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Rhododendron arboreum In Himalayan Agroecosystem: A Review of its Ethnobotany, Sustainable Use and Value Addition

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ABSTRACT: The Indian Himalayan Region is a hotspot of biodiversity, rich in wild flora that provides not only ecological services but also socio-economic benefits. *Rhododendron arboreum*, commonly known as Burans, is one of the most valuable non-timber forest products (NTFPs) of the region, supporting local communities through traditional knowledge and growing markets. This evergreen shrub is well-known for its vibrant red flowers, traditionally used in food, medicine, and rituals. In recent years, the species has gained economic attention due to its potential in value-added products such as juices, squashes, jams, and functional health supplements. However, increasing market demand, habitat disturbance, and changing climate conditions pose challenges to its sustainable utilization. This review provides a comprehensive overview of the ethnobotanical relevance, phytochemical and pharmacological properties, product development, and conservation needs of *R. arboreum*. It highlights sustainable harvesting protocols, community participation, forest certification models, and habitat modelling approaches that can support both biodiversity conservation and rural development in the Himalayan region.

Keywords: *Rhododendron arboreum*, NTFP, traditional medicine, value addition, sustainability, forest certification, climate change, conservation.

INTRODUCTION

The genus *Rhododendron*, derived from the Greek words *rhodon* (“rose”) and *dendron* (“tree”), belongs to the family Ericaceae and order Ericales. It comprises nearly 1,000 species globally, predominantly distributed across Nepal, India, China, and Malaysia (Singh *et al.*, 2003). In India, approximately 102 species are recorded, showcasing the country’s significant contribution to the genus's global diversity (Panda and Kirtania 2016). Among these, *Rhododendron arboreum* Sm. is one of the most ecologically and socioeconomically significant species. It is a small evergreen tree or shrub bearing vibrant red to pink flowers, often blooming in compact clusters called trusses (Tabassum *et al.*, 2018). Locally, the species is known by different names such as Pu, Billi, Eras, and Adrawal (Rawat *et al.*, 2017).

This species frequently forms dense pure or mixed populations in high-altitude forests alongside *Juniperus*, *Abies*, and bamboo, forming characteristic "Rhododendron thickets". These populations are commonly observed along moist, exposed hill slopes. Its vibrant blossoms enhance the scenic beauty of the Himalayan landscape and attract numerous visitors (Srivastava, 2012). *R. arboreum* holds deep cultural and symbolic importance: it is the national flower of Nepal, the state flower of Himachal Pradesh and Nagaland (Paul *et al.*, 2010), and the state tree of Uttarakhand (Keshari and Pradeep 2017).

In recent years, *R. arboreum* has gained considerable attention not only for its ornamental and medicinal uses but also as a valuable non-timber forest product (NTFP) supporting rural livelihoods. Studies from the Indian Himalayas and Nepal show that the species regenerates successfully in mid-elevation forests with mixed canopies, though its regeneration declines in degraded sites and higher elevations (Negi *et al.*, 2011; Chauhan *et al.*, 2017).

Ecological modelling indicates that the species' suitable habitat—currently estimated at over 32,000 km² in Nepal—may shrink significantly by 2050 and 2070 due to climate change, with marked upward shifts in elevational distribution (Gaira *et al.*, 2014). Dendroecological studies have demonstrated that *Rhododendron arboreum* shows a strong sensitivity to variability in the Indian Summer Monsoon rainfall, highlighting its efficacy as a bio-indicator of long-term hydroclimatic changes in Himalayan ecosystems (Dhyani *et al.*, 2023).

Ethnobotanical practices surrounding *R. arboreum* include harvesting its brightly colored petals for traditional preparations such as squash, juice, chutney, jams, and herbal wine. These products not only provide seasonal nutrition but also serve as an income source for local communities (Negi *et al.*, 2011).

Phytochemical investigations have revealed that the flowers are rich in health-benefiting compounds like flavonoids, quercetin, and tannins, with antioxidant, hepatoprotective, and antimicrobial properties (Swaroop *et al.*, 2005; Verma *et al.*, 2020).

The increasing demand for *R. arboreum*–based products has led to commercialization in several Himalayan states. Women-led Self-Help Groups (SHGs) and local enterprises have emerged as key players in the collection, processing, and marketing of these products, particularly in Uttarakhand and Himachal Pradesh (Sukumaran and Basnett 2025).

These efforts not only contribute to household incomes but also encourage responsible harvesting and conservation practices. From a conservation and forest governance perspective, *R. arboreum* has become a model species in discussions around sustainable harvesting, value chain development, and eco-certification schemes such as those promoted by the Forest Stewardship Council (FSC). Field-based studies emphasize the importance of integrating scientific knowledge with community forest governance to ensure ecological sustainability and economic viability (Chauhan *et al.*, 2021).

Given its multifunctional roles—cultural, ecological, medicinal, and economic—*R. arboreum* holds immense potential as a sustainable NTFP in the Himalayan agroecosystem. This review synthesizes traditional knowledge, recent scientific advancements, value-addition opportunities, and strategies for conservation-based rural development, highlighting the species' relevance in contemporary mountain livelihoods and biodiversity management. The morphology of *R. arboreum* is particularly striking, with dense floral clusters that serve as a visual indicator of seasonal transitions in mid to high-altitude forests (Fig. 1).

