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Seabuckthorn (*Hippophae* spp.) Conserve Plant Diversity in the Fragile Mountain Ecosystem of Cold Desert Himalaya*

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ABSTRACT The present study signifies the importance of Seabuckthorn in conserving plant diversity in cold arid trans-Himalaya. Phytosociological surveys conducted in the Lahaul valley provide the estimation floral assemblage with Seabuckthorn (*Hippophae* spp.). In the survey, a total 148 plant species belonging to 43 families and 109 genera were noticed with a varied proportion of tree (11), shrub (10), herb (126) and fern (1) species. The vegetation parameters {(Shannon diversity (H') and Concentration Dominance (CD)} show an average contribution of tree and shrub species, while the contribution of herb species is surprisingly very high in comparison to the normal trend of the study areas. A 'hump shaped' diversity pattern in the altitudinal range varied from 3134 to 3254 m asl can be correlated with favorable environmental condition. Many plant species come in IUCN list of endangered plant species and their abundance was quite high in comparison to the other studies in the same area. The vegetation association shows a positive response to the ecological viability, making this species a good option for long term conservation strategy in cold desert Himalaya.

INTRODUCTION

The complex geo-botanical landscape of Himalaya is the result of long term climatic oscillation that brings unique habitat diversity. Among this, the part of cold arid trans-Himalaya is one of the extreme that comes under the long stretch of more than 2,800 km and 220 to 300 km wide area of Indian Himalaya Region (IHR), which is always been a subject of interest among scientific community due to the high number of endemic plant species (Anonymous 1997; Samant et al. 2007). In the Himalayan region the cold arid zone covers Ladakh region of Jammu and Kashmir, parts of Himachal Pradesh and dry temperate high altitude regions of Uttarakhand, Sikkim and Arunachal Pradesh and contains about 18 percent geographical area of India. The unique environmental conditions lead to high proportion of endemic plant species. The region is also identified as a hotspot of biological diversity (Myers et al. 2000). While in the present scenario the biodiversity challenges are serious, especially for the hotspots area (Ashton 2018).

In diversity statistics, this area inhabits a high proportion of endemic plant species, which includes about 8,000 species of angiosperms (40% endemic), 44 species of gymnosperms (16% endemic), 600 species of pteridophytes (25% endemic) (Singh and Hajra 1996; Samant et al. 2007; Kumar et al. 2014). In the study area the altitude increases very rapidly, while covering the small distance on the ground and so the effect of climatic change can be very prominent on plant diversity in the area. The environmental conditions are very extreme, a few indigenous plant species can survive and become a part of agroforesty system. The local inhabitants in the area are still dependent on this diversity component for their livelihood. Large scale plantation of any tree species without considering the ecological aspect can be a threatening issue in the long term ecological viability of the Himalayan ecosystem. This can be evident from the large scale plantation of *Pinus* spp. in the tropical and subtropical regions of Himalaya. The fallen leaves from *Pinus* spp. considered as one of the most recalcitrant component due to the presence of lignin, degraded only by a specific group of fungi (Dwivedi et al. 2016) that threatens the existence of other plant in association. In the present scenario the area of hotspots of biological di-

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versity threaten by anthropogenic disturbances and invasion of alien plant species (Mehraj et al. 2018). So choosing any plant species for large scale plantation strategies can bring a question mark on long term viability of ecosystem, especially in a fragile mountainous region. In high altitude Himalaya, a very few plant species are dominant, among them, Seabuckthorn is one of the most important multipurpose species, currently in use for large scale plantation programmes not only in India but also in the other part of the world. In India, this plant species is mainly presented in higher altitude Himalaya including the Ladakh region of Jammu and Kashmir, Lahaul-Spiti and Kinnaur districts in Himachal Pradesh and some higher ridges of Uttarakhand, Sikkim and Arunachal Pradesh. Seabuckthorn is a member of Family 'Elaeagnaceae' naturally distributed in cold desert areas of the Himalaya (Singh and Dogra 1996) as tree (*Hippophae salicifolia*), shrub (*Hippophae rhamnoides* ssp. *turkestanica*) form. Fruits and leaves are rich in vitamins and other antioxidants, which have potential in food and health industries. It is also an important fuel wood and fodder plant of the region. Due to its multiple uses, this species is also regarded as *"Sanjeevani"* (gives new life) in higher Himalaya (Kumar et al. 2014). A number of studies on genetic diversity (Singh and Singh 2004; Raina et al. 2011), propagation (Singh 1995), medicinal values (Gupta et al. 2006) and metabolites identification, species differentiation and quality assessment (Liu et al. 2017) is already done. In the long term, with economic aspect, ecological viability is also necessary for strong sustainability and defining the future scope of this species for Indian Himalayan region and other part of the world. Also for the last few years, this species is being over exploited by the local inhabitants for the extraction of fuel wood, fencing material and through traditional method of fruit collection for the industries. This is further a subject of interest as the species have capability to fix atmospheric nitrogen two times as much of soybean owing to symbiotic association with a fungus *Frankia* sp. (Actinomycetes) leading to the formation of root nodules (Lu 1992; Tamchos and Kaul 2015) that help in nutrient uptake and improve tree growth (Zhou et al. 2017). The bird and animal species are fairly dependent on Seabuckthorn for their food and shelter and make the natural system more harmonious and stable (ICIMOD 2006). Even more positive response has been seen in term of low mortality rate for broiler chickens when used as feed additive at high altitude cold desert area (Kalia et al. 2018). Information on some studies based on biodiversity conservation and management (Singh et al. 2009) and floristic composition (Bhattacharya and Uniyal 1982; Jain 1991; Aswal and Mehrotra 1994; Chauhan 1997; Murti 2001; Kala 2006, 2011) for the cold desert area is available. The diversity studies in Rohtang Pass (4000 m asl) in Kullu-Lahaul border area shows the higher status of these threatened plant species (Singh et al. 2008) and some of these also belong to IUCN (International Union for Conservation of Nature). However, studies on the vegetation association of Seabuckthorn have not been done so far as per literature. Therefore, time to time assessment on biodiversity of Seabuckthorn population is required and this survey provides first-hand information on surface level to understand the ecological viability in Seabuckthorn populations. This will further be helpful in making more effective strategies to conserve Himalayan ecosystem.

