not Evaluated
- Pearly Everlasting *(Anaphalis neelgerryana)*
  Conservation status: Not Evaluated
- Shrubby Seablite *(Suaeda fruticosa)*
  Conservation status: Not Evaluated
- Wire Grass *(Ochthochloa compressa)*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Sociable Lapwing *(Vanellus gregarius)*
Conservation status: Critically Endangered



Asian Houbara *(Chlamydotis macqueenii)*
Conservation status: Vulnerable



Peregrine Falcon *(Falco peregrinus)*
Conservation status: Least Concern



Striped Hyaena *(Hyaena hyaena)*
Conservation status: Near Threatened



Desert Fox *(Vulpes vulpes pusilla)*
Conservation status: Least Concern



Indian Desert Gerbil *(Meriones hurrianae)*
Conservation status: Least Concern



Spiny-tailed Lizard *(Saara hardwickii)*
Conservation status: Vulnerable

Fauna

Mammals

- Indian Wolf *(Canis lupus pallipes)* — Conservation status: Vulnerable
- Asiatic Wildcat/Indian Desert Cat *(Felis lybica ornata)* — Conservation status: Least Concern
- Baluchistan Gerbil *(Gerbillus nanus)* — Conservation status: Least Concern
- Jungle Cat *(Felis chaus)* — Conservation status: Least Concern
- Banni Buffalo *(Bubalus bubalis)* — Conservation status: Not Evaluated
- Kharai Camel *(Camelus dromedarius)* — Conservation status: Not Evaluated

Birds

- Steppe Eagle *(Aquila nipalensis)* — Conservation status: Endangered
- Dalmatian Pelican *(Pelecanus crispus)* — Conservation status: Near Threatened
- Laggar Falcon *(Falco jugger)* — Conservation status: Near Threatened
- Pallid Harrier *(Circus macrourus)* — Conservation status: Near Threatened
- Red-headed Falcon *(Falco chicquera)* — Conservation status: Near Threatened
- Asian Openbill (Stork) *(Anastomus oscitans)* — Conservation status: Least Concern
- Common Crane *(Grus grus)* — Conservation status: Least Concern
- Cream-coloured Courser *(Cursorius cursor)* — Conservation status: Least Concern
- Demoiselle Crane *(Anthropoides virgo)* — Conservation status: Least Concern
- Eurasian Spoonbill *(Platalea leucorodia)* — Conservation status: Least Concern
- European Roller *(Coracias garrulus)* — Conservation status: Least Concern
- Greater Hoopoe-Lark *(Alaemon alaudipes)* — Conservation status: Least Concern
- Grey Hypocolius *(Hypocolius ampelinus)* — Conservation status: Least Concern
- Pale Sparrow/Pale Rockfinch *(Carpospiza brachydactyla)* — Conservation status: Least Concern
- Sykes's Nightjar *(Caprimulgus mahrattensis)* — Conservation status: Least Concern
- White-tailed Lapwing *(Vanellus leucurus)* — Conservation status: Least Concern

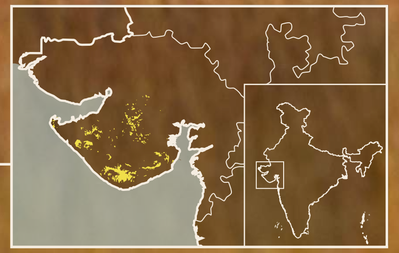
Reptiles

- Bengal Monitor Lizard *(Varanus bengalensis)* — Conservation status: Near Threatened
- Brilliant Ground Agama *(Trapelus agilis)* — Conservation status: Least Concern
- Jerdon's Snake-eye/Punjab-snake-eyed Lacerta *(Ophisops jerdonii)* — Conservation status: Least Concern
- Indian Cobra *(Naja naja)* — Conservation status: Least Concern

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NE	DD	LC	NT	VU	EN	CR	EW	EX

Saurashtra Grasslands and Scrub Savannas



Geography

Saurashtra, a peninsula that forms the southern part of Gujarat, hosts arid and semi-arid grasslands and scrub-savanna ecosystems. According to the 2011 State Forest Report of Gujarat, the total grassland cover of Saurashtra was estimated at approximately 1810 square kilometres, contributing about ~20% of Gujarat's total grassland area. As per the Gujarat Forest Department's online portal, the total area of *vidis* (local term for pastures) is 1325 square kilometres.

Historically *vidis* were a source of revenue generation for the princely states of this region through leasing. At present some *vidis* are formally managed by the Forest Department, while many other ecologically important open habitats form part of village commons and pastoral landscapes. *Vidis* occur across diverse micro-topographies, including gravelly uplands, alluvial plains, dry hill slopes, and saline marshes.

Physiographically, Saurashtra consists of a rocky basaltic tableland formed from the lava flows of the Deccan Volcanic Province. The landscape is characterized by undulating terrain, low hills, saline flats, and dissecting seasonal rivers. Most of the region lies below 300 metres above sea level.

The eastern fringe of the Saurashtra peninsula forms a low-lying transitional zone separating the peninsula from mainland Gujarat, marking the site of an ancient marine connection between the Gulf of Kachchh and the Gulf of Khambhat.

Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal

~600 mm
Average Annual Rainfall

<400 mm to ~1200 mm
High rainfall variability

Frequent drought years

Winter

NOVEMBER TO FEBRUARY

January
Peak

~5°C
Minimum Temperature

Summer

MARCH TO JUNE

May
Peak

46°C
Maximum Temperature

Key Ecological Features and Processes

Roosting Ground for Migratory Harriers

Blackbuck National Park at Velavadar in Saurashtra hosts the world's second-largest harrier roost. Harriers are migratory birds that come to India in the winter, and roost communally in large numbers on the ground in short grasslands, often with different harrier species at a single site.

Last Remaining Breeding Refuge for the Critically Endangered Lesser Florican

Blackbuck National Park and other grasslands of Saurashtra are one of the last remaining breeding habitats for the critically endangered lesser floricans. Historically, the *Bhal* area was also home to the great Indian bustard. Currently, the largest numbers of lesser floricans (30-60 individuals) are annually reported at the National Park.

A Multi-predator Multi-prey Savanna Grassland System

The mosaic of open ecosystems of the Saurashtra peninsula supports a diverse herbivore and carnivore community. Antelope species such as blackbuck, blue bull or nilgai, and Indian gazelle occur at particularly high densities in these open grassland systems, in addition to the high numbers of livestock. These areas also support a unique assemblage of large carnivores, including the Indian wolf, leopard, striped hyena, and the only population of Asiatic lions that have now established across large parts of southern Saurashtra. The savannas, grasslands and agriculture mosaic thus function as ecological "stepping stones" within the wider Asiatic lion landscape, supporting prey populations and enabling lion movement across human-dominated areas, making Saurashtra one of the few remaining large carnivore-herbivore savanna systems in Asia.

Blackbuck National Park at Velavadar is also one of the last places in India, where a typical grassland predator-prey dynamic can be seen, with the resident wolf population as the primary large predator of blackbuck and nilgai. Elsewhere, wolves subsist mainly on livestock, and only occasionally prey on wild ungulates such as blackbuck and chinkara. Thus, this is one of the last functioning wolf-ungulate systems in India. Wolves help regulate prey population, which is crucial for preventing overgrazing and maintaining grassland health.





Conservation Status

Gir National Park (NP) and Wildlife Sanctuary (WLS), Velavadar Blackbuck NP as well as the **Barda WLS** are notable protected areas in the Saurashtra region.

As per Gujarat Forest Department's web-portal, there are 162 reserved *vidis* and 465 non-reserved *vidis* distributed across multiple forest and wildlife divisions including Jamnagar, Bhavnagar, Junagadh, Barda, and Gir.

Based on their production capacity, *vidis* producing above 93,000 kg of grass per annum were classified as reserved. At present, about 36,457 hectares of reserved vidis are under the jurisdiction of the Forest Department.

Many of the *vidis* remain under private control, even after the Gujarat Agricultural Land Ceiling Act of 1960. The heirs of erstwhile kings have not relinquished their estates, and the practice of leasing the land to pastoralists continues. Although pastoralists have historical rights over these resources for use and management under the Scheduled Tribes And Other Traditional Forest Dwellers (Recognition Of Forest Rights) Act, 2006, the *vidis* continue to be managed for economic gains or converted to farmland.

People and Livelihoods

Semi-nomadic to sedentarised pastoralists of this region, the **Maldhari** (*Maal* meaning livestock, and *Dhari* meaning owners) migrate only during periods of droughts. Maldhari is not a single community but comprise several distinct pastoral communities, among which the **Bharwad** and the **Rabari** are major groups in Saurashtra.

Bharwad

They are traditionally associated with sheep, goat, cattle, and buffalo rearing. The Motabhai Bharwad are concentrated in northwestern Saurashtra and largely rear sheep and goats, while the Nanabhai Bharwad of eastern and southeastern Saurashtra are associated more with cattle and buffalo husbandry.

Rabari/ Rebari

Among different sub-groups of the Rabari, the Bhopa Rabari historically practisced camel breeding in the Okhamandal region along the western Saurashtra coast. The Sorathi Rabari are associated with the Gir and Barda landscapes. Panchali and Zalawadi Rabari are among the Rabari sub-groups.

Charan/ Gadhvi

In parts of Gir, Barda, and Alech, the Charan Maldharis lived in nesses, small pastoral settlements linked closely with forest and grazing landscapes, mostly herding cattle and buffalo.

Ahir

Historically associated with cattle keeping and dairying, many Ahir families became settled cultivators or agro-pastoralists, but livestock remained central to their livelihoods and cultural history.

The Maldhari hold detailed knowledge of forage species, seasonal movement, water sources, livestock breeds, wildlife behaviour and customary livestock management practices. This knowledge can be important for conservation and restoration planning.



Fragrant Ceropegia *(Ceropegia odorata)*
Conservation status: Critically Endangered



Babul/Gum Arabic Tree *(Vachellia nilotica)*
Conservation status: Least Concern



White-barked Acacia *(Vachellia leucophloea)*
Conservation status: Least Concern



Common Needle Grass *(Aristida adscensionis)*
Conservation status: Not Evaluated



Mauritian Grass *(Apluda mutica)*
Conservation status: Not Evaluated



Palmarosa Grass *(Cymbopogon martinii)*
Conservation status: Not Evaluated



Thorny Staff Tree *(Maytenus emarginata)*
Conservation status: Not Evaluated



Black Cutch *(Senegalia catechu)*
Conservation status: Least Concern

Biodiversity

Flora

- Indian Bdellium-tree *(Commiphora wightii)*
  Conservation status: Critically Endangered
- Desert Teak *(Tecomella undulata)*
  Conservation status: Endangered
- Indian Bitter Pea *(Tephrosia jamnagarensis)*
  Conservation status: Endangered
- Kachchh Cudweed *(Helichrysum cutchicum)*
  Conservation status: Vulnerable
- Desert Date *(Balanites aegyptiaca)*
  Conservation status: Least Concern
- Gum Arabic *(Senegalia senegal)*
  Conservation status: Least Concern
- Kharijaal/Peelu/Piludi *(Salvadora persica)*
  Conservation status: Least Concern
- Kusha Grass/*Halfa Grass (Desmostachya bipinnata)*
  Conservation status: Least Concern
- Roundleaf Jujube *(Ziziphus nummularia)*
  Conservation status: Least Concern
- Grader Grass *(Themeda quadrivalvis)*
  Conservation status: Not Evaluated
- Kleberg's Bluestem/Bluegrass *(Dichanthium annulatum)*
  Conservation status: Not Evaluated
- Mangrove Grass *(Aeluropus lagopoides)*
  Conservation status: Not Evaluated
- Pawana *(Sehima sulcatum)*
  Conservation status: Not Evaluated

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Asiatic Lion *(Panthera leo leo)*
Conservation status:Endangered



Blackbuck *(Antilope cervicapra)*
Conservation status: Least Concern



Rufous-tailed Lark *(Ammomanes phoenicura)*
Conservation status: Least Concern



Desert Cat *(Felis lybica)*
Conservation status: Least Concern



Gujarat Gecko *(Hemidactylus gujaratensis)*
Conservation status: Vulnerable



Indian Courser *(Cursorius coromandelicus)*
Conservation status: Near Threatened



Golden Jackal *(Canis aureus indicus)*
Conservation status: Least Concern

Fauna

Mammals

- Four-horned Antelope/Chousingha *(Tetracerus quadricornis)*
  Conservation status: Vulnerable
- Indian Wolf *(Canis lupus pallipes)*
  Conservation status: Vulnerable
- Rusty-spotted Cat *(Prionailurus rubiginosus)*
  Conservation status: Near Threatened
- Indian Fox *(Vulpes bengalensis)*
  Conservation status: Least Concern
- Jungle Cat *(Felis chaus)*
  Conservation status: Least Concern
- Ruddy Mongoose *(Herpestes smithii)*
  Conservation status: Least Concern

Birds

- Lesser Florican *(Sypheotides indicus)*
  Conservation status: Critically Endangered
- Steppe Eagle *(Aquila nipalensis)*
  Conservation status: Endangered
- Bristled Grassbird *(Schoenicola striatus)*
  Conservation status: Vulnerable
- Houbara Bustard *(Chlamydotis macqueenii)*
  Conservation status: Vulnerable
- Tawny Eagle *(Aquila rapax)*
  Conservation status: Vulnerable
- Laggar Falcon *(Falco jugger)*
  Conservation status: Near Threatened
- Pallid Harrier *(Circus macrourus)*
  Conservation status: Near Threatened
- Red-headed Falcon *(Falco chicquera)*
  Conservation status: Near Threatened
- Eurasian Roller *(Coracias garrulus)*
  Conservation status: Least Concern
- White Stork *(Ciconia ciconia)*
  Conservation status: Least Concern
- Sand Lark *(Calandrella raytal krishnakumarsinhji)*
  Conservation status: Not Evaluated
- Wren-warbler *(Prinia hodgsoni pallidior)*
  Conservation status: Not Evaluated

Reptiles

- Indian Spiny-tailed Lizard *(Saara hardwickii)*
  Conservation status: Vulnerable
- Brilliant Ground Agama *(Trapelus agilis)*
  Conservation status: Least Concern
- Stoliczka's Slender Blind Snake *(Indotyphlops porrectus)*
  Conservation status: Least Concern
- Wallace's Striped Snake *(Wallaceophis gujaratensis)*
  Conservation status: Least Concern

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Phumdis: Floating Mats of Loktak Lake



Geography

Located almost centrally in the state of Manipur is Loktak Lake, the largest freshwater lake in northeastern India. While the area of the lake is often stated to be 287 square kilometres, Loktak is a 'pulsating' lake, swelling during the rainy season and shrinking in the dry season to about 250 square kilometres. Loktak occupies over a quarter (28%) of the central valley of Manipur, surrounded by hills and mountains from all sides. According to a 2014 study by Laishram and Dey, the Lake has a direct catchment of around 980 square kilometres and indirect catchment area of 7157 square kilometres. The lake is at an elevation of 768 metres above the mean sea level while the highest elevation of the catchment in the hilly region is 2559 metres. The lake receives water from about 30 streams and nine rivers. The outlet of the lake is the Manipur river also known as the Imphal river.

A Ramsar site underlining its international recognition as an important wetland, Loktak Lake has circular floating mats that appear like floating islands called *phumdis*. *Phumdi*s are made of soil, plants, and organic matter at different stages of decomposition. *Phumdi*s are thick enough to hold the huts that fisherfolk have built on some of them for generations. They also support the only population of the Indian Eld's (brow antlered) deer or "Sangai".

Loktak is often called the lifeline of Manipur since it provides livelihood to over two lakh people through fishing, agriculture including wild rice and fodder crops, collection of aquatic plants and other edibles including medicinal plants, and, tourism.

Climate

Rainfall

JUNE TO SEPTEMBER/OCTOBER
Monsoon

~1400
Average annual rainfall

>35°C
Maximum temperature in summers

<5°C, dropping below 2°C
Minimum temperature in winters, with heavy dew and early morning frost

Key Ecological Features and Processes

Seasonal Sink-float Life Cycle

During the monsoon months of July–August, rising water levels cause phumdis to float to the surface; in the dry season, as levels recede, they sink closer to the lakebed — a movement that allows the vegetation growing on them to absorb nutrients through their roots. The construction of the Ithai barrage has disrupted this cycle by preventing any significant dry-season drawdown.

Migratory and Resident Birds

Loktak draws migratory waterfowl — ducks, geese, gulls, grebes, storks and others — from China, Mongolia, and the Siberian reaches of Russia, arriving each winter to escape harsh conditions. The lake also supports resident waterbirds year-round, including the lesser whistling duck.

Conservation Status

Loktak is one of India's 101 Ramsar sites, recognised under the Convention on Wetlands of International Importance. It serves as an important breeding and roosting ground for migratory birds and a breeding ground for numerous fish species.

The lake's southern reaches are dominated by a vast phumdi network that forms the Keibul Lamjao National Park — the only floating national park in the world. Its core area covers 40 square kilometres (sq km), of which roughly 26 sq km is phumdi, and constitutes the last natural refuge of the Sangai, or Indian Eld's deer. The Sangai is an endangered subspecies distinguished by its distinctive brow-antlered silhouette and an unusual splayed, elongated hoof that grants it sure footing on the spongy, waterlogged phumdi surface. Manipur's state animal and a deeply revered cultural symbol, it was once declared extinct in the wild before a small population was rediscovered at Keibul Lamjao in 1953.



People and Livelihoods



Rongmei women in their traditional festival attire

Meitei

The predominant community around and on the lake, the Meitei — Manipur's dominant ethnic group — live in huts built atop phumdis and depend primarily on fishing and agriculture. Meitei Pangals similarly draw their livelihoods from the lake's resources.

Rongmei

A small Rongmei tribal population occupies the western shores.