Fig. 1. A vibrant *Rhododendron* tree in full bloom, its striking red flowers set against the majestic Himalayan backdrop in Uttarakhand. (**Photo Credit**: Prem Pancholi, 04 March 2025)

Taxonomic Classification and Distribution. *Rhododendron arboreum* Sm. is well-known for its colourful and attractive flowers, most of which are found in mountainous and temperate climates. *R. arboreum* is an evergreen tree or large shrub that thrives in cool, moist habitats and acidic soils. *Rhododendron arboreum* Sm. is an evergreen tree or large shrub, widely distributed across elevations of approximately 1,500 to 3,300 m in the Indian Himalayan Region, where it significantly contributes to the biodiversity of temperate and sub-alpine forests (Mamgain *et al.*, 2017; Tiwari *et al.*, 2010). The taxonomical classification of *R. arboreum* is as follows:

Table 1: Taxonomic Classification of *R. arboreum.*

Kingdom	Plantae
Phylum	Magnoliophyta
Class	Magnoliopsida
Order	Ericales
Family	Ericaceae
Genus	*Rhododendron*
Species	*Rhododendron arboreum* Sm.

Rhododendron arboreum Sm. was first formally published by Sir James Edward Smith in *Exotic Botany* based on specimens collected in the Himalayan foothills in 1796, recognizing it as one of the most splendid Rhododendron species in botanical literature. Verma *et al.* (2020) specifically highlight its bell- or tubular-shaped flowers, which range in colour from red to pink and white across different subspecies and regions. The leaves are thick, leathery, and oblong, with a silvery or rusty underside, providing a distinct morphological identity (Polunin and Stainton 1984).

In India it is found in the Himalayas from Kashmir eastwards to Nagaland, particularly in the region of Sikkim, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Jammu and Kashmir, Uttarakhand, West Bengal (Mao, 2010, Sekar and Srivastava 2010) and Himachal Pradesh (Samant *et al*., 2007). In the Western Himalayas, particularly in Himachal Pradesh and Uttarakhand, *R. arboreum* is the most dominant among three major species—*R. arboreum*, *R. anthopogon*, and *R. campanulatum* (Mehta *et al.*, 2010; Prakash *et al.*, 2007). Major species found in India are as follows (Table 2 and Fig. 2).

Table 2: Major species of *Rhododendron* found in India (Mehta *et al.*, 2010).

Species Name	Altitudinal Range (m)	Region Found	Key Features & Importance
Rhododendron arboreum (Red Brass)	1,500–3,000	Western to Eastern Himalayas (J&K to Arunachal Pradesh)	State tree of Uttarakhand; red flowers; widely used in medicine and beverage
Rhododendron campanulatum (Pink Brass)	2500–4,000	Himachal Pradesh, Uttarakhand, Sikkim	Showy flowers; dominant in subalpine forests
Rhododendron anthopogon (Brass)	3,500–4,500	Uttarakhand, Sikkim, Arunachal Pradesh	Aromatic dwarf shrub; incense and medicinal use
Rhododendron lepidotum (Brass)	3,000-4,500	J&K, Himachal, Uttarakhand	Typically found in open alpine meadows, rocky slopes, and forest edges

Fig. 2. Different Species of *Rhododendron* found in India (a) *Rhododendron arboreum* (Credit: Nuwan Chathuranga), (b) *Rhododendron campanulatum* (Credit: Timothy A. Gonsalves), (c) *Rhododendron lepidotum*, (d) *Rhododendron anthopogon* (Source (c), (d): GHNP official site)

Regional and Vernacular Names. The widespread use of *R. arboreum* in different parts of the Indian Himalayan Region has led to a variety of vernacular names (Table 3), reflecting the plant's local importance and cultural attachment. These vernacular names are deeply embedded in local languages and frequently used in markets, folklore, and traditional medicine. For instance, in Nepal the plant is popularly known as "Lali Gurans," a name that appears in folk art, poetry, and cultural festivals—reflecting its aesthetic and emotional resonance (Kumar & Srivastava 2002; Srivastava, 2012).

Table 3: Some common regional names of *R. arboreum* (Rawat *et al.*, 2017).

Region/Language	Vernacular Name
Garhwal (Uttarakhand)	Buransh/Burans
Kumaon (Uttarakhand)	Eras
Himachal Pradesh	Brass/Chimal
Punjab	Adrawal
Nepal	Laligurans

The multiple vernacular names of *Rhododendron arboreum* reflect its wide distribution and deep-rooted cultural presence. Local communities possess detailed traditional knowledge—ranging from flowering seasonality to edible, medicinal, and harvesting practices. Families in Himalayan villages have passed down recipes for chutney, sherbet, and herbal tea using the flowers, and older women often discern the optimal flower-maturity stage for squash or jam preparation (Uzma *et al.*, 2022).

The flowers of *Rhododendron arboreum* hold profound ceremonial importance in Himalayan societies, especially during festivals like Sankranti and Navaratri, when they are offered in temples or fashioned into garlands. Local belief reinforces that consuming rhododendron squash in summer enhances blood circulation and helps prevent heatstroke—benefits likely attributed to its high antioxidant contents. Additionally, many children collect fresh blossoms during the flowering season and sell them at roadside stalls, thus contributing modestly to household incomes (Sharma and Kala 2016).