Objectives

The objective of the present study is to find out the vegetation associated with Seabuckthorn in Lahaul valley. Phytosociological study provide an input to access the current diversity pattern that will also help to understand the future scope of large scale plantation of this plant species in the area.

METHODOLOGY

To achieve the objective, surveys were conducted in Bhaga and Patan valley at different altitudinal ranges of the Lahaul region of Lahaul-Spiti district, NW Himalaya, India in the year 2011. Phytosociological studies provide status of current plant diversity and there association pattern in natural Seabuckthorn stand. Seabuckthorn species were identified on the basis of morphological features. Details of the sites were noticed for different parameters like altitude, latitude, longitude, habitat type, slope and aspect.

Study Area

The Lahaul valley is a part of a cold arid region of district Lahaul-Spiti located between

31°44'57"- 32°59'57"N, 76°46'29"-78°41'34"E with total area 13,835 sq km in Himachal Pradesh, India. The landscapes and vegetation are almost similar to the Spiti area (Cold Desert Biosphere Reserve since 2009 under Man and Biosphere (MAB) programme of UNESCO). The valley is approachable through Rohtang Pass, Baralacha Pass and Kunzum Pass. The main rivers are Chandra and Bhaga, which merge at Tandi that bring huge sediments with fresh washes from the river. This study was conducted in two valley subregions of Lahaul named Patan and Bhaga. Patan valley is a semi-arid lower altitude area with sparse vegetation, sites selected from Patan valley includes Kukumseri, Jahlama and Sansa. While the Bhaga valley cover the broader areas with high altitude arid environment and has more easily accessible sites and those were selected from Beiling, Keylong, Tinoo, Gamour, Jispa and Darcha (Fig. 1).