Tall Reed *(Phragmites karka)*
Conservation status: Least Concern



Giant Reed *(Arundo donax)*
Conservation status: Least Concern



Siamese Ginger *(Alpinia galanga)*
Conservation status: Data Deficient



Starry Osbeckia *(Osbeckia stellata)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Black Fruited Galanga *(Alpinia nigra)*
  Conservation status: Least Concern
- Java Water Dropwort *(Oenanthe javanica)*
  Conservation status: Least Concern
- Ravenna Grass *(Tripidium ravennae)*
  Conservation status: Least Concern
- Red Rice *(Oryza sativa)*
  Conservation status: Least Concern
- Rice Grass *(Leersia hexandra)*
  Conservation status: Least Concern
- Smallflower Umbrella Sedge *(Cyperus difformis)*
  Conservation status: Least Concern
- White Ginger Lily *(Hedychium coronarium)*
  Conservation status: Data Deficient
- Manchurian Wild Rice *(Zizania latifolia)*
  Conservation status: Not Evaluated
- Mountain Scented-Top *(Capillipedium assimile)*
  Conservation status: Not Evaluated
- Munj Grass *(Saccharum munja)*
  Conservation status: Not Evaluated
- Wild Sugarcane *(Tripidium procerum)*
  Conservation status: Not Evaluated

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Sangai/Manipur Brow-antlered Deer *(Rucervus eldii eldii)*
Conservation status: Endangered



Hog Deer *(Axis porcinus)*
Conservation status: Endangered



Asian Golden Cat *(Catopuma temminckii)*
Conservation status: Vulnerable

Fauna

Mammals

- Large Indian Civet *(Viverra zibetha)*
  Conservation status: Least Concern
- Small Indian Civet *(Viverricula indica)*
  Conservation status: Least Concern
- Lesser Bamboo Rat *(Cannomys badius)*
  Conservation status: Least Concern
- Wild Boar *(Sus scrofa)*
  Conservation status: Least Concern

Birds

- Ferruginous Pochard *(Aythya nyroca)*
  Conservation status: Near Threatened
- Mandarin Duck *(Aix galericulata)*
  Conservation status: Least Concern
- Black-necked Stork *(Ephippiorhynchus asiaticus)*
  Conservation status: Least Concern
- Oriental Darter *(Anhinga melanogaster)*
  Conservation status: Least Concern

Reptiles

- The Indian Python *(Python molurus)*
  Conservation status: Near Threatened
- Striped Keelback *(Amphiesma stolatum)*
  Conservation status: Least Concern

Amphibians

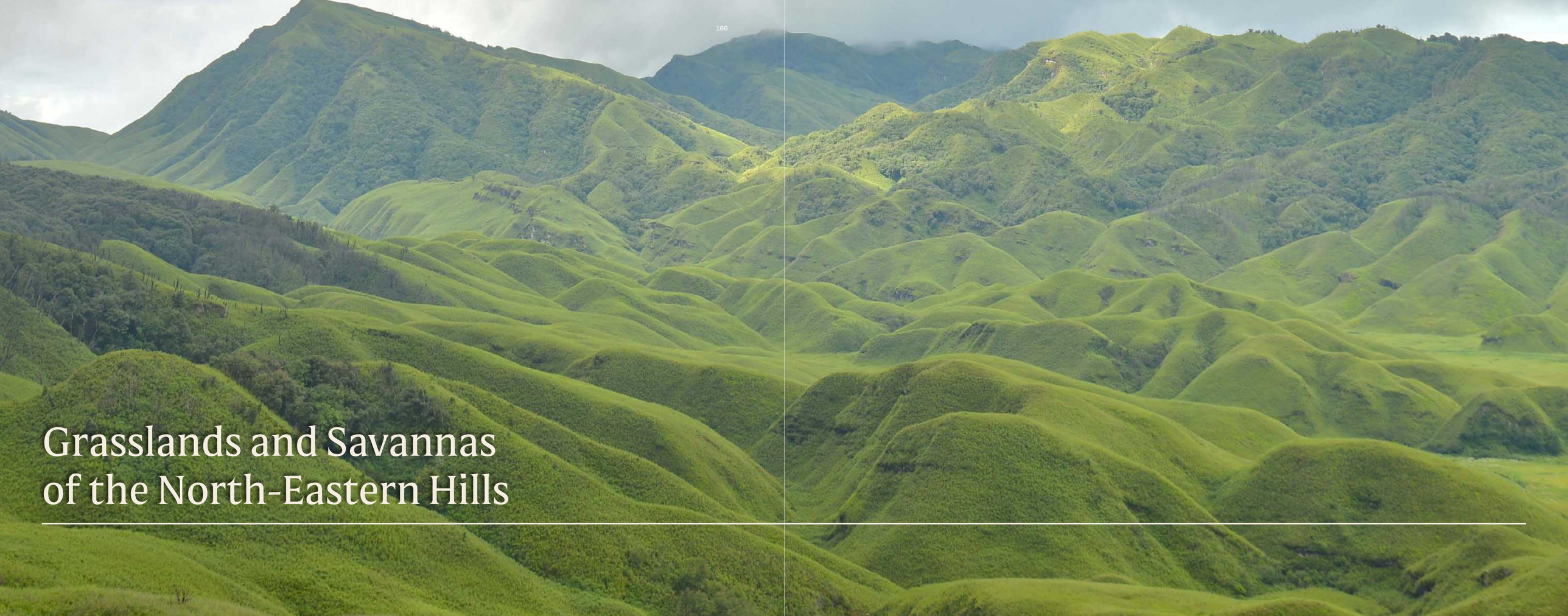
- Bhamo Frog (Humerana humeralis)
  Conservation status: Least Concern
- Six-Toed Burrowing Frog *(Euphlyctis hexadactylus)*
  Conservation status: Least Concern
- Indian Green Frog *(Chalcorana erythraea)*
  Conservation status: Least Concern

Insects

- *Archibasis oscillans*
  Conservation status: Least Concern
- *Orthetrum chrysis*
  Conservation status: Least Concern
- *Neurothemis fulvia*
  Conservation status: Least Concern
- *Heliothrips parvus*
  Conservation status: Not Evaluated
- *Neurothemis tullia*
  Conservation status: Least Concern
- *Merothrips indicus*
  Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
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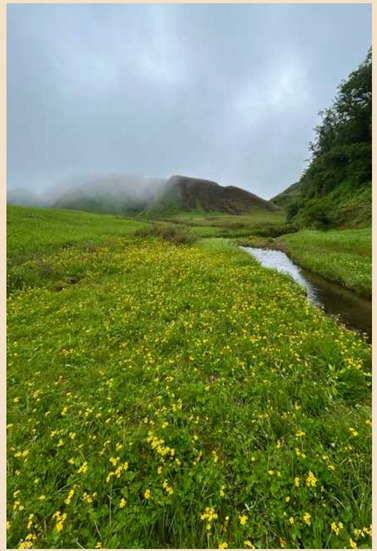
Grasslands and Savannas of the North-Eastern Hills

Geography

While tall grasses adorn the riverine floodplains of north-east India, many hills and their valleys host rolling grasslands and savannas set within forest. Rather than a patchwork, these open habitats are better understood as distinct vegetation communities, each occupying a particular combination of slope exposure (aspect), geomorphology, soil depth and land-use history. They are prominent in the Garo, Khasi and Jaintia hills of Meghalaya; the Dzükou valley on the Nagaland–Manipur border; the Shirui (Siroi) Hills of Manipur; and Mount Saramati and the higher Naga Hills, among other sites. Grasslands typically occupy the upper spurs and ridges while forest dominates the lower, moister slopes; in places they carry scattered trees and grade into savanna, in some cases shaped by centuries of shifting cultivation and fire.

The open vegetation of the north-eastern hills is not a single formation. At least five recurring types can be distinguished by their dominant plants and by the physical setting that maintains each:

1. **Sohra (Cherrapunjee) plateau grasslands:** short-grass and herb-dominated communities on the shallow, heavily leached soils of the East Khasi Hills. Depending on soil depth and fire history they grade through several intermediate or transitional stages of ecological succession (called seral types) and are held open by frequent fire and soil-induced drought despite extremely high rainfall.
2. **Balpakram grasslands (*shola*-grassland-like mosaic):** a result of heavy wind and rain erosion leaving little soil on the exposed tabletops, these grasslands have interspersed forests in valleys similar to the *shola*-grasslands mosaic of the southern Western Ghats.
3. **Dzükou-valley dwarf-bamboo grassland:** the open valley floor and surrounding hillocks are carpeted by dwarf bamboo (*Yushania rolloana*), which resembles grassland from a distance. A recurrent fire–bamboo cycle keeps the valley open.
4. **Moist savanna vegetation:** scattered Khasi pine (*Pinus kesiya*) or other conifers and broad-leaved trees standing over a continuous grassy layer, as seen around Phawngpui (Blue Mountain), Mizoram.
5. **Steep open slopes:** south-west-facing aspects (for example in Mizoram) carrying a mix of deciduous trees, bamboo and grasses.
6. **Landslide successional grasslands** — grassy, open vegetation that establishes as primary succession on fresh landslide scars.



Climate

Rainfall

JUNE TO SEPTEMBER
Mostly monsoonal (Southwest)

2,000–3,000mm, ~11,000mm in Cherrapunji (East Khasi Hills)
Average Annual Rainfall

Summer

MARCH TO JUNE

May
Peak

30–33 °C (Valleys)
Maximum Temperature, mean 20°C in higher altitudes

Winter

NOVEMBER TO FEBRUARY

January
Peak

<0°C
Minimum Temperature

Key Ecological Features and Processes

Natural Bamboo Brakes

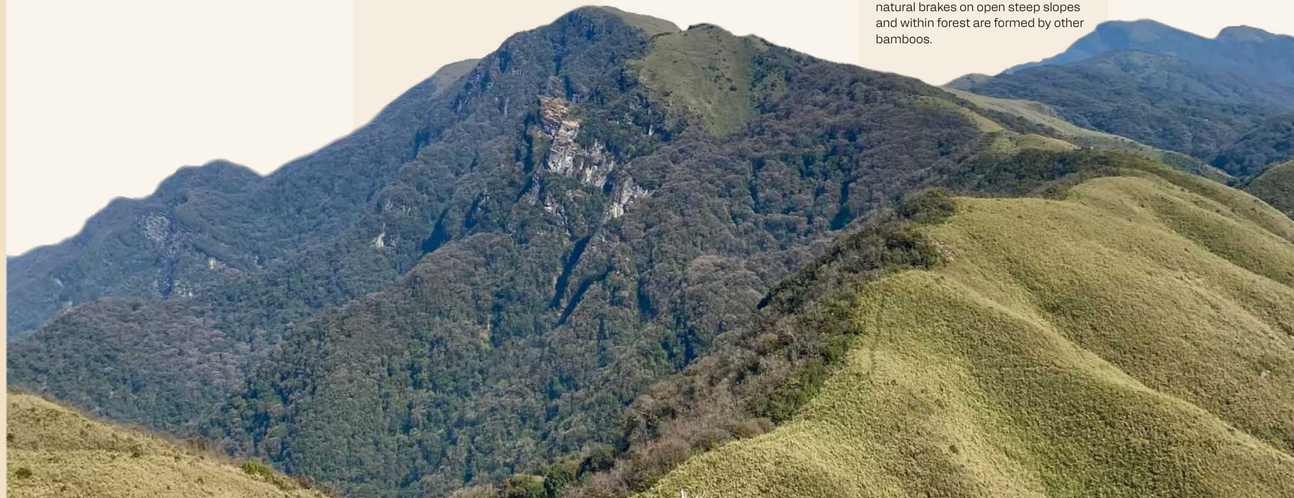
North-east India is a global centre of bamboo diversity, and many bamboos form dense "brakes" naturally — within closed (often dense) forest as well as on steep slopes — quite independently of cultivation. These natural brakes are distinct from the bamboo that colonises abandoned shifting-cultivation land (see below), which is usually made up of different species. Where they occur, brakes are ecologically and economically valuable: they aid soil conservation, provide wildlife habitat and supply building material to local communities.

Dwarf Bamboo and the Fire–bamboo Cycle

In the Dzükou valley, dwarf bamboo *(Sinarundinaria rolloana)* forms an almost continuous, grassland-like cover. It burns readily in the dry season, and the resulting fires favour its own rapid regeneration over that of other plants, sustaining a self-perpetuating fire–bamboo cycle that keeps the valley open. A single fire burned for over a week and, by aerial survey, was found to have spread across roughly 70 km² of the Dzükou hills and adjacent Japfu ranges.

Shifting Cultivation (Jhum) Landscapes

Indigenous communities practise slash-and-burn cultivation, or jhum: a patch of forest is cut, burned and cropped for one to two years, then left fallow to recover. Fallow lengths vary; many communities now leave the land for only about ten years, because the labour of re-clearing rises with longer fallows — as, for example, among the Adi of Upper Siang, Arunachal Pradesh. Recovering fallows are typically taken over by fast-growing pioneers, often a bamboo but usually a different species from those of natural brakes. In Mizoram, for instance, most jhum regeneration is dominated by mautak *(Melocanna baccifera)*, whereas natural brakes on open steep slopes and within forest are formed by other bamboos.



Conservation Status

Balpakram National Park in South Garo Hills of Meghalaya, Phawngpui (Blue Mountain) National Park (NP) in south-eastern Mizoram, and Shirui (or Sirohi) NP (Manipur are some of the protected areas in these hills. The Dzüko Valley located at the borders of the states of Nagaland and Manipur is a community-conserved area.

People and Livelihoods



Khasi women in a cultural performance

Lushai (Mizo)

Found in the Lushai Hills of Mizoram, the community uses bamboo extensively, from construction to craft. The bamboo brakes that supply them shape the region's ecology and are associated with *mautam*, a cyclical phenomenon in which the gregarious flowering and mass death of mautak *(Melocanna baccifera)* every ~48–50 years triggers a rodent boom and resultant famine.

Khasi

A matrilineal people associated with open plateaus, rolling grasslands and forested hills. Although they depend heavily on jhum, they also graze livestock on the grasslands while keeping their sacred groves off-limits to grazers.

Garo (Achik)

A Tibeto-Burman matrilineal group indigenous to western Meghalaya and parts of Bangladesh. The Kundulgup or Balpakram Gorge and Chutmang Hill within the Balpakram National Park are sacred to the Garos. They practice the jhum method of agriculture.

Jaintia (Pnar)

Closely related to the Khasi and occupying the Jaintia Hills of the eastern Meghalaya plateau. Like the Khasi they are matrilineal and combine jhum with livestock grazing on open grasslands, and likewise protect their sacred groves from grazing.



Shirui Lily *(Lilium mackliniae)*
Conservation status: Not Evaluated



Oval-leaf Lyonia *(Lyonia ovalifolia)*
Conservation status: Least Concern



Pogostemon quadrifolius
Conservation status: Data Deficient



Drosera burmannii
Conservation status: Not Evaluated



Himalayan Crinum Lily *(Crinum amoenum)*
Conservation status: Not Evaluated



Osbeckia stellata var. *crinita*
Conservation status: Not Evaluated



Hill Turmeric *(Curcuma pseudomontana)*
Conservation status: Vulnerable

Biodiversity

Flora

- *Rhododendron wattii*
  Conservation status: Vulnerable
- *Arundinella nepalensis*
  Conservation status: Least Concern
- Marsh Marigold *(Caltha palustris)*
  Conservation status: Least Concern
- Chinese Guger Tree *(Schima wallichii)*
  Conservation status: Least Concern
- Khasi Pine *(Pinus kesiya)*
  Conservation status: Least Concern
- Griffith's Spurge *(Euphorbia griffithii)*
  Conservation status: Data Deficient
- *Aconitum elwesii*
  Conservation status: Not Evaluated
- *Agapetes borii*
  Conservation status: Not Evaluated
- Alpine leek *(Allium victorialis)*
  Conservation status: Not Evaluated
- *Arundinella khaseana*
  Conservation status: Not Evaluated
- *Begonia adscendens*
  Conservation status: Not Evaluated
- *Cephalostachyum capitatum*
  Conservation status: Not Evaluated
- *Chimonobambusa callosa*
  Conservation status: Not Evaluated
- *Chrysopogon gryllus*
  Conservation status: Not Evaluated
- Dwarf Bamboo *(Yushania rolloana)*
  Conservation status: Not Evaluated
- Elliott's Rhododendron *(Rhododendron elliotii)*
  Conservation status: Not Evaluated
- *Eulalia trispicata*
  Conservation status: Not Evaluated
- Green Bonnet Bellflower *(Codonopsis griffithii)*
  Conservation status: Not Evaluated
- Johnstone's Rhododendron *(Rhododendron johnstoneanum)*
  Conservation status: Not Evaluated
- Monkshood *(Aconitum nagarum)*
  Conservation status: Not Evaluated
- *Narenga fallax var. aristata*
  Conservation status: Not Evaluated
- Ngai Noi Ginger *(Roscoea ngainoi)*
  Conservation status: Not Evaluated
- *Osbeckia capitata*
  Conservation status: Not Evaluated
- Sikkim Spurge *(Euphorbia sikkimensis)*
  Conservation status: Not Evaluated
- *Themeda villosa*
  Conservation status: Not Evaluated
- Tufted Leucas *(Leucas ciliata var. ciliata)*
  Conservation status: Not Evaluated
- Tiger Grass *(Thysanolaena maxima)*
  Conservation status: Not Evaluated

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Dark-rumped Swift *(Apus acuticauda)*
Conservation status: Near Threatened



Grey Bushchat *(Saxicola ferreus)*
Conservation status: Least Concern



Mountain Bamboo Partridge *(Bambusicola fytchii)*
Conservation status: Least Concern



Garo Hills Reed Snake *(Calamaria garoensis)*
Conservation status: Not Evaluated



Barking Deer/Northern Red Muntjac *(Muntiacus vaginalis)*
Conservation status: Least Concern



Spot-breasted Parrotbill *(Paradoxornis guttaticollis)*
Conservation status: Least Concern



Bamboo Rats *(Rhizomys spp.)*

Fauna

Mammals

- Chinese Pangolin *(Manis pentadactyla)* — Conservation status: Critically Endangered
- Asian Elephant *(Elephas maximus)* — Conservation status: Endangered
- Dhole/Asiatic Wild Dog *(Cuon alpinus)* — Conservation status: Endangered
- Gaur/Indian Bison *(Bos gaurus)* — Conservation status: Vulnerable
- Burmese Red Serow *(Capricornis rubidus)* — Conservation status: Vulnerable
- Sambar *(Rusa unicolor)* — Conservation status: Vulnerable
- Small Indian Civet *(Viverricula indica)* — Conservation status: Least Concern
- Wild Boar *(Sus scrofa)* — Conservation status: Least Concern
- Rufous-tailed Hare *(Lepus nigricollis ruficaudatus)* — Conservation status: Not Evaluated

Birds

- Manipur Bush Quail *(Perdicula manipurensis)* — Conservation status: Critically Endangered
- Blyth's Tragopan *(Tragopan blythii)* — Conservation status: Vulnerable
- Olive-backed Pipit *(Anthus hodgsoni)* — Conservation status: Least Concern
- Yellow-throated Laughingthrush *(Pterorhinus galbanus)* — Conservation status: Least Concern

Reptiles

- Buff-striped Keelback *(Amphiesma stolatum)* — Conservation status: Least Concern
- Khasi Hills Forest Lizard *(Calotes maria)* — Conservation status: Least Concern
- Garo Hills Reed Snake *(Calamaria garoensis)* — Conservation status: Not Evaluated

Invertebrates

- Jumping Spider *(Habrocestum togansangmai)* — Conservation status: Not Evaluated
- Jumping Spider *(Phintelloides manipur)* — Conservation status: Not Evaluated

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Sub-Himalayan Tall Grasslands and Savannas:

Terai-Bhabar Belt and Brahmaputra Floodplains

*This map indicates the broader region in which these Open Natural Ecosystems are found.This map indicates the broader region in which these Open Natural Ecosystems are found.



