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ORIGINAL ARTICLE

Quantitative ethnobotanical assessment of woody species in a representative watershed of west Himalaya, India

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Abstract The study attempts quantitative assessment of the use value of traditionally used woody species in a representative mid-Himalayan watershed of west Himalaya. Ethnobotanical surveys were conducted in the fringe villages of altitudinally diverse forested area of the watershed covering different age group respondents. A total of 34 woody species (27 trees and 7 shrubs) belonging to 25 families were identified as useful in the watershed, and their availability varied considerably across the altitudes. The relative frequency citation and use value for each identified species were analysed. Further, vegetation surveys were conducted in nearby forests to assess the availability of identified useful species. Outcomes of this study can be used to develop an effective augmentation plan for the community forests within the watershed and other Himalayan forests.

Keywords Use value · Woody species · Species availability · Conservation implications

1 Introduction

The term ethnobotany explains the comprehensive relationship between people and plants, and also explores the extent of traditional botanical knowledge of local people and use of this knowledge to exploit plants for a variety of purposes (Amjad and Arshad 2014; Arshad et al. 2014). This type of knowledge remains accessible and reliable source of information on vegetation dynamics, which provides valuable information about the species, and forms basis for the local resource management (Wezel and Lykke 2006). Ethnobotany is gaining most research interests worldwide on natural resource management, and its role in the conservation of biological diversity is well recognized by the Convention on Biological Diversity (Sop et al. 2012).

Indian Himalaya region (IHR), which forms large part of globally recognized Himalayan Biodiversity Hotspot, is well known for its goods and services that sustain millions of people within the region and much beyond its physical boundaries (Rawal et al. 2013). The estimated conservation value of ecosystem service of Himalayan forests is \$1150 ha^{-1} $year^{-1}$ (Singh 2007) and the IHR contributes significantly to this. The IHR holds over 1748 plant species of medicinal value (Samant et al. 1998), 675 species of wild edible plants (Samant and Dhar 1997), 279 fodder species (Samant 1998), 155 religious plants (Samant and Pant 2003), 119 fibre-yielding plants and 118 species with essential oil-yielding properties. A recent study has reported 490 tree species used for various purposes, i.e. edible: 53, fodder: 100, fuel: 62, medicinal: 34, miscellaneous: 167, ornamental/avenue purpose: 35, resin: 18, sacred: 8, timber: 22 in the western part of IHR (Bhatt et al. 2016).

The rural inhabitants in the region are heavily dependent on forest resources for their daily needs such as firewood, fodder, fibre, agriculture tools and medicine (Samant and Dhar 1997). Most of these information on use potential of plants are qualitatively described following the traditional knowledge of inhabitants. However, only a few studies in IHR have considered quantitative use value (Kala et al. 2004; Ahmed et al. 2016; Negi et al. 2017) of forest resources in the IHR. As a result, most of the management prescriptions remain subjective in nature.

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Recent researches have used some well-defined methods and systematic tools to guide conservation priority based on quantitative ethnobotanical approaches (Pandey et al. 2018; Albuquerque et al. 2009; Oliveira et al. 2007; Aldieri and Vinci 2017; Hájek and Stejskal 2018) mostly using an approach adapted from Oliveira et al. (2007) through construction of a local conservation priority index that combines a citation richness (number of use categories given to species), a degree of attention (frequency of occurred species) and a relative density of the species in the considered area.

Most of studies (van Andel et al. 2015; Yaoitcha et al. 2015; Bhattarai and Acharya 2015; Albuquerque et al. 2011; Oliveira et al. 2007; Bisht et al. 2006; Kala et al. 2004; Dhar et al. 2000; Janni and Bastien 2000) have prioritized plant species for conservation through ethnobotanical data by different approaches. Nevertheless, these studies have unheeded non-medicinal uses of woody species (i.e. construction, energy, technology, food) which are often the most significant threats for the species.