Forest Type. The distribution of *Rhododendron arboreum* is closely linked with the various forest types across the Indian Himalayan region. In Uttarakhand, *R. arboreum* is predominantly found in the Himalayan Moist Temperate Forests and Subtropical Pine Forests. The spatial extent of these forest type groups is depicted in **Fig. 3**, which highlights areas that support the natural habitat of *R. arboreum*. The map also highlights non-forest and water-covered areas across district boundaries.

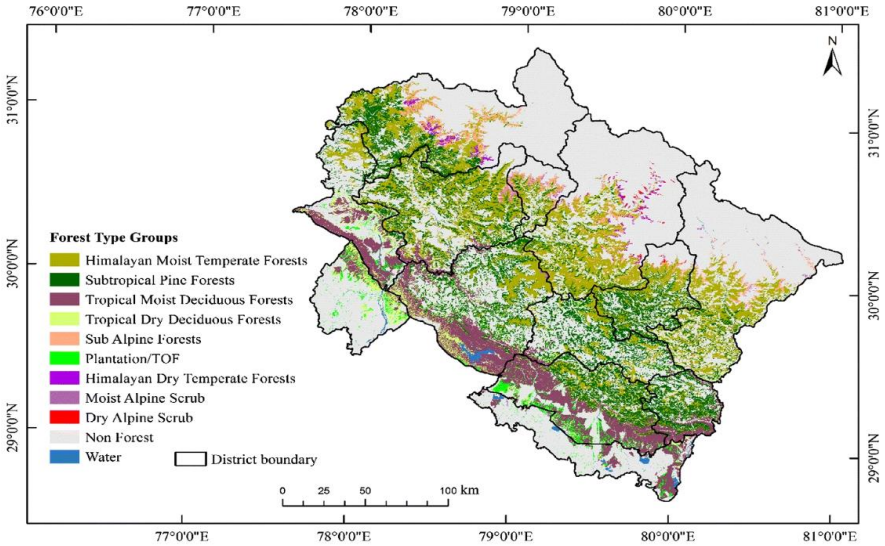

Fig. 3. Forest type distribution map of Uttarakhand showing various forest types (Singh & Chatterjee 2022).

Phenology and Climate Change. Climate change has been shown to significantly alter the flowering phenology of *Rhododendron arboreum* in the Western Himalayas, leading to earlier blooming patterns by up to 20–25 days in certain elevational belts (Rana *et al.*, 2024). In addition, *R. arboreum* is exhibiting an upward shift in its altitudinal range due to warming temperatures. As lower elevation zones become warmer and drier, the species is migrating toward higher elevations where it may face limited habitat space, competition with alpine species, and harsher climatic conditions. This "climate squeeze" could potentially lead to local extinction in areas where upward migration is not possible. Therefore, any conservation strategy for *R. arboreum* must consider both anthropogenic pressure and climate resilience.

Sukumaran and Basnett (2025) report that *Rhododendron arboreum* in the Sikkim Himalaya exhibits distinct pollination strategies tied to flower color morphs: red-flowered morphs, common at lower elevations, are primarily pollinated by sunbirds (e.g. *Aethopyga* spp.), while lighter-colored variants attract insect pollinators such as bees and flies. This dual pollinator interaction influences fruit set and seed dispersal, supporting flexible reproductive strategies across ecological zones (Ollerton *et al.*, 2020).

As illustrated in Fig. 4, each reproductive phase (bud development, flowering, fruiting, and seed maturation) occurs within a narrow window and is vulnerable to climatic variability. In particular, the reproductive cycle is increasingly shifting in response to winter warming trends in Uttarakhand and Sikkim, potentially affecting long-term regeneration and genetic variability.

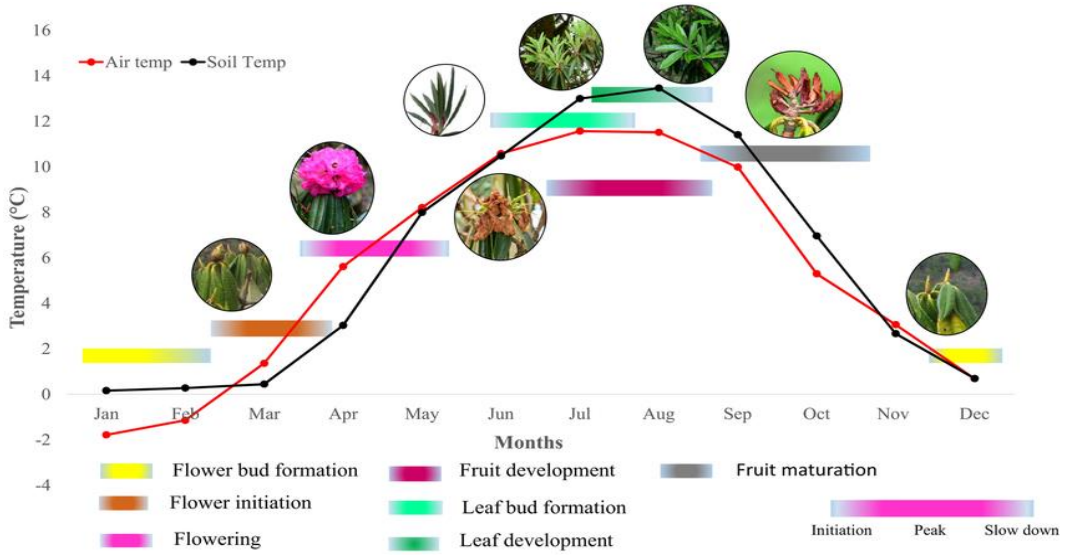

Fig. 4. Reproductive cycle of *Rhododendron arboreum* Sm. at treeline ecotone (Chandra *et al.*, 2022).