Geography

The Himalayan rivers carry vast alluvial deposits as they descend the steep mountain slopes and spread across the foothills and northern plains. Bhabar and Terai are two adjacent yet distinct zones of this belt, running parallel to the Himalayan ranges.

Over centuries, these rivers have deposited boulders and gravel along the foothills, forming a thick, highly permeable layer into which surface streams often seem to disappear. This narrow belt, about 8–16 km wide and lying just south of the Outer Himalayas or Shivaliks, is known as the Bhabar; it is generally wider in the west and narrower in the east.

The coarse deposits gradually give way to finer, less permeable alluvium, made of silt, sand, and clay, deposited mainly by the larger perennial Himalayan rivers. Water flowing below the surface in the Bhabar belt reemerges near the surface, creating the swampy and marshy landscape of the Terai. About 10–30 km wide, wider in the east in Assam and narrower in the west towards Uttar Pradesh, the Terai supports a mosaic of wetlands, tall grasslands, savannas, woodlands, and dense sal-dominated forests.

The Bhabar-Terai belt extends from the western Union Territory of Jammu and Kashmir to the eastern state of Arunachal Pradesh passing through the states of Himachal Pradesh, Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar, West Bengal, and Assam. Forming a continuous stretch along the Himalayan foothills, they also run along the southern border of Nepal and southwest Bhutan.

The eastern extension of Terai is known as Dooar, which is located primarily in the northeastern Indian states of West Bengal and Assam, and the ecoregion is known as the Terai–Duar Savanna and Grasslands Complex. The Brahmaputra floodplains form the eastern extremity of the Terai-Duar complex and are ecologically continuous with it, sharing the same character of alluvial tall grasslands, savannas, and wetlands.

Climate

Rainfall in the Terai region is mostly concentrated in the monsoon months of June to September. The region receives over 1200 mm rainfall, increasing from west to east (over 2000 mm). The summer is hot and humid with temperatures crossing 40°C. Dense fog is characteristic of the winter months, and minimum temperatures drop to single digits in the peak winter months of December and January.

Key Ecological Features and Processes

Terai-Duar complex supports one of the **world's tallest grasslands**, with grasses growing up to seven metres in some areas.

The **annual monsoonal flooding** and the **alluvium deposited** by the Himalayan rivers are critical to sustain these grasslands.

Seasonal fires and **herbivory** play an important role in maintaining the wet alluvial grasslands.

Some of the **highest mammal densities in the world** are observed in these grasslands, especially in the Assam section. They support important global populations of tiger, elephant, and crucially the only populations of endemic species like the Greater One-horned Rhinoceros and the Hispid Hare.



Winter morning fog



Conservation Status

There are several protected areas in the Bhabar-Terai and the larger Terai-Duar landscape like Jim Corbett National Park (NP)/ Tiger Reserve (TR) and Rajaji NP/TR, and Nandhaur Wildlife Sanctuary (WLS) in Uttarakhand, Amangarh TR, Dudhwa NP/TR, and Pilibhit TR and Kishanpur, Katerniaghat, and Suhelwa WLSs in Uttar Pradesh, Valmiki TR in Bihar, Jaldapara NP, Gorumara NP, and Buxa NP/TR and Mahananda and Chapramari WLSs in West Bengal, and Manas NP/TR and Kaziranga NP/TR in Assam. Kaziranga NP/TR, Orang NP/TR, and Pobitora WLS in Assam are part of the tall-grassland habitat of the Brahmaputra floodplain, which is ecologically continuous with the Terai landscape.

People and Livelihoods

Bhabar-Terai belt (west/central):

Tharu
Indigenous to the Terai (mostly in Uttarakhand, Uttar Pradesh, and Bihar in India), the Tharu are traditionally engaged in agriculture, cattle-herding, hunting, fishing, and collection of forest produce. They are known for their handicrafts and for building houses from natural materials. Several subgroups exist within the broader Tharu community, including the Dangaura, Kathariya, Sonha, and Rana Tharu.

Bhoksa/Buksa
Indigenous to the Terai-Bhabar belt of Uttarakhand, the Bhoksa (also known as Buksa) are traditionally and primarily engaged in agriculture and animal husbandry (raising sheep).

Van Gujjar
Traditionally nomadic forest pastoral community mainly herding buffaloes, many members still practise seasonal migration between mountains of the outer Himalayas and the Terai-Bhabar belt.

Anwal
A mobile shepherd group of Uttarakhand, many Anwal practice transhumance, migrating from the alpine meadows (*bugyals*) from Uttarakhand to the Bhabar region in the winter.

Terai-Duar region (east):

Koch, Koch-Rajbongshi/Rajbanshi
Indigenous to the eastern Terai and Duar belt, these traditionally agrarian people of the Terai-Duar region reside in the states of Assam, West Bengal, Bihar in India and the adjoining Terai of Nepal and Bangladesh.

Dhimal
Indigenous to the eastern Terai, the Dhimal are found in much larger numbers in Nepal than in India, where they are mostly concentrated in the Darjeeling district of West Bengal. They engage mainly in cultivation, and many work as agricultural or tea garden labourers.

Bodo-Kachari groups
Some Bodo-Kachari groups such as Bodo/ Boro or Mech of Dooars and Brahmaputra floodplains are engaged primarily in farming.

Rabha
A group practising settled agriculture, forest use, and small-scale livestock rearing in the North Bengal Dooars and foothills.

Toto
A small indigenous community living in the Himalayan foothills near Bhutan, dependent on agriculture, livestock, and forest resources.

Karbi
Traditionally practising shifting cultivation, forest use, and mixed farming in hill-foothill ecosystems in Arunachal Pradesh.



Kans/Wild Sugarcane *(Saccharum spontaneum)*
Conservation status: Least Concern



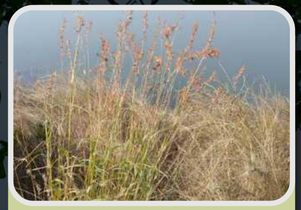
Semul/Red Silk-Cotton Tree *(Bombax ceiba)*
Conservation status: Least Concern



Cogon Grass *(Imperata cylindrica)*
Conservation status: Least Concern



Tall Reed *(Phragmites karka)*
Conservation status: Least Concern



Palmarosa Grass *(Cymbopogon martinii)*
Conservation status: Not Evaluated



Munj *(Saccharum bengalense)*
Conservation status: Not Evaluated



Purple Narenga *(Narenga porphyrocoma)*
Conservation status: Not Evaluated



Ulla Grass *(Themeda arundinacea)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Sal *(Shorea robusta)*
  Conservation status: Near Threatened
- Kusha Grass/Halfa Grass *(Desmostachya bipinnata)*
  Conservation status: Least Concern
- Ravenna Grass *(Tripidium ravennae)*
  Conservation status: Least Concern
- Hardy Sugarcane *(Tripidium arundinaceum)*
  Conservation status: Not Evaluated
- Ratwa *(Sclerostachya fusca)*
  Conservation status: Not Evaluated
- Silky Kangaroo Grass *(Themeda villosa)*
  Conservation status: Not Evaluated
- Vetiver Grass *(Chrysopogon zizanioides)*
  Conservation status: Not Evaluated

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Pygmy Hog *(Porcula salvania)*
Conservation status: Endangered



Hog Deer *(Axis porcinus)*
Conservation status: Endangered



Hispid Hare *(Caprolagus hispidus)*
Conservation status: Endangered



Wild Water Buffalo *(Bubalus arnee)*
Conservation status: Endangered



Fishing Cat *(Prionailurus viverrinus)*
Conservation status: Vulnerable



Finn's Weaver *(Ploceus megarhynchus)*
Conservation status: Endangered



Greater One-horned Rhinoceros
(Rhinoceros unicornis)
Conservation status: Vulnerable



Bengal Florican *(Houbaropsis bengalensis)*
Conservation status: Critically Endangered

Fauna

Mammals

- Barasingha/Swamp Deer *(Rucervus duvaucelii)*
  Conservation status: Vulnerable
- Greater Hog Badger *(Arctonyx collaris)*
  Conservation status: Vulnerable
- Sambar *(Rusa unicolor)*
  Conservation status: Vulnerable

Birds

- Jerdon's Babbler *(Chrysomma altirostre)*
  Conservation status: Vulnerable
- Sarus Crane *(Antigone antigone)*
  Conservation status: Vulnerable
- Indian Grassbird/Rufous-rumped Grassbird *(Graminicola bengalensis)*
  Conservation status: Near Threatened
- Lesser Adjutant Stork *(Leptoptilos javanicus)*
  Conservation status: Near Threatened
- Swamp Francolin *(Ortygornis gularis)*
  Conservation status: Near Threatened
- Kalij Pheasant *(Lophura leucomelanos)*
  Conservation status: Least Concern

Invertebrates

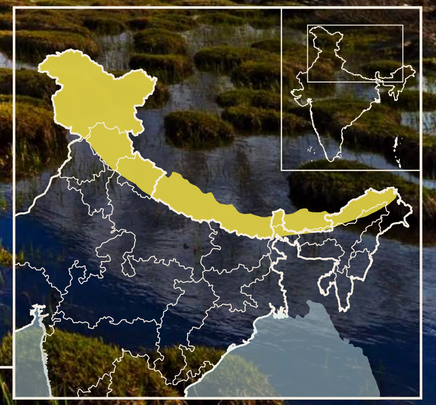
- Great Blue Mime Swallowtail *(Papilio paradoxa)*
  Conservation status: Not Evaluated

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Open Natural Ecosystems of the Himalayas

*This map indicates the broader region in which these Open Natural Ecosystems are found.This map indicates the broader region in which these Open Natural Ecosystems are found.



The Himalayas span an immense arc of roughly 2,400 km from the Nanga Parbat mountain and the Indus gorge in the west to the Namche Barwa mountain along the Brahmaputra gorge in the east. This deeply 3-dimensional geography alone generates one of the most complex gradients of vegetation on Earth from east to west, and south to north.

Two moisture sources dominate the region: the southwest monsoon, which funnels into the eastern and central Himalaya from June to September, and western disturbances, which deliver winter snowfall predominantly to the northwestern ranges. The result is a steep west-to-east gradient in annual precipitation — from lesser than 200 mm in the arid trans-Himalayan valleys of Ladakh to over 3,000 mm in the foothills of Arunachal Pradesh — overlaid with equally sharp south-to-north and elevation-driven gradients within each valley system. Further, the interplay of slope, aspect, elevation, geologic substrate and soils creates a profusion of guilds and niches for highly adapted species of flora and fauna.

These gradients directly govern where trees grow and, by extension, where open natural ecosystems (ONEs) occur. In the eastern Himalayas, abundant moisture allows forests to push upslope to 4,000 m and beyond, compressing the belt of alpine meadows into a narrow band. In the western Himalayas, the treeline is generally lower, around 3,200 m, and the sub-alpine and alpine ONEs are correspondingly wider with grasses and forbs adapted to a colder, drier continental climate. Further west, in the Afghan and Pakistani ranges, the monsoon influence vanishes almost entirely: the landscape at mid-elevations becomes an open mosaic of wild pistachio *(Pistacia vera)*, almond *(Prunus dulcis)*, and scrub steppe — ecosystems with no analogue in the wetter Himalayas.

South to north, the glacial in geological origin and unstable Shivalik foothills give way to the Middle Himalayan ranges (3,500 to 4,500 m) rising to the Greater Himalayas, the highest mountain range on Earth (exceeding 8,000m). Beyond these are the trans-Himalayan cold deserts – the monsoon rain shadow region of the monsoon. In the Western Himalayas, the largely east to west axis of the Greater Himalayas becomes more southeast to northwest, and the range splits into parallel ranges – Dhaula Dhar, Pir Panjal, and Zanskar. These parallel ranges bring in some transient rain shadow regions such as the Lahaul and the Kashmir Valley, that have floral-faunal elements of both the Greater and the trans-Himalayan ecosystems.

Within any given valley, elevation, aspect, slope and soil type carve the vegetation into fine-grained mosaics. South-facing slopes dry quickly and carry open rocky grasslands or shrublands; north-facing slopes hold snow longer and are moister and support denser vegetation. Even in the alpine zone, subtle differences in soil depth and drainage separate sedge meadows from boulder grasslands within metres. This edaphic complexity means that Himalayan ONEs are rarely uniform: a traverse of a few kilometres displays several distinct vegetation types.

Not all Himalayan ONEs are natural in origin, and this distinction matters for conservation. The alpine meadows above the treeline, and the trans-Himalayan steppes north of the main Himalayan crest, have formed naturally in response to climate -- primarily the short growing season, low temperatures, and persistent winds that prevent tree establishment. By contrast, many of the grasslands and scrublands at lower and middle elevations have a long history of being shaped by humans. Millennia of agro-pastoral use -- forest burning, cattle grazing, shifting cultivation -- have kept lower-elevation areas that would otherwise carry forest or scrub, more open. In the sub-alpine belt as well, centuries of high-altitude herding have pushed treeline downward in many areas. Some of these human-modified ONEs now support their own distinctive biodiversity and cultural landscapes, but their origin and maintenance are anthropogenic. More recent pressures -- overgrazing, infrastructure development, fire suppression, and land-use change, are degrading some ONEs and making them ecologically unproductive landscapes.

Understanding this layered history of climate, terrain, soils, and human use, is essential to interpreting the Himalayan ONEs described in the chapters that follow.

Himalayan Low and Mid-Elevation ONEs

Geography

Between the Himalayan foothills of the Bhabar and the alpine meadows of the Higher Himalayas, a mosaic of Open Natural Ecosystems (ONEs) occurs interspersed with forests, either as open forest patches, or grasslands on the desiccated south-facing slopes. In the lower Himalayas these are in chir pine *(Pinus roxburghii)* stands and in the Shivaliks, in sal *(Shorea robusta)* and mixed forests. These have formed either due to edaphic or sustained human use over the millennia.

Climate

The climate across this belt varies substantially from east to west. In the east (Assam, West Bengal, northern parts of the northeast India), annual rainfall is high (1,500 to 3,000 mm) delivered mainly during the southwest monsoon (June–September). Towards the west, rainfall is lower (1,000–1,500 mm). Across the range, in the lower elevation, winter temperatures can reach low single digits, but can be well below freezing as elevation increases. Summer maxima may touch 40°C in the lower valleys.

Key Ecological Features and Processes

Shivalik Rocky Open Grasslands

At higher elevations in the Shivalik hills, thin soils, rocky outcrops, and steep slopes support more open, species-rich grasslands with *Eulaliopsis binata*, *Andropogon pumilus*, and scattered shrubs. These are often maintained by a combination of seasonal dryness and cattle grazing. The rocky outcrops interspersed with grass and scrub patches is an important habitat for the goral (*Naemorhedus goral*).

Fire Ecology

Annual grassland burning, conducted by forest departments and traditional communities, is critical for maintaining the openness of these ONEs and for nutrient cycling. It suppresses woody encroachment and promotes the flush of new grass growth that supports large herbivores.

Human-modified Origin

Much of this grassland belt reflects centuries of clearing, burning, and grazing by the agropastoral communities. The grasslands are not climax vegetation at these elevations; they are maintained, anthropogenic ONEs with significant conservation value.



Conservation Status

Several protected areas cover this wide arc, from famous National Parks such as Rajaji and Corbett in the West to Manas in the East (their upper reaches). Although predominantly forested, the ONEs are adequately represented within these protected areas (PAs). Dachigam National Park (NP), Overa-Aru Wildlife Sanctuary (WLS) in Jammu & Kashmir, a large part of the Great Himalayan NP, Majathal WLS, Chail WLS in Himachal Pradesh, Singalila NP in West Bengal, Binsar WLS in Uttarakhand, and Eaglenest WLS in Arunachal Pradesh are some other PAs in these mid-elevation region of the Himalaya. Overall however, across the Himalayan range, these ONEs are found most commonly as van panchayat commons, *ghasnis* (grazing lands) and reserve/protected forests.

People and Livelihoods



Bakarwal pastoralist



Gaddi pastoralist

The Himalayan foothills (the Shivaliks, Dooars, Bhabar-Terai belt, and lower hill ecosystems) support a remarkable diversity of communities whose livelihoods are linked to forests, agriculture, livestock grazing, seasonal migration, and river systems. Below is a broad west-to-east overview, focusing on communities that either permanently inhabit the foothills or use them as wintering grounds during transhumance.

Bakarwal

A predominantly nomadic sheep and goat herding community that undertakes long-distance transhumance between alpine meadows in the summer and winter grazing grounds in the foothills.

Gaddi

Among the most prominent transhumant groups of Himachal Pradesh, they move livestock between Dhauladhar Pir Panjal alpine meadows and foothill winter ranges.

Gujjar/ Van Gujjar

Semi-nomadic buffalo herders who move seasonally between Shivalik foothill forests and higher Himalayan grazing grounds. They are a well-known forest-dependent pastoral community of India.

Jaunsari

Primarily settled agriculturists and livestock keepers inhabiting lower Himalayan landscapes of Uttarakhand.

Lepcha

Among the earliest inhabitants of the Sikkim/Darjeeling region, known for agroforestry, cardamom cultivation, with strong cultural connections to forests and rivers.

Bhutia

Historically engaged in trade, pastoralism, and mountain agriculture especially in Sikkim and Uttarakhand.

Nepali communities

A diverse set of groups engaged in terrace farming, livestock keeping, and horticulture along much of Eastern Himalayas.