Realizing this knowledge gap, the present study attempts to quantitatively asses: (1) preferred woody species of inhabitants, (2) quantum of availability and use value of such species and (3) species requiring special conservation attention in a representative watershed of Uttarakhand (west Himalaya). The outcomes of this study can be effectively used to develop an augmentation plan for the community forests in the watershed and comparable areas elsewhere in west Himalaya.

2 Materials and methods

2.1 Study area

Study was carried out in a representative watershed (i.e. Hat Kalika, District Pithoragarh, Uttarakhand) of mid-Himalayan zone in west Himalaya. This watershed has an area of approximately 37 km^2 and located between (latitude 29°39″22.99′N and longitude 80°03″38.93′E), with a wide altitude range (600–2100 masl). It is rich in biophysical and socio-cultural diversity and forms an intensive study site for Kailash Sacred Landscape. A total of 45 villages are located in the watershed with a population of 13,465 persons (Census 2011). The forests in the watershed range from subtropical sal (*Shorea robusta*) forest to temperate banjh oak (*Quercus leucotrichophora*) forest with several intermixing categories. Also, traditional agroforestry system is prominent in the watershed. As per the land-cover assessment, nearly 54.5% (20.59 km^2) area is under forest, of which banjh oak (*Q. leucotrichophora*) covers 38.4%, chir pine (*Pinus roxburghii*) 56.7% and sal (*S. robusta*) 3.3% area (Fig. 1). The inhabitants in the watershed are traditionally dependent on diverse type of resources drawn from the forests and neighbouring agroforestry systems. As a result, a rich knowledge base on use and protection of plant resources exists in the study area.

2.2 Ethnobotanical investigations

2.2.1 Data collection

Following a reconnaissance of the entire watershed, a total of nine villages (three in each altitude) surrounding the forest were selected for the ethnobotanical survey according to their nearness to the forest. More details of selected villages are given in Table 1. Villagers were interviewed about useful species of the area. The species mentioned by villagers were documented, and specimens were collected for scientific identification. Identification was done with the help of herbarium records, photographs and related research papers (Pangtey et al. 1988; Purohit and Samant 1995).

The quantification of use values was conducted during the years 2015 and 2016 with the help of villagers. Personal interviews with 30 randomly selected respondents in each altitude zone were conducted. The informants were randomly chosen across different age groups (i.e. 20–35, 36–45 and 46–60 and > 60 years). The number of respondents in each age group, across the watershed, is depicted in Fig. 2. Each of the respondents was shown the specimen/photograph of the plant and asked to answer: (1) whether he/she knows any use of that plant species and (2). If yes, how many uses of that species he/she knows.

2.3 Data analysis

The data collected were analysed using quantitative value analysis [i.e. relative frequency citation (RFC), use value (UV)] that include most commonly used indices in quantitative ethnobotanical investigations.

1. Relative frequency citation (RFC)

This indicates the locally realized significance of a species. The RFC is analysed using the formula:

$$\boldsymbol{RFC} = \frac{\boldsymbol{FC}}{\boldsymbol{n}} \tag{1}$$

where 'FC' is the number of informants mentioning the use of given species and 'n' represents total number of informants participating in the survey. RFC value varies from 0 to 1, 0 RFC reflects that the respondents have not realized any use of the plant and 1 RFC exhibits that the plant is recognized as useful by all the respondents (Tardio and Pardo-de-Santayana 2008; Vitalini et al. 2013).

