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# Utilization Pattern, Population Density and Supply Chain of *Rhododendron arboreum* and *Rhododendron campanulatum* in the Dhauladhar Mountain Range of Himachal Pradesh, India

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**Abstract** Among various natural forest products rhododendrons in the Himalayan region are regarded as one of the most important products in terms of consumption and high exchange values. Himachal Pradesh in India endows with many species of rhododendron, of which *Rhododendron arboreum* (Brash phool) and *Rhododendron campanulatum* (Kashmiri Patta) are studied in the Kangra district, which falls in Dhauladhar mountain range of the Indian Himalaya. The utilisation of *R. arboreum* flower as medicine, food supplements and cultural purpose is designated through Use Value Index (UVI). *R. campanulatum* is primarily used by temporary settlers for fuel wood or for making sheds to animals in the high reaches of the Himalaya because of its presence in this area, which is mainly deprived of other woody species. The population density of *R. arboreum* was 344.70±0.009 individuals/ha and the IVI was 241.05. *R. campanulatum* was found in much higher regions with the density of 120.95±0.007 per ha and the IVI 58.94. With respect to the distance from the road the average price of fresh and dry *R. arboreum* flowers varied. The market value chain of the raw material is complex. It is important to implement sustainable value chains for the management and conservation along with sustainable utilisation of rhododendrons in the study area.

***Keywords:*** *rhododendron, indigenous uses, marketing, population density, management, himachal pradesh*

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## 1. Introduction

Natural forest products, including medicinal and aromatics plants (MAPs) and food supplements, play a significant role in people's livelihoods living in rural areas. In India, about 275 million rural populations depend on natural products for their subsistence and livelihood [1]. Traditionally, the local natural products were consumed by locals in and around the community but with the rapid demand of these natural products, the magnitude has widened to not only regional but national as well as international markets [2]. The contribution of the Himalayan mountain system is significant in providing a range of natural products, of which many species of rhododendrons are regarded as the important products in terms of consumptive and high exchange values [3].

The Indian Himalayan region is a treasure trove of rhododendron species as it harbours about 87 species and 12 subspecies of rhododendrons, out of which 6 species and one sub species belong to western Himalayan region [4]. The Indian state of Himachal Pradesh is known to have some of the highly economic rhododendron species such as *Rhododendron arboreum* (Brash phool), *Rhododendron campanulatum* (Kashmiri Patta), *Rhododendron anthopogon* (Talispatra) and *Rhododendron lepidotum* (Kashmiri Patta). R. *arboreum* is considered as one of the high value species with its ecological as well as economical significance. It is one of the major sources of livelihood for the rural population in Himachal Pradesh. Based on the Forest Statistical Report, about 238 quintals of rhododendron flowers have been exported from the Himachal Pradesh [5], which has increased to about 240 Quintals in 2013-14 [6].

The increasing demand of rhododendrons by various food processing units has invited a massive trade of rhododendrons in and out of Himachal Pradesh. The collection of rhododendron flowers for preparation of chutneys and jams now is not merely a local approach but expanded as one of the highly economical natural produce. The local people are hired for collection of flowers by the owners of different small scale and processing units and there is an increasing trend. Scaling the increase in collection of flower and number of collector, their may be pressure on the rhododendron species in nature. Therefore,

there is an urgent need to monitor the ecological as well as economic value of rhododendron species. Besides, it is important to measure the potential utilisation as well as marketing of various species of rhododendrons in the region. Keeping in view, two high valued species of rhododendron i.e., R. *arboreum* (Brash phool) and R. *campanulatum* (Kashmiri Patta) were studied for understanding the pattern in their utilization, population density, diversity, and market value chains.

# 2. Methodology

## 2.1. Study Area

The present study was conducted in the Kangra district of Himachal Pradesh, India, situated on the southern escarpment of Dhauladhar mountain range which extends to the bank of the Beas River in the Kullu district of Himachal Pradesh between 31°2 to 32°5 N and 75° to 77°45 E . The area is surrounded by Lahaul-Spiti to the north, in south by Hamirpur and Una, in east by Mandi and in west by Jammu and Kashmir and Punjab. Kangra district spans over an area of 5063 sq km within the altitudinal gradient from 427 to 6401 m above sea level (amsl). The annual average rainfall in this region accounts for about 1539 mm [6]. The annual average maximum temperature of the district is 35˚C in the southern part and 25ºC in the northern part. Kangra district is one of the most populated districts as it has 1,507,223 populations, which is the highest in the state (21.98% of the population). The rural population accounts 94.27% whereas the urban population is about 5.73% [7]. The area constitutes nomadic tribe (Gaddis) and the pahari folks. Along with the altitude the soil of the region varies from loamy to sandy soil. Maximum percentage of medium to deep loamy soil in found in this area. The area is rich in flora and fauna, with distinct forest types particularly subtropical forest between 1000-1500m, moist temperate forest (both broad and coniferous) between 1500-3300m, subalpine and alpine forest >3300m [8].