Himalayan Sub-tropical Grassland Mosaics

Across the Shivalik hills and the lower outer ranges of the Himalaya - broadly between 400 m and 1,200 m, Jammu and Kashmir in Himachal Pradesh, Uttarakhand, and the lower hills of West Bengal's Darjeeling and Kalimpong districts and the northeast - open grassy patches form a fine-grained mosaic within the dominant sal (*Shorea robusta*) and chir pine (*Pinus roxburghii*) forests of this belt. These are not extensive grassland tracts but rather a patchwork of glades, ridge-top openings, and degraded forest clearings, shaped by shallow, often eroded soils, south-facing rocky slopes, and a long history of grazing, lopping, and ground fires. Chir pine forests, with their naturally open canopy and fire-adapted understorey, are particularly prone to developing a grassy floor of *Themeda*, *Heteropogon*, and *Chrysopogon* species, especially where annual fires sweep through the pine needle litter. Within sal forests, similar grass-dominated openings occur on ridgelines, old, terraced fields, and heavily grazed patches, often close to villages.

These mosaics are ecologically significant. They provide critical grazing ground for domestic livestock from hillside villages and forage for wild ungulates such as sambar and barking deer that move between forest cover and open grass patches. The open, sun-exposed glades also support a distinct understory flora, including several medicinal and fodder species, that cannot survive under closed canopy. However, this is also one of the more degraded Open Natural Ecosystems (ONEs) types in the Himalayan foothills: frequent uncontrolled fires, overgrazing, and resin-tapping damage to chir pine have in many areas pushed succession away from productive grass-forest mosaic and toward impoverished, weed-dominated scrub.

Himalayan Temperate Grassland Mosaics

Between 1,500 m and 3,000 m in the inner Himalayan valleys and on the mid-montane slopes, patches of temperate grassland and scrub occur within a matrix of mixed broadleaf and conifer forest. These mosaics arise where steep rocky slopes, shallow soils, or south-facing exposures prevent forest establishment, and also where centuries of burning and grazing by transhumant pastoralists have cleared and maintained open patches. In the wetter eastern Himalayas (Sikkim, Arunachal Pradesh), these mid-elevation open areas are relatively restricted and shrubby — dominated by *Rhododendron* scrub alternating with patchy grasslands. In the western Himalayas (Himachal Pradesh, Uttarakhand), the temperate grassland patches — locally called *bugyals* or thatches (*thaches*) on the higher slopes — are more extensive and are used as summer pastures for livestock.

Many of these mid-elevation grasslands are critical transition habitats: they link the lower foothill grasslands to the alpine meadows above, providing seasonal grazing corridors for migratory herbivores and stopover habitat for birds moving between elevational zones. Structurally, they are often characterised by a mix of bunchgrasses (*Festuca, Danthonia, Poa)* with forb-rich patches and isolated shrub clumps. Overgrazing by livestock has degraded many of these mosaics, replacing native grass communities with weedy forbs and bare soil.

Himalayan Sub-tropical Grassland Mosaics

Biodiversity

Flora

- Chir Pine *(Pinus roxburghii)*
  Conservation status: Least Concern
- Khair/Black Cutch *(Senegalia catechu)*
  Conservation status: Least Concern
- Bundled Browntop Grass *(Microstegium ciliatum)*
  Conservation status: Not Evaluated
- Golden-beard Grass *(Chrysopogon spp.)*
  Conservation status: Not Evaluated
- Himalayan Lemon Grass *(Cymbopogon distans)*
  Conservation status: Not Evaluated
- Mauritian Grass *(Apluda mutica)*
  Conservation status: Not Evaluated
- Red Oat Grass *(Themeda triandra)*
  Conservation status: Not Evaluated
- Reddish-Yellow Beardgrass *(Chrysopogon fulvus)*
  Conservation status: Not Evaluated
- Small-flower Scented-top *(Capillipedium parviflorum)*
  Conservation status: Not Evaluated
- Black Speargrass *(Heteropogon contortus)*
  Conservation status: Not Evaluated



Oriental Fountain Grass *(Pennisetum orientale)*
Conservation status: Least Concern



Sal *(Shorea robusta)*
Conservation status: Near Threatened



Nepal Reedgrass *(Arundinella nepalensis)*
Conservation status: Least Concern



Cogon Grass *(Imperata cylindrica)*
Conservation status: Least Concern





Barking Deer/Northern Red Muntjac *(Muntiacus vaginalis)*
Conservation status: Least Concern



Himalayan Buzzard *(Buteo refectus)*
Conservation status: Least Concern



Himalayan Goral *(Naemorhedus goral)*
Conservation status: Near Threatened



Himalayan Griffon *(Gyps himalayensis)*
Conservation status: Near Threatened

Fauna

Mammals

- Asian Elephant *(Elephas maximus)*
  Conservation status: Endangered
- Tiger *(Panthera tigris)*
  Conservation status: Endangered
- Leopard *(Panthera pardus)*
  Conservation status: Vulnerable
- Sambar *(Rusa unicolor)*
  Conservation status: Vulnerable
- Sloth Bear *(Melursus ursinus)*
  Conservation status: Vulnerable

Himalayan Temperate Grassland Mosaics

Biodiversity

Flora

- East Himalayan Yew *(Taxus wallichiana)*
  Conservation status: Endangered
- Deodar Cedar *(Cedrus deodara)*
  Conservation status: Least Concern
- Rhododendron *(Rhododendron arboreum)*
  Conservation status: Least Concern
- Banj Oak *(Quercus leucotrichophora)*
  Conservation status: Not Evaluated
- Brush Grass *(Chrysopogon gryllus)*
  Conservation status: Not Evaluated
- Himalayan Barberry *(Berberis asiatica)*
  Conservation status: Not Evaluated
- Himalayan Bluestem Grass *(Andropogon tristis)*
  Conservation status: Not Evaluated
- Lanceleaf Herminum *(Herminium lancium)*
  Conservation status: Not Evaluated
- Loonder Grass *(Themeda anathera)*
  Conservation status: Not Evaluated
- Pearly Everlasting *(Anaphalis spp)*.
  Conservation status: Not Evaluated
- Red-Hair Plumegrass *(Erianthus rufipilus)*
  Conservation status: Not Evaluated
- Schrader's Bromegrass *(Bromus unioloides)*
  Conservation status: Not Evaluated
- *Themeda tremula*
  Conservation status: Not Evaluated
- Wood False Brome *(Brachypodium sylvaticum)*
  Conservation status: Not Evaluated



Nepal Satyrium *(Satyrium nepalense)*
Conservation status: Not Evaluated



Himalayan Fairy Grass *(Miscanthus nepalensis)*
Conservation status: Not Evaluated



Chir Pine *(Pinus roxburghii)*
Conservation status: Least Concern



Intermediate Habenaria *(Habenaria intermedia)*
Conservation status: Not Evaluated

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Himalayan Tahr *(Hemitragus jemlahicus)*
Conservation status: Near Threatened



Cheer Pheasant *(Catreus wallichii)*
Conservation status: Vulnerable



Himalayan Serow *(Capricornis sumatraensis thar)*
Conservation status: Vulnerable



Upland Buzzard *(Buteo hemilasius)*
Conservation status: Least Concern

Fauna

Mammals

- Himalayan Musk Deer *(Moschus leucogaster)*
  Conservation status: Endangered
- Himalayan Black Bear *(Ursus thibetanus laniger)*
  Conservation status: Vulnerable
- Snow Leopard *(Panthera uncia)*
  Conservation status: Vulnerable
- Himalayan Goral *(Naemorhedus goral)*
  Conservation status: Near Threatened

Birds

- Himalayan Griffon *(Gyps himalayensis)*
  Conservation status: Near Threatened
- Blood Pheasant *(Ithaginis cruentus)*
  Conservation status: Least Concern
- Himalayan Buzzard *(Buteo refectus)*
  Conservation status: Least Concern
- Himalayan Monal *(Lophophorus impejanus)*
  Conservation status: Least Concern



Himalayan Alpine Meadows

Geography

The Himalayan Alpine Meadows occur in a broad zone above the treeline, broadly between 3,200 m and 5,000 m across the Indian states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh. Often wind-gnarled trees *(Rhododendron*, *Juniperus)* line the lower limits of the alpine meadows. In the eastern Himalayas, where precipitation is higher, the treeline is higher (around 4,000 m or above), and the alpine zone is narrower and compressed against the nival belt. In the western Himalayas, the treeline descends to around 3,200–3,500 m, and the alpine meadows are more extensive. These meadows are characteristically flat to gently rolling in valleys and on high plateaus, but often steep and rocky on the higher ridges. The *bugyals* of Uttarakhand — broad, gently sloping high-altitude meadows — are among the most celebrated landscapes in the region. In Sikkim and Arunachal Pradesh, equivalent landscapes are often interspersed with bogs and characteristic cushion plant communities dominated by species including *Silene*, *Androsace*, and *Arenaria*.

Climate

The alpine meadows experience a short season of growth between three to four months (June–September), intense solar radiation, high UV exposure, high wind speeds, and very low temperatures for much of the year. Minimum temperatures routinely fall below -20°C in winter. Snowpack typically persists from November to May, with the depth and duration of snow cover varying considerably between years and between aspects. In the eastern Himalayas, the monsoon delivers heavy summer rainfall (1,000–2,500 mm); in the western Himalayas, summer rainfall is lower (400–800 mm) and winter snowfall from western disturbances is more significant. Strong katabatic and anabatic winds shape the physical structure of the meadow vegetation, pruning shrubs and concentrating snow in specific topographic pockets.

Key Ecological Features and Processes

Alpine Turf and Meadow Communities

The core of the alpine meadow is dense, low-growing turf dominated by *Kobresia* sedges and fine-leaved grasses such as *Poa*, *Festuca*, and *Deschampsia*, and some scattered forbs. These are highly resilient to grazing and trampling but are slow to recover from mechanical disturbances and soil erosion.

Snowbed and Late-lying Snow Communities

Where snow remains longest — in north-facing hollows and depressions — specialised snowbed vegetation develops, often dominated by tiny rushes (*Juncus*), mosses, and slow-growing cushion plants (*Androsace* and *Arenaria)* that complete their life cycle in just a few weeks after snowmelt.

Seasonal Grazing and Ecological Pulse

The alpine meadow system is driven by a strong seasonal pulse: snow-melt triggers a rapid flush of plant growth, attracting migratory transhumant livestock upslope in summer. The high grazing pressure in this short season, followed by deep snow in winter, creates a highly dynamic vegetation mosaic.

Forb-rich Meadows and High-altitude Wildflowers

On moister slopes and in snow-melt hollows, diverse forb communities develop with *Primula*, *Meconopsis*, *Potentilla*, *Gentiana*, and *Anemone*, producing remarkable seasonal floral displays sustain a reciprocal ecological relationship with pollinators.

Alpine Bogs and Wetlands

Seeps, springs, and small peatlands occur throughout the alpine zone and support a distinct community of sedges (*Carex)*, bog forbs, and mosses. These are important water sources for wildlife in the dry late-spring period and store high amount of carbon

Soil and Carbon

Alpine meadow soils, especially those under *Kobresia* turf, store significant quantities of organic carbon accumulated over millennia of slow decomposition. Disruption of this turf through overgrazing or soil disturbances releases carbon and the process is extremely slow to reverse.



Primula flower



Water pools

Conservation Status

The Himalayan Alpine Meadows in the Greater Himalaya of India encompasses some of the country's most important high-altitude protected areas which are home to flagship species such as snow leopard and include vast high-altitude rangelands and wetlands. Some of these are the Khangchendzonga National Park (NP) (~1,780 km²), a UNESCO Mixed World Heritage Site encompassing glaciers, alpine meadows, rich culture and sacred landscapes; Nanda Devi NP (~630 km²) and Valley of Flowers NP (~88 km²), together forming a globally significant high-mountain biodiversity complex; Gangotri NP (~2,390 km²), protecting the headwaters of the Ganga and extensive alpine ecosystems; Great Himalayan NP (~1,170 km²), renowned for its intact temperate and alpine habitats; Dibang Wildlife Sanctuary (~4,150 km²), one of the largest protected areas in the Eastern Himalayas; and Namdapha NP (~1,985 km²), a unique landscape spanning tropical forests to alpine habitats, supporting exceptional biodiversity.

People and Livelihoods



Gaddi pastoralist



Bakarwal pastoralist

Gaddi

A transhumant pastoral community of Himachal Pradesh and Jammu, seasonally moving large flocks of sheep and goats to alpine pastures, their ecological knowledge of the alpine terrain is extensive.

Brokpa/Dokpa

Semi-nomadic high-altitude pastoral communities of the North-eastern Himalaya and trans-Himalaya, traditionally dependent on yak herding and seasonal movement between lower winter pastures and high-elevation alpine meadows.

Gujjar

A transhumant pastoral community whose seasonal routes in Uttarakhand and J&K reach the high-altitude *bugyal* pastures.

Bhotia

A trans-Himalayan trading and pastoral community of Uttarakhand with traditional use rights on high-altitude meadows for summer grazing.

Lachen and Lachungpa

Indigenous agro-pastoral communities of North Sikkim who, through their traditional *Dzumsa* governance system, have long managed high-altitude forests, alpine meadows, and grazing lands while sustaining livelihoods based on agriculture, yak herding, and increasingly nature-based tourism.

Bakarwal

A predominantly nomadic sheep and goat herding community that undertakes long-distance transhumance between alpine meadows and winter grazing grounds in the foothills.

Gujjar/ Van Gujjar

Semi-nomadic buffalo herders who move seasonally between Shivalik foothill forests and higher Himalayan grazing grounds. They are among the well-known forest-dependent pastoral community of India.



Rhododendron *(Rhododendron arboreum)*
Conservation status: Least Concern



Himalayan Blue Poppy *(Meconopsis aculeata)*
Conservation status: Not Evaluated



Carpet Rock Jasmine *(Androsace tapete)*
Conservation status: Not Evaluated



Snowball Plant/Kasturi Kamal
(Saussurea gossypiphora)
Conservation status: Not Evaluated



Lemon-Yellow Primrose/Stuart's Primrose
(Primula stuartii)
Conservation status: Not Evaluated



Himalayan Primrose *(Primula denticulata)*
Conservation status: Not Evaluated



Sikkim Rhubarb/Noble Rhubarb *(Rheum nobile)*
Conservation status: Not Evaluated



Snow Lotus *(Saussurea obvallata)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Himalayan Gentian *(Gentiana kurroo)*
  Conservation status: Critically Endangered
- Jatamansi/Spikenard/Indian Nard *(Nardostachys jatamansi)*
  Conservation status: Critically Endangered
- Himalayan Yarrow *(Achillea millefolium)*
  Conservation status: Least Concern
- Himalayan Rhubarb *(Rheum australe)*
  Conservation status: Data Deficient
- Alpine Cinquefoil *(Potentilla fruticosa)*
  Conservation status: Not Evaluated
- Alpine Fescue *(Festuca spp.)*
  Conservation status: Not Evaluated
- Bistort *(Bistorta affinis)*
  Conservation status: Not Evaluated
- Brahmakamal *(Saussurea speciosa)*
  Conservation status: Not Evaluated
- Cushion Willow *(Salix spp.)*
- Himalayan Anemone *(Anemone obtusiloba)*
  Conservation status: Not Evaluated
- Himalayan Edelweiss *(Leontopodium himalayanum)*
  Conservation status: Not Evaluated
- Himalayan Kobresia/Alpine Sedge *(Kobresia pygmaea)*
  Conservation status: Not Evaluated
- Tube Lousewort *(Pedicularis siphonantha)*
  Conservation status: Not Evaluated

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Himalayan Tahr *(Hemitragus jemlahicus)*
Conservation status: Near Threatened



Himalayan Red Fox *(Vulpes vulpes montana)*
Conservation status: Least Concern



Royle's Pika *(Ochotona roylei)*
Conservation status: Least Concern



Takin *(Budorcas taxicolor)*
Conservation status: Vulnerable



Lammergeier/Bearded Vulture *(Gypaetus barbatus)*
Conservation status: Near Threatened



Himalayan Monal *(Lophophorus impejanus)*
Conservation status: Least Concern

Fauna

Mammals

- Himalayan Musk Deer *(Moschus leucogaster)*
  Conservation status: Endangered
- Himalayan Black Bear *(Ursus thibetanus)*
  Conservation status: Vulnerable
- Himalayan Ibex *(Capra sibirica)*
  Conservation status: Near Threatened
- Himalayan Marmot *(Marmota himalayana)*
  Conservation status: Least Concern

Birds

- Alpine Swift *(Tachymarptis melba)*
  Conservation status: Least Concern
- Blood Pheasant *(Ithaginis cruentus)*
  Conservation status: Least Concern
- Golden Eagle *(Aquila chrysaetos)*
  Conservation status: Least Concern
- Himalayan Grasshopper-warbler *(Locustella kashmirensis)*
  Conservation status: Least Concern
- Himalayan Snowfinch *(Montifringilla adamsi)*
  Conservation status: Least Concern
- Himalayan Snowcock *(Tetraogallus himalayensis)*
  Conservation status: Least Concern

Invertebrates

- Apollo Butterfly *(Parnassius apollo)*
  Conservation status: Least Concern

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Indian Trans-Himalayan Steppe

Geography

North and east of the main Himalayan crest, a high-altitude cold desert and steppe landscape extends across Ladakh, Spiti, the upper Kinnaur valleys, and the upper reaches of the Uttarakhand and Sikkim Himalayas. These are the driest, coldest, and most continental of India's open natural ecosystems, lying in the rainshadow of the Himalayas at elevations generally between 3,500 m and 5,500 m. The western parts of Ladakh, including the Zanskar and Karakoram ranges, are rugged mountains that give way to the rolling high plateaus of Changthang and the northern banks of the Spiti River. In contrast, the southern bank of Spiti and Uttarakhand remain relatively rugged. The Trans-Himalaya of Sikkim is characterized largely by expansive high plateaus.

The landscape is essentially open: vast flat or gently undulating valley floors and inter-montane basins carry sparse grasses, forbs and shrubs, while steep rockfaces and talus scree slopes have scattered shrubs and grasses. The steppe in the rest of the slopes is a mix of low shrubs such as *Lonicera*, *Caragana*, *Krascheninnikovia*, forbs and grasses. The major river systems — the Indus, Shyok, Spiti, Zanskar, upper Ganga and Teesta — run through this landscape in deep gorges, their floodplains and lower terraces supporting the only relatively lush vegetation in an otherwise arid terrain.

Climate

The trans-Himalayan steppe has an extreme continental climate. Annual precipitation is typically 50–200 mm, falling mostly as snow between November and March from western disturbances. The monsoon barely penetrates beyond the main Himalayan crest. Summers are short, with daytime temperatures exceeding 30°C in low-elevation valleys while nights remain cold (below 5°C). Winters are severe, with minimum temperatures regularly falling to -30°C or lower in several parts of the region. The thin atmosphere means extreme diurnal temperature variation, with shifts of 20–25°C between day and night common in the summer months. Strong winds, especially the katabatic winds off glaciers, are a feature of most valleys.