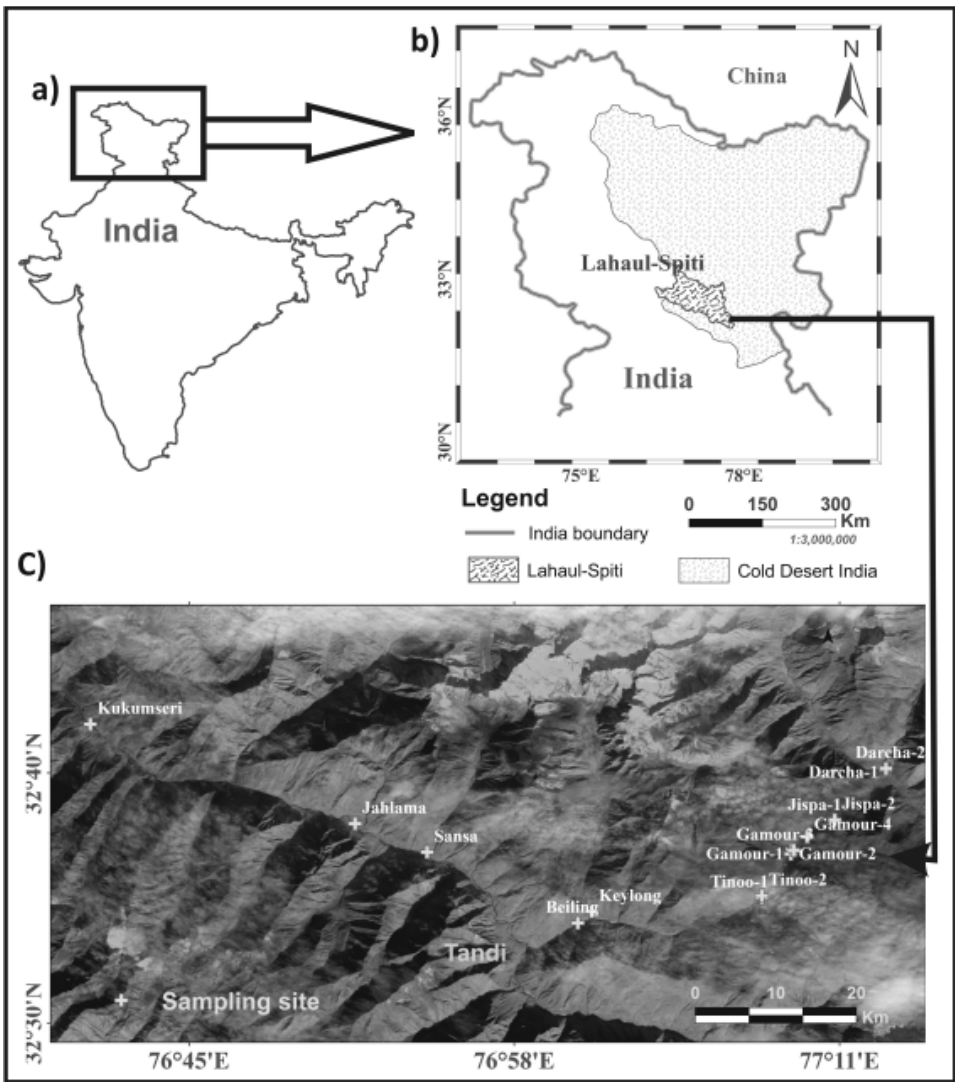

Fig. 1. a) India; b) Geographical location of cold arid area in district Lahaul-Spiti, India; c) Location of sampling sites plotted on Landsat imagery (adapted from USGS) represent sites selected in Seabuckthorn stands

The area receives heavy snowfall in winter and is cut off from the rest of the country for more than six months due to blockage of passages. The climate of the valley varies from dry temperate to alpine type, which is characterized by sharp fluctuations in temperature with low atmospheric pressure and humidity. This area is also prone to soil erosion, which is favored by high wind speed, splashing floods and overgrazing that highlight the need for time to time biodiversity survey to make more effective conservation strategy.

Phytosociological Studies

After selecting the natural Seabuckthorn stands, phytosociological study was carried out using the quadrat method. For each sampling site, 50×50 m plot was selected in the center of the stand. Within this plot, 10 quadrat of size 10×10 m for tree and 5×5 m for shrub species and 20 quadrat of size 1×1 m for herb species was placed to note different population parameters. The individual measurement for tree was carried out at circumference at breast height (cbh) with the help of measuring tape. The population assessment of tree species present with Seabuckthorn was carried out by dividing the cbh into three classes that is, sapling (cbh=10.5-31.4 cm), seedling (cbh<10.5 cm) and tree (cbh>=31.5 cm). Unidentified plant species were collected and herbarium was prepared by following guidelines from Jain and Rao (1977). Necessary precautions were taken at the site during collection and pressing of the fresh samples. The collected species were identified using standard available floras and research papers of the concerned area (Chowdhery and Wadhwa 1984; Polunin and Stainton 1984; Aswal and Mehrotra 1994; Murti 2001; Singh et al. 2009). The data were analyzed for density, frequency, total basal area, IVI (Importance Value Index) etc., using standard methods (Curtis and Mc Intosh 1950; Mishra 1968). The IVI for the tree species was calculated by taking sum of Relative Frequency (RF) + Relative Density (RD) + Relative Basal Area (RBA). Species richness was obtained by calculating the number of species of trees, shrubs and herbs in different sites. To understand the vegetation association pattern Shannon diversity index (H') was used (Shannon and Weaver 1963) followed by Concentration Dominance ($CD=\Sigma pi^2$), where, pi= ni/N, ni= individuals of species 'i', N= total number of individuals of all species.

Soil Studies

Soil samples were collected from 20 cm depth from each corner, center and mixed together to make a composite sample of 250 g and kept in an airtight polythene for further laboratory analysis. The soil pH was determined by glass electrode pH meter using soil, water suspension in the ratio of 1:2.5. The textural class was determined by using textural triangle given by the International Society of Soil Science. Water Holding Capacity (WHC) was estimated by the formula: WHC = (a-b)/ (b-c), where 'a', is the weight of the saturated sample, 'b' is the weight of oven dried sample at 105^0C and 'c' is weight of empty box.

RESULTS AND DISCUSSION

Habitat Diversity and Vegetation Association with Seabuckthorn

The morphological characterization of Seabuckthorn species shows tree form in Beiling, Tinoo and Sansa, while shrub form in Kukumseri, Jahlama, Keylong, Gamour, Jispa and Darcha. Generally, under high density, *H. rhamnoides* shows shrub like character, whereas under wide spacing they sometimes show tree like morphology. However, *H. salicifolia* remain in tree form in all conditions. Table 1 shows the conditions of the habitats in the surveyed sites. Seabuckthorn show varied morphology from tree to shrub forms as noticed by Yadav et al. (2006) in Uttaranchal, India also. The *H. salicifolia* is mostly distributed in sloppy agricultural grassland, whereas, the patches of *H. rhamnoides* are dominant along riversides, over the riverbed and in the bouldery area (Fig. 2).

Different characteristics of the study site have been noticed to find out the correct habitat and condition that define the microclimate of the study area. Seabuckthorn stands are easily available near riverside due to broader valley having a moderate topography near the side of the river with alluvial gravel in fan area. The slope varies from 5° to 35° and the soil texture vary from loam, sandy loam, silty loam to loam with a pH range varied from 6.35 to 8.03. This species is present in a wide range of soil moisture {1.989% (Gamour) to 73.49% (Jispa)}, representing different habitat conditions varied from bouldery to riversides or marshy land. Lu (1992) also