Ethnobotanical and Medicinal uses. *Rhododendron arboreum* has been integral to Himalayan communities for centuries, used in food, medicine, rituals, and local trade. Indigenous people in Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh, and eastern Nepal use its flowers, leaves, and bark in traditional practices. Traditional healers also use flowers to remedy diarrhea, dysentery, headaches, and inflammation, while bark and leaves are applied to relieve rheumatic pain (Nitika *et al.*, 2021). Buildup of imperishable consumption of this plant can seize an excellent future for local employment for farmers (Rawat *et al.*, 2020).

Ethnobotanical studies in the Nanda Devi Biosphere Reserve report that *Rhododendron arboreum* is widely used by local communities for healthcare and income; these researchers emphasized sustainable harvesting and community involvement in conservation efforts (Nautiyal *et al.*, 2001). Contemporary research highlights the transition from traditional uses of its flowers in food, medicine, and rituals to modern value-addition—such as juices, squashes, teas, and nutraceuticals—that benefit rural economies and preserve cultural heritage (Sharma and Samant 2014).

Phytochemical investigations of *R. arboreum* flowers, leaves, and bark have identified high levels of flavonoids, phenolic acids, tannins, saponins, glycosides, quercetin, rutin, chlorogenic acid, and kaempferol. These bioactive compounds exhibit antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective potentials (Shyaula *et al.*, 2024). In vitro assays further demonstrate antimicrobial activity of methanolic and acetone extracts against *E. coli*, *S. aureus*, *A. niger*, and *C. albicans* (Gautam *et al.*, 2018).

In conclusion, the ethnobotanical and medicinal uses of *R. arboreum* demonstrate the strong relationship between biodiversity and traditional knowledge in Himalayan cultures. With growing scientific validation of its therapeutic properties, this species holds great potential for integration into mainstream healthcare, herbal formulations, and functional food systems.

Various minerals are present in *Rhododendron* such as lead, arsenic, nickel, molybdenum, copper, zinc, manganese, chromium, sodium, cadmium, and cobalt etc, that are essential in maintaining certain physicochemical processes of life. Sodium plays a vital role in maintaining the osmotic equilibrium between interstitial fluids and cells (Soetan *et al.*, 2010). Scientific research has validated its medicinal properties, particularly antioxidant, antimicrobial, and hepatoprotective effects, attributed to its rich content of

phytochemicals such as flavonoids, phenolics, and essential trace minerals (Swaroop *et al.,* 2005).

The leaves of *Rhododendron arboreum* are traditionally recognized for their medicinal properties, being effective in the treatment of ailments such as headache, fever, and lung infections. Rich in flavonoids and vitamin C, the leaves are commonly used in indigenous medicine to treat conditions like gout, rheumatism, coughs, colds, and fever. A dried leaf tincture is particularly used for rheumatic and gouty conditions. Additionally, the leaves can be distilled to extract aromatic oils, which have potential applications in perfumery and cosmetic industries (Pradhan and Lachungpa 1990).

Essential oil is obtained from the flowers and leaves OF Rhododendron via steam distillation. Widely used as sacred incense in Nepal and Tibetan Buddhist rituals, it cleanses the environment and fosters spiritual harmony. In traditional Himalayan medicine, healers brew the plant's leaves and flowers as tea to stimulate appetite, support digestion and liver health, and alleviate sore throat, nausea, and headaches. *R. anthopogon* is revered as sacred and its aroma is believed to bring peace to the spirits of the earth (Innocenti *et al.,* 2010).

Value-added products and functional applications. Rhododendron arboreum flowers are traditionally used for preparing a range of value-added food products in the Himalayan region. One such product is rhododendron juice, extracted either by the traditional hot-pressing method or the cold-pressing method. While hot pressing yields more juice, it compromises thermosensitive phytochemicals. Cold pressing is therefore recommended to retain the nutritional quality (Hillsjester, 2014). Rhododendron flowers are also used to make chutney, a common homemade condiment in Uttarakhand and Himachal Pradesh. The preparation involves removing stamens from the flowers, washing the petals, and blending them coarsely with mint leaves, onions, chilies, jaggery, yogurt, salt, and lemon juice to retain texture and enhance flavour **(**Fig. 5). The flower is further used in the form of dried powder to produce biscuits. After cleaning, grading, and sun drying the petals, they are ground and sieved. These are then blended with wheat flour in varying ratios. Studies have shown that incorporation of Rhododendron flower powder in biscuits significantly increases protein, fiber, and iron content, with improved mineral composition. For instance, biscuits fortified with rhododendron powder at 15% substitution showed 4.96% protein and 4.19 mg/100g iron, as opposed to 3.06% protein and 3.90 mg/100g iron in control samples (Devi *et al.,* 2018). Additionally, a local delicacy known as '*Buransh ka Kachru'* is widely prepared in hilly regions. It involves mixing flower paste with besan or corn flour, coriander leaves, green chilies, turmeric, and other spices to form a batter, which is then shallow-fried to create a pancake-like dish rich in flavor and nutrients.