## 2.2. Survey Methods

The ethnobotanical survey was carried out along the Dhauladhar mountain range located in Kangra district. Randomly selected villages were surveyed for collection of information on utilisation of R. *arboreum* (Brash phool) and R. *campanulatum* (Kashmiri Patta). About 253 informants distributed over different villages were interviewed. These include both permanent (residence of the place) and temporary settlers (shepherds). Structured questionnaires and interviews were carried out among the locals, following [9,10]. The questionnaire survey covered utilisation pattern of plant parts and consumption (domestic/commercial) in the particular harvesting season. Personnel interviews from the collectors, local traders and small entrepreneurs were carried exclusively to gather information to know the commercial market value of selected rhododendron species in the region. The region was divided into three major classes based on road proximity i.e. <5kms, 5-10kms and >10kms distance from the road for commercial uses.

To study the natural population density and diversity of R. *arboreum* and *R. Campanulatum* to forest areas were surveyed in the study area from March 2013 to December 2015. Quadrats were laid across the selected village forest along the altitudinal gradient. The quadrats were laid at interval of 200m. The quadrat size used for sampling standing trees was 10×10m and for assessing tree saplings it was 5×5m. R. *arboreum* and *R. campanulatum* number in each quadrat were recorded. The circumference at breast height (CBH) was measured using a meter tape. From the GPS, the quadrat points were recorded for the analysis.

## 2.3. Analytical Methods

The use-value (UV) index was prepared to calculate the citation of plants during interviews [11]. It is calculated as follows:

$$UV = \frac{\Sigma Uis}{ns}$$

Where, *Uis* is the sum of the total number of use citations by all informants for a given species divided by the total number of informants (ns).

For the rhododendron distribution the relative density, relative frequency and relative dominance was estimated, and the importance value index (IVI) was calculated [12,13]. Species Diversity was calculated using Simpson's index (D).

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

Where, N = the total number of organisms of all species and n = the total number of organisms of a particular species. Simpson's Diversity Index = 1 – D.

The distribution of species was displayed digitally using Arc GIS 10.3.1. The significant differences among the various parameters like price, quantity of species commercially used, at 95% confidence level were analysed using SPSS Statistic 20.0.

# 3. Results

## 3.1. Utilisation Pattern

R. *arboreum* (Brash phool) and R. *campanulatum* (Kashmiri Patta) are used by both permanent and temporary settlers in the study area. As per the information collected from the informants R. *campanulatum* is primarily used by temporary settlers as fuel wood and making shed to animals as it occurs in high altitude area having scarcity of tree and shrub species. Its leaves in some places are collected and brought to the local traders. On the other hand, R. *arboreum* is considered as one of the highly economic plant species and is used indigenously by the locals for medicinal, food supplement and cultural purposes. The flowers of R. *arboreum* are edible and are used for making chutneys, jams and squashes. Among the locals the most cited use of R. *arboreum* is as medicine for the treatment of diarrhoea, blood dysentery, nasal bleeding, preventing high altitude sickness and headache.

The paste made from the flowers is applied on the head for curing headaches.

The use value index for various plant part of R. *arboreum* as used for domestic purpose include preparation of squash, jams and chutneys is 0.91. The flowers, whether fresh or dried, are used to make chutney at homes which serves as a good appetizer (0.61). Ornamentally, the flowers are used for decorating houses and temples (0.78). Also, *R. arboreum* flowers are considered to have spiritual value so are specifically used in festivals and temples (0.78). Other uses with reference to part used are mentioned in the Table 1.