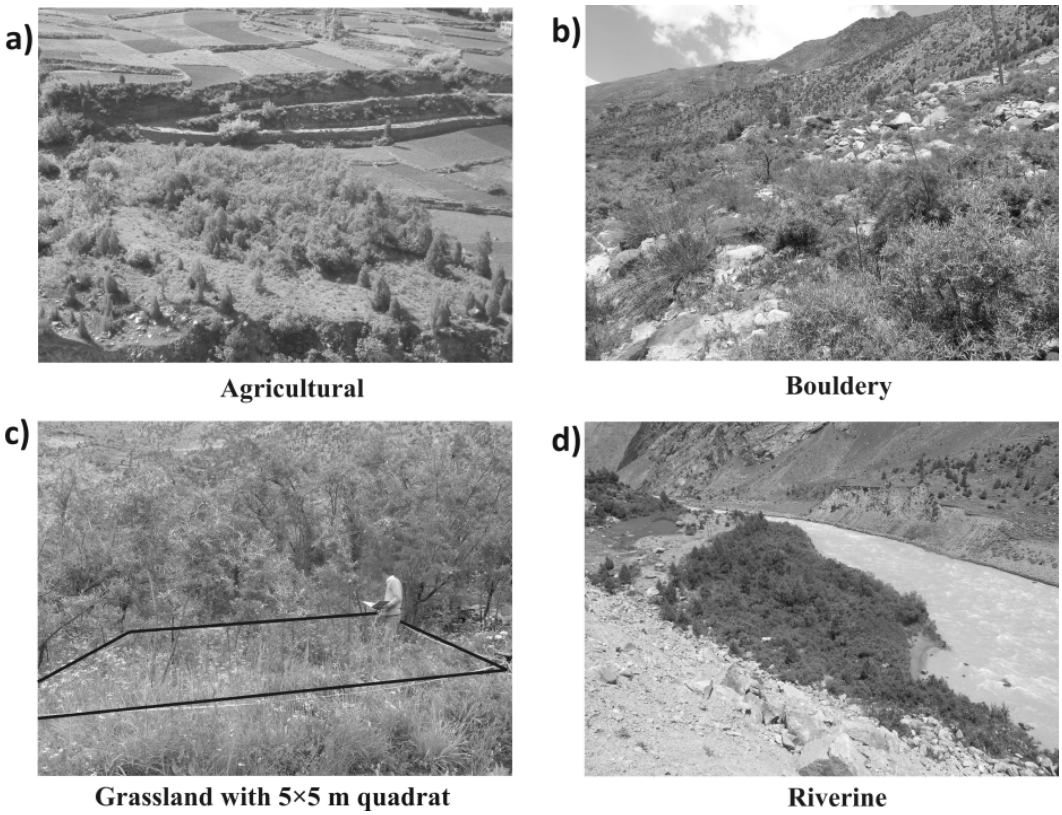

Fig. 2. Habitat diversity with Seabuckthorn in Lahaul valley

reported the low humid, alluvial gravel and riverside habitat was preferred by this species. Kala (2006) finding also support that this plant species is restricted to marshy and moist areas, followed by dry scrub, rocks, boulders and undulating land or alpine meadows. The occurrence of the natural Seabuckthorn stand was also affected by many factors like habitat, aspect, slope and physico-chemical properties of soil and its cummulative effect. Singh and Gupta (1990) noticed silty, clayey and loamy texture with alkaline (pH 7.2-8.1) nature of soil in the Lahual-Spiti. Wei et al. (2006) reported that different habitats had different vegetation structure with Seabuckthorn and productivity was higher in shady areas as compared to other habitats. Some of the important plant species present in Seabuckthorn stand includes *Aconitum heterophyllum, Betula utilis, Carum carvi, Dactylorhiza hatagirea, Ephedra gerardiana, Juniperus polycarpos, Rheum australe* and *Taraxacum officinale*. These are used by local inhabitants and some of these fall in the category of threatened plant species (Singh et al. 2009; Verma 2014). The diversity of plant species represents habitat specific distribution as supported by various researchers in the region (Uniyal et al. 2006; Singh et al. 2008).

Variation of Plant Diversity with Altitudinal Gradient

Spatial distribution of diversity can be linked with many ecological factors, including environmental condition and altitudinal variation, which can act as a major deciding factor to alter the shape of plant community (Szaro 1989; Lomolino 2001; Chawla et al. 2008). According to Hortal et al. (2013), plant diversity not always decrease with altitude, but this can increase also where the habitat conditions are favorable for growth of plant communities. This is also ob-

served in the present research, where plant diversity is high in the mid-altitudinal range (3134-3260 m asl) which bring a 'hump shaped' diversity pattern (Table 1). Singh (2007) also noticed higher species richness of plant species at 3400 to 3700 m asl in cold desert area.

McCain and Grytnes (2010) also demonstrated mid peak elevational pattern of species richness along the mountain gradient. The higher number of plant individual in the mid-altitudinal range 3134 to 3254 m asl in the present study may be due to favorable habitat condition and microclimate of the area. Species richness in these areas may increases due to favorable habitat as most of the sites in the mid-altitudinal range were selected near grasslands, farmer fields and even close to home garden crops. The grassland and riverine habitats represent a luxurious growth of Seabuckthorn that is well associated with other plant species.

The previous studies carried out in the Lahaul valley sub-region also report an altitudinal specific diversity pattern (Singh 2007; Chawla et al. 2008; Singh et al. 2008). The high plant diversity in isolated location is related to favorable habitat diversity, regional microclimate of the area and less human intervention. This has also been supported by Singh and Samant (2010) observation of species richness among different habitat and aspect for the area.