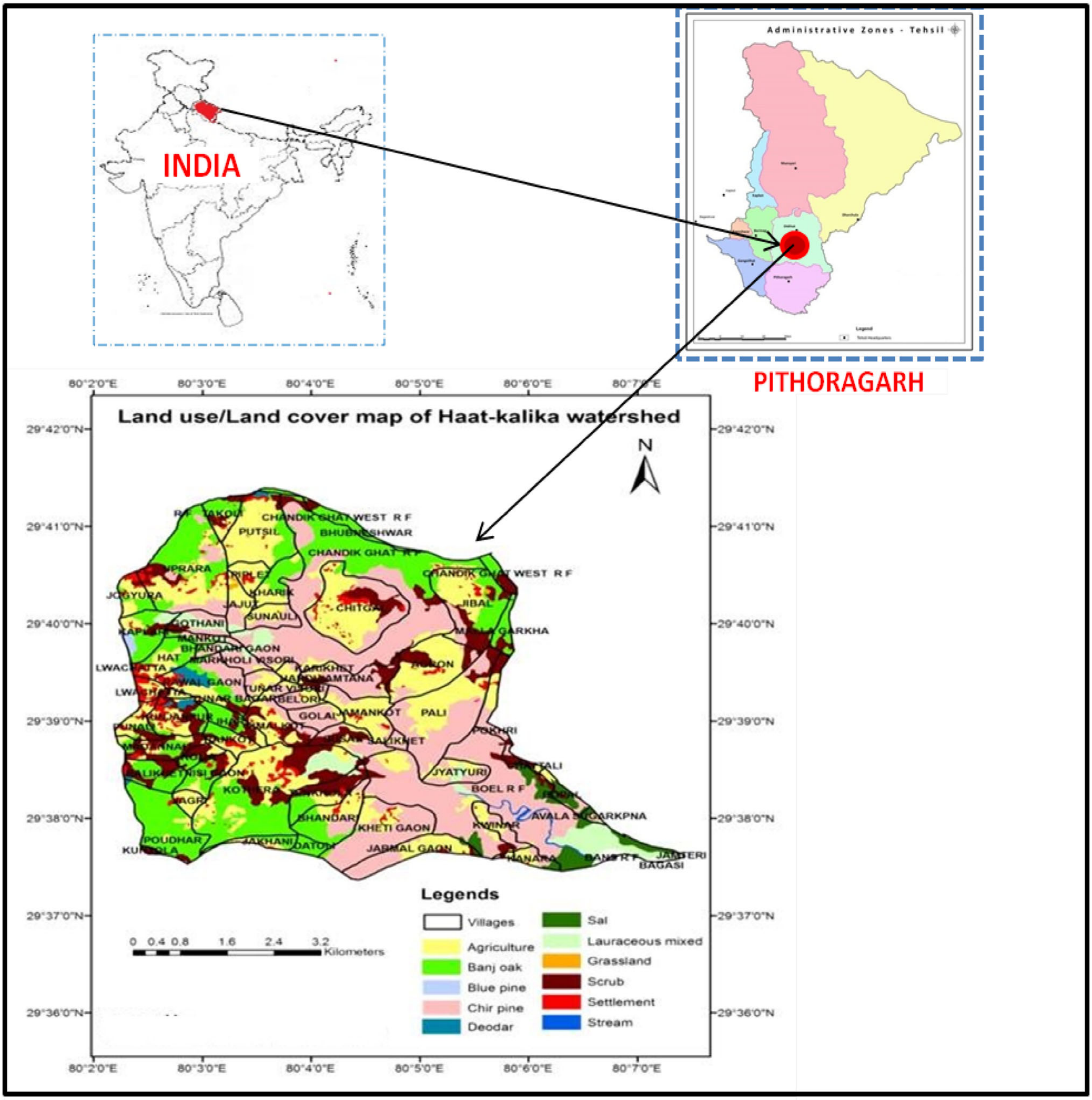

Fig. 1 Land-use and land-cover map of Hat Kalika watershed. *Source*: KSLCDI Project-2015

2. Use value (UV)

This exhibits the relative importance of plants recognized as useful. UV is applied to determine the plants with the highest uses (most frequently indicated). UV was calculated by using the formula given by Phillips et al. (1994) with slight modification:

$$\mathbf{UV} = \sum \frac{\mathbf{U_{is}}}{\mathbf{n}} \tag{2}$$

where $\mathbf{U_{is}}$ is the number of uses mentioned by each informant for a given species and '**n**' is the total number of informants.