**Table 1. Indigenous uses of R. *arboreum* and R. *campanulatum* by the local people of Kangra district of Himachal Pradesh**

| Species | Plant parts | Uses | Informants | Use value index |
|---|---|---|---|---|
| R. *arboreum* | Flowers (dry) | • Diarrhoea | 90 | 0.75 |
| | | • Blood dysentery | 90 | 0.75 |
| R. *arboreum* | Flowers(fresh) | • Preparation of squash, jams and jellies | 110 | 0.91 |
| | | • Local brew | 75 | 0.63 |
| | | • Appetizer | 81 | 0.67 |
| | | • Prevent high altitude sickness | 77 | 0.64 |
| | | • Headache (paste) | 84 | 0.70 |
| | | • Nasal bleeding | 93 | 0.78 |
| | | • Religious purpose | 93 | 0.78 |
| | | • Decorations | 81 | 0.67 |
| R. *arboreum* | Bark | • Prevent Jaundice, piles, liver disorder and worms. | 25 | 0.21 |
| R. *arboreum*<br>*R. campanulatum* | Stem/wood | • Fuel wood | 110 | 0.90 |
| | | • Agricultural implements | 97 | 0.72 |
| | | • Fuel wood by temporary settler | 82 | 0.68 |
| R. *arboreum*<br>*R. campanulatum* | Leaves | • Prevent headache | 62 | 0.43 |
| | | • Resting Bed for animals | 81 | 0.67 |
| R. *arboreum* | Corolla | • To get rid of the fish bones struck in the gullet used in Tibetan medicinal system. | 21 | 0.17 |

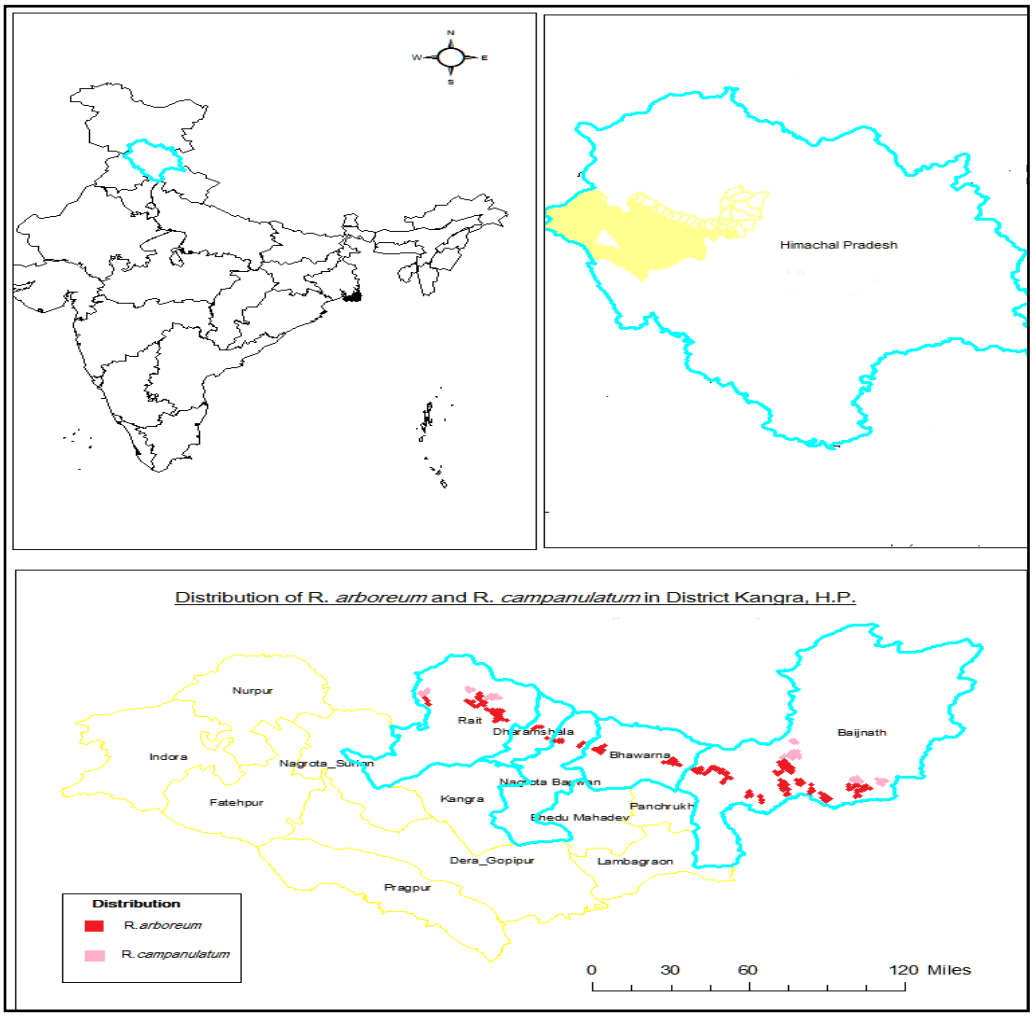


**Figure 1.** Map showing distribution of *R. arboreum* and *R. campanulatum* in the Kangra district of Himachal Pradesh

**Table 2. Density, frequency, abundance and IVI of R. *arboreum* and R. *campanulatum* in the Kangra district of Himachal Pradesh**

