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Provisioning Ecosystem Services of Rhododendron rich forests in Western Himalayas

Sanchi Singh [1], Sudipta Chatterjee *

[1] Department of Natural Resources, The TERI School of Advanced Studies New Delhi, Delhi 110070, India; sanchi1216@gmail.com
[2] The TERI School of Advanced Studies, Vasant Kunj, Institutional Area, New Delhi, Delhi 110070, India
* Correspondence: s.chatterjee@terisas.ac.in; Tel: +91 11 71800222
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Abstract: Himalayan forests are an important component of the global biodiversity and play a crucial role in maintaining the ecosystem balance. The genera of *Rhododendron* belongs to the Ericaceae family and are found at an altitudinal range of 1500m-3000m in the Himalayan region. It acts as an important keystone species in the Himalayan ecosystem with high ecological and medicinal value. The present study focuses on highlighting the provisioning ecosystem services offered by the *Rhododendron* species which provides a variety of services to the locals and its extraction for the commercial utilization provides many livelihood opportunities for the Himalayan native communities. However, due to the high demand for the Rhododendron products and services there has been a rampant harvest of the species in the Himalayan region posing a risk to the *Rhododendrons* which are an important keystone species for maintaining the Himalayan ecosystem. Hence our research lies in the assessment of the provisioning ecosystem services of the *Rhododendron* species and to provide various conservation strategies for its sustainable utilization in the Western Himalayas.

Keywords: Himalayas; Provisioning services; Rhododendrons; Sustainable use

1. Introduction

Himalayan region covers approximately 18% of the geographical area of the country, but accounts for more than 50% of India's forest cover and harbors 40% species endemic to the Indian subcontinent [1]. The rich plant diversity of the Indian Himalayas and its services are utilized by the native communities in various forms like edible food, fodder, fuel, timber, and for different medicinal purposes. These plants are utilized in various forms such as fruits, shoots, leaves, flowers, and tubers to provide various forest-based resources to the local communities [2]. The Western Himalayas, Uttarakhand region of India, having a total area of 53,484 Km^2out of which the total forest area is 38,000 Km^2 which comprises around 71.05 percent of the total providing various forest resources in the region [3]. *Rhododendron* species belonging from the Ericaceae family are found at an altitude of 1500m-3000m in the Himalayan region and provides a variety of ecosystem services to the communities. *Rhododendrons* are not only utilized for the local use but are also utilized for its commercial and economic benefits which acts as an important source of livelihood generation for the locals [4,5]. However, with the increase in the demand of the species for its various provisioning services there exists a risk on the valuable rhododendron forest resource. As *Rhododendrons* are an important keystone species in the Himalayan ecosystem, it is vital to maintain the forest health and vitality of the species as it plays a key role in maintaining the overall ecosystem balance [6]. Therefore,

our research lies in the assessment of the provisioning ecosystem services of Rhododendron rich forests in Western Himalayas for its sustainable use.

2. Material and Methods

2.1. Description of the Study Location

The present study is undertaken in the Uttarakhand region of Indian Western Himalayas which is located between 30°17′N-30°41′N latitude and 79°40′E-80°5′E longitude as shown in Figure 1. The entire region is divided into three agroecological zones; the lower elevation (<1000m asl); the middle elevation (between 1000m and 1800m asl), and the higher elevation (>1800m asl). The fragile landscapes of the Himalayan region are highly susceptible to anthropogenic pressures posing a risk for the natural hazards and the loss of biodiversity. In India's Western Himalayas, changes in altitude are intense and tends to produce a very specific pattern of vegetation types that include subtropical forests, alluvial grasslands, conifer mountain forests and alpine meadows [7]. The Uttarakhand state of Western Himalayas is of immense ecological importance due to its rich biodiversity and ecosystem services. Rhododendron rich forests are widespread in the region and are utilized for providing various provisioning services to the communities. The Western Himalaya has six *Rhododendron* species viz., *Rhododendron arboreum, R. anthopogon, R. barbatum, R. campanulatum, R. lepidotum* and *R. nivale.* which are present at different altitudinal range with the maximum rhododendron species being present at 1500-3000m altitudinal belt and the minimum at less than 1000m [8].