Key Ecological Features and Processes

Changthang Plateau and High-Altitude Steppe

The broad plateau of the Changthang at 4,200–5,000 m carries low, sparse vegetation of *Stipa*, *Poa*, *Carex*, and cushion plants *(Thylacospermum caespitosum, Arenaria spp.)*, with bare stony ground dominating the landscape. *Krascheninnikovia ceratoides* is a crucial forage species for the domestic as well as wild ungulates. Biomass production is low, yet this landscape supports globally significant populations of large mammals.

Valley Floor and Terrace Vegetation

On slopes, alluvial terraces and relatively sheltered valley floors, slightly moister conditions support a richer steppe vegetation with *Caragana* and *Artemisia* shrubs, tall grasses, and in places the distinctive Tibetan willow *(Salix spp.)* lining the water channels.

Wetlands and Saline Lakes

The Changthang and trans-Himalayan valleys contain numerous high-altitude lakes (tso), many saline, and extensive seasonal wetlands. Pangong Tso, Tso Moriri, Tso Kar, Hanle wetlands, Chandra Tal, Gurudogmar Lake are among the most significant, supporting migratory waterbirds and breeding populations of the Black-necked Crane.

Wind and Cryogenic Processes

Freeze-thaw cycles and wind erosion are the dominant geomorphic processes shaping the trans-Himalayan steppe. patterned ground caused by frost heave, and deflation of fine material create a micro-topographic diversity that drives local variation in plant communities at small scales. The annual temperature range experienced by rocks and substrates spans from about –40 °C in winter to over 35 °C in summer—nearly 75 °C in total, perhaps the widest range in any ecosystem. This extreme variation likely plays a crucial role in soil formation.

Nomadic Pastoralism as Ecological Driver

The Changpa nomads of the Changthang practise a highly mobile form of yak and Pashmina goat and sheep herding, moving seasonally across the plateau to exploit patchy forage. This nomadic pattern has shaped the steppe vegetation over centuries and is an integral part of the ecosystem's ecological dynamics.



Conservation Status

The Indian Trans-Himalayas contains some of Asia's largest and most ecologically significant high-altitude protected landscapes, including Hemis National Park (NP) (~4,400 km²), a globally important stronghold for the snow leopard; Changthang Wildlife Sanctuary (WLS) (~4,000 km²), protecting vast cold-desert grasslands, lakes, and wetlands; Karakoram WLS (~5,000 km²), encompassing some of the highest mountains and glaciers in the region supporting ibex, urial, and snow leopard habitats; Tso Moriri Wetland Conservation Reserve (~1,200 km²), centred on a high-altitude Ramsar lake and important breeding grounds for migratory birds; Tso Kar Wetland Conservation Reserve (~500 km²), known for black-necked cranes and unique saline wetland ecosystems; Pin Valley NP (~675 km²), representing the cold-desert landscapes of Spiti along with Kibber WLS (~2,200 km²), an important habitat for snow leopard, Himalayan ibex, and Tibetan wolf; Chandra Taal WLS (~40 km²), protecting alpine wetlands and surrounding high-altitude ecosystems; and Rupi Bhaba WLS (~740 km²), which forms a critical ecological transition between the Greater Himalayas and the Trans-Himalayan cold desert. The recently established Tsarap Chu Conservation Reserve (~1,500 km²) in Spiti is an experiment in this legal category in the Western Himalaya. Together with the contiguous Upper Spiti Landscape (~4,000 km²) established under the Project Snow Leopard, it forms one of the largest well managed conservation areas in the trans Himalaya.

People and Livelihoods



Changpa pastoralist



Brokpa/Dokpa pastoralists

Changpa

The indigenous nomadic pastoralists of the Changthang plateau, herding Pashmina goats and yaks across seasonal routes; their Pashmina fibre is one of the most prized natural fibres in the world.

Brokpa/Dokpa

Semi-nomadic high-altitude pastoral communities of the North-eastern Himalaya and trans-Himalaya, traditionally dependent on yak herding and seasonal movement between lower winter pastures and high-elevation alpine meadows.

Bodh/Ladakhi/Spiti farmers

Settled communities along river valleys who practise irrigated agriculture at remarkable elevations, maintaining oasis-like village landscapes within the steppe.

Lachenpa and Lachungpa

Indigenous agro-pastoral communities of North Sikkim who, through their traditional *Dzumsa* governance system, have long managed high-altitude forests, alpine meadows, and grazing lands while sustaining livelihoods based on agriculture, yak herding, and increasingly nature-based tourism.



Pea Shrub *(Caragana versicolor)*
Conservation status: Not Evaluated



Wild Rose/ Webb's Rose *(Rosa webbiana)*
Conservation status: Not Evaluated



Alpine Clover *(Trifolium repens)*
Conservation status: Not Evaluated

Biodiversity

Flora

- Asmania *(Ephedra gerardiana)*
  Conservation status: Vulnerable
- Alpine Cat's-tail *(Phleum alpinum)*
  Conservation status: Least Concern
- Desert Thorn *(Lycium ruthenicum)*
  Conservation status: Least Concern
- Alpine Meadow Grass *(Poa alpina)*
  Conservation status: Not Evaluated
- Creeping Azalea *(Loiseleuria procumbens)*
  Conservation status: Not Evaluated
- Cushion Plant *(Thylacospermum caespitosum)*
  Conservation status: Not Evaluated
- Cushion Sandwort *(Arenaria polytrichoides)*
  Conservation status: Not Evaluated
- High-altitude Sedge *(Carex moorcroftii)*
  Conservation status: Not Evaluated
- Himalayan Knotweed *(Polygonum viviparum)*
  Conservation status: Not Evaluated
- *Kraschenninnikovia ceratoides*
  Conservation status: Not Evaluated
- *Oxytropis microphylla*
  Conservation status: Not Evaluated
- Rhubarb *(Rheum webbianum)*
  Conservation status: Not Evaluated
- Sibbaldia *(Sibbaldia cuneata)*
  Conservation status: Not Evaluated
- Siberian Wormwood *(Artemisia sieversiana)*
  Conservation status: Not Evaluated
- Tibetan Feather Grass *(Stipa purpurea)*
  Conservation status: Not Evaluated
- Tibetan Willow *(Salix spp.)*
  Conservation status: Not Evaluated

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Ladakh Urial *(Ovis vignei vignei)*
Conservation status: Vulnerable



Himalayan Brown Bear *(Ursus arctos isabellinus)*
Conservation status: Endangered



Tibetan Wolf *(Canis lupus chanco)*
Conservation status: Vulnerable



Himalayan Blue Sheep/Bharal *(Pseudois nayaur)*
Conservation status: Least Concern



Altai Weasel *(Mustela altaica)*
Conservation status: Vulnerable



Himalayan Marmot *(Marmota himalayana)*
Conservation status: Least Concern



Snow Leopard *(Panthera uncia)*
Conservation status: Vulnerable



Tibetan Gazelle/Goa *(Procapra picticaudata)*
Conservation status: Near Threatened



Tibetan Sandgrouse *(Syrrhaptes tibetanus)*
Conservation status: Least Concern

Fauna

Mammals

- Chiru/Tibetan Antelope *(Pantholops hodgsonii)*
  Conservation status: Near Threatened
- Himalayan Ibex *(Capra sibirica)*
  Conservation status: Near Threatened
- (Tibetan) Argali *(Ovis ammon)*
  Conservation status: Near Threatened
- Himalayan Blue Sheep/Bharal *(Pseudois nayaur)*
  Conservation status: Least Concern
- Kiang/Tibetan Wild Ass *(Equus kiang)*
  Conservation status: Least Concern
- Pallas's Cat *(Otocolobus manul)*
  Conservation status: Least Concern
- Royle's Pika *(Ochotona roylii)*
  Conservation status: Least Concern
- Tibetan Fox *(Vulpes ferrilata)*
  Conservation status: Least Concern

Birds

- Saker Falcon *(Falco cherrug)*
  Conservation status: Endangered
- Himalayan Griffon *(Gyps himalayensis)*
  Conservation status: Near Threatened
- Lammergeier/ Bearded Vulture *(Gypaetus barbatus)*
  Conservation status: Near Threatened

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX

Trans-Himalayan Riparian Valley Vegetation and Wetlands

Within the otherwise arid trans-Himalayan landscape, the floodplains, lower terraces of the main river valleys — the Indus, Shyok, Nubra, Spiti, and their tributaries — and some side streams, support narrow but ecologically important ribbons of riparian vegetation and wetlands. Where groundwater or irrigation provides sufficient moisture, dense stands of giant sedges *(Carex spp.)*, bulrushes *(Typha minima, Scirpus spp.)*, and, tall grasses *(Poa, Phleum)* form reed beds and sedge marshes, creating a striking contrast with the surrounding sparse steppe vegetation. The Hanle marshes, the Tso Kar wetland complex, the Skagzung meadows in the upper Indus basin, and sections of the Indus floodplain near Leh and Stok, represent the best examples of this habitat type within India. The glacial side streams also have similar green strips of sedges and some planted trees.

These valley wetlands are critical refugia in an extreme landscape. They serve as the primary breeding habitat for the Black-necked Crane, and as staging and feeding areas for thousands of migratory waterbirds on the Central Asian Flyway. The dense sedge and rush vegetation provides forage and cover for livestock and wildlife alike, and the associated water channels are the principal source of drinking water for both nomadic herders and settled villages. The sedge meadows on the Changthang plateau serve as crucial winter reserve pastures for the livestock of Changpa herders, and in late summer provide forage for wildlife such as the Tibetan wild ass. In the lower valleys, these green strips become vital spring grazing grounds for endemic ungulates like the Ladakh urial. Climate change is affecting the hydrological regime of these wetlands: reduced glacial meltwater, warmer summers causing faster evaporation, and altered precipitation patterns are collectively reducing wetland extent and threatening the species that depend on them.

Biodiversity

Flora

- Amphibious Bistort *(Persicaria amphibia)*
  Conservation status: Least Concern
- Branched Horsetail *(Equisetum ramosissimum)*
  Conservation status: Least Concern
- *Carex orbicularis*
  Conservation status: Least Concern
- *Carex pseudofoetida*
  Conservation status: Least Concern
- Elegant False Tamarisk *(Myricaria elegans)*
  Conservation status: Least Concern
- *Epilobium latifolium*
  Conservation status: Least Concern
- Grey Club-rush
  Schoenoplectus tabernaemontani)
  Conservation status: Least Concern
- Petite Massette *(Typha minima)*
  Conservation status: Least Concern
- *Salix pycnostachya*
  Conservation status: Least Concern
- *Salix sericocarpa*
  Conservation status: Least Concern
- *Carex kokanica*
  Conservation status: Not Evaluated
- Himalayan Willow *(Salix karelinii)*
  Conservation status: Not Evaluated
- Kashmir False Tamarisk
  (Myricaria bracteata or Myricaria germanica alopecuroides)
  Conservation status: Not Evaluated
- Tibetan Sea Buckthorn *(Hippophae tibetana)*
  Conservation status: Not Evaluated



Leh Berry/ Himalayan Sea Buckthorn
(Hippophae rhamnoides ssp. turkestanica)
Conservation Status: Not Evaluated



White-winged Redstart
(Phoenicurus erythrogastrus)
Conservation status: Least Concern



Great Crested Grebe *(Podiceps cristatus)*
Conservation status: Least Concern



Black-necked Crane *(Grus nigricollis)*
Conservation status: Near Threatened

Fauna

Mammals

- Eurasian Otter *(Lutra lutra)*
  Conservation status: Near Threatened
- Nubra Pika *(Ochotona nubrica)*
  Conservation status: Least Concern
- Woolly Hare/Tibetan Hare *(Lepus oiostolus)*
  Conservation status: Least Concern

Birds

- Long-billed Grasshopper-warbler
  (Locustella major)
  Conservation status: Endangered
- Bar-headed Goose *(Anser indicus)*
  Conservation status: Least Concern
- Brown-headed Gull
  (Chroicocephalus brunnicephalus)
  Conservation status: Least Concern
- Bluethroat *(Luscinia svecica)*
  Conservation status: Least Concern
- Brahminy Duck/ Ruddy Shelduck
  (Tadorna ferruginea)
  Conservation status: Least Concern
- Common Redshank *(Tringa totanus)*
  Conservation status: Least Concern
- Ibisbill *(Ibidorhyncha struthersii)*
  Conservation status: Least Concern
- Streaked Rosefinch *(Carpodacus rubicilloides)*
  Conservation status: Least Concern
- Tibetan Sandplover *(Charadrius atrifrons)*
  Conservation status: Least Concern

IUCN RED LIST

NOT EVALUATED	DATA DEFICIENT	LEAST CONCERN	NEAR THREATENED	VULNERABLE	ENDANGERED	CRITICAL ENDANGERED	EXTINCT IN THE WILD	EXTINCT
NE	DD	LC	NT	VU	EN	CR	EW	EX



Pastoralism in India

Aniruddh Sheth, Yash Ketkar and Anushka Verma

Centre for Pastoralism



Pastoralism deserves serious attention because it remains one of the few large-scale land-use systems capable of producing food, sustaining livelihoods, maintaining social cohesion and managing ecological variability simultaneously across some of the most fragile and intractable environments in the country.

Introduction

Every year in April, when the rhododendrons are in bloom, the shepherds in the western Himalaya read them much like a farmer gauges rain from the clouds and wind. The appearance of the flowers signals the melting of snow and the onset of summer. They must now head higher with their herd across mountain passes into alpine pastures, full of nutritious grasses. This predictable snow melt guides them towards these vast and open grassland ecosystems that support summer grazing for their herd. Most of these open landscapes are above the treeline, spread out at an elevation too high for infrastructure and development projects.

Pastoralism is one of India's largest human land-use systems after agriculture and, by far, the least understood. It contributes milwk, meat, fibre and manure from landscapes where settled agriculture is often risky or impossible. Pastoralism also plays an important ecological role in nutrient cycling, carbon sequestration, fire and hazard management, and preventing growth of invasive plants. **Many of India's open natural ecosystems have been shaped not only by climate and geology, but by centuries of grazing, movement, and seasonal use.** These movements are not random. They are carefully timed responses to environmental variability.

Yet pastoralism remains largely invisible in public policy and contemporary discourse. Modern land governance, because it originated during colonial rule, is organised around fixed settlement, fixed property, and fixed infrastructure. Pastoralism, on the other hand, depends on movement. Migration routes cut across district boundaries, state borders, forests, roads, agricultural fields and commons.

India's open landscapes, which are largely used by pastoralists, are often described as empty, degraded, or unproductive and administratively often classified as 'wasteland' or land to be improved. Alpine meadows, savannas and deserts are imagined as remote frontier spaces even though these landscapes support one of the largest mobile livestock economies in the world. Across the Himalaya, the Thar Desert, the Deccan Plateau, the Western Ghats, and the floodplains of peninsular India, pastoralist communities move with their livestock through seasonal grazing systems that have evolved over centuries. Sheep, goats, buffalo, cattle, camels, yaks, ducks and pigs are herded across ecological gradients in response to rainfall, snowmelt, forage cycles, seasonal disease vectors, water availability and agricultural harvests.

Pastoralist systems are being compressed into smaller and more fragmented spaces, affecting a livelihood tradition and a way of managing ecological variability across some of India's most extensive and fragile open ecosystems.

Rationale of Pastoralism

Land Cover	% in 2023	Description
Agriculture	49.2	Planted/plotted cereals, grasses, and crops not at tree height.
Rangelands	19.5	Open areas covered in homogenous grasses with little to no taller vegetation.
Forests	18.6	Any significant clustering of tall (~15 feet or higher) dense vegetation, typically with a closed or dense canopy.
Built Area	7.0	Human made structures; major road and rail networks; large homogenous impervious surfaces including parking structures, office buildings and residential housing; examples: houses, dense villages / towns / cities, paved roads, asphalt.
Bare ground	2.5	Areas of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation; examples: exposed rock or soil, desert and sand dunes, dry salt flats/pans, dried lake beds, mines.
Water	2.1	Areas where water was predominantly present throughout the year.
Snow/Ice	1.0	Large homogenous areas of permanent snow or ice, typically only in mountain areas or highest latitudes; examples: glaciers, permanent snowpack, snow fields.
Flooded vegetation	0.1	Areas of any type of vegetation with obvious intermixing of water, flooded mangroves, emergent vegetation, rice paddies and other heavily irrigated and inundated agriculture.

Data compiled from ESRI Sentinel-2 10m Land Use/Land Cover Time Series for 2023.



Nearly half of India's land area is covered by agriculture, half of which is entirely dependent on rainfall for water. **Close to a fifth of India's land area (see table below) is classified as rangelands**, (the UN's Food and Agriculture Organisation (FAO) defines rangelands as "lands dominated by grasses, grass-like plants, forbs, shrubs and sometimes trees that are grazed or have the potential to be grazed by livestock and wildlife.") which has historically been referred to as wastelands given that it lacks utility from an agricultural perspective. About another fifth of India is covered with forests. Pastoralists in India use fallow plots across large areas of the country's rainfed agricultural land to pen their animals, and depend on significant forest areas for movement and grazing on forest floors. Pastoralism may use more than 35-40% of India's land area, thus being one of the largest users of land. To put this in perspective, 10-12 million people manage the majority of India's sheep, camel and yak populations, nearly half of its goat population and 10-15 % of India's bovine livestock. Most of the 150 million livestock in India (~30% of the total livestock population) graze on lands that are either suboptimal from an agricultural perspective or are entirely dependent on rainfall and therefore remain fallow for large periods of time.

Rainfall in semi-arid India is unpredictable. One area may receive rain while another nearby remains dry. In mountain systems, snow cover determines when pastures become accessible. Water availability, disease risk, temperature, and crop cycles also shift seasonally. Fixed livestock systems struggle in such environments because fodder availability changes continuously. Mobility allows pastoralists to respond to this variability.

While different pastoral systems organise movement differently, they all operate on the same basic principle: livestock move to where forage is available. In Ladakh, Changpa pastoralists move pashmina goats across high-elevation plateaus, tracking sparse seasonal vegetation in one of the harshest inhabited landscapes in the world. In Himachal Pradesh, Gaddi shepherds move sheep and goats between alpine meadows and lower elevation forests through seasonal transhumance. In Rajasthan and Gujarat, Raika and Rabari pastoralists travel across semi-arid landscapes with sheep, goats, and camels, often covering hundreds of kilometres annually. These movements are structured through migration calendars that are closely tied to ecological rhythms. In Himalayan systems, snow retreat determines when herds can ascend into alpine grazing areas. The arrival of winter snow prompts descent into foothill forests and lower valleys. In semi-arid western and peninsular India, the monsoon shapes migration patterns. Dry seasons often involve outward movement across open grazing landscapes and harvested agricultural fields, while the onset of rainfall draws herders back toward village commons and home settlements.