| Plant name | Density/ha | Frequency | Abundance | IVI | n-1 | n (n-1) |
|---|---|---|---|---|---|---|
| *R. arboreum* | 344.70±0.009 | 77.65 | 4.43 | 241.05 | 909 | 828100 |
| *R. campanulatum* | 120.95±0.007 | 67.61 | 1.78 | 58.94 | 126 | 16002 |

## 3.2. Distribution Pattern

R. *arboreum* and R. *campanulatum* are mainly found in the moist temperate forest area (2200-3200m) and sub alpine region (>3200m) (Figure 1). R. *arboreum* is widely distributed across the temperate region and is associated with *Quercus semecarpifolia* primarily. The other associated species include *Taxus waliichiana, Picea* sp., *Princepia utilis, Abies pindrow,* V*aleriana* sp., *Indigofera sp.* and *Quercus leucotrichophora*. R. *arboreum* has a density/ha of about 344.70±0.009 with the IVI 241.05. R. *campanulatum* is found in much higher regions with the density of 120.95±0.007 per ha and the IVI 58.94 (Table 2).

## 3.3. Commercial Consumption

In addition to the domestic consumption, R. *arboreum* flowers have a well established local market. The locals derive a substantial part of the income through its trade. In Kangra district, R. *arboreum* flower trade has increased since last decade due to establishment of local market, increase in number of trader and small entrepreneurs. Since R. *campanulatum* is found in higher reaches a very few collectors collect its parts. On demand, only leaves are collected by the collectors for commercial purpose. The average cost of the R. *arboreum* flowers in Kangra district is estimated to about 36.9 Indian Rupees (INR) per kilogram (fresh flowers) and 55.33 INR per kilogram for dried flowers, whereas R. *campanulatum* leaves are sold at 30.28 INR per kilogram. With respect to the distance from the road the average price of fresh and dry *R. arboreum* flowers per kg in <5 km are 35±5.4 and 50±13.2; 5-10 km INR 35.6±10.8 and 54±10.3; >10km INR 43.1±10.2 and 62±5.8 (Table 3).

The price and quantity for the export of plant part was calculated based on the data collected by the identified agents at different locations. Based on road proximity, the price and quantity of R. *arboreum* flowers (Dried) is <5km, INR 3000 and 77.9 quintal; 5-10 km, INR 5267.5 and 83.78 quintal; >10km, INR 5250 and 88.79 quintal annually (Table 4).

## 3.4. Value Chain

The value chain of both rhododendron species has been identified and formulated through flowchart (Figure 2). The commercial trade involves various parties in the market value chain system starting from villagers at local level who collect flowers from the forest or domestic farms. Other than the villagers, small entrepreneurs/industries established in the district or nearby place, who have owned labour to collect the flower and directly use the flowers for making juices or ayurvedic medicines. The collected flowers by the villagers are either directly put on the local market places or local vendors/shopkeepers. The flowers are also sold to the local agent who collects from different sources and trade the product to the nodal agent/trader or the small entrepreneurs resulting in the uneven structure of the value chain. Similarly, the leaves of R. *campanulatum* are also collected by locals and supplied to local agent. The nodal agents advertise the raw material at herbal mandis, which is a market place for large number of companies including pharmaceuticals and food processing units where juices, jams, chutneys, squash and herbal medicines are prepared and sold in markets.

**Table 3. Average price (in INR) of the fresh and dried R. *arboreum* flowers and R. *campanulatum* leaves in the Kangra district of Himachal Pradesh**

| Distance (km) | Average Price of fresh R. *arboreum* flowers per kilogram | Average Price of dry R. *arboreum* flowers per kilogram | Average Price of R. *campanulatum* leaves per kilogram |
|---|---|---|---|
| **<5 km** | 35 ± 5.4* | 50 ± 13.2 | - |
| **5-10 km** | 35.6 ± 10.8* | 54 ± 10.3* | - |
| **>10 km** | 43.1 ± 10.2* | 62 ± 5.8 | 30.28±5.91* |
| **Overall** | 36.23 ± 6.27 | 52.38 ± 7.29 | 59.26 |

Based on observed mean *significance, α=0.05.

