Barsey Rhododendron Sanctuary: a model for preserving Himalayan biodiversity and nature-based tourism

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Abstract

Established in 1996 in response to substantial anthropogenic pressure, Barsey Rhododendron Sanctuary (Barsey) in Sikkim, India, serves as a model for biodiversity conservation. Spanning 104 km^2 in area and elevations ranging from 2,200 to 4,100 m asl, Barsey protects a high diversity of *Rhododendron*, oaks and bamboos, as well as critical habitats for endangered fauna. Following the exclusion of grazing and the implementation of active community engagement through Eco-Development Committees, the sanctuary has demonstrated forest regeneration, increased carbon stocks, restored springs and a rise in ecotourism during *Rhododendron* flowering seasons. Here, we review the historical transformation of Barsey from a highly disturbed forest landscape to a recovering protected area, highlighting ecological outcomes, biodiversity gains and the role of local communities in conservation. We outline future research and conservation priorities, and ways to regulate tourism pressure, support off-season livelihoods and habitat restoration, and promote sustainable *Rhododendron* cultivation. Furthermore, we highlight the need to strengthen long-term ecological research and climate monitoring through community-led conservation initiatives.

Introduction

Located within the Eastern Himalayan biodiversity hotspot (87 °E – 95 °E longitude) and representing 0.2% of the country's land area, Sikkim is India's second-smallest state and a recognised hotspot of high biodiversity (Singh & Sanjappa, 2011; Chettri *et al.*, 2018). As part of the Eastern Himalaya, Sikkim exhibits heterogeneous environmental conditions across its elevational zones, resulting from long-term surface uplift, climatic fluctuations and erosion (Rawat & Tambe, 2012; Bhutia *et al.*, 2019; Manish *et al.*, 2022; Pandit *et al.*, 2025). The region exhibits a remarkable elevation gradient, ranging from 300 to over 5,000 m asl, and the landscape includes the world's third-highest mountain, Khangchendzonga, at 8,586 m asl (Tambe

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et al., 2011) (Figs 1a & 2b). Recent reports indicate that Sikkim harbours approximately 5,000 species of flowering plants, 144 species of mammals, 568 species of birds and 5,892 species of insects within 7,096 km^2 of its land area (Gogoi *et al.*, 2021; Sikenvis, 2021). However, much of the biodiversity in Sikkim and the Himalaya remains largely undiscovered, making this region one of the world's biodiversity dark spots (Ondo *et al.*, 2024).

Recently, biodiversity in Sikkim has been under intense anthropogenic pressure (Banerjee *et al.*, 2019), and balancing development with environmental protection remains a major challenge. Over the past two decades, the state has actively implemented conservation and environmental policies. For example, in 2006, the Sikkim Biodiversity Board was established and it has played an essential role in raising awareness of biodiversity conservation. Sikkim is also the first Indian state to ban disposable polystyrene foodware, plastic bags and firecrackers. In 2016, it became the world's first organic state, conducting all agricultural activities without chemical pesticides or fertilisers. To support long-term biodiversity conservation, the Government of India and the state government have established eight protected areas, including sanctuaries and national parks, which currently encompass almost 47% of Sikkim's total area (Banerjee *et al.*, 2019). Barsey Rhododendron Sanctuary (hereafter Barsey) in the south-west of Sikkim was thus established to conserve the region's *Rhododendron* (Ericaceae) species, along with its endemic fauna and flora.

In this article we review the history of Barsey and highlight its transformation from a disturbed landscape into a thriving sanctuary. We highlight improvements in local biodiversity following its establishment as a sanctuary and examine the local community's relationship with the forest. Given the increase in tourism pressure, we conclude by providing recommendations, following the Kunming-Montreal Global Biodiversity Framework (CBD, 2022), to improve the management of Barsey.