2.4 Vegetation sampling

To determine the availability of the species, a detailed phyto-sociological study was conducted in surrounding forests and agroforestry areas under continuous use for

Table 1 General information of villages across Hat Kalika watershed

Altitude range (masl)	Name of village	House holds	Total population	Informants		Total informants
				Women	Men	
Low (800–1200)	Kanara	52	243	3	7	10
	Jarmal gaon	95	414	4	4	8
	Bhandari gaon	99	391	5	7	12
Middle (1200–1600)	Kothera	183	785	3	8	11
	Simalkot	66	270	6	3	9
	Jajut	40	180	4	6	10
High (> 1600)	Chitgal	209	983	3	5	8
	Futsil	136	619	5	6	11
	Uprada	200	785	3	8	11

*Population according to census data 2011

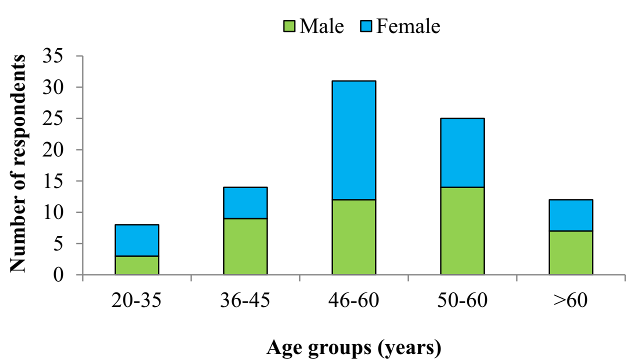

Fig. 2 Number of respondents across age groups

woody species. A total 42 plots of 50 m × 50 m (14 plots in each altitude zone) were randomly laid in forests and agroforestry sites of the study area. Trees, saplings and seedlings were sampled by randomly placed 10 (10 m × 10 m) quadrats for trees, 5 (2 m × 2 m) quadrats for shrubs and 10 (1 m × 1 m) quadrats for seedlings in each plot. Sampling and data generation followed Misra (1968) and Muller-Dombois and Ellenberg (1974). While enumerating tree species, circumference at breast height (cbh at 1.37 m height from the ground) was measured and individuals > 31.5 cm cbh were considered as trees, 31.5–10.5 cm cbh as saplings and < 10.5 cm cbh as seedlings.

3 Results and discussion

3.1 Diversity and use categories

The study identified a total of 34 woody species (27 trees and 7 shrubs) belonging to 25 families as useful for different purposes in the watershed. Rosaceae (five spp.) and Fagaceae (three spp.) were the families with maximum woody species under use. The number of species being used under different plant families is presented in Fig. 3.

Considering various uses mentioned by the inhabitants, the identified species can be grouped into seven general use categories (Table 2). Across the altitude zones, most of the species were being used as fuel (67–78%) followed by fodder (30–60%). Among altitude zones, maximum number of species in use was recorded for high-altitude zone (23 spp.). In this zone, diversity of species in use for fuel wood was considerably high (18 spp.) as compared to low-altitude (10 spp.) and mid-altitude (11 spp.) zones. This can be explained as an adaptation strategy of indigenous communities in mountains, whereas a general rule climate becomes colder with increasing altitude, which enhances the requirement of fuel wood. Therefore, inhabitants use wider base of species to meet fuelwood need. Contrary to this, the mid-altitude (43.7%) and low-altitude (60.0%) villages were using most of the available woody species diversity in respective zones to meet the fodder requirement (Table 2).