**Table 4. Average export per year (Quintal) and price of R. *arboreum* flowers per quintal in the Kangra district of Himachal Pradesh**

| Distance from highway | Village | Nodal agents | Average Export Price per quintal | Average Export per year (Quintal) |
|---|---|---|---|---|
| <5km | Maderh | 3 | 3500 | 75.48 ± 12.87 |
| | Naddi | 2 | 2500 | 80.32 ± 12.43* |
| 5-10km | Bir Khas | 6 | 5335 | 83.24 ± 29.88* |
| | Deol Khas | 6 | 5200 | 84.32 ± 21.31 |
| >10km | Multhan | 7 | 5400 | 90.32 ± 13.61* |
| | Salli | 5 | 5100 | 87.26 ± 22.71* |

Based on observed mean *significance, α=0.05.

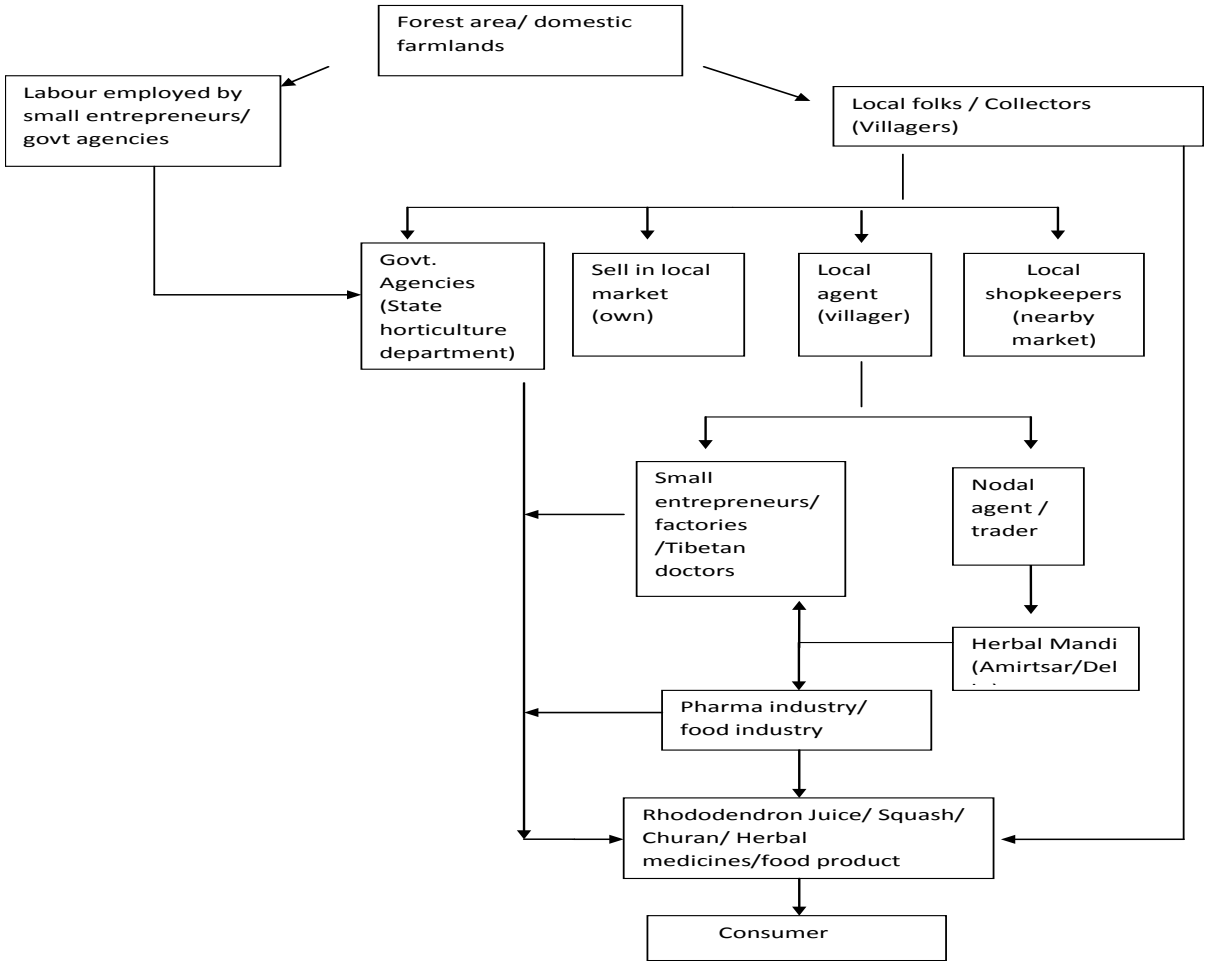


**Figure 2.** Representation of various actors in the supply chain of *R. arboreum* and *R. campanulatum* in the Kangra district of Himachal Pradesh

## 4. Discussion

The findings of this study reveal that both species of rhododendron viz., R. *arboreum* and R. *campanulatum* have a potential for increasing the cash economies and market at local as well as national and international levels. The peer pressure on the species is observed, the use of wood as fuel. At the higher altitudes, the period from June till November is considered as the arrival of many temporary settlers along with thousands of livestock. As per the information given by informants during this period R. *campanulatum* wood is consumed for cooking and heating purposes. A mesh is made out of twigs and leaves for preparing resting place for the household livestock. Other than this a study reveals the use of R. *campanulatum* wood for drying the medicinal plants harvested from wild [14] in the same area.

The local people of Kangra have discovered number of indigenous uses of R. *arboreum* i.e. medicinal, food supplement as well as ornamental purposes. There are many other similar reports on the medicinal uses of R. *arboreum* from other parts of the Himalaya, especially for the treatment of diarrhoea and blood dysentery [15], prevent high altitude sickness [16], and to remove fish bones struck in the gullet [17]. Bark of R. *arboreum* is used by traditional healers in the study area to cure jaundice, piles and liver disorders. Other important uses of bark for treatment of cough and diabetes are mentioned by [16].With the advent of Tibetan medicine system in the region, the amchis or the practitioners of Tibetan medicine system use leaf extract to prevent headache caused by high altitude sickness. The leaves are used for gout and rheumatism in other parts of the Himalaya [18].Wood is used for multiple purposes such as making agricultural implements, box and handles [16]. The locals use wood primarily as fuel or making local agriculture tools. The branches are easily cut and are stored extensively. The wood used as fuel for cooking, heating water and keeping the houses warm in the region in winter season.