Barsey Rhododendron Sanctuary

History and geographical setting

The documentation of Himalayan rhododendrons started when the British botanist Sir Joseph Dalton Hooker visited Nepal and the Eastern Indian Himalaya between 1848 and 1851 for botanical exploration (Hooker, 1891). In his monograph *Rhododendrons of Sikkim Himalaya*, Hooker provided a detailed account of 43 species from the Indian Himalaya of which he described 31 new species (Hooker, 1849, 1851, 1855). A century later, Pradhan (1985, 1986) and Pradhan & Lachungpa (1990) conducted a notable *Rhododendron* expedition and compiled a comprehensive catalogue of Sikkim rhododendrons. Later, the Botanical Survey of India (Mao *et al.*, 2017; Gogoi *et al.*, 2022) and the Government of Sikkim, India, began implementing measures to conserve the region's rich *Rhododendron* biodiversity. To date, 46 *Rhododendron* taxa have been reported from Sikkim by Basnett & Ganesan (2022), while Gogoi *et al.* (2022) documented 45 taxa from the state. Of these, 24 *Rhododendron* species have been recorded from Barsey (Kushwaha *et al.*, 2005; Sharma *et al.*, 2025). The Barsey Rhododendron Sanctuary was declared a Protected Area on 8 June 1996, under the Wildlife (Protection) Act 1972 (Act no. 53 of 1972; Notification number: 50/WL/F/95/269/F & WL), for the conservation of its *Rhododendron* forests

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and high-altitude Himalayan ecosystems threatened by unchecked exploitation and habitat degradation (Government of Sikkim, 2018–2028). Barsey is located in the Soreng district of Sikkim and spans approximately 104 km^2. The sanctuary also serves as a corridor connecting the Khangchendzonga Biodiversity Reserve to the north and the Singalila National Park in West Bengal to the south. Towards the west, it is bounded by the Singalila Ridge, which forms the natural international border with Nepal. The wide altitudinal variation, ranging from 2,000 to 4,100 m asl, supports a range of vegetation types, from subtropical moist deciduous forests and wet temperate forests to subalpine and alpine forests at higher elevations (Champion & Seth, 1968; Sharma, 2001; Banerjee *et al.*, 2019; Key Biodiversity Areas, 2024).

The sanctuary receives an average rainfall of 200–350 cm, and humidity during the wet season ranges from 60% to 95% (Maity *et al.*, 2006). The sanctuary thereby serves as a watershed for the surrounding villages and a major source for tributaries of the river Rangit in West Sikkim (Tambe *et al.*, 2005). It is surrounded by almost 30 villages, and it has several entry points. Hilley, in West Sikkim, is one of the most frequently visited villages by tourists. The bridle trail leading from Hilley to Barsey is particularly favoured, especially during the *Rhododendron* blooming season running from February to May (Figs 1c & 2a, g).

Forest resources and anthropogenic pressure

Before the establishment of Barsey, there was no restriction on the use of forest resources (Bhagwat *et al.*, 2012). The forests of Barsey are reported to have experienced extensive exploitation as a result; forest areas were subjected to rampant tree felling for firewood, and lopping for fodder and timber (Tambe *et al.*, 2005; Government of Sikkim, 2018–2028). Unmanaged livestock grazing was yet another disturbance, one of the most critical factors contributing to forest depletion (Tambe *et al.*, 2005). Cattle sheds were built within the forests, and the surrounding vegetation was cleared to create open space for livestock grazing. Over time, the area around the cattle sheds became completely barren due to trampling and overgrazing. Very few healthy trees were found within the 1 ha area surrounding each cattle shed (Tambe *et al.*, 2005). There were 288 herders, each of whom had, on average, two cattle sheds within the sanctuary, and so a total of 576 ha of land was left barren (Tambe *et al.*, 2005). These activities led to the proliferation of thorny shrubs of *Berberis* sp. (Berberidaceae), *Rosa* sp. (Rosaceae) and *Viburnum* sp. (Adoxaceae) in overgrazed areas (Tambe *et al.*, 2005).

Other exploitative activities included the extraction of medicinal herbs, and poaching *Lophura leucomelanos* (Kalij pheasant) and other wild animals (Government of Sikkim, 2018–2028). At higher elevations (> 3,000 m), slow-growing rhododendrons and *Abies densa* (silver fir) were the only source of energy for fuelwood (Bhagwat *et al.*, 2012). Forest fires, particularly those in 1973 and 2005, further degraded both broadleaf and conifer habitats. During this period, scientific documentation of biodiversity loss remained limited, with only anecdotal reports indicating declines in wildlife and forest health. Permanent drinking water sources dried out due to deforestation by herders and their cattle, and this was one of the pressing issues raised by the villagers when Barsey had no restrictions in place (Tambe *et al.*, 2005).