The rising demand for natural health products, functional foods, and herbal remedies has opened new avenues for the commercialization of *Rhododendron arboreum* in the Indian Himalayan Region. Krishna *et al*. (2014) demonstrated that the optimal preparation involved extracting petals at 80°C and combining them with 0.5% ginger juice, resulting in superior sensory and nutritional quality. This squash retained its color and high phenolic content for up to 90 days under ambient storage conditions. Similarly, Thakur *et al.* (2020) developed a spiced beverage using *R. arboreum* flowers, formulated as a natural appetizer rich in antioxidants and suitable for commercial production with a shelf life of up to six months. Other products like rhododendron jam and jelly are prepared using petal extract combined with pectin and sugar under hygienic conditions, and are particularly valued for their natural anthocyanin content, which imparts vibrant color and antioxidant activity.

Fig. 5. Products made from Rhododendron flowers (Rhododednron chutney and juice).

A study by Gautam *et al.* (2016) found that the flowers of *Rhododendron arboreum* contain several important bioactive compounds. These include flavonoids, phenols, and antioxidants, which help explain the plant's medicinal properties. Different types of flower extracts were tested, and all showed strong potential for health-related uses.

The commercialization of *Rhododendron arboreum* has broadened to include fortified bakery products, artisanal beverages, and value-added local goods that combine traditional knowledge with contemporary food technology. For instance, Devi (2017) incorporated up to 15% *Rhododendron* flower powder into biscuit dough, increasing protein (from 3.06% to 4.96%), iron (3.90 to 4.19 mg/100 g), fiber, and ash content—while retaining acceptable taste and texture up to 10% inclusion. In another innovation, Mehra *et al.* (2020) developed a craft-style red rice and barley beer infused with rhododendron flower extracts; the resulting brew demonstrated significantly higher levels of flavonoids, anthocyanins, and polyphenols and possessed a favourable sensory profile (taste, aroma, colour) compared to control beer.

In the Himalayan region, bees feeding almost exclusively on *Rhododendron* flowers produce a special "mad honey" that contains neurotoxins known as grayanotoxins, primarily grayanotoxin I and III.). Overconsumption can induce hypotension, bradycardia, dizziness, and other symptoms, mild doses are believed to provide cardiovascular and analgesic benefits when used carefully and under supervised conditions.

In summary, the transformation of *R. arboreum* from a traditional wild edible to a multi-functional product line offers enormous potential for sustainable rural development. Its value-added forms—from beverages and jams to smart films and bakery items, demonstrate how biodiversity can be linked with economic empowerment and health promotion, especially when

communities are trained, organized, and supported by policies and institutions.

Sustainable harvesting and conservation of *Rhododendron arboreum*. Sustainable harvesting of *Rhododendron arboreum* is critical to maintaining its natural population and preserving ecosystem health. Research in the Garhwal Himalaya indicates that limits on flower extraction—specifically a maximum of around 60% per tree—are essential to allow sufficient blooms to mature into seeds and support regeneration. Local forest groups such as the Van Panchayats collaborate with scientists to manage harvest timing, processing techniques, grading, and storage to enhance sustainability and employment opportunities (Iqbal *et al.*, 2017). Moreover, rhododendrons serve as bio-indicators of climate change, given their sensitivity to phenological shifts, emphasizing the need for adaptive and community-inclusive forest governance (Bhattacharyya and Sanjappa 2008).

Negi *et al.* (2011) showed that non-timber forest products like *Rhododendron arboreum* can help both conserve biodiversity and improve rural livelihoods. They emphasized community involvement and sustainable harvesting for long-term benefits in the Central Himalayas.

Field research in the Eastern Himalayas shows that red flower morphs, prized for their vibrant color, attract the highest pollinator activity—so overharvesting these can directly impair reproductive success, especially in mid- to high-altitude zones with limited pollinator diversity (Basnett *et al*., 2019). This means that removing too many red flowers can directly reduce reproductive success, especially in mid- to high-altitude populations where pollinator diversity is already limited. Apart from overharvesting, habitat degradation and forest fragmentation have also contributed to the poor regeneration of *R. arboreum*. In degraded forests, natural regeneration is often low due to the loss of canopy cover, soil erosion, grazing pressure, and climatic stress.

Maikhuri *et al.* (2004) emphasized the potential of wild edible plants, including *Rhododendron arboreum*, in supporting rural livelihoods in the Central Himalayas. Climate change has emerged as another major challenge in the conservation of *R. arboreum*. Several phenological studies in the Himalayas have indicated a marked shift in flowering time, with blooming occurring earlier than in previous decades. Gaira *et al.* (2014) found that flowering at higher elevations is now happening up to 88–97 days earlier compared to historical records. This phenological shift is associated with increased winter and spring temperatures, and it may affect synchrony with pollinators, fruiting patterns, and seed dispersal.