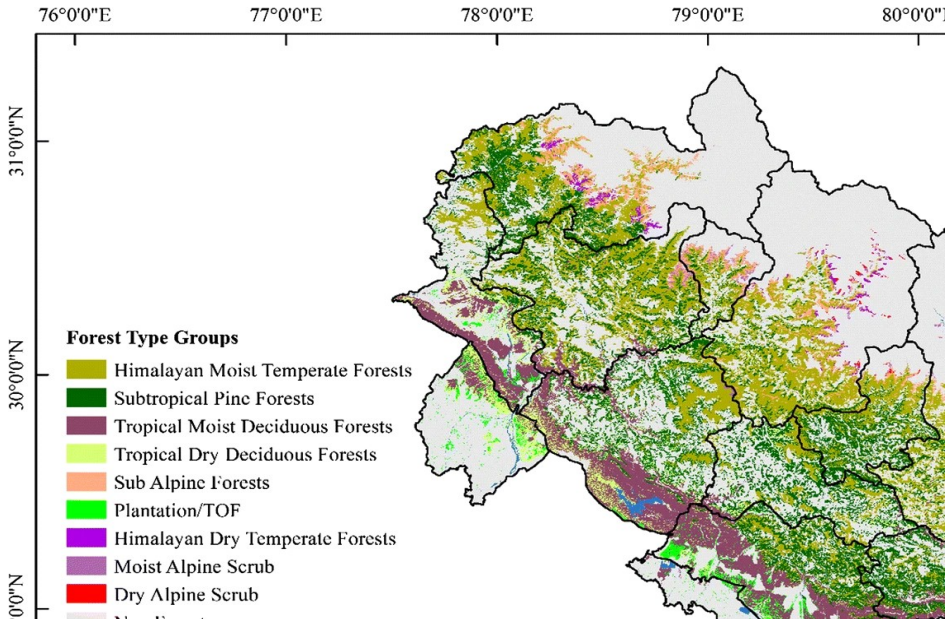

Figure 1. Map of Study location with forest type groups [9].

2.2. Survey Methods

For the data collection on the provisioning ecosystem services of the rhododendron rich forests, an ethnobotanical survey was carried out in the study region to collect the baseline information on the utilization of the *Rhododendron* species. Structured questionnaires and interviews were carried out among the local communities following the methods by [10]. The questionnaire survey covered the utilization pattern of rhododendron plant parts to provide the provisioning services for various local and medicinal use. Personnel interviews were also carried out from the collectors and local traders to collect information on the commercial market value of selected *Rhododendron* species like *R.arboreum* in the study area.

2.3. Ethnobotanical Index Used

The use-value (UV) index by [11,12] was used for analyzing the use value of *Rhododendron* species in Western Himalayas viz; *R.arboreum, R. anthopogon, R. barbatum, R. campanulatum, R. lepidotum* and *R. nivale.* The index helps in listing the relative importance of the *Rhododendron* species w.r.t the utilization of the provisioning services offered by each of the species in the study location.

3. Results

Based on the observations from the data collection *Rhododendron* species provides a variety of provisioning services to the communities ranging from medicinal services, beverages, food supplements, fuelwood to various other local and cultural usages. The flowers of *R. arboreum* are edible and are used for making of the local brew, rhododendron squash which is widely utilized by the local communities for generating livelihood. For medicinal services, *R.arboreum* and *R.campanulatum* is utilized medicinally for the treatment of diarrhea, blood dysentery, nasal bleeding and for preventing high altitude sickness and headache. The wood of *R.anthopogon* and *R.campanulatum* are utilized for the fuelwood and *R. lepidotum* in the traditional medicine system. The parts of the *Rhododendron* species utilized for providing different provisioning services to the communities are listed in Table 1. and the category usage of *Rhododendrons* in the study area as shown in Figure 2.

Table 1. List of provisioning services by *Rhododendron* species in the study area.

Species	Part Used	List of Provisioning Services
R.arboreum	Flowers (dry)	• Diarrhea • Blood dysentery
R.arboreum	Flowers(fresh)	• Preparation of Rhododendron juice/squash • Appetizers , jams and jellies • Prevent high altitude sickness • Headache (paste) • Nasal bleeding • Local tea • Local use and religious purpose
R.campanulatum	Bark	• Medicinal use in Jaundice, piles, liver disorder and worms
R.campanulatum *R.anthopogon*	Stem/Wood	• Fuel wood • Agricultural implements
R.barbatum *R.anthopogon*	Leaves	• Prevent headache • Resting Bed for animals
R. lepidotum	Corolla	• To get rid of the fish bones struck in the gullet used in Homeopathic medicinal system