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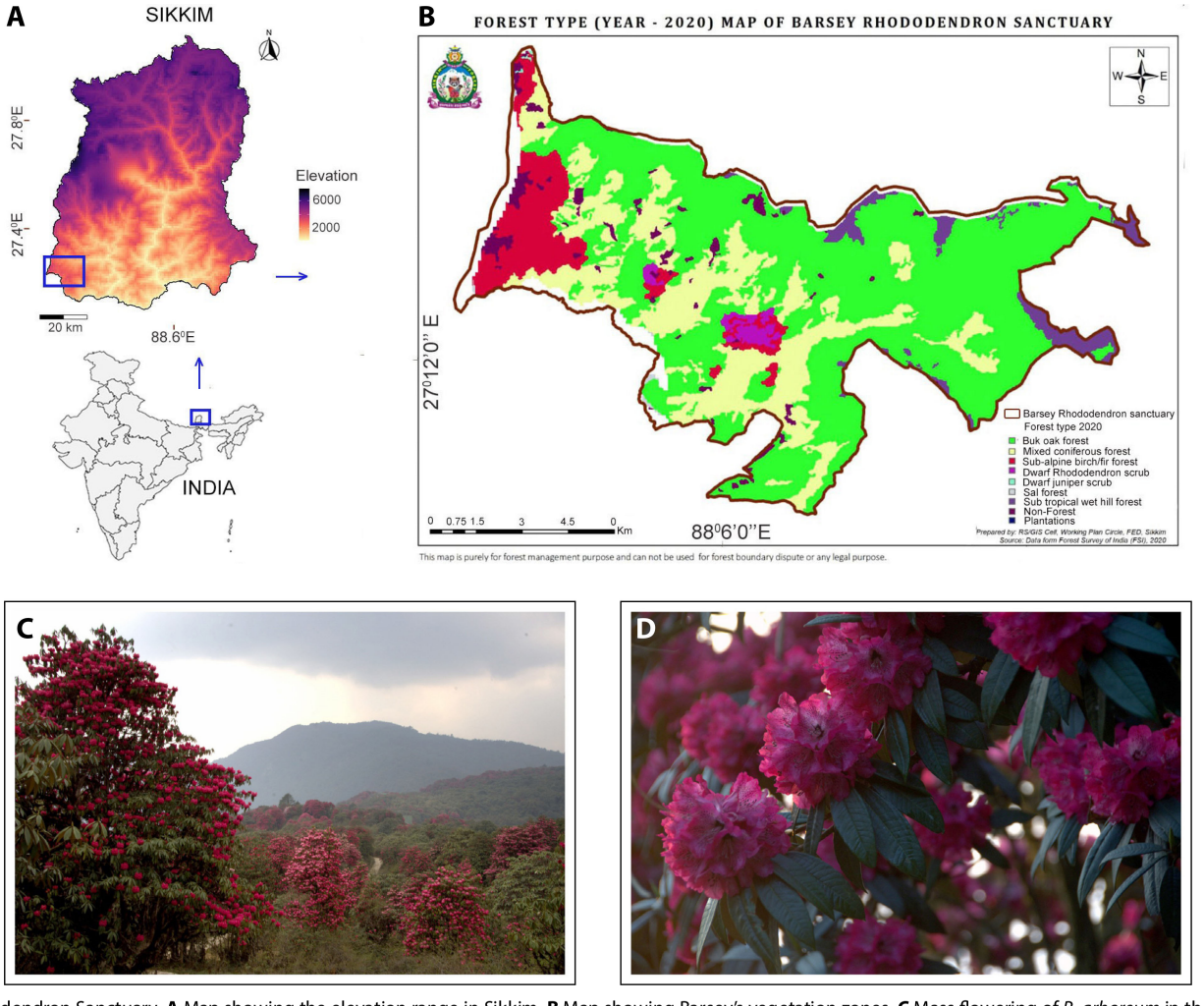

Fig. 1 Barsey Rhododendron Sanctuary. **A** Map showing the elevation range in Sikkim. **B** Map showing Barsey's vegetation zones. **C** Mass flowering of *R. arboreum* in the sanctuary during peak bloom. **D** Close-up of a *R. arboreum* inflorescence. Photos: A Sandeep Sen; B RS/GIS Cell, Forest & Environment Department, Government of Sikkim; C & D Dipanker Basnett.