Phytosociological Aspect of Vegetation Associated with Seabuckthorn

The diversity indices show less number of tree and shrub species and this is quite low in comparison to the other ecologically rich habitats. As the survey in subtropical Himalaya showed a higher diversity of tree and shrub species (Jyoti et al. 2014), the current proportion of plant diversity (tree and shrub) is acceptable for the cold arid region, where the climate is very harsh in comparison to lower Himalaya. But the outcomes are surprisingly very interesting in case of herb species that show high contribution of plant diversity in the total vegetation association with Seabuckthorn. The dominant plant species noticed are *Hippophae salicifolia, Salix daphnoides, Juniperus communis* (tree form); *Hippophae rhamnoides, Cotoneaster microphyllus, Caragana versicolor* (shrub form), *Agrostis pilosula, Eragrostis minor, Sonchus wightianus Eragrostis minor, Elymus nutans* and *Carex setosa* (herbaceous form). In Patan valley, *Hippophae salicifolia* (224.322) showed the highest value of IVI, followed by *Juniperus polycarpos* (49.511) and then *Salix lindleyana* (12.811), while the Concentration Dominance (CD) was highest for *Hippophae salicifolia* (0.5277) followed by *Salix daphnoides* (0.0228) and *Salix lindleyana* (0.0057). In case of Bhaga valley, the *Hippophae salicifolia* (172.164) also

Table 1: Description of study sites and variation of total number of plant individuals in Lahaul valley

Site name	*Altitude (m asl)*	*Habitat*	*Aspect*	*Life form (Hippophae* spp.*)*	*Total number of tree individual*	*Total number of shrub individual*	*Total number of herb individual*	*Total number of plant individual*
Kukumseri	2654	Riverine	SW	S	7	353	289	649
Jahlama	2781	Grassland	SW	S	11	153	5006	5170
Sansa	2864	Grassland	E	T	83	0	1551	1634
Beiling	2985	Waste land	E	T	63	2	801	866
Keylong	3134	Grassland	E	S	6	134	3906	4046
Tinoo-1	3160	Grassland	W	T	79	0	2739	2818
Gamour-1	3225	Riverine	E	S	5	161	4068	4234
Gamour-2	3254	Grassland	E	S	7	117	4297	4421
Gamour-4	3260	Riverine	EN	S	20	161	1852	2033
Gamour-3	3266	Bouldery	EN	S	5	150	518	673
Jispa-1	3280	Marshy land	E	S	36	158	3367	3561
Jispa-2	3290	Waste land	E	S	9	136	1947	2092
Tinoo-2	3305	Grassland	W	T	116	4	2421	2541
Darcha-1	3316	Riverine	NW	S	2	235	1037	1274
Darcha-2	3370	Grassland	NW	S	4	179	1832	2015

Abbreviations used: SW= South-west; E= East; W= West; EN= East-north, NW= North-west; S= Shrub; T= Tree

represent the highest value of IVI, followed by *Salix daphnoides* (56.711) and *Juniperus polycarpos* (49.511), while the CD value was highest for *Hippophae salicifolia* (0.3980) followed by *Salix daphnoides* (0.0536) and *Juniperus communis* (0.0134). The herb species like *Eragrostis minor, Chaerophyllum villosum* and *Equisetum arvense* show the longest ecological amplitude. In Patan valley, *Agrostis pilosula* (0.2660) followed by *Eragrostis minor* (0.2650), *Equisetum arvense* (0.2602) show the highest value of the Shannon diversity index (H'), while in case of Bhaga valley *Sonchus wightianus* (0.2629) reported the highest value of H' followed by *Eragrostis minor* (0.2429) and *Elymus nutans* (0.230). The diversity indices show less number of tree and shrub species are present in both of the valley sub-region, while the herb species the value of diversity indices show high proportion of herb species (Table 2).

Table 2: Diversity indices in different valley sub-region of Lahaul

Valley sub-region	*Life form*	*Shannon index (H')*	*Concentration Dominance (CD)*
Bhaga Valley	Tree	0.909	0.557
	Shrub	0.773	0.650
	Herb	3.319	0.055
Patan Valley	Tree	0.992	0.465
	Shrub	1.127	0.472
	Herb	3.275	0.063

The plant community is dominated by fewer numbers of tree and shrub species, while the proportion of herb species is quite higher. This variation is not only observed in the sub region, but also within the location at different habitats. The proportion is quite comparable with the Rohtang area (4000 m asl), where herb species show dominance in comparison to the tree and shrub species (Singh et al. 2008). The vegetation pattern is similar to the assessment in Jahlama watershed of Lahaul, which show higher species richness, diversity indices (H') and lower Concentration Dominance **(**CD) in agroforestry systems with good association with shrub species like *Rosa webbiana, Berberis pseudumbellata Hippophae rhamnoides, Ribes grossularia* and *Cotoneaster microphyllus* (Rawat et al. 2010). The high value of Concentration Dominance (CD) of tree and shrub species in Patan and Bhaga valley shows that the community is dominated by a few species, while the lower CD in the case of herb species reflects that dominance is shared by more than one species. Table 3 shows proportion of sapling, seedling and tree where Bhaga valley shows the high proportion in comparison to Patan valley.

Table 3: Status of tree individual as sapling, seedling and tree from different valley sub region of Lahaul

Valley sub-region	*Sapling*	*Seedling*	*Tree*
Bhaga valley	125	74	79
Patan valley	91	52	37

The high proportion in the status of tree individual is due to broader Bhaga valley with a higher number of sampling sites for the survey in comparison to Patan valley. The highest contribution for vegetation association belong to family Poaceae followed by Asteraceae and Fabaceae covering 15, 14 and 9 genera, respectively. The angiosperms contribute to the major proportion of plant species followed by gymnosperms and then pteriodophytes. The distribution pattern of dominant families and genera show alpine meadow nature of the vegetation. Vegetation pattern show Seabuckthorn community has huge variety of plant species and their proportion is quite higher than normal trend of species richness in the area (Table 4). This indicates that Seabuckthorn plantation is an ecologically viable option for making sustainable strategy for conservation of Himalayan cold desert ecosystems.