Experienced herders know which grasses emerge first after rain, which grazing patches retain moisture longest into the dry season, and which routes expose livestock to seasonal disease outbreaks. Gaddi shepherds in Himachal Pradesh, for instance, observe rhododendron flowering and snowmelt patterns to assess whether high-elevation pastures are ready for grazing. **Migration routes are supported by a wider ecological and social infrastructure that includes watering points, forest edges, overnight resting areas, village commons, and long-standing relationships with farming communities.**

Although these routes are rarely visible in formal planning systems, they function much like transport networks. When migration corridors are blocked by highways, fenced by industrial projects, or fragmented by changing land use, pastoral systems struggle. Restricting movement concentrates livestock into smaller areas for longer periods and weakens the ecological logic on which pastoralism depends.



Pastoralism as Ecosystem Management

Pastoralism is often understood as environmentally destructive, where grazing is frequently framed as the source of degradation. The ecological relationship between grazing and open ecosystems is more complex than these assumptions suggest. **Many of India's grasslands, scrublands, and alpine meadows have evolved with herbivory and periodic disturbance.** Livestock grazing influences which plants dominate landscapes and how vegetation structure changes over time. Where grazing disappears entirely, a small number of competitive grasses or woody species begin to dominate open ecosystems. In some regions, invasive shrubs and trees spread rapidly into formerly open landscapes. Moderate grazing can maintain vegetation heterogeneity by reducing dominance and creating space for different plant species to coexist. This matters because many insects, reptiles, birds, and small mammals depend on open habitats. Grazing also contributes to seed dispersal and stimulates new plant growth through tillering.

Pastoralists are aware of their impact on ecosystems and often maintain mixed-species herds that use landscapes differently. Sheep and cattle primarily graze grasses, while goats browse shrubs and woody vegetation. This distributes grazing pressure across different kinds of vegetation rather than concentrating it on a single forage type. The ecological effects of grazing depend heavily on timing, intensity, and movement.

Mobility distributes livestock across large landscapes instead of concentrating animals permanently in one location. When access to migration routes or seasonal pastures is restricted, livestock are forced into smaller spaces for longer periods, increasing the risk of localised degradation. This recognition is important because efforts to exclude grazing can sometimes produce the ecological problems they aim to prevent. In western India, invasive species such as *Neltuma juliflora* (previously *Prosopis juliflora*) have transformed extensive grazing landscapes. In the Nilgiri grasslands, warming temperatures are already altering the balance between open grasslands and woody vegetation. The absence of grazing and disturbance can accelerate these adverse shifts in some ecosystems.

The relationship between pastoralism and biodiversity is more complicated than older conservation models assumed. Many landscapes now valued for biodiversity, including the alpine meadows of the Himalaya, the Banni grasslands of Kachchh, the scrublands of western India, and the shola-grassland mosaics of the Nilgiris, have long histories of pastoral use.



Knowledge, Breeds, and Adaptation

Pastoralism depends on knowledge accumulated through movement across landscapes over generations. This detailed understanding of forage, weather, water, animal behaviour, and disease is based on observation and experience, built through repeated engagement with changing ecological conditions across seasons and years. **Experienced herders continuously monitor animal condition, forage quality, reproductive cycles, and climatic conditions while adjusting movement patterns accordingly.**

Much of this knowledge is inseparable from mobility itself. It is learned while moving through landscapes rather than from remaining fixed in one place. Pastoralism therefore produces not only livestock economies, but systems of distributed ecological observation. This knowledge is also embedded within livestock breeds. **Across India, pastoral communities have developed livestock adapted to highly specific ecological conditions through long-term selection.** The Changpa of Ladakh rear pashmina goats adapted to the cold, wind, and sparse vegetation of the trans-Himalayan plateau. In western India, the Banni buffalo has been bred for mobility, heat tolerance, and the ability to graze saline grasslands. Deccani sheep are adapted to long migrations and dry conditions in the semi-arid Deccan.

Pastoral systems also depend on a wide range of practical skills developed through migration. Pastoralists construct temporary shelters, process wool and dairy products, manage herd movement across difficult terrain, and travel with limited material resources over long distances. Ethnoveterinary knowledge remains important in many regions where formal veterinary infrastructure is limited. Herders use herbal treatments, dietary adjustments, and movement strategies to reduce disease risk among livestock. Mixed herds provide another form of adaptation. Sheep, goats, cattle, and camels use landscapes differently and allow pastoralists to access a wider range of forage across the same terrain. This flexibility increases the productive capacity of open ecosystems without relying heavily on external inputs.

Pressures on Pastoralism

Sedentarisation, along with the fragmentation of migration routes and the shrinking of commons, undermine the ecological and social conditions that sustain pastoral knowledge. Pastoralism in India is therefore under increasing pressure, not because its ecological logic has disappeared, but because modern land-use systems don't accommodate mobility. **One of the most immediate pressures is the fragmentation of grazing landscapes.** Commons across India have steadily shrunk through privatisation, agricultural expansion, infrastructure development, industrial projects, mass tree-planting drives, and changing land tenure systems.

Changing patterns of land use have emerged as a major challenge for pastoralists across India. Open grazing landscapes are under pressure from competing land uses, resulting in fragmentation of rangelands and disruption of traditional migratory routes.

Conservation approaches have produced similar tensions, because of a conflating of sedentary grazing with nomadic pastoralism. Yet many landscapes now recognised for their ecological value have been shaped, in part, through long histories of pastoralist use. Recognising pastoralists as active stewards of these ecosystems is therefore essential to both biodiversity conservation and the long-term sustainability of pastoral livelihoods.

Pastoralists also face deep tenure insecurity. Migration routes, seasonal grazing areas, and commons are often governed through customary access arrangements rather than documented entitlement. As a result, pastoral systems remain highly vulnerable to displacement.

Climate change is intensifying many of the pressures on pastoralism. In semi-arid India, increasing rainfall variability is disrupting forage availability and seasonal predictability. Droughts are becoming more frequent while recovery periods between droughts are becoming shorter. Invasive species are spreading across stressed landscapes, and changing temperatures are altering disease environments for livestock. Pastoralism itself is climate-adapted and is equipped to manage and respond to environmental variability through mobility. Climate adaptation therefore becomes far more difficult when mobility is restricted.

Pastoral communities across India are also facing growing difficulty in finding young people willing to follow the traditional livelihood. Expanded access to education, wage labour, urban employment, and state services has widened the aspirations of younger generations. Besides a cultural decline this shift also reflects greater social mobility and expanding economic choice.

With fewer younger people entering pastoralism, the transfer of highly specialised knowledge becomes increasingly fragile. However, in several regions, younger herders continue to retain a foothold in pastoralism, combining herding with education, wage labour, or other livelihoods, while in some cases pastoralist youth have returned to pastoralism after periods away from it.



Why Pastoralism Matters Now

Pastoralism survives because it continues to be productive ecologically, economically, and socially in environments defined by uncertainty. It produces food from landscapes that often cannot support intensive agriculture. It maintains livestock breeds adapted to climatic extremes. It supports nutrient cycling across agricultural systems and manages ecological variability through movement rather than through heavy external inputs. At a time of accelerating climate uncertainty, these qualities matter increasingly.

This does not mean pastoralism should be romanticised or that pastoral communities should remain frozen in time. **Pastoralists, like all communities, should have access to education, healthcare, political representation, and economic choice.** But to treat the decline of pastoralism as progress elides its deeper value.

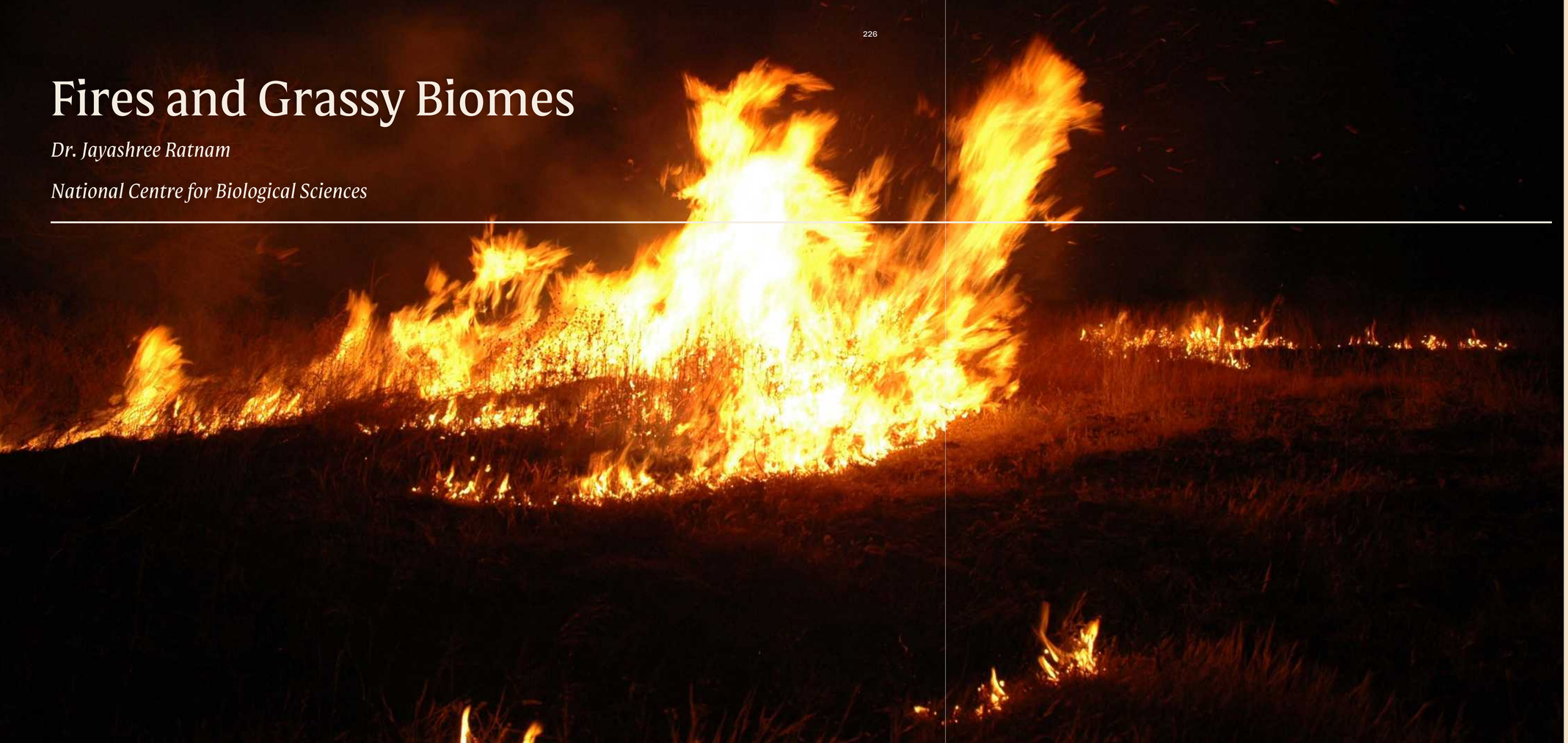
The future of many of India's open ecosystems will depend partly on whether mobility can still be accommodated within modern land governance. The question is not whether India can afford to support pastoralism. It is whether it can afford not to.



Fires and Grassy Biomes

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A long history of fire on earth

Fire has been an integral part of the earth system for millions of years. The paleo-ecological record of wildfires, indicated by the presence of charcoal remnants of plants in ancient sediments, begins 420 million years ago, when land plants became abundant on terrestrial earth.

For wildfires to occur, three conditions must be met- there must be enough oxygen in the atmosphere, there must be enough dry fuel (biomass) to burn, and there must be sources of ignitions such as lightning. With these conditions first being met when photosynthesis from abundant land plants pumped enough oxygen (> 13%) into the earth's atmosphere, the same plants drying out during the dry season to provide fuel, and lightning storms igniting this dry fuel, fires have burnt on earth for many millions of years. While fire signatures in the paleo-ecological record alternate between periods of high and low activity, wildfire has always been present in some form for more than 400 million years of our planet's history.

While ignitions are important for starting a fire, climate and vegetation together exert the primary controls on the spread and intensity of wildfires. As a very general rule, wildfires are rare in wet and aseasonal climates where, although there may be plenty of vegetation, it is always too moist to burn. In arid climates, despite a long dry season, the vegetation is sparse, such that it cannot provide enough fuel for fires to spread. Fires are thus most frequent in mesic and seasonally dry climates, where there is enough rain for biomass to accumulate in the wet season and a dry season when it cures and provides abundant fuel for the fire.

In what may come as a surprise to many readers, the 21st century in which we now live, notwithstanding regular news headlines of "destructive" wildfires from different regions on the planet, is in fact a period of very low fire activity relative to earth's deep past. Human activities over the past few centuries have transformed earth's ecosystems: agriculture and built-up areas have changed earth's land-cover at scale, dramatically reducing vegetation biomass from natural baselines and fragmenting natural ecosystems, such that wildfires today are much less prevalent relative to the deep past.

Fire and earth's tropical grasslands and savannas

Of particular relevance to tropical grasslands and savannas, the paleo-ecological record shows that between 8-6 million years ago, earth's tropical grassy biomes expanded across the tropics, alongside high wildfire activity. This is one of the most dramatic examples of biome assembly in the paleo-ecological record, and tells us that tropical grasslands and savannas have evolved with wildfire in deep time.

The signature of this co-evolution can be seen clearly in the functional ecology of C_4 grasses that dominate earth's tropical grasslands and savannas today. These C_4 grasses follow the C_4 photosynthetic pathway which makes them very efficient in the hot and seasonally dry conditions that characterize large parts of the tropics. C_4 grasses are very productive in the wet season, growing abundant canopies of green leaves. This abundant green biomass dries out rapidly in the dry season and has a characteristic composition, high in lignin and volatile compounds, that makes it very prone to burning. During seasonal fires in tropical grasslands and savannas, it is this dry grass biomass that serves as the primary fuel for the fires, resulting in ground fires that move rapidly through landscapes as dry grass burns very quickly. The trees that occur in these habitats have also evolved to withstand fires and often have thick barks that protect their tissues from fire damage. Thus, the rapidly moving, relatively cool ground fires that are typical in grasslands and savannas rarely harm adult trees, and in the following wet season, the grasses and tree seedlings rapidly resprout from belowground reserves and grow again. This cycle of fire and regrowth that characterizes tropical grasslands and savannas has caused scholars to liken these ecosystems to the legendary *Phoenix* bird of Egyptian and Greek mythology, which routinely bursts into flames and then resurrects itself from the ashes.

The ancient grasslands and savannas of India

Consistent with the global pattern, paleo-ecological data from marine sediment cores extracted from the Bay of Bengal, which capture sediment flows from peninsular Indian rivers, establish that wildfires and C_4 grasses have been prominent in the Indian subcontinent from about 7 million years ago to the present. Critically, these data also establish that the burnt compounds in these sediments are derived from the C_4 grasses, telling us that fires fueled by C_4 grasses have been present in India for millions of years.

Unlike marine sediment cores which date back deep in time, terrestrial sediment cores, generally obtained from dried lake-beds or craters in the ground, typically only date back to more recent history. Fossil pollen and charcoal data from such terrestrial cores taken from across the Indian peninsula, including the western Thar desert, the Deccan plateau and the Central highlands, establish the continuous presence of mixed tree-C_4 grass ecosystems and wildfires, from at least 14000 years ago to the present.

Together, these paleo-ecological data establish the ancient and widespread presence of fire-prone tropical grasslands and savannas across the Indian subcontinent. Reflecting this long history, these grassy biomes are home to a number of distinctive specialist species such as the great Indian bustard, caracal, chinkara, blackbuck and the Indian wolf, with studies establishing many of these to be ancient genetic lineages, dating back from 2-1 million years. Likewise, the number of endemic herbaceous species reported from these ecosystems has grown exponentially over the past decades, attesting to their antiquity. Recent studies have also reported fire-triggered flowering in some of these herbaceous species, hinting at the long evolutionary history of fire in these biomes. Finally, many species of trees that occur in these savannas have thick and corky barks, well established as an adaptive response to fire.

In the current day, these ecosystems include the arid and semi-arid grasslands of western India, the floodplain grasslands of the Central Indian plains, the semi-arid thorn and scrub savannas of western India and the Deccan plateau, and the mesic deciduous savanna woodlands that occur throughout peninsular India. Structurally, these ecosystems range from being mostly grassy with few trees in the more arid regions, to becoming more densely treed with abundant grasses in the understory in the more mesic regions. Fires occur across these grassy biomes to varying degrees. While fires are less prominent in arid regions with sparse grassy growth, they are more prevalent in mesic regions and floodplains where grasses are very productive and provide abundant fuel.

Finally, it is important to note that the subcontinent is also home to wet tropical forests, often in close proximity to mesic woodland savannas. However, these wet forests typically do not have C_4 grasses in their understory, remain moist and shaded through the dry season, and generally do not support fires. Analyses of recent fire trends across one such mosaic landscape in southern India, based on remotely-sensed fire data, confirm that most fires occur in mesic savannas, while wet forests and very dry grasslands rarely burn.



Fires and humans

While wildfires in the deep past would have arisen from natural ignition sources such as lightning, most fires on earth today, especially in tropical regions, are ignited by humans.

Combined evidence from the hominid fossil record and archaeological sites across the world suggests that suggests that routine domestic uses of fire by humans, for cooking and staying warm, were established between 100000 - 50000 years ago, while the widespread use of fires to transform and manage habitats probably began with settlement and agriculture about 11000 - 10000 years ago. In the Indian subcontinent, where there is evidence for settled human civilizations from about 5000 years ago, it is likely that humans have impacted fire regimes from about 5000-3000 years ago.