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Grazing exclusion policy

In 1998, the Government of Sikkim adopted a grazing exclusion policy for domestic livestock in reserve forests owing to escalating pressure on the forest ecosystem and its rapid degradation (Singh *et al.*, 2021). Following the ban on grazing, the removal of cattle sheds began in Barsey, and by 2004, the policy had been successfully implemented in the protected area (Bhagwat *et al.*, 2012). During this process, awareness programmes, audiovisual shows, street plays and nature games about the implications of unmanaged grazing on biodiversity were regularly organised by the state government in coordination with local NGOs, such as the Khangchendzonga Conservation Committee (KCC). To further mitigate impacts on livelihood and formally integrate local communities into conservation planning and decision-making, Ecodevelopment Committees (EDCs) were established in 2001. These committees comprised village elders, local NGOs, panchayats (Indian village councils) and schoolteachers (Government of Sikkim, 2018–2028). Although local communities' perceptions of the establishment of Barsey were initially mixed, most residents supported the grazing ban, viewing it as essential for conserving regional natural resources (Rai, 2008).

From disturbed forest to thriving sanctuary

The designation of Barsey as a sanctuary marked a major transition from a disturbed forest to a recovering montane ecosystem. After grazing exclusion and forest protection, the sanctuary has seen improvements in vegetation, plant regeneration, and bird and wildlife diversity. These changes show the effectiveness of targeted conservation in supporting forest recovery and biodiversity in the Eastern Himalaya (Government of Sikkim, 2018–2028).

High plant diversity in Barsey

A distinctive ecological feature of Barsey is its diverse vegetation types (Fig. 1b). The forest is primarily composed of tall, fruiting broadleaf trees such as *Quercus*, *Lithocarpus* and *Symplocos* species, as well as gymnosperms including silver fir, *Taxus wallichiana* (yew) and *Tsuga dumosa* (hemlock) (Sharma *et al.*, 2025). Flowering trees, particularly *Rhododendron*, constitute a significant floristic component in the region, and the sanctuary harbours some pure stands of *R. arboreum*, *R. grande* and *R. falconeri* (> 15.25 m, Fig. 2e) which sometimes co-occur with fir, hemlock, oak and stone oak. The common *Rhododendron* tree species identified in Barsey include *R. arboreum* (Fig. 1d), *R. falconeri*, *R. grande*, *R. barbatum*, *R. griffithianum*, *R. wightii* and *R. hodgsonii*, whereas *R. triflorum*, *R. decipiens*, *R. campanulatum* and *R. lepidotum* occur as shrubs, and *R. dalhousiae* and *R. vaccinoides* occur as epiphytes (Government of Sikkim, 2018–2028). Among these, *R. arboreum*, *R. falconeri* and *R. grande* are among the most abundant species at lower and mid elevations (Maity *et al.*, 2006; Subba *et al.*, 2018). The forest has an extensive stand of pure *Lithocarpus* (stone oak) and some patches of mixed stands with various *Rhododendron* species. Stone oak trees, which belong to the family Fagaceae and have diameters exceeding 1.5 m at breast height, contribute the largest proportion of forest biomass in the sanctuary, followed by rhododendrons (Subba *et al.*, 2018). The forest also has dense thickets of *Yushania maling* (malingo bamboo) (Fig. 2f). The understorey of bamboo and rhododendrons serves as the primary habitat for the endangered state animal of Sikkim, *Ailurus fulgens* (red panda).

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Fig. 2 **A** Entry point to Barsey from Hilley, showing visitor instructions and guidelines. **B** View of Khangchendzonga, the third-highest mountain in the world, from Barsey. **C** Visitors hiking through the closed-canopy Barsey forest dominated by bamboo, *Quercus* and *Rhododendron* species. **D** *R. arboreum* flowers used as offerings to local deities. **E** Pure stand of *R. arboreum*. **F** Bamboo-dominated understorey in Barsey. **G** Popular tourist track through dense *Rhododendron* and fir forest from Hilley into the core area of Barsey. Photos: A, B, D & E Shweta Basnett; C Dipanker Basnett; F & G Krishna Dahal.

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The forest floor is covered with a thick carpet of leaf litter, which forms a major source of moisture and a favourable habitat for mushrooms and other fungi and underground life. The climate, being essentially wet and cold, also fosters a high diversity of epiphytic orchids, pteridophytes, mosses and lichens (Government of Sikkim, 2018–2028).