3.2 Relative importance of plants

The use value index for identified woody species in the watershed ranged between 0.03 and 0.13, and sal (*Shorea robusta*) emerged as the most important species (UV—0.13) across the watershed. While considering the altitude zones, in low-altitude zone along with *S. robusta* other important species include queral (*Bauhinia variegata*), sanan (*Ougeinia oojenesis*), bhimal (*Grewia optiva*) and kheenuwa (*Ficus semicordata*) all with UV 0.10. In mid-altitude zone, chir pine (*Pinus roxburghii*), bhimal (*G. optiva*) and kheenuwa (*Ficus semicordata*) emerged as most important tree species all having UV 0.10. In high-

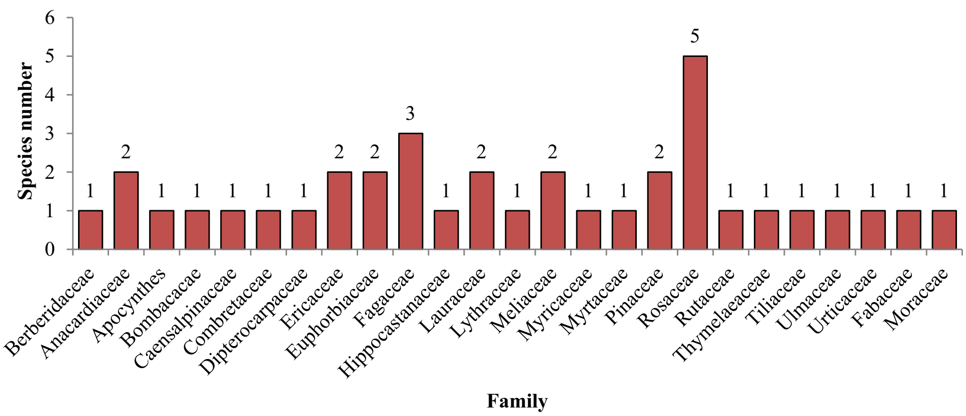

Fig. 3 Diversity of useful woody species in different plant families

Table 2 Number of woody species preferred for different uses

Number of species (%)			
Use categories	High-altitude zone	Mid-altitude zone	Low-altitude zone
Fuel wood	18 (78.2)	11 (68.7)	10 (66.6)
Fodder	7 (30.4)	7 (43.7)	9 (60.0)
Timber	3 (13.0)	1 (6.3)	2 (13.3)
Medicinal	4 (17.3)	1 (6.3)	3 (20.0)
Agricultural implements	3 (13.04)	3 (18.8)	4 (26.6)
Edible	5 (21.7)	3 (18.8)	4 (26.6)
Religious	3 (13.0)	1 (6.3)	1 (6.6)
Total species use	23 (100)	16 (100)	15 (100)

altitude zone, banjh oak (*Quercus leucotrichophora*), rianj oak (*Q. lanata*), deodar (*Cedrus deodara*) and bhimal (*G. optiva*), all with UV 0.10, ranked high in use value.

The UV assessment, therefore, clearly suggested the potential priorities for promotion of useful species in respective altitude zones. Various government programmes, concerning plantation-based livelihood promotion in mid-hills of west Himalaya, specifically in Kumaun region, need to consider plantation of such species to benefit people at large.

During the present study, the RFC of woody plant species ranged from 0.13 to 0.93, thereby suggesting that none of the species scored perfect ‘1’; however, *P. roxburghii* (RFC 0.80–0.90) has been identified as a significant species across all three zones. Among the altitude zones, *S. robusta* (RFC 0.93), *B. veriegata* (RFC 0.86) in low altitude, *P. roxburghii* (RFC 0.90), *Grewia optiva* (RFC 0.80) in mid-altitude, and *Q. leucotrichophora* (RFC 0.86), *Q. lanata* (RFC 0.83) in high altitude assumed high use significance for inhabitants. While considering UV and RFC, a positive correlation exists between UV and RFC of each species (Fig. 4). The other studies have also reported that increase in species RFC generally increases the value of UV (Vijayakumar et al. 2014; Ahmed et al. 2016). The low UV of species is often also be attributed to generational changes in preferences, transformation of ancient patterns of use