Rhododendron arboreum, locally known as *buransh*, plays a vital role in supporting livelihoods in the Garhwal Himalayas (Fig. 6). Its flowers and wood are used for fuel, food, and medicinal products. Village-level enterprises produce value-added items like juice, squash, and wine, though most lack proper branding. Sustainable harvesting—leaving 40% of flowers for seed production, is essential for conservation (Nair *et al*., 2023).

Fig. 6. Women sorting harvested *R. arboreum* flowers on a tarpaulin, with baskets nearby. (Photo credit: Anil Vijayeshwar Dangwal).

Another important step is the introduction of Forest Stewardship Council (FSC) certification or similar community-based certification systems that ensure traceability, fair trade, and environmental sustainability in the collection and trade of *R. arboreum* products. Acharya (2019) conducted a longitudinal study across CFUGs (Community Forest User Groups) in central and far-western Nepal, tracking changes from 2003 to 2016. He reported improvements in operational planning, record-keeping, community decision-making, non-timber forest product value addition, and equitable benefit-sharing, all contributing to reduced rural poverty and more sustainable forest management. Such models could be adapted for India, especially in states like Uttarakhand and Himachal Pradesh, where community forest management systems already exist.

Participatory conservation involving local communities is crucial for long-term success. Community seed nurseries and replantation drives can further help regenerate degraded rhododendron habitats. Women's self-help groups, which are often the primary producers of rhododendron squash and jams, should be supported with technical know-how, packaging equipment, and branding tools to create eco-friendly businesses that promote both conservation and income generation.

Sustainable harvesting and conservation of *Rhododendron arboreum* require a multi-pronged approach involving ecological research, local participation, policy frameworks, and climate adaptation. If these elements are successfully integrated, *R. arboreum* can continue to serve as a symbol of Himalayan biodiversity and a pillar of sustainable mountain livelihoods.

CONCLUSION AND FUTURE SCOPE

Rhododendron arboreum holds immense ecological, cultural, medicinal, and economic significance across the Indian Himalayan Region. It has traditionally been revered not only for its ornamental beauty but also for its nutritional and therapeutic properties.

The increasing demand for flower-based products in both local and urban markets indicates that this species has strong potential for commercialization and livelihood enhancement. At the same time, its high-altitude adaptation, resilience to cold conditions, and ecological interactions with pollinators make it an important species for ecosystem functioning and forest health.

However, growing commercial interest, along with unregulated harvesting practices and environmental stress, has raised serious concerns about the long-term sustainability of *R. arboreum*. Therefore, there is an urgent need for integrated strategies that promote both utilization and conservation. Forest departments and local institutions should invest in training, certification programs, and participatory conservation approaches. Eco-labelling and Forest Stewardship Council (FSC) certification can help trace the origin of rhododendron products and ensure that they are harvested responsibly.

The future scope for *R. arboreum* is vast and multifaceted. Educational institutions and research organizations should collaborate with forest user groups and NGOs to implement pilot programs on sustainable harvesting, quality control, and fair trade practices. Policymakers must also recognize the contribution of *R. arboreum* to mountain livelihoods and include it in government schemes such as the National Medicinal Plants Board (NMPB), the National Mission on Himalayan Studies (NMHS), and eco-tourism initiatives.

In conclusion, *Rhododendron arboreum* is more than a flowering tree, it is a cultural icon, a nutritional powerhouse, and a livelihood resource. With the right blend of traditional knowledge, scientific innovation, and policy support, it can serve as a model species for sustainable development in Himalayan agroecosystems.

REFERENCES

Acharya, R. P. (2019). Does forest certification improve socio-economic and governance issues? A case of community forestry from Nepal. *Open Access Journal of Biomedical Science, 1*(1).

Basnett, S., Ganesan, R. and Devy, S. M. (2019). Floral traits determine pollinator visitation in *Rhododendron* species across an elevation gradient in the Sikkim Himalaya. *Alp. Bot., 129*, 81–94.

Bhattacharyya, D. and Sanjappa, M. (2008). Rhododendron habitats in India. *Journal of the American Rhododendron Society, 62*(1), 14–18.

Chandra, S., Singh, A., Mathew, J. R. and Singh, C. P. (2022). Phenocam observed flowering anomaly of *Rhododendron arboreum* Sm. in Himalaya: A climate change impact perspective. *Environmental Monitoring and Assessment, 194*(12).

Chauhan, D. S., Lal, P. and Singh, D. (2017). Composition, population structure and regeneration of *Rhododendron arboreum* Sm. temperate broad-leaved evergreen forest in Garhwal Himalaya, Uttarakhand, India. *Journal of Earth Science & Climatic Change, 8*(12).

Chauhan, D. S., Lal, P. and Shrama, A. K. (2021). Extraction of *Rhododendron arboreum* Smith flowers from the forest for the livelihood and rural income in Garhwal Himalaya, India. *Scientific Reports, 11*(1), 20844.

Devi, T. (2017). Ethnobotany plus nutritional, medicinal, economical potential and sustainable use of *Rhododendron arboreum* spp. arboreum in watershed Rissa-khad of Distt. Mandi, Himachal Pradesh, India. *IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS), 12*(3 Ver. II), 1–7.