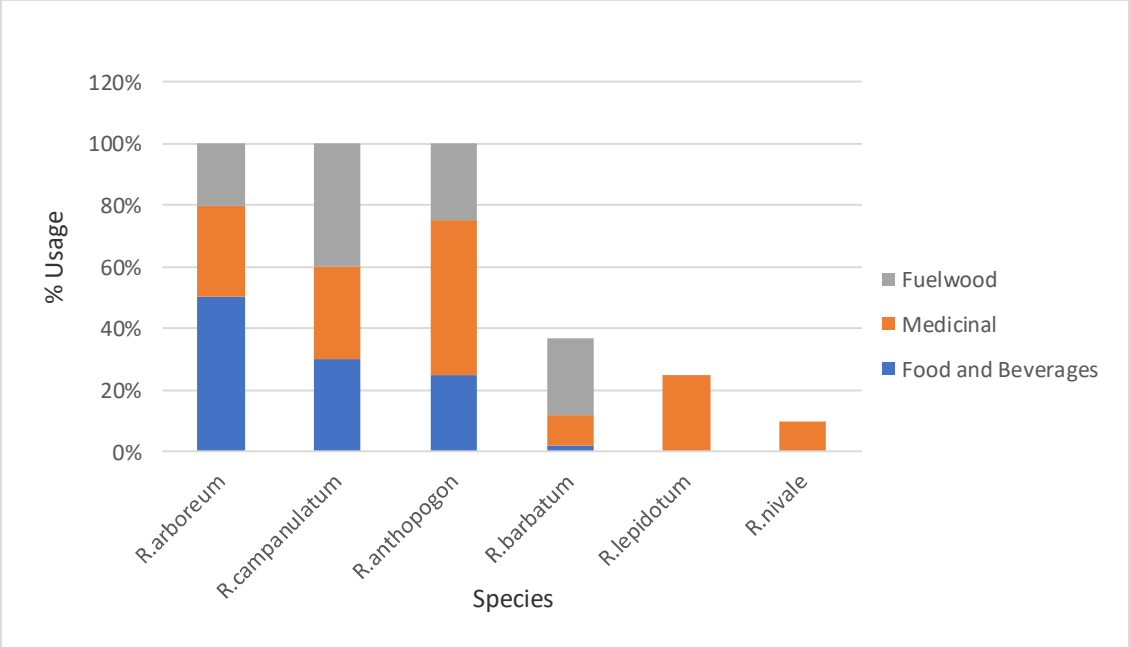

Figure 2. Use categories of *Rhododendron* species in the study area.

The use-value (UV) index was calculated for the *Rhododendron* species in the study area viz; *R.arboreum, R. anthopogon, R. barbatum, R. campanulatum, R. lepidotum* and *R. nivale* listed in Table 2. Based on the utilization of the provisioning services offered by each of the species *R.arboreum* covers the highest UV index as it is widely used in all the categories of the provisioning services such as for fuelwood, medicinal and food industries at both local and commercial level where as *R. nivale* covers the lowest with its limited usage for the medicinal purposes in the study location.

Table 2. Use- Index Values for *Rhododendron* species in study area.

Species	Use -Value Index
R.arboreum	0.81
R. campanulatum	0.54
R. anthopogon	0.45
R. barbatum	027
R. lepidotum	0.22
R. nivale	0.09

4. Discussion

The study highlights that *Rhododendron* species provides a variety of provisioning ecosystem services to the locals which is utilized both domestically and commercially in the study location. These provisioning services are discussed below.

4.1. Fuel wood

Native people of the Himalayan community collect the dry tree logs and branches from the forests for cooking food and heating purposes and the bark of *R.arboreum* and *R.campanulatum* which are found at high altitudes of the Himalayan region are widely utilized by the locals for the fuelwood purpose. It has also been reported that rhododendron fuelwood has the quality and efficiency to burn even under raw conditions due to the presence of poly-flavonoids and other resinous substances [13, 14, 15].

4.2. Food and Beverages

The flowers of *Rhododendron arboreum* are used in the making of *Rhododendron* juice/squash locally called as 'buransh' which possess high medicinal properties. The ethyl acetate fraction of *R. arboreum* flowers is found to reduce magnesium sulfate-induced diarrhoea which could be due to increased absorption of water and electrolytes [16]. It also possess high anti-inflammatory properties which are a result of the presence of flavonoids, tannins, saponins and other phytochemicals present in the flower extract [17]. These flavonoids isolated from the *R. arboreum* were found to have high antioxidant properties [18]. The other food and beverages from these *Rhododendrons* are utilized in the preparation of jams, jellies, appetizers and local brew. These products also offers a wide commercial market in the study area that aids to provide various economic benefits to the local communities.

4.3. Medicinal

The *Rhododendron* species contains several chemical constituents which are used for various medicinal purpose. Similar studies on the medicinal uses of rhododendrons are also reported from the other parts of the Himalayas such as by [15,19,20,21]. From our study on the provisioning services of the rhododendron forests in Western Himalayas it has been found that the fresh flowers of *R.arboreum* are used as medicine in the treatment of hill diarrhoea, dysentery and curing of the high-altitude sickness. Bark of *R. arboreum* is used by traditional practitioners in the study area to cure jaundice, piles and liver disorders. Other important uses of bark of *R.arboreum* and *R. campanulatum* are for the treatment of cough and diabetes. Leaves of *R.campanulatum* are used in treating of chronic rheumatism, syphilis and sciatica where as others like *R.anthopogon* are used in the treatment of cold, cough and chronic bronchitis.

4. Conclusion

The *Rhododendrons* in Western Himalayas provides a range of provisioning services to the communities and is being utilized for its various medicinal and economic benefits. As *Rhododendrons* are an important species for the Himalayan ecosystem it is vital to raise community awareness and engage the locals at the community level for maintaining the overall health of the Rhododendron forests. Some of the conservation methods and management strategies for the sustainable utilization of the *Rhododendron* species from the forests are suggested as follows:

- Effective engagement of the '*van samitis'* or the community forest groups which play a key role in the management of the forests in the study area.
- Encouraging the plantations of the locally grown, adaptable and associative species like *Quercus* species which is found to increase the water holding capacity of soil, thus promoting the establishment of *Rhododendron* species [22].
- Plantation programmes and trainings for raising the awareness of the native Himalayan communities.
- Engagement of the forest government officials for implementing strong policies and practices for the conservation of the *Rhododendron* species for its sustainable harvest.

Conflicts of Interest: The authors declare no conflict of interest.

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