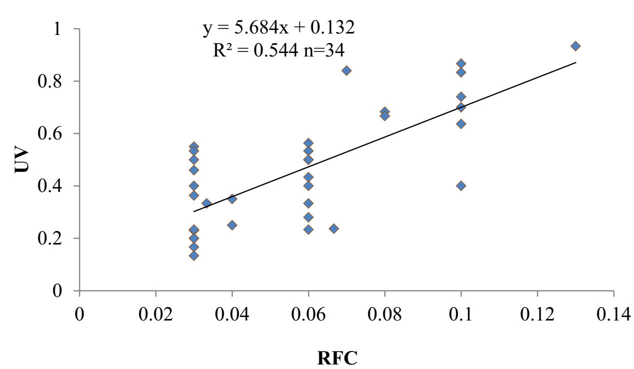

Fig. 4 Relationships between use value (UV) and relative frequency citation (RFC) values of the woody species

and the diminishing local traditional knowledge (Stoffle et al. 1990; Rashid et al. 2015).

3.3 Availability and use of species

For each altitude zone, availability of useful species varied considerably. In high-altitude zone, *Q. leucotrichophora* was observed in maximum density (trees 587, saplings 123, seedlings 535 ind ha^{-1}) followed by *P. roxburghii* (trees 45, saplings 62, seedlings 98 ind ha^{-1}), and other species showed low availability in the area. Among shrubs, *B.*

Table 3 Utilization pattern, use value, relative frequency of citation and availability status of tree species in the study area

High altitude (> 1600 m)	Family	Use categories									Availability density (ind ha^{-1})		
Name of species		Fl	Fo	Ti	Me	Ag	Ed	RE	UV	RFC	TR	SA	SE
Pyrus pashia (Mehal)	Rosaceae	√					√		0.06	0.40	8	4	28
Celtis australis (Karik)	Ulmaceae	√	√						0.06	0.23	5	12	10
Debregeasia salicifolia (Tusari)	Urticaceae		√						0.03	0.20	10	6	5
Rhododendron arboreum (Burans)	Ericaceae	√							0.03	0.40	20	27	37
Aesculus indica (Pangar)	Hippocastanaceae	√							0.03	0.16	4	11	25
Prunus cerasoides (Paya)	Rosaceae	√						√	0.06	0.53	6	8	10
Cedrus deodara (Deodar)	Pinaceae	√		√				√	0.10	0.40	14	16	170
Pinus roxburghii (Chir)	Pinaceae	√		√					0.06	0.80	45	62	98
Melia azedaracht (Betain)	Meliaceae	√	√						0.06	0.26	4	12	10
Myrica esculenta (Kaphal)	Myricaceae	√					√		0.06	0.50	37	75	114
Symplocos chinensis (Lodh)	Symplocaceae	√	√						0.06	0.26	6	14	20
Quercus leucotrichophora (Banjh oak)	Fagaceae	√	√			√			0.10	0.86	587	123	535
Quercus lanata (Latuwa Banj)	Fagaceae	√	√			√			0.10	0.83	28	80	58
Toona ciliata (Toon)	Melliaceae	√							0.03	0.33	6	0	10
Grewia optiva (Bhimal)	Tiliaceae	√	√			√			0.10	0.50	16	9	14
Lyonia ovailifolia (Ayar)	Ericaceae	√							0.03	0.30	21	33	30
Mid-altitude zone (1200-1600 m)													
Cinnamomum tamala (Tejpat)	Lauraceae						√		0.03	0.53	4	0	10
Pyrus pashia (Mehal)	Rosaceae	√							0.03	0.4	9	12	7
Celtis australis (Kharik)	Ulmaceae	√							0.03	0.46	7	0	15
Debregeasia salicifolia (Tusari)	Urticaceae	√							0.03	0.26	12	8	20
Prunus cerasoides (Paya)	Rosaceae		√					√	0.06	0.33	6	0	0
Melia azedaracht (Betain)	Meliaceae	√							0.03	0.23	5	12	0
Grewia optiva (Bhimal)	Tiliaceae	√	√			√			0.10	0.80	11	10	0
Ficus semicordata (Kheenuwa)	Moraceae	√	√			√			0.10	0.66	9	5	15
Pinus roxburghii (Chir)	Pinaceae	√		√		√			0.10	0.90	975	130	135
Quercus leucotrichophora (Banjh oak)	Fagaceae	√	√						0.06	0.46	43	0	36
Quercus glauca (Falyat)	Fagaceae	√	√						0.06	0.53	59	54	86
Low-altitude zone (800–1200masl)													
Bombox ceiba (Semal)	Bombacacae	√	√						0.03	0.13	4	0	5
Terminalia Chebula (Harar)	Combretaceae		√		√				0.06	0.50	8	10	30
Mallotus Philippensis (Rhohini)	Euphorbiaceae	√	√						0.06	0.33	6	15	12
Syzigium cumini (Jamun)	Myrtaceae	√	√						0.06	0.53	20	38	57
Shorea robusta (Sal)	Dipterocarpaceae	√	√	√		√			0.13	0.93	379	150	546
Cinnamomum tamala (Tejpat)	Lauraceae				√		√		0.06	0.60	5	0	12
Bauhinia variegata (Queral)	Caensalpinaceae		√		√		√		0.10	0.86	7	6	16
Phyllanthus emblica (Aawala)	Euphorbiaceae						√	√	0.06	0.50	4	0	20
Ougeinia oojeinensis (Sanan)	Fabaceae	√	√			√			0.10	0.70	8	9	17
Ficus semicordata (Kheenuwa)	Moraceae	√	√			√			0.10	0.60	9	0	10
Grewia optiva (Bhimal)	Tiliaceae	√	√			√			0.10	0.63	7	4	13
Pinus roxburghii (Chir)	Pinaceae	√		√					0.06	0.80	30	40	110