R. *arboreum* is commercially established species which has suitable market position regionally and nationally. There is a well established market value chain system for flow of raw material with several participants or actors across the region. The inhabitants harvesting flowers from far place i.e. >5kms from the road proximity tend to sell at high rate as compared to the near ones. With the establishment of manufacturing units in the district, the villagers are replaced by other factory employee making the chain more complex. With the initiation of flowering season, they start collecting flowers with consecutive visits across the region leading to the high pressure among the locals. Similar observations are explained by Kop and Alam in 2006 [19]. According to them, the challenges faced relates to five areas i.e. market information, capital and skills, volume, quality, and consistency of supply. To reduce the pressure, studies suggest industry-community partnership approach [19] and public-private partnership approach [20].

Other than this MAPs market chains have been studied by number of researchers [5,19,21-26] reflecting primary collector and consumer relationships and suggests collaboration among locals, research organizations and manufacturing units for the development of sustainable value chain for high economic species including R. *arboreum* and R. *campanulatum*. Other than this, the conservation of these two species is important to reduce the loss either ways. Community forestry groups or the van-samitis play a crucial role in the study area; they have undertaken conservation methods like the cutting of rhododendron species from a specific area yearly on rotational bases. The same method is followed for the private forests in the area. With this process there is less damage to the tree species [27]. Plantation programmes and training and awareness programmes for the conservation of these two species are other methods which are commenced by the van-samitis and the forest department in the area.

## 5. Conclusions

R. *campanulatum* and R. *arboreum* are used for indigenous use as well for commercial purpose, which eventually create peer pressure on the species density in its natural habitats. The indigenous uses of R. *arboreum* as medicines and food supplements formulate the traditional practices being passed from one generation to the other, further preserving the knowledge. R. *campanulatum* which is used at an indiscriminate amount by temporary settlers in the high altitude areas can result in its low density in the coming time. The involvement of many actors in the value chain is harnessing the basic assets. Therefore, it is important to monitor each phase of value chain and educate the locals about the same. Consequently, the management and conservation along with sustainable utilisation of these species is very significant.

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