The removal of cattle sheds and bans on grazing have led to the natural recovery of medicinal plants such as *Aconitum* sp. (bikhma), *Bergenia ligulata* (pakhan bed) and *Heracleum nepalense* (chimping) (Tambe *et al.*, 2005; Government of Sikkim, 2018–2028). In addition, restrictions on timber and litter collection have led to an increase in wild mushrooms (~46 spp.) growing on dead or decaying trunks and leaf litter (Das, 2010). A study by Subba *et al.* (2018) reported forest cover ranging from 10% to 60% across different types. These ecological enhancements have facilitated the revival of numerous mountain springs, with the resulting spring water now supplying drinking water to several neighbouring villages. A field assessment conducted before and after the implementation of grazing exclusion in Barsey showed a significant increase in carbon stock after the ban (Bhagwat *et al.*, 2012). The study reported that the policy intervention had resulted in 585,000 tonnes of carbon being retained or sequestered compared with a scenario without the policy. The study also reported increased regeneration in *Rhododendron* and coniferous species in Barsey (Bhagwat *et al.*, 2012).

Biodiversity in Barsey

The coexistence of flowering and fruiting species, such as *Rhododendron* spp., *Quercus* spp., *Lithocarpus* spp. and many others, supports a wide diversity of birds and insects year-round. Barsey has been recognised as an Important Bird Area in Sikkim, supporting a wide range of bird species (Lachungpa *et al.*, 2011). Barsey is home to 33 bird species belonging to 31 genera and 20 families (Subba, 2019). The bright red flowers and high nectar production of *R. arboreum* (Fig. 1d) and *R. barbatum* attract a high diversity of bird species. Common bird pollinators of *Rhododendron* in Barsey include *Aethopyga gouldiae* (Mrs. Gould's sunbird), *Myzornis pyrrhoura* (fire-tailed myzornis), *Trochalopteron affine* (black-faced laughing thrush), *Yuhina gularis* (stripe-throated yuhina), *Y. occipitalis* (rufous-vented yuhina), *Heterophasia capistrata* (rufous sibia), *Actinodura nipalensis* (hoary-throated barwing) and *Turdus albocintus* (white-collared blackbird). In addition, bees such as *Bombus* sp. and *Apis* sp. are important insect pollinators in the sanctuary (Basnett *et al.*, 2025). Over the years, camera traps, sightings and studies in Barsey have recorded increases in endangered mammals such as *Panthera pardus* (common leopard), *Prionailurus bengalensis* (leopard cat) and *Ursus thibetanus laniger* (Himalayan black bear), ungulates such as *Muntiacus muntjak* (barking deer) and *Naemorhedus goral* (Himalayan goral), and *Martes flavigula* (yellow-throated marten) (as reported by WWF-India and F&ED, 2016–2017).

Barsey and local communities

In the Himalayan region, forests and local communities are inextricably linked, with many people depending on forest resources for their livelihoods. Similarly, in the Sikkim Himalayan region, local communities have been closely connected to forests for centuries, as reflected in folklore, traditions and daily practices (Sukumaran & Basnett,

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2023). However, raising awareness and educating local communities about the impacts of biodiversity loss is essential for long-term conservation and preservation of their livelihoods.

Barsey sets a successful example in which community-based conservation initiatives, such as local involvement in patrolling, education and ecotourism, have strengthened partnerships between forest managers and local communities. These efforts have enhanced biodiversity conservation outcomes while reducing direct pressure on biodiversity by creating alternative livelihood opportunities, including ecotourism-related employment. More than 30 villages surrounding Barsey are inhabited by diverse ethnic communities, including Lepchas, Bhutias and Nepalese. In this human-dominated landscape, local community participation is essential for effective conservation. Barsey has facilitated such involvement by establishing conservation management committees that include residents. The success of Barsey conservation efforts is attributed mainly to collaboration among local ethnic groups, forest policies and NGOs in Sikkim, including the Eco-Tourism and Conservation Society of Sikkim, the WWF Sikkim Programme, The Mountain Institute and the KCC. These organisations focused on outreach, education and capacity building within local communities. Furthermore, EDCs and Joint Forest Management Committees promoted participatory stewardship and connected biodiversity recovery to improvements in local well-being (Tambe *et al.*, 2005; Government of Sikkim, 2018–2028).

Despite these initiatives, the social impacts of restrictions on forest use are not well understood (Tambe *et al.*, 2005). There is limited empirical evidence on how displacement from forest-based activities has affected household economies, cultural practices and overall well-being, particularly during the early years following sanctuary establishment. Future socio-ecological research can address these gaps to inform more inclusive conservation strategies that acknowledge historical dependencies and support management of protected areas in the Himalayan region.