Fu fuel wood, *Fo* fodder, *Ti* timber, *Me* medicinal, *Ag* agriculture impalements, *Ed* edible, *Re* religious, *RFC* relative frequency citation, *UV* use value, *TR* tree, *SA* sapling, *SE* seedling

asiatica (643 ind ha^{-1}) followed by *Rhus parviflora* (589 ind ha^{-1}), *Pyracantha crenulata* (458 ind ha^{-1}) were most commonly available species (Table 4). In the mid-altitude zone, *P. roxburghii* (trees 957, saplings 130, seedlings 135 ind ha^{-1}), *Q. glauca* (trees 59, saplings 39, seedlings 48 ind ha^{-1}) were dominant species. However, in

Table 4 Utilization pattern, use value, relative frequency of citation and availability status of shrub species in the study area

High altitude (> 1600 masl)		Use categories									Availability density (ind ha^{-1})
Name of species	Family	Fu	Fo	Ti	Me	Ag	Ed	Re	UV	RFC	D
Rhus parviflora (Tang)	Anacardiaceae	√							0.03	0.33	589
Berberis asiatica (Kilmora)	Berberidaceae				√		√		0.06	0.23	643
Urtica dioica (Bichu)	Urticaceae				√				0.03	0.70	68
Prinsepia utilis (Jhtalu)	Rosaceae	√						√	0.06	0.13	25
Rubus ellipticus (Hisalu)	Rosaceae						√		0.03	0.23	324
Pyracantha crenulata (Ghingaru)	Rosaceae	√					√		0.06	0.30	458
Mid-altitude zone (1200–1600 masl)											
Rhus parviflora (Tang)	Anacardiaceae	√							0.03	0.40	346
Berberis asiatica (Kilmora)	Berberidaceae				√		√		0.06	0.33	540
Urtica dioica (Bichu bati)	Urticaceae		√						0.03	0.40	20
Prinsepia utilis (Jhtalu)	Rosaceae		√						0.03	0.80	38
Pyracantha crenulata (Ghingaru)	Rosaceae	√					√		0.06	0.16	240
Low-altitude zone (800–1200 masl)											
Woodfordia fruticosa (Dhaula)	Lythraceae	√							0.03	0.53	465
Rhus parviflora (Tang)	Anacardiaceae	√							0.03	0.33	386
Berberis asiatica (Kilmora)	Berberidaceae						√		0.03	0.27	126