CONCLUSION

The complex geo-botanical landscape inhabits the high proportion of endemic plant species with peculiar floral assemblage in cold desert Himalaya. Seabuckthorn is one of the important plant species which is well distributed in many European and Asian countries like India, China, Mongolia, Russia, northern Europe and Canada. Seabuckthorn is also well a part of many plantation programmes in large scale to avoid the ameliorating downstream impacts that degrade Himalayan ecosystems. Currently for cold desert Himalaya Seabuckthorn is a part of current innovation under DDP (Desert Development Programme) in district Lahaul and Spiti.

The main objective of this plantation in such areas should not limit up to the improvement of short term livelihood of local inhabitants, but

Table 4: Details of vegetation associated with Seabuckthorn in cold arid region of Lahaul valley

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Adiantaceae						
Adiantum capillus-veneris L.	Hansraj	H	G,I,K	3254-3305	+	-
Amaryllidaceae						
Nasturtium officinale (L.) Hayek	-	H	F	3280	+	-
Apiaceae						
Bunium persicum B. Fedtsch	Jeera, Kalagira	H	N	3134	+	-
Bupleurum falcatum L.	-	H	C,D,E,L,N	2864-3370	+	-
B. lanceolatum Wall.	-	H	H,I	3160-3305	+	-
Carum carvi L.	Gonyorog, Gonyod, Shingu Jeera, Gsyon Shakkara	H	F,G,H,I, M	3160-3305	+	+
Chaerophyllum reflexum Lindl.	Ampang, Shakrag	H	E	3370	+	-
C. villosum Wall. ex DC.	Shakkara, Methapatees, Nyo	H	B,C,E,F,G,H,I, K,M,N,O	2781-3370	+	+
Ferula jaeschkeana (L.) Vatke	Bakhyot, Kalyash	H	E	3370	+	-
Heracleum candicans Wall. ex DC.	Dundu, Raswal	H	B,C,D,G,H,I,K,N	2781-3305	+	+
Asteraceae						
Achillea millefolium L.	Chabu, Shugumentog	H	B,C,J,N	2781-3225	+	+
Anaphalis busua (Buch. Ham. ex Don.) DC.	Zoon	H	J,L	3225-3266	+	-
Arctium lappa L.	Pichawag	H	F	3280	+	-
Artemisia biennis Willd.	Karkatang, Khampa	H	E	3370	+	-
A. dracunculus L.	Chamary, Burtse	H	C,D,E,F,G,H,I, J,K,L,M,N,O	2985-3370	+	+
A. gmelinii Web. ex Stechm.	Nurcha, Karkatang	H	D,M	3260-3316	+	-
A. indamellus Grierson	-	H	A, K	2654-3254	+	+
A. laciniata Willd.	Bintso	H	B	2781	-	+
A. maritima L.	Seski, Nyurcha, Garpeg, Nyurchi, Sensi	H	A,E,I,J,L,M,N	3134-3370	+	+
Aster flaccidus Bunge	Lugmig Chunwa	H	B,E	2781-3370	+	+
Cirsium wallichii G. Don. var. *glochidiatumWallich* ex Benth	Chawag	H	E,F,N,K,L,M	3134-3370	+	-
Cousinia thomsonii Cl.	Changchher,Bacha Chawag, Khibsha	H	E,G	3290-3370	+	-
Erigeron canadensis L.	Fleabane	H	E	3370	+	-
E. alpinus L.	Bashakar	H	A,D	2654-3316	+	+
E. bellidioides (D. Don.) Benth. ex Cl.	Pa-sa-ka	H	B,E,N	2781-3370	+	+
Hieracium raui Aswal and Mehrotra	-	H	B,D,E,K,M,N	2781-3370	+	+
Lactuca lessertiana (DC.) Cl.	-	H	G	3290	+	-
Saussurea albescens (DC.) Sch. Bip.	Bacha-Shang, Drapada, Prabachi	H	D,E,N	3116-3370	+	-
S. costus (Decne.) Sch. Bip.	Kuth	H	I	3305	+	-

Table 4: Contd...