Barsey as a source of livelihood

Over the last few decades, Barsey has become an important tourist spot, and it has seen a considerable increase in visitor numbers during the flowering seasons. The flowering season provides locals with a temporary livelihood. Local people living on the fringes of Barsey, such as in Hilley, Okhrey, Dentam and many other regions, have converted their homes into commercial homestays, which not only serve food and provide accommodation but also allow guests to experience local lifestyles and traditions. Additionally, during this time, the homestays organise cultural events and serve homemade rhododendron juice, wine or flower infusions to guests. However, as some *Rhododendron* species contain grayanotoxins (compounds known to cause intoxication when consumed in sufficient quantities), appropriate caution and species-specific knowledge are required when preparing and consuming products derived from these plants (Jansen *et al.*, 2012). The *Rhododendron* flowering season (February–May) attracts trekkers, birdwatchers and nature lovers from around the world. People visit Barsey to experience the scenic landscape and engage in recreational activities (Fig. 2b, c). During the *Rhododendron* flowering season, local villagers work as tour guides and porters, and some are even trained as local bird

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guides (Government of Sikkim, 2018–2028). The flowering season also overlaps with the *Ram Navami* festival, locally known as *Chaite Dashain*. During this festive period, villagers visit sacred forest patches with families, offer prayers (Fig. 2d) and sometimes undertake community clean-up rituals around natural springs and forest trails. Following the establishment of Barsey, community members, many of whom were formerly engaged in activities such as livestock herding, medicinal plant collection and hunting, were subsequently engaged by the Government of Sikkim to support biodiversity conservation and protection efforts in the region. Their skills and vast knowledge of forests were used to design and implement conservation strategies (Rai, 2008).

Future directions for conservation and management of Barsey

To ensure long-term biodiversity conservation and sustain local community well-being, we propose four management and policy recommendations based on existing research and local socio-ecological conditions. Together, these recommendations show how local-level management at Barsey can help achieve the 2030 Global Biodiversity Framework (GBF) targets (CBD, 2022) by integrating biodiversity conservation with sustainable livelihoods, participatory governance and climate-resilient management in mountain protected areas.

Promoting community-based native plant cultivation

Rhododendron-based tourism during the flowering season provides an important, though seasonal, source of income for local communities surrounding Barsey. To ensure livelihood security while supporting biodiversity conservation and reduce dependence on forest extraction, the cultivation of fuelwood species, fodder species, wild edible plants and ecologically important tree species should be considered outside protected areas.

Implementing such community-led initiatives may further enhance livelihood security and conserve biodiversity. The state government could encourage local communities to establish village nurseries to grow native flowering and fruiting tree species common to Barsey, including *R. hodgsonii*, *R. griffithianum*, *R. grande*, *R. falconeri* and associated species such as *Tsuga dumosa*, *Abies densa*, *Lithocarpus* spp. and *Quercus* spp. Such initiatives could support habitat restoration and enhance the availability of floral and fruit resources for wildlife. This is particularly important because recent research in the sanctuary has reported poor natural regeneration in several of these tree species, raising concerns about their long-term persistence (Sharma *et al.*, 2025).

Seedlings from these nurseries can be integrated with ongoing state flagship programmes such as *Mero Rukh Mero Santati* ('My Tree My Legacy'), *Ek Ped Maa Ki Naam* ('Plant a Tree in Your Mother's Name'), *Day to Mother Earth*, and other afforestation, plantation and catchment restoration initiatives led by the state government. This approach would help generate year-round employment, enhance local stewardship of native biodiversity and alleviate pressure on natural forest resources.

Regulated cultivation of commercially valuable *R. arboreum* species outside the sanctuary can also satisfy high market demand for *Rhododendron*-based products without impacting wild populations. Although large-scale illegal extraction from Barsey is not widely documented, increasing

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commercial demand for *Rhododendron*-based products and medicinal plants may create future harvesting pressure on wild populations, particularly on species with poor natural regeneration. This strategy would support sustainable supply chains and preserve genetic diversity within natural populations. Overall, this integrated approach would contribute to GBF targets (CBD, 2022) related to species conservation, sustainable use and trade of wild species, reduction of illegal extraction and maintenance of genetic diversity.

Improve research and education

Despite the growth of ecotourism, Barsey remains overlooked in biodiversity conservation. Mainly because of its location and often inhospitable weather, there is a limited focus on ecological and field-based research. Strengthening research and education through citizen science can therefore contribute to biodiversity conservation in this region.