Devi, S., Vats, C. K. and Dhaliwal, Y. S. (2018). Quality evaluation of *Rhododendron arboreum* flowers of different regions of Himachal Pradesh for standardization of juice extraction technique. *International Journal of Advances in Agricultural Science and Technology, 5*(1), 51–57.

Dhyani, P. P., Borgaonkar, H. P., Pant, G. B. and Sikder, A. B. (2023). A 694-year tree-ring based rainfall reconstruction from Himachal Pradesh, India. *The Holocene, 33*(1), 132–145.

Gaira, K. S., Rawal, R., Rawat, B. and Bhatt, I. D. (2014). Impact of climate change on the flowering of *Rhododendron arboreum* in Central Himalaya, India. *Current Science, 106*(12), 1735–1738.

Gautam, V., Sharma, A., Arora, S. and Bhardwaj, R. (2016). Bioactive compounds in the different extracts of flowers of *Rhododendron arboreum* Sm. *Journal of Chemical and Pharmaceutical Research, 8*, 439–444.

Gautam, V., Kohli, S. K., Arora, S., Bhardwaj, R., Kazi, M., Ahmad, A. and Ahmad, P. (2018). Antioxidant and antimutagenic activities of different fractions from the leaves of *Rhododendron arboreum* Sm. and their GC-MS profiling. *Molecules, 23*(9), 2239.

Hillsjester (2014). Juice/squash of Rhododendron flowers. Hillsjester. https://hillsjester.com/2013/04/29/juice-squash-of-rhododendron-flowers/

Innocenti, G., Dall'Acqua, S., Scialino, G., Banfi, E. and Sosa, S. (2010). Chemical composition and biological properties of *Rhododendron anthopogon* essential oil. *Molecules, 15*(4), 2326–2338.

Iqbal, K., Negi, A. K., & Bahuguna, H. N. B. (2017). Rhododendrons in Uttarakhand: diversity and conservation. *International Journal of Environment, 6*(1), 31–44.

Keshari, P. and Pradeep, P. S. (2017). Pharmacognostical and chromatographic evaluation of market sample of *Rhododendron arboreum* stem bark as a source plant for Rohitaka in Nepal. *Journal of Pharmacognosy and Phytochemistry, 6*(5), 296–306.

Krishna, H., Attri, B. L. and Kumar, A. (2014). Improvised Rhododendron squash: processing effects on antioxidant composition and organoleptic attributes. *Journal of Food Science and Technology, 51*(11), 3404–3410.

Kumar, P. and Srivastava, R. C. (2002). *Rhododendron arboreum* (Lali Gurans): cultural significance, market use, and role in traditional medicine. In *Topics in Agricultural and Biological Sciences*. Elsevier.

Maikhuri, R. K., Rao, K. S. and Saxena, K. G. (2004). Bioprospecting of wild edibles for rural development in the Central Himalayan Mountain of India. *Mountain Research and Development, 24*(2), 110–113.

Mamgain, H., Bhandari, A. and Sharma, V. P. (2017). Population assessment, mapping and flowering response of *Rhododendron arboreum* Sm. – a keystone species in Central Indian Himalayan region of Uttarakhand, India. *International Journal of Ecology & Environmental Sciences, 43*(2), 208–217.

Mao, A. A. (2010). The genus *Rhododendron* in north-east India. *Botanica Orientalis: Journal of Plant Science, 7*, 26–34.

Mehra, R., Kumar, H., Kumar, N. and Kaushik, R. (2020). Red rice conjugated with barley and *Rhododendron arboreum* extracts for a new variant of beer. *Journal of Food Science and Technology, 57*(11), 4152–4159.

Mehta, P. S., Negi, K. S. and Ojha, S. N. (2010). Native Plant Genetic Resources and Traditional Foods of Uttarakhand Himalaya for Sustainable Food Security and Livelihood. *Indian J. Nat. Prod. Resour., 1*(1), 89–96.

Nair, R. G., Sharma, V. and Dangwal, A. V. (2023). How rhododendrons are empowering people living in the remote reaches of Garhwal Himalayas. *Scroll.in*.

Nautiyal, S., Maikhuri, R. K. and Rao, K. S. (2001). Medicinal plant resources in Nanda Devi Biosphere Reserve in the Central Himalayas. *Journal of Herbs, Spices & Medicinal Plants, 8*(4), 47–64.

Negi, V. S., Maikhuri, R. K. and Rawat, L. S. (2011). Non-timber forest products (NTFPs): a viable option for biodiversity conservation and livelihood enhancement in Central Himalaya. *Biodiversity and Conservation, 20*(3), 545–559.

Nitika, R., Kumar, M. and Singh, A. (2021). Health benefits, utilization and characterization of *Rhododendron arboreum* (Ericaceae). *Journal of Pharmaceutical Research International, 33*(54B), 124–133.

Ollerton, J., Koju, N. P., Maharjan, S. R. and Bashyal, B. (2020). Interactions between birds and flowers of Rhododendron spp., and their implications for mountain communities in Nepal. *Plants, People, Planet*, *2*(4), 320-325.

Panda, S. and Kirtania, I. (2016). Variation in *Rhododendron arboreum* Sm. complex (Ericaceae): insights from exomorphology, leaf anatomy and pollen morphology. *Modern Phytomorphology, 9*, 27–49.