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Senecio laetus Edgew.	Parpat,Sangebala	H	C,E,G,H,K	2864-3370	+	+
Sonchus oleraceus L.	Panu Aag	H	A,D,K,O	2654-3316	+	+
S. wightianus DC.	-	H	C,K	2864-3254	+	+
Taraxacum officinale Wigg.	Paranbala, Quanti, Sarkhen Mentok, Dudhi	H	A,B,D,E,F,G,H, I,J,K,L,M,N,O	2654-3370	+	+
Balsaminaceae						
Impatiens glandulifera Royle	Mewa	H	G,H,K,N	3134-3290	+	-
Berberidaceae						
Berberis pseudumbellata Parker	Pakkad	S	A,D,E	2654-3370	+	+
Betulaceae						
Betula utilis D. Don.	Bhojpatra, Shag, Bhuj	T	I		+	-
Boraginaceae						
Cynoglossum lanceolatum Forssk.	-	H	A,D	2654-3316	+	+
Lindelofia longiflora (Royle ex Benth.) Baill. *var. falconneri* (Cl.) Brand	-	H	C,E,G,K,M,O	2864-3370	+	+
Brassicaceae						
Capsella bursa-pastoris L.	Maslam	H	C,G,M,P	2864-3290	+	+
Cicerbita macrorhiza (Royle) G. Beauve.	-	H	G,H,I	3160-3305	+	-
Campanulaceae						
Campanula latifolia L. Gaint	-	H	D	3316	+	-
Codonopsis rotundifolia Benth.	-	H	A	2654	-	+
C. ovata Benth.	Golchokpa	H	E	3370	+	-
Caprifoliaceae						
Lonicera angustifolia Wall. ex DC.	-	H	G	3290	+	-
L. spinosa Decne. Jacquem. ex Walp	-	S	A	2654	-	+
Caryophyllaceae						
Dianthus angulatus Royle ex Benth.	-	H	N	3134	+	-
Minuartia biflora L.	-	H	D	3316	+	-
Silene gonosperma (Rupr.) Bocquet	Sukpa	H	N	3134	+	-
Stellaria media L.	Shichi	H	F	3280	+	-
Chenopodiaceae						
Chenopodium album L.	Em, Ear, Ayar	H	A,C,L,M,O	2654-3266	+	+
C. botrys L.	Sokann, Sanyek	H	D	3316	+	-
Convolvulaceae						
Convolvulus arvensis L.	Grachi	H	O	2985	+	-
Crassulaceae						
Hylotelephium ewersii Syn. *Sedum ewersii* (Ledeb.) Ohba	-	H	I	3305	+	-
Cruciferae						

Table 4: Contd...

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Sisymbrium brassicaeforme C.A. Mey.	-	H	O	2985	+	-
S. irio L.	-	H	D,E	3316-3370	+	-
Cupressaceae						
Juniperus communis L.	Petada, Shukpa, Dhup	T	E,I	3305-3370	+	-
J. polycarpos Boiss.	Shur, Leyur	T	D,E,F,G,H,I, K,L,M,N	3134-3370	+	-
Cyperaceae						
Carex setosa Boott.	Prekchi	H	E,F,H,J,N,M	3134-3370	+	+
Elaeagnaceae						
Hippophae salicifolia D. Don.	Sarla	T	C,H,I,O	2864-3305	+	+
H. rhamnoides sub sp. *turkastanica* L.	Sarla	S	A,B,D,E,F,G, J,K,L,M,N	2654-3370	+	+
Ephedraceae						
Ephedra gerardiana Wall. ex Stapf	Kiok, Buchchur,Chhe, Somlata	S	D,M	3260-3316	+	-
Equisetaceae						
Equisetum arvense L.	Khin	F	B,C,E,F,H,I,J, K,M,N,O	2864-3370	+	+
Fabaceae						
Astragalus grahamianus Royle ex Benth.	Rangchawag	H	A,D,H,I	2654-3316	+	+
Caragana versicolor (Wall.) Benth.	Bramswak, Zomoshing	S	A,L	2654-3266	+	+
Cicer microphyllum Benth.	-	H	L	3266	+	-
Hedysarum microcalyx Baker	-	H	E,K,L,N	3134-3370	+	-
Lotus corniculatus L.	-	H	D,E,H,J,M,N	3160-3370	+	-
Medicago falcata L.	Kunyok, Gunyok	H	B,D,E,F,G,H, J,K,M,N	2781-3370	+	+
M. lupulina L.	Gunyok	H	B	2781	-	+
Robinia pseudoacacia L.	Kiker	T	A	2654	-	+
Trifolium pratense L.	-	H	B,C,F,G,H,I,J,K,N	2781-3305	+	+
Trigonella emodi Benth.	Tuljima, Kuchona,Buksup, Ampang	H	B,E	2781-3370	+	+
Gentianaceae						
Swertia angustifolia Buch. Ham. ex D. Don.	-	H	B,I,M,N	2781-3305	+	+
S. petiolata Royle ex D.	-	H	B	2781	-	+
Geraniaceae						
Geranium pratense L.	Porlo	H	E,H,K,M	3160-3370	+	-
Grossulariaceae						
Ribes alpestre Decne	Piliktsa	S	E,K	3254-3370	+	-
R. orientale Desf.	Nyangada	S	K,M	3254-3260	+	-

Table 4: Contd...