From their ancestral stories and lived memory, elders from different indigenous communities spread across peninsular India recount the many uses of fire to manage vegetation. Across the more mesic woodland savannas, fires were set for clearing the vegetation on the ground to enable the collection of forest produce such as flowers and honey, to reduce hemi-parasitic loads on fruit trees so that they produce larger fruit crops and to encourage larger underground reserves in tubers that are harvested for food. In the more semi-arid grasslands and open savannas, as is common across the world, fires were set to encourage fresh forage growth for livestock, but which also benefited wild herbivores. In this traditional knowledge system, fires are seen as an integral part of the ecology of grasslands and savannas, maintaining the balance between trees and grasses, and critical to the regeneration and growth of many species of trees, herbs and grasses. Importantly, in this system of fire management, fires are set early in the dry season, when temperatures are relatively cool and the grass is not entirely dry, such that these cool, early dry season burns are both easily managed and less intense. In this way, traditional knowledge systems used fire such that it was a manageable and beneficial force. It is worth noting that these human-driven fire regimes diverged from natural fire regimes in important ways. While natural fires most likely occurred late in the dry season when lightning storms occurred, and were probably less frequent as ignitions were unpredictable, human-driven fire regimes resulted in predicable, frequent and cooler early dry-season fires. However, given their short tenure relative to the deep history of natural fire regimes, human-driven fire regimes are not likely to have impacted evolutionary adaptations to fire in flora and fauna. Critically, these regimes acknowledged and retained fire as an important component of these ecosystems.

Beginning in the colonial era, the management of natural ecosystems and fires in the subcontinent underwent a dramatic shift. Colonial foresters, who hailed from temperate forested systems that were fire-sensitive and were trained in European forestry practices, viewed fires as destructive forces that destroyed woodlands and forests, and degraded ecosystems. Indigenous fire practices were perceived as unscientific. The lighting of fires by local communities was forbidden and declared a punishable offence. The colonial era thus ushered the start of official state policies that suppressed savanna and forest fires and criminalized the setting of fires by local communities. While these laws were difficult to enforce and fires continued to occur in many regions, they certainly decreased relative to the pre-colonial extent.

These negative perceptions of wildfire and associated practices have persisted from the colonial era into the contemporary era, making fire suppression the main strategy. However, with the availability of modern technology and equipment to detect and fight fires, forest departments today have succeeded in greatly reducing the frequency and extent of fires across the ecosystems that they manage.



Fire suppression and the invasion problem

One of the most noticeable features of semi-arid and mesic savanna woodlands in India today is the extensive presence of the invasive woody shrub *Lantana camara*. *Lantana* was introduced in India in the late 19th century for ornamental use in gardens but it has since spread into many natural habitats, with a dramatic expansion in its range over the past five decades. At the current time, *Lantana* occupies thousands of square kilometers of semi-arid and mesic savannas in India, where it has replaced the open grassy understory with dense woody thickets. These thickets have reduced visibility and movement pathways for animals and people moving in these landscapes and greatly reduced forage availability as most ungulate grazers that feed on grasses do not consume *Lantana*.

Indigenous elders from different communities across the southern peninsula associate the spread of Lantana with the decades of fire suppression. In their understanding, traditional burning suppressed the regeneration and growth of this invasive species, limiting its spread. Indeed, burning also controlled many other parasites and vectors, maintaining a "healthy" ecosystem. In the absence of fire, a primary control over *Lantana* populations has been removed, allowing it to proliferate. Consistent with this idea, experimental studies suggest that fewer Lantana germinate from the seedbanks of soils from burnt areas. Fire suppression in a fire-adapted system thus appears to have transformed the defining features of these systems over a very short period of time.



Fire as a tool for the restoration and management of savannas

A natural question that emerges from the above scenario is whether a return to traditional burning regimes can restore invaded woodland savannas to pre-invasion states that were characterized by fire-adapted trees in a grassy understory. However, this reversal may not be as simple as it seems. Fires fueled by dense woody biomass of *Lantana* in the understory may be more intense and slow moving relative to grass-fueled fires, and may reach higher into the tree canopies than grass fires. Restoration of these invaded savannas may thus require the uprooting of *Lantana* and removal of its biomass, followed by the introduction of fires to reduce *Lantana* in the seed bank and promote the growth of grasses. Once these initial efforts recover the grassy understory to some extent, it will be important to consider the reintroduction of indigenous burning regimes as a way to maintain these savannas and woodlands.

Controlled burning in ecosystems that are known to be fire-adapted, which is done in a planned and careful manner across mixed tree-grass landscapes, has the potential to enhance biodiversity, provide forage for livestock and wild ungulates, and conserve these ancient ecosystems. Scientists, forest managers and indigenous knowledge holders should combine their knowledge and work together to come up with best practices for such fire management.

India's Grassy Carbon Sinks

Sangita Ganesh and Dr. Abi T. Vanak

Inputs from Dr. Manan Bhan and Dr. Sanjay Singh



Around the world, strategies to combat climate change have traditionally focused on restoring forests and tropical landscapes. Trees are described as the earth's lungs and are deemed to be the solution towards combating our greenhouse gas emissions. However, there is another ally of climate change mitigation, one that is much closer to the ground.

Open Natural Ecosystems (ONEs), comprising grasslands, grassy shrublands, and savannas, cover about 40% of the Earth's surface and play a critical role in climate change mitigation by acting as natural carbon sinks. These ecosystems have existed for millions of years, formed by the complex ecological and evolutionary interactions between herbaceous plants, environmental change, fire, and herbivory.

Global estimates indicate that ONEs hold approximately one-third of Earth's terrestrial carbon. However, unlike forests, which store their carbon predominantly in trunks and canopies, grasslands, hold around 90% of their total carbon entirely below ground in root networks and as soil organic carbon (SOC). A majority of this carbon is vulnerable to land-use conversion and may be 'irrecoverable'; once lost, it would not be recoverable over timescales relevant to climate change mitigation.

One of the principal threats to these grasslands is unscientific tree-planting efforts to meet carbon sequestration targets. The logic of such climate change mitigation proposals, however, is increasingly being challenged due to their damaging impacts on natural grasslands and their inflated carbon sequestration potential. This chapter explores India's grassland carbon potential and how protecting these ecosystems can transform India's climate strategy from the ground up.

How grasslands trap CO_2

Grasslands are powerful carbon sinks due to their extensive root networks and soils. In a forest, carbon is stored mostly aboveground, in the wood, branches, and leaves. If these catch fire or are destroyed by a pest infestation, the stored carbon is released into the atmosphere as carbon dioxide. Conversely, grasslands have co-evolved over millions of years with wildfires and massive herds of grazing herbivores that consume the vegetation. To survive these disturbances, grasses store their energy belowground, building dense and intricate root systems. This root biomass builds organic carbon, which binds directly to soil minerals, creating Soil Organic Carbon (SOC). This carbon is shielded from environmental disturbances and hence, is a more stable and dependable form of carbon storage. There are several factors that affect carbon sequestration in grasslands, including climate and moisture, age of ecosystem and soil depth. In general, the length of the growing season and water-holding capacity of the soil, the historic vegetation and carbon accumulation, and the depth of the soil all determine how much carbon can be sequestered by grass roots. However, despite the stability and enduring nature of their root systems, grasslands are often overlooked because of the historical bias towards forests, which limits the achievement of their full sequestration potential.

Issues with conversion of Open Natural Ecosystems

In meeting climate targets, open natural ecosystems are deemed as 'wastelands' and are thus seen as areas perfectly suited for afforestation. However, scientific evidence suggests that planting trees indiscriminately can have a damaging effect on these ecosystems. For example, when non-native tree species like *Neltuma juliflora* (formerly *Prosopis juliflora*) or eucalyptus are planted intensively, especially on semi-arid grasslands, they deplete ground water, crowd out the native perennial grasses, and alter soil chemistry, often resulting in lower SOC compared to grasslands.

Furthermore, across grasslands, there are losses of carbon as a result of conversion. Studies suggest that, on average, approximately 23% of the SOC contained within the top 30 centimetres is released to the atmosphere following conversion to agriculture; meanwhile, 100% of the biomass is lost during conversion and once lost, may be slow to recover.

Role of Open Natural Ecosystems in land-based climate action

Globally, grasslands have a total SOC stock of 131.7 Petagrams of Carbon (PgC - 1PgC is equivalent to 1 Gigaton of Carbon), whereas savannahs have a SOC stock of 143.0 PgC up to 30cm depth. Studies estimate that the achievable SOC sequestration potential in global grasslands is at 2.3-7.3 billion tons of CO_2 equivalent per year, contingent on appropriate management and avoidance of conversion. In India, models suggest that grasslands can sequester 19.81 million tons of CO2 per year (2020-2050), or 594 million tons of CO2 equivalent in total, over 11.6 Million hectares. This shows that India's commitments towards meeting its Nationally Determined Contributions under the Paris Agreement can be achieved through protection and restoration of its grasslands.

Grassland restoration to speed or guide this recovery has received less attention than forest restoration, often due to the prevailing assumption that grasslands are recently formed habitats due to human disturbance, and that these ecosystems cannot deliver equivalent benefits rapidly and at scale. There is now a global and growing national recognition of the importance of these unique ecosystems.

Consequently, soil carbon sequestration is now recognised as an effective natural climate solution. In international climate governance, the need to enhance SOC across land uses and across ecosystems is now a common denominator, highlighted by the adoption of the 4 *per Mille* Initiative at COP21 in Paris in 2015 and the formal recognition of SOC sequestration at COP23 in 2017 (COP23 decision 4/CP.23).

To avail their benefits of sequestering carbon, grassland restoration must operate on a two-pronged strategy, conserving existing stocks (avoiding losses) and restoring stocks in carbon-depleted soils. This could be done through employing proper management strategies, including rotational grazing and reducing ecosystem conversion, restoring legumes, and herb and forb diversity. Evidence suggests that all of these management practices lead to increased soil carbon stocks, with the average across all studies adding nearly half a tonne (t) of carbon per hectare per year (C/ha/yr).

In India, recent studies provide growing evidence of the carbon sequestration potential from restored ONEs with findings suggesting that total carbon stocks (aboveground plus soil) increased from 12.74 t C/ha in 1-year restoration sites to 22.11 t C/ha in 3-year sites, with soil carbon alone ranging from 8.72 to 12.54 t C/ha, representing a 34% increase in total carbon relative to unrestored controls within three years. Additionally, in the Banni grasslands, Gujarat, restoration has been shown to maintain high SOC stocks of approximately 143 t C/ha (~525 t CO_2eq/ha), indicating that intact and restored tropical grasslands can function as significant soil carbon reservoirs. Given that India's drylands cover approximately 228 million Mha and that much of this area is under rangelands and associated ONEs, the SOC stored in these systems constitutes a major component of the national land-based carbon available.



Restoration of grasslands for carbon sequestration

Successful restoration of grasslands means having long-lived perennial plants; a complex diversity of below-ground structures that enable resprouting after above-ground disturbances such as fire and grazing occur; and substantial below-ground carbon stores, which are characteristics typical for 'old-growth' semi-arid grasslands.

Achieving this is a slow process, while the destruction and degradation of grasslands can occur rapidly, recent research indicates that complete recovery of carbon storage potential and essential structure, composition, and functions occurs slowly, often in the order of decades or even centuries.

In conclusion, protecting our Open Natural Ecosystems can capture millions of tons of carbon and serve as a natural climate solution. In addition, they can deliver additional co-benefits, including, but not limited to, (1) increasing soil fertility and reducing soil erosion, (2) maintaining or increasing resilience to climate change for communities, and (3) providing habitat to endemic species. All these actions align with Land Degradation Neutrality (LDN) objectives with India's Nationally Determined Contributions (NDCs), the UN Sustainable Development Goals, the UN Convention on Combating Desertification (UNCCD) and the Global Biodiversity Framework, and can easily be achieved by moving away from conversion and forest-centric interventions on open natural ecosystems, and instead, welcoming the native shrubs, grasses and vegetation.



How Open Natural Ecosystems can contribute to India's Land Degradation Neutrality targets

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India is a party to the United Nations Convention to Combat Desertification (UNCCD) and has adopted the goal of achieving Land Degradation Neutrality (LDN) by 2030. The UNCCD defines LDN as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services to enhance food security remain stable, or increase, within specified temporal and spatial scales and ecosystems." India's commitment includes restoration of 26 million hectares (Mha) of degraded land, an upward revision from the earlier 21-million-hectare Bonn Challenge pledge.

National assessments by the National Academy of Agricultural Sciences (NAAS) and Ministry of Environment, Forest and Climate Change (MoEFCC), estimate that approximately 96.4 Mha (roughly 30% of India's total geographical area, TGA) are affected by land degradation or desertification. The economic cost of land degradation and land-use change is estimated at 3.17 lakh crore rupees (INR) per year (~2.5% of GDP) for 2014-15.

Much of these degraded lands fall under the Open Natural Ecosystems (ONEs) category: grasslands, savannas, scrublands, alpine meadows, and open forest ecosystems with less than 15% canopy cover. They are ecologically distinct from degraded forests, and support unique biodiversity, ecosystem functionality, grazing systems, soil carbon, hydrological regulation, and socio-ecological resilience.

High-resolution mapping of semi-arid ONEs (excluding the ONEs of the Himalayan and the North-Eastern states) estimates their area to be approximately 3,20,000 km^2 (~10% of India's TGA or land area). Less than 5% of this area lies within protected areas, while 68.6% remains classified as 'wasteland' in official records. This figure far exceeds the Ministry of Agriculture's official record of 10.21 Mha for "Permanent Pastures and Other Grazing Lands". The UNCCD Global Land Outlook (GLO) estimates India's total rangeland area at around 121 Mha, underscoring a tenfold discrepancy between administrative and ecological accounting. The UN's Food and Agriculture Organisation (FAO) defines rangelands as "lands dominated by grasses, grass-like plants, forbs, shrubs and sometimes trees that are grazed or have the potential to be grazed by livestock and wildlife." Almost all of India's ONEs are rangelands.

Despite their ecological and socio-economic significance, the contribution of ONEs to national LDN planning remains poorly recognised. Most restoration programmes continue to prioritise tree-based interventions, creating a gap between ecological understanding and restoration practice.

According to the UNCCD framework the achievement of LDN rests on three operationalised indicators: land cover, land productivity, and Soil Organic Carbon (SOC). India's drylands (approximately 228 Mha, or ~69% of TGA) are ecologically dominated by grasslands, and scrublands. The way ONEs are classified and managed therefore directly shapes LDN outcomes. Historically, however, these ecosystems have been treated as "wastelands" or "open degraded forests," making them default targets for tree-planting programmes despite being structurally intact ecosystems maintained by climate, soils, and natural disturbance regimes. Recognising, conserving, and restoring ONEs as functional ecosystems is thus fundamental to ecologically meaningful LDN implementation in India.

Contribution of ONEs to Land Degradation Neutrality

Land Cover Stability

Globally, rangelands cover approximately 54% of the Earth's terrestrial surface (~80 million km²), making them the single largest land-cover category, according to the UNCCD, and International Livestock Research Institute (ILRI). In India, this ecological reality is largely obscured by official statistics: the Wastelands Atlas (2019) categorises many grassland-linked landscapes as "degraded pastures/grazing lands" (6,450 km²), open scrub (99,602 km²), and dense scrub (73,972 km²), without recognising them as functional ONEs. India lost approximately 31% of its grasslands (5.65 Mha) between 2005 and 2015, primarily through conversion to cropland, a loss that directly undermines land-cover stability across dryland landscapes.

ONEs contribute to land-cover stability by maintaining continuous perennial vegetative cover adapted to low and variable rainfall, thereby preventing bare soil formation and desertification. Root systems of perennial grasses and shrubs stabilise soils and reduce wind and water erosion. Globally, drylands already account for 10–20% of land classified as degraded in LDN assessments, and maintaining vegetative cover in these areas is a priority. A key challenge is that LDN reporting aggregates broad land-cover classes like forest, grassland, cropland, and other land. Correctly classifying ONEs as "grassland" or "shrubland," rather than as "degraded" or "other," is therefore essential to ensure that natural openness is not misinterpreted as degradation, and that real threats transitions to bare land, invasive thickets, or dense monoculture plantations are detected accurately.

Land Productivity

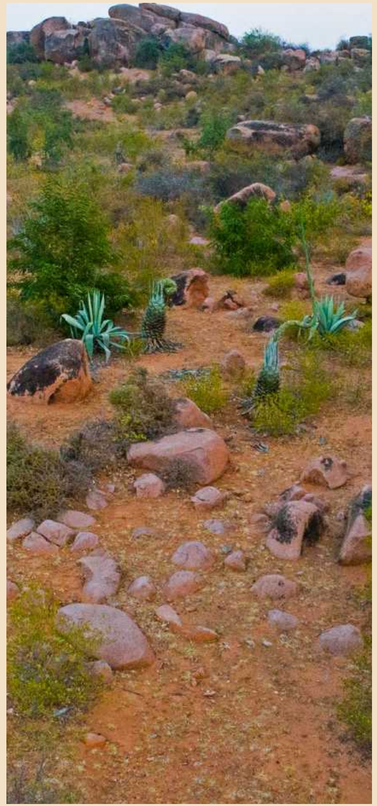
Land productivity in the LDN framework is assessed through satellite-derived vegetation indices and trends interpreted as proxies for biomass production and ecosystem functioning. Globally, rangelands support approximately 2 billion people's livelihoods, including around 500 million pastoralists, and sustain 70–80% of the world's domestic herbivore population; they also contain approximately 38% of all Key Biodiversity Areas. In India, roughly 13 million pastoralists across 46 groups manage approximately 77% of India's total livestock which itself constitutes about 20% of the world's livestock population. As per Indian Grassland and Fodder Research Institute (IGFRI), extensive rangeland systems contribute an estimated 53% of India's milk and 74% of its meat production , demonstrating the direct link between rangeland condition and national food security.

Restoration of degraded ONEs can enhance land productivity by improving forage availability, stabilising seasonal biomass production, and reducing drought vulnerability. Evidence from Himachal Pradesh silvipastoral systems (that integrate trees and grazing livestock operations on the same land) demonstrates that sustainable stocking rates measured at a maximum carrying capacity of 1.36 Adult Cattle Units (ACU)/ha/yr at monitored sites can guide management that prevents degradation and maintains productivity. In Rajasthan drylands, experimental agroforestry treatments combining root barriers and lopping in open tree grass systems increased grass dry-matter yields and enhanced soil water availability, showing that structurally open systems compatible with ONEs can boost fodder production. Within the LDN framework, sustainable land management (SLM) in ONE's through stocking control, rotational grazing, and invasive species management can stabilise or enhance productivity without necessitating land-use conversion, directly contributing to the second LDN objective of reducing existing degradation.

Soil Organic Carbon

SOC is the third global LDN indicator and a critical component of both soil health and climate mitigation.

Please refer to previous chapter titled "India's Grassy Carbon Sinks".