Paul, A., Khan, M. L., Das, A. K. and Dutta, P. K. (2010). Diversity and distribution of *Rhododendrons* in Arunachal Himalaya, India. *Journal of the American Rhododendron Society, 64*, 200–205.

Polunin, O. and Stainton, A. (1984). *Flowers of the Himalaya*. Oxford University Press.

Pradhan, U. C. and Lachungpa, S. T. (1990). *Sikkim Himalayan Rhododendrons*. Kalimpong, West Bengal: Primulaceae Books.

Prakash, D., Upadhyay, G., Singh, B. N., Dhakarey, R., Kumar, S. and Singh, K. K. (2007). Free-radical scavenging activities of Himalayan *Rhododendrons*. *Current Science, 92*(4), 526–532.

Rana, N., Manish, K. and Pandit, M. K. (2024). Effect of climate change on the flowering phenology of *Rhododendron arboreum* Sm. in the Western Himalaya. *Journal of Asia-Pacific Biodiversity, 18*(1).

Rawat, P., Rai, N., Kumar, N. and Waheed, S. M. (2020). *Rhododendron*: traditional vs modern, benefits for Himalayan communities. *Ecology, Environment and Conservation, 26* (October Suppl. Issue), 224–231.

Rawat, P., Rai, N., Kumar, N. and Bachheti, R. K. (2017). Review on *Rhododendron arboreum*—a magical tree. *Oriental Pharmacy and Experimental Medicine, 17*(4), 297–308.

Samant, S. S., Pant, S., Singh, M., Lal, M., Singh, A., Sharma, A. and Bhandari, S. (2007). Medicinal plants in Himachal Pradesh, northwestern Himalaya, India. *International Journal of Biodiversity Science and Management, 3*(4), 234–251.

Sekar, K. C. and Srivastava, S. K. (2010). Rhododendrons in Indian Himalayan region: diversity and conservation. *American Journal of Plant Sciences, 1*, 131–137.

Sharma, P. and Samant, S. S. (2014). Diversity, distribution and indigenous uses of medicinal plants in Parbati Valley of Kullu district in Himachal Pradesh, northwestern Himalaya. *Asian Journal of Advanced Basic Sciences, 2*(1), 77–98.

Sharma, N. and Kala, C. P. (2016). Utilization pattern, population density and supply chain of *Rhododendron arboreum* and *R. campanulatum* in the Dhauladhar Mountain Range of Himachal Pradesh, India. *Applied Ecology & Environmental Sciences, 4*(4), 102–107.

Shyaula, S. L., Choudhary, M. I., Musharraf, S. G., Joshi, B., Maharjan, R. and Ali, A. (2024). Identification of Anthocyanin, Flavonoids, Triterpenoids and Phosphatidylcholines from *Rhododendron arboreum* by Using LC-ESI-MS/MS Analysis. *Mass Spectrometry Letters, 15*(3), 141-148.

Singh, S. and Chatterjee, S. (2022). Value chain analysis of *Rhododendron arboreum* squash "buransh" as a non-timber forest product in Western Himalayas: case study of Chamoli District, Uttarakhand, India. *Trees, Forests and People, 7*, 100200.

Singh, K. K., Kumar, S., Rai, L. K. and Krishna, A. P. (2003). Rhododendron conservation in Sikkim Himalaya. *Current Science, 85*(5), 602–606.

Soetan, K. O., Olaiya, C. O. and Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants—a review. *African Journal of Food Science, 4*, 200–222.

Srivastava, P. (2012). *Rhododendron arboreum*: an overview. *Journal of Applied Pharmaceutical Science, 2*(2), 158–162.

Sukumaran, S. and Basnett, S. (2025). Ecosystem services provision by Rhododendron forests in the Sikkim Himalaya. *Naturalis Biodiversity Center*.

Swaroop, A., Gupta, A. P. and Sinha, A. K. (2005). Simultaneous determination of quercetin, rutin, and coumaric acid in flowers of *Rhododendron arboreum* using HPTLC. *Chromatographia, 62*, 649–652.

Tabassum, I. F., Udayan, P. S., Somashekar, R. K., Ved, D. K., & Mohammed, A. J. (2018). Prioritization of medicinal plants in sholas of Western Ghats: a case study. *Academia Journal of Medicinal Plants, 6*(1), 6–10.

Thakur, N. S., Aarti, Hamid, and Gautam, S. (2020). Utilization of edible *Rhododendron arboreum* flowers for development of a spiced beverage (appetizer) and its shelf life evaluation during storage. *International Research Journal of Pure and Applied Chemistry, 21*(7), 52–62.

Tiwari, J. K., Tiwari, S. and Prakash, A. (2010). Genus *Rhododendron* status in Sikkim Himalaya: an assessment. *Journal of the American Rhododendron Society, 59*(3), 131–137.

Uzma, Z., Farooq Khan, N., Ahmad Shah, M. and Reshi, Z. A. (2022). Cultural and socio-economic perspective of some promising edible plants from Uttarakhand Himalaya. In *Wild Edible Plants of Uttarakhand Himalaya* (Book Chapter).

Verma, K., Kumar, I. and Thakur, N. (2020). A complete review on *Rhododendron arboreum*: phytochemistry, pharmacological activities and future prospectives. *Human Journals, 19*(3).

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