The high diversity of flagship plants such as *Rhododendron* makes Barsey a strong candidate for long-term monitoring of plant phenology. Interestingly, comparative findings from a published study in Barsey (Sharma *et al*., 2025) indicate changing regeneration patterns among flagship *Rhododendron* species. Earlier observations reported positive seedling emergence of species such as *R. arboreum* and *R. falconeri*, while recent studies along trekking routes recorded fair regeneration of *R. arboreum* and absence of regeneration in *R. falconeri*, highlighting the urgent need for long-term ecological monitoring and climate-linked research in the sanctuary. Also, installing weather stations at different elevations would allow the recording of spatial and temporal fluctuations in temperature and precipitation, as well as their influence on plant phenology. However, due to the region's remoteness and Barsey's inaccessibility, especially at higher elevations, such a long-term monitoring project would only be sustainable through scientific collaborations with local stakeholders. The state can build adequate capacity for research and action on climate change by collaborating with subject experts, research institutes, state forests, scientific departments and local communities through citizen science programmes. Strengthening long-term ecological monitoring and community-engaged research in Barsey supports GBF targets (CBD, 2022) by building scientific capacity, fostering understanding and promoting the integration of local knowledge.

Encourage sustainable tourism

Tourism in Barsey has increased to several thousand visitors annually, concentrated during February to May along limited-access routes, particularly the Hilley-Barsey trail, resulting in waste accumulation, fuelwood extraction and wildlife disturbance (Government of Sikkim, 2018–2028). Undoubtedly, *Rhododendron* flowering seasons generate revenue for the state and provide livelihoods for villagers. However, the rise in tourist numbers requires stricter management of entry permits and recreational activities within the sanctuary. In this context we propose sustainable tourism management plans to enhance biodiversity conservation in Barsey.

Recommended actions include the following:

(1) There should be a cap on the number of daily visitors and camping permits issued at each entry point.

(2) Camping should be restricted to designated sites outside the core wildlife

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habitats and no-go buffers set during the breeding periods of wild animals.

(3) Tourist permits should have clear conservation-focused guidelines, such as bans on plastic, restrictions on loud music and a prohibition on feeding wildlife.

(4) Interpretation facilities at Hilley and Uttarey should be fully operational, with mandatory pre-trek briefings covering *Rhododendron* ecology, red panda conservation and sensitivity to human–wildlife conflict.

(5) Visitor numbers should be regulated, with the zoning of recreational activities and the issuing of conservation-oriented guidelines to align with GBF targets (CBD, 2022) by reducing tourism-related pressures on biodiversity while supporting sustainable ecosystem services.

Better management of human–wildlife conflict

Human–wildlife conflict around fringe villages of Barsey includes crop raiding (particularly of maize and potato), livestock killing and occasional human injuries caused by wildlife, including *Sus scrofa* (wild boar), macaques, barking deer, leopards and Himalayan black bears (Government of Sikkim, 2018–2028; Dialogue Earth, 2021).

Although Barsey is a popular ecotourism destination during the *Rhododendron* flowering season, peak tourist influx may indirectly intensify human–wildlife conflict. Improper waste disposal during peak season can attract species such as wild boar, macaques and Himalayan black bears to village edges, increasing crop raiding and human–wildlife encounters. In addition, noise pollution from tourists may disturb sensitive species such as the red panda and *Ithaginis cruentus* (blood pheasant), potentially displacing these wild animals from core habitats towards fringe agricultural areas (Dialogue Earth, 2021).

Here, we propose plans to strengthen conflict mitigation through regulation and research. Recommended actions include enforcing strict zero-waste policies along *Rhododendron* bloom trails and trekking routes, limiting daily visitor numbers during peak season and establishing noise curfews in core sanctuary areas. Monitoring tools, such as camera traps, can be deployed throughout Barsey to assess wildlife activity patterns, movement and habitat use, and to evaluate their relationship to the frequency of human–wildlife conflict incidents. Furthermore, enhanced collaboration between the Forest Department and research organisations is essential to facilitate systematic, long-term research on tourism–wildlife interactions and to inform evidence-based management within the wildlife-rich sanctuary. The enforcement of zero-waste tourism practices will help achieve Target 5 by mitigating pollution impacts on biodiversity. Additionally, camera-trap monitoring will enhance long-term biodiversity assessment.

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