Risks of inappropriate restoration approaches

India's primary LDN instruments the Green India Mission, National Afforestation Programme, and various state-level plantation schemes are strongly tree-centric, reflecting a broader tendency to equate ecological restoration with increases in forest and tree cover. While tree-based restoration is ecologically appropriate in genuinely deforested or degraded forest areas, applying it to naturally open ecosystems generates significant ecological and accounting risks.

Since high-resolution mapping shows that semi-arid ONEs cover approximately 320,000 km² (~10% of India), and that 68.6% of this area is classified as "wastelands", lands with ONEs become a primary target for compensatory afforestation and Compensatory Afforestation Fund Management And Planning Authority (CAMPA)-funded planting under current policy frameworks. Empirical work in Indian savannas has demonstrated that conversion of old-growth savannas to tree plantations eliminates distinctive herbaceous communities and reduces native plant diversity, with little evidence of spontaneous recovery after land abandonment. These changes alter hydrology, diminish forage availability, and may cause net soil carbon declines when below-ground SOC losses are accounted for alongside above-ground biomass gains. Ancient grasslands and savannas are increasingly recognised as distinct biomes whose conservation value may be compromised by inappropriate tree-planting interventions.

This misclassification creates a self-reinforcing accountability gap in LDN monitoring. When functional grasslands and rangelands are recorded as "wastelands," LDN accounting may register transitions from grassland to plantation as positive land-cover changes, and increases in Normalised Difference Vegetation Index (NDVI, a satellite-derived metric used to quantify the health and density of vegetation) following tree establishment may be interpreted as productivity gains even when biodiversity, forage availability, and SOC are simultaneously being compromised.

The UNCCD's LDN conceptual framework explicitly states that land-cover transitions must be interpreted in light of ecosystem type and reference conditions, and that restoration must be ecologically appropriate. For ONEs, this implies that LDN strategies should prioritise restoration of native grasses, shrubs, and soil functions rather than tree densification, and that LDN accounting systems must not automatically treat grassland-to-forest transitions as improvements without ecological justification.

Strategic Pathways for Integrating ONEs into India's LDN Agenda

Integrating ONEs into India's LDN agenda requires a shift from generic tree-centric restoration toward ecosystem-specific, biome-sensitive strategies anchored in the following priorities.

Ecosystem-Specific Restoration Approaches

Restoration in ONEs should be designed around native ecosystem structure and function. In grasslands and savannas, this means reseeding or facilitating natural regeneration of native grasses and forbs, controlling invasive woody species such as *Neltuma juliflora* (formerly *Prosopis juliflora*), which has invaded more than half of the Banni grasslands), and reinstating context-appropriate grazing and fire regimes. In alpine meadows, it involves regulating tourism infrastructure, stabilising eroded patches, and managing grazing within scientifically measured carrying capacities, as illustrated by judicial directions for Himalayan *bugyals*. In silvipastoral systems of Himachal Pradesh and Rajasthan, it entails optimising tree density, lopping, and root management to enhance fodder yields and SOC while maintaining open canopies.

Revision of land classification and LDN baselines

Revising the Wastelands Atlas and national land-use classifications to distinguish ONEs from genuinely degraded or barren lands is a prerequisite for sound LDN accounting. Integrating satellite-derived vegetation maps and high-resolution ONE maps into LDN baselines would ensure that semi-arid ONEs (~320,000 km², ~10% TGA) and grassland-linked mosaics (~29.98 Mha, ~9.1% TGA) are correctly represented, preventing misdirected afforestation and enabling accurate distinction between conservation of intact ONEs, genuine degradation, and ecologically appropriate restoration.

Sustainable grazing governance

Given that extensive rangeland systems supply 53% of India's milk and 74% of its meat, and that approximately 13 million pastoralists manage 77% of the national livestock herd, LDN strategies must embed grazing governance as a core SLM instrument. This includes recognising common-property rights and pastoral mobility, co-developing stocking rules based on measured carrying capacity, and integrating traditional land stewardship systems such as the gauchar and orans of Rajasthan into formal planning frameworks. Such measures reduce overstocking, prevent land degradation, and enhance productivity, directly supporting LDN's productivity indicator.

Ecosystem-specific LDN indicators and remote-sensing tools

LDN monitoring for ONEs should complement the three global indicators mentioned earlier in the chapter with ecosystem-specific metrics, such as native grass cover, forage availability, infiltration rates, and presence of key indicator species. SOC monitoring should explicitly track grassland and rangeland soils, capturing gains like the ~34% carbon increase documented in semi-arid savanna restoration sites and the ~143 tonnes of carbon per hectare (t C/ha) levels maintained in restored Banni. Remote-sensing platforms including the ONE Maps explorer and Trends.Earth can distinguish natural grasslands from croplands and plantations by combining canopy cover thresholds, phenological patterns, and high-resolution imagery, reducing misclassification in national LDN reporting.

Integration into national restoration planning and finance

National and state LDN plans, including the National Action Programme and LDN concept notes, may consider explicitly allocating an appropriate share of the 26 Mha restoration target to ONE-appropriate interventions in drylands. In this regard, afforestation and CAMPA funding guidelines could be revised to ensure that intact Open Natural Ecosystems (ONEs) are managed and maintained in accordance with their grassland character. Resources may thereby be directed toward sustainable land management practices, with particular emphasis on grassland and rangeland restoration, thereby strengthening ecological integrity and resilience.

Conclusion

In conclusion, the available evidence suggests that conserving and restoring ONEs directly advances all three LDN indicators: land-cover stability through maintenance of perennial vegetative cover, land productivity through sustainable rangeland management, and SOC through belowground carbon protection and recovery. India's LDN targets cannot be achieved through tree-centric restoration strategies that treat increased canopy cover as a universal proxy for land improvement; in naturally open ecosystems, such approaches risk degrading ecosystem function and distorting LDN accounting. Biome-sensitive restoration grounded in ecosystem-specific reference states, indicators, and management practices is essential for ecologically meaningful LDN outcomes. Recognising, conserving, and restoring ONEs within national land-classification systems, restoration planning, and LDN monitoring frameworks is not an optional refinement but a prerequisite for delivering genuine neutrality in India's land condition, consistent with the ecological diversity and socio-ecological heritage of its landscapes.



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Kuruthu Pillu/Swollen Fingergrass: Dinesh Valke (License: CC BY-SA 2.0), via Wikimedia Commons
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Black-winged Kite: S. Sakthi Manickam
Indian Hare/Black-naped Hare: Kalyan Varma
Indian Fox: Sakthi Manickam
Indian Grey Mongoose: S. Sakthi Manickam
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Grey Francolin: Kalyan Varma
Indian Silverbill: Parth Kansara (License: CC BY-4.0), via Wikimedia Commons
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Dryland Complex of Southern and Southeastern Tamil Nadu

Page 44: Thanigaivel Annamalai
Page 46: Thalavaipandi S.
Page 47: Konar Pastoralist: Sudalaimani G.
Page 48: (Biodiversity - Flora)
Background: From the archive of The Agasthyamalai Community Conservation Centre (ACCC) at ATREE
Lindernia minima: From the archive of The Agasthyamalai Community Conservation Centre (ACCC) at ATREE
Cyanotis Papilionaca: Vinayaraj V. R. (License: CC BY-SA 3.0), via Wikimedia Commons
Mvunganjati: Dinesh Valke (License: CC BY-SA 2.0), via Wikimedia Commons
Karai: J. M. Garg (License: CC BY-SA 3.0), via Wikimedia Commons
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Spherical Rattlepod/Poonapudukukodi: From the archive of The Agasthyamalai Community Conservation Centre (ACCC) at ATREE
Theriophonum sivaganganum: Thalaivaipandi
Umbrella Thorn: P. Jeganathan (License: CC BY-SA 4.0), via Wikimedia Commons

Page 50: (Biodiversity - Fauna)
Background: Palmathi Vinod
Serrated Fan-throated Lizard: S. Sakthi Manickam
Indian Pangolin: A. J. T. Johnsingh, WWF-India and NCF (License: CC BY-SA 4.0), via Wikimedia Commons
Madras Hedgehog: Samson Kirubakaran
Pallid Harrier: Thijs
Page 41:
Rock Eagle-owl: S. Sakthi Manickam
Schneider's Toad: David V. Raju (License: CC BY-SA 4.0), via Wikimedia Commons
Peregrine Falcon: S. Sakthi Manickam

Theri Kaadu: Red Sands of Southern Tamil Nadu

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Madras Hedgehog: Samson Kirubakaran
Rough-tailed Sand Boa: Surya Narayanan
Indian Roller: Kalyan Varma
Red-headed Falcon: S. Sakthi Manickam
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Common Kestrel: Thanigaivel Annamalai
Scaly Gecko: Seshadri K. S. (License: CC BY-SA 4.0), via Wikimedia Commons
Giant Red Velvet Mite: Thalavaipandi S.

Shola Grassland Mosaic

Page 60: Dhritiman Mukherjee

Page 62:
Background: Kalyan Varma
Page 63 Toda pastoralists: Ramesh Lalwani (License: CC BY 2.0), via Wikimedia Commons

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Nilgiri Champa: Dr. Suresh V (License: CC BY-SA 4.0), via Wikimedia Commons
Ladies'-tresses: Kalyan Varma
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Whorled Hedyotis: Kalyan Varma
Shield Sundew: Kalyan Varma
Garden Balsam: Kalyan Varma
Indian Persea: Dinesh Valke (License: CC BY-SA 2.0), via Wikimedia Commons

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Nilgiri Tahr: Kalyan Varma
Leopard: Kalyan Varma
Gaur: Kalyan Varma

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Anaimalai Spiny Lizard: Kalyan Varma
Nilgiri Flycatcher: Kalyan Varma
Broad-tailed Grassbird: Kalyan Varma

Rocky Plateaus of the Northern Western Ghats and the Konkan Coast

Page 68: Dhritiman Mukherjee, curated by Living Lightly

Page 70 Spread 2:
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Page 71: A geoglyph at Rundhe Tali, Ratnagiri district: Rutwij Apte (License: CC BY-SA 4.0), via Wikimedia Commons

Page 72: (Biodiversity - Flora)
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Jaini Ceropegia: Jayesh Patil (License: CC BY-2.0), via Wikimedia Commons
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Tiny Bladderwort: Viraj Aathalye
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Deccan Plateau grassland and scrubland mosaic

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Background: Kalyan Varma

Page 78:
Background: Kalyan Varma
Page 79 Dhangar pastoralist: Kalyan Varma

Page 80: (Biodiversity - Flora)
Background: Dhritiman Mukherjee
Page 81 Indian Spurge Tree: Dinesh Valke (CC BY-SA 2.0), via Wikimedia Commons
Khair: Dinesh Valke (License:CC BY-SA 2.0), via Wikimedia Commons
Ber/Indian Jujube: Shanmugam P. (License: CC BY-SA 3.0), via Wikimedia Commons
Anjan Tree: Shyamal (License: CC BY-SA 3.0), via Wikimedia Commons

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Background: Mihir Godbole
Indian wolf: Dhritiman Mukherjee
Lesser Florican: Devesh Gadhavi
Painted sandgrouse: Mihir Godbole
Indian Courser: Mihir Godbole
Page 83:
Indian Fox: Abi T. Vanak
Yellow Wattled Lapwing: Dhritiman Mukherjee
Saw-Scaled Viper: Kalyan Varma

Deccan Rocky Outcrops: Inland Hills, Hillocks, and Inselbergs

Page 84:
Background: Ashish Jha
Ephemeral Rock Pool: Ashish Jha

Page 86: (Biodiversity)
Background: Ashish Jha
Krishna Siris: J. M. Garg (License: CC BY 3.0), via Wikimedia Commons
Painted Spurfowl: Nagesh Kamath (License: CC BY 3.0), via Wikimedia Commons
Kolar Leaf-nosed Bat: Rajesh Puttaswamaiah (License: CC BY-SA 4.0), via Wikimedia Commons
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Yellow-throated Bulbul: Ashish Jha

Savannas within the Central Highlands Mosaic

Page 88: Joanna Van Gruisen

Spread 90: (Biodiversity - Flora)
Background: Dhritiman Mukherjee
Babul/Gum Arabic Tree: Chetan Misher
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Chinese Hat Plant: Dr. Raju Kasambe (License: : CC BY-SA 4.0), via Wikimedia Commons
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Tiger: Kalyan Varma
Barasingha/ Swamp Deer: Dhritiman Mukherjee
Dhole/Asiatic Wild Dog: Kalyan Varma
Rough-scaled/Common Sand Boa: Surya Narayanan
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Gaur/Indian Bison: Kalyan Varma
Chital: Kalyan Varma
Red Sand Boa: Surya Narayanan

Grasslands and Meadows of the Tiger Reserves of India

Page 94: Kalyan Varma

Ravine lands of Central India: Yamuna Chambal Zone

Pages 96, 98, 100 Background Photos: Dharmendra Khandal

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Indian Rock Python: Pratik Jain (License: CC BY-SA 3.0) via Wikimedia Commons
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Scrub Savanna Mosaic of the Aravallis

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Thar Desert

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Page 118:
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Jawai riverbed: Dhritiman Mukherjee
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Jaisalmer limestone with fossils: Pradip Krishen
Raika pastoralists: ICARDA - Science for Resilient Livelihoods in Dry Areas (License: CC BY-NC-ND 2.0), via Flickr

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Bui: Pradip Krishen
Khejri: Pradip Krishen
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Sewan Grass: Abi T. Vanak
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Dune Cricket: Bsr.buddy (License: CC BY-SA 4.0), via Wikimedia Commons
Toad-Headed Agama: Kalyan Varma
Cinereous Vulture: Kalyan Varma

Rann of Kachchh

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Page 126: Dhritiman Mukherjee

Page 128:
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Page 129 Agariya salt farmers: AIDIndia (License: CC BY-3.0), via Wikimedia Commons

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Black-tailed Godwit: Uday Kiran (License: CC BY-SA 4.0), via Wikimedia Commons
Greater Flamingo: Tisha Mukherjee (License: CC BY-SA 4.0), via Wikimedia Commons
Page 133 Great White Pelican: Dhritiman Mukherjee
Indian Spiny-tailed Lizard: Dhritiman Mukherjee
Saw-scaled Viper: Kalyan Varma

Grasslands of Kachchh

Page 134: Arati Kumar-Rao

Page 136:
Background: Devesh Gadhvi

Page 138:
Background: Devesh Gadhvi
Maldhari Pastoralist: Sahjeevan

Page 139: (Biodiversity - Flora):
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Banni Grassland

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Peregrine Falcon: Dhritiman Mukherjee
Striped Hyena: Kalyan Varma
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Desert Fox: Sumeet Moghe (License: CC BY-SA 4.0), via Wikimedia Commons
Indian Desert Gerbil: Kalyan Varma
Spiny-tailed Lizard: Kalyan Varma

Saurashtra Grasslands and Scrub Savannas

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Blackbuck: Kalyan Varma
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Desert Cat: Kalyan Varma
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Gujarat Gecko: Harshil Patel (License: CC BY-4.0)
Indian Courser: Hardik Parmar
Golden Jackal: Tisha Mukherjee (License: CC BY-SA 4.0), via Wikimedia Commons

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Phumdis: Floating Mats of Loktak Lake

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Page 161 Rongmei women in their traditional festival attire: Ashok Ningthoujam (License: CC BY-SA 4.0), via Wikimedia Commons

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Page 165 Hog Deer: Mirza Ghazi
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Grasslands and Savannas of the North-Eastern Hills

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Page 168: Mesasieno Chase
Page 169: Mesasieno Chase

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Pogostemon quadrifolius: Kashmira Kakati
Drosera burmannii: Kashmira Kakati

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Himalayan Crinum Lily: Dr. Karthik Teegalapalli
Osbeckia stellata var. crinita: Kashmira Kakati
Hill Turmeric: Kashmira Kakati
Page 174: (**Biodiversity - Fauna**)
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Barking Deer/Northern Red Muntjac: Kashmira Kakati
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Sub-Himalayan Tall Grasslands and Savannas: Terai-Bhabar Belt and Brahmaputra Floodplains

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Page 178:
Background: Dhritiman Mukherjee
Winter morning fog: Kalyan Varma

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Pygmy Hog: Kalyan Varma
Hog Deer: Kalyan Varma
Hispid Hare: Bed Bahadur Khadka (License: CC BY 4.0), via Wikimedia Commons
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Fishing Cat: Kalyan Varma
Finn's Weaver: Koshy Koshy (License: CC BY 2.0), via Wikimedia Commons
Greater One-horned Rhinoceros: Kalyan Varma
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Open Natural Ecosystems of the Himalayas

Pages 184,186: Dhritiman Mukherjee

Himalayan Low and Mid-Elevation ONEs

Page 188: G. S. Rawat

Page 190:
Background: G. S. Rawat
Page 191
Bakarwal pastoralist: Amit Kanwar (License: CC BY-SA 4.0), via Wikimedia Commons
Gaddi pastoralist: Dhritiman Mukherjee

Himalayan Sub-tropical Grassland Mosaics

Pages 192: G. S. Rawat

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Page 194 Flora:
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Page 195 Fauna:
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Himalayan Temperate Grassland Mosaics

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Page 196: (**Biodiversity**)
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Page 196 Flora:
Nepal Satyrium: B. S. Adhikari
Himalayan Fairy Grass: Dinesh Valke (License: CC BY-SA 2.0), via Wikimedia Commons
Cheer Pine: Biswaroop Ganguly (License: CC BY 3.0), via Wikimedia Commons
Intermediate Habenaria: Shyamal (License: CC BY-SA 3.0), via Wikimedia Commons

Page 197 Fauna:
Himalayan Tahr: Dhritiman Mukherjee
Cheer Pheasant: G. S. Rawat
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Upland Buzzard: Dhritiman Mukharjee

Himalayan Alpine Meadows

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Page 200:
Background:
Primula flower: Dhritiman Mukherjee
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Water pools: Dhritiman Mukherjee
Gaddi pastoralist: Dhritiman Mukherjee
Bakarwal pastoralist: Ritayan Mukherjee

Page 202: (**Biodiversity - Flora**)
Background: Dhritiman Mukherjee
Rhododendron: Nakul Chettri
Carpet Rock Jasmine: Pema Yanden Lepcha
Snowball Plant: Nakul Chettri
Himalayan Blue Poppy: Pema Yanden Lepcha
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Page 204: (**Biodiversity - Fauna**)
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Trans-Himalayan Riparian Valley Vegetation and Wetlands

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Page 216: (**Biodiversity**)
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Great Crested Grebe: Dhritiman Mukherjee
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