Fu fuel wood, *Fo* fodder, *Ti* timber, *Me* medicinal, *Ag* agriculture impalements, *Ed* edible, *Re* religious, *UV* use value, *RFC* relative frequency citation, *D* density

low-altitude zone *S. robusta* (trees 379, saplings 150, seedlings 546 ind ha^{-1}) followed by *P. roxburghii* (trees 30, saplings 40, seedlings 110 ind ha^{-1}) exhibited maximum availability (Table 3). In the shrub layer, *B. asiatica* (540 ind ha^{-1}) in mid-altitude zone and *Woodfordia fruticosa* (465 ind ha^{-1}) in low-altitude zone were most commonly available (Table 4).

Considering the availability of useful species in tree and shrub layers, it was observed that the number of species with adequate availability is invariably more for shrubs as compared to trees. In case of trees, low-, mid- and high-altitude zones have only one species each with high density, whereas for shrubs low-altitude exhibited two species, mid-altitude three species and high altitude four species dominance, respectively.

3.4 Conservation implications and conclusion

Species those recognized as useful are obvious to face greater extraction pressure from fringe communities. However, the extent of pressure varies. This is clearly reflected in the present study with a wide range of variation in realized use value of all 34 species. Also, the tree species are being given large use priority as compared to the shrubs. This implies that in spite of adequate availability of certain shrub species inhabitants of the watershed are traditionally leaned towards using tree species. It is, therefore, imperative to make people more aware for further diversifying their use attention on shrubs so that the pressure from preferred trees can be reduced. This seems more likely, if the shrub species are promoted as fuel wood option.

While assuming that the species with high use value will be facing higher extraction pressure, it is important to look into the available stock and demographic profiles of the species. For instance, *S. robusta* which ranked best in use value exhibits relatively low density (150 ind ha^{-1}) in sapling stage. This suggests conversion of seedlings to sapling is not adequate. Therefore, replacement in tree layer is also likely to remain inadequate, and with the realized use demand, the species may face problem for existence in near future.

Considering the altitude zones, *B. variegate* and *P. roxburghii* in low-altitude zone are in higher use demand, but both the species exhibit low availability, hence requiring special management attention. Among others, *O. oojeinesis* with relatively higher use value (0.70) exhibiting very low availability. Moreover, the species being preferred for agricultural implements are also facing pressure of destructive harvesting (e.g. root extraction). As the tree stock of this species is extremely thin and young recruits are not so frequent, one can easily assume that the species may be wiped out from the watershed if trends of use continue and no immediate efforts made for species promotion.

In mid-altitude zone, the most significant species (*P. roxburghii*) despite the adequate availability of adults, adequate populations of seedlings and saplings are missing. The other important species of this zone *G. optiva* suffer from low availability and poor natural recruitment. This species, being a premier agroforestry tree, needs effective promotion in agriculture area by way of plantation. In high-altitude zone, most importance species *Q. leucotrichophora* has relatively poor stock in sapling layer, which may cause regeneration problem in future, if the present conditions prevail. Interestingly, the next important species *Q. lanata* and *P. roxburghii* are not having adequate adult tree stock as well as the new recruits in high altitude. Therefore, both these species are likely to face problem if the current preference of the inhabitants continues. The study, therefore, highlights major species of conservation concerns in the target watershed. Thus, special conservation efforts would be required to address these concerns adequately.

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