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Iris ensata Thumb.	-	H	C	2864	-	+
Juncaceae						
Juncus himalensis Klotz. et Garcke	-	H	B,F,G,H,I,J	2781-3305	+	+
Lamiaceae						
Mentha longifolia (L.) Huds.	Takchi, Marini, Madaen	H	A,B,D,E,F,L,N	2654-3370	+	+
Nepeta eriostachya Benth.	-	H	C,D,E,F,G,H, I,K,M,N,O	2864-3370	+	+
N. podostachys Benth.	-	H	E	3370	+	-
Origanum vulgare L.	Lamay masha, Massow	H	A,L,N	2654-3266	+	+
Thymus linearis Benth.	Kochi masha	H	A,G,L,N	2654-3290	+	+
Liliaceae						
Polygonatum cirrhifolium (Wall.) Royle	-	H	B	2781	-	+
Oleaceae						
Fraxinus xanthoxyloides (G.Don.) DC.	Thrung, Sanjal, Shunu	T	A	2654	-	+
Orchidaceae						
Dactylorhiza hatagirea (D. Don.) Soo	Salampanja,Hathpanja	H	F,I	3280-3305	+	-
Plantaginaceae						
Plantago depressa Willd.	Maran	H	J	3225	+	-
Poaceae						
Agrostis pilosula Trin.	Nakchi	H	A,B,E	2654-3370	+	+
Avena fatua L.	Kasam, Gwajung	H	D,E,GH,I,J, K,L,N,P	3134-3370	+	-
A. sterilis L. ssp. *ludoviciana* (Durieu) Gillet and Magne	Winter white oat	H	C	2864	-	+
Bothriochloa ischaemum L.	-	H	B	2781	-	+
B. pertusa (L.) *A. Camus*	-	H	C	2864	-	+
Brachypodium sylvaticum Huds.	-	H	C,G,J,K	2864-3290	+	+
Briza media L.	-	H	B,N	2781-3134	+	+
Bromus japonicus Thunb. ex Murr.	-	H	D,E,G	3160-3370	+	-
B. pectinatus Thunb.	-	H	C	6864	-	+
Calamagrostis emodensis Griseb.	Chupcha preg	H	E	3370	+	+
C. holciformis Jaub. and Spach.	-	H	G,H	3160-3290	+	-
Deschampsia caespitosa (L.) P. Beauv.	-	H	B	2781	-	+
Elymus nutans Griseb.	-	H	F,G,H,I,J,K,M,N	3134-3305	+	-
Eragrostis minor Host.	-	H	B,E,F,G,H,I,J, K,L,M,N	2781-3370	+	+
E. pilosa L.P. Beauv.	-	H	E	3370	+	-

Table 4: Contd...

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Phacelurus speciosus (Steud.) C.E. Hubb.	-	H	G,O	2985-3290	+	-
Phalaris arundiancea L.	-	H	B,G,H,I,J	2781-3305	+	+
Phragmites australis (Cav.) Trin. ex Steud.	-	H	C,G,N	2864-3290	+	-
Poa alpina L.	-	H	A	2654	-	+
Setaria viridis (L.) P. Beauv.	-	H	D,E,G,H,K,O	2985-3370	+	-
Polygonaceae						
Bistorta affinis Greene	Chunru, Kapad	H	G,H,I	3160-3305	+	-
B. amplexicaulis var. *amplexicaulis* D. Don.	Bao jing liao	H	H	3160	+	-
Fagopyrum esculentum Moench	Brafo	H	H	3160	+	-
Oxyria digyna (L.) Hill	Surjilap	H	J	3225	+	-
Polygonum alpinum All.	Alipap	H	B,E,G,H	2781-3370	+	+
P. plebium R.Br.	-	H	A,B,D,G,J,L,M,O	2654-3316	+	-
Rheum australe Spreng.	Archo	H	G	3290	+	-
Rumex acetosa L.	Surjilove	H	B,C,F,G,H,L,J, K,M,N,O	2781-3305	+	+
R. nepalensis Spreng.	Napchati	H	A,D,F,G,I,K, L,M,N	2654-3316	+	+
Primulaceae						
Primula denticulata Sm.	-	H	H,I	3160-3305	+	-
Ranunculaceae						
Aconitum heterophyllum Wall. ex Royle	Bonga, Atees,Boa	H	H,I	3160-3305	+	-
Aquilegia fragrans Benth.	Zadul-dorje	H	E	3370	+	-
Ranunculus laetus Wall. ex D. Don.	-	H	B,D,E,G,J,K,M	2781-3370	+	-
Thalictrum cultratum Wall.	-	H	C,E,K,N	2864-3370	+	+
T. secundum Edgew.	-	H	G	3290	+	-
Rosaceae						
Crataegus songarica G. Koch	Ramjag	T	A	2654	-	+
Cotoneaster microphyllus Wall. ex Lindl.	-	S	A	2654	-	+
Rosa webbiana Wall. ex Royle	Chawag	S	A,C,D,E,G,I,J, K,L,M,N,O	2654-3370	+	+
Fragaria vesca var. *nubicola* L.	Palla	H	B,F,G,J	2781-3290	+	+
Potentilla arbuscula D. Don. var. *ochreata* (Lindl. ex Lehm.)	-	H	H,I	3160-3305	+	-
Sibbaldia cuneata Hornem. ex O. Kuntze	Rosaceae	H	G	3290	+	-
S. parviflora Willd.	Rosaceae	H	G,H,I	3160-3305	+	-

Table 4: Contd...

Taxa/Family	*Local name*	*Life form*	*Locality*	*Altitude (m asl)*	*Valley wise distribution*	
					Bhaga valley	*Patan valley*
Rubiaceae						
Galium aparine L.	-	H	E,F,G,H,L,N	3134-3370	+	-
G. asperifolium Wall.	-	H	C,F,G,H,I,K,M,O	2864-3305	+	+
Salicaceae						
Salix alba L.	Chanker	T	F	3280	+	-
S. daphnoides Vill.	Belley	T	A,F,G,H,I,J, K,L,M	2654-3305	+	+
S. fragilis L.	Shen-bhut	T	E,G	3290-3370	+	-
S. lindleyana Wall. ex Anders.	Chikas	T	A	2864	-	+
Scrophulariaceae						
Euphrasia foliosa Pennell	-	H	O	2985	+	-
E. himalayica Wettst.	-	H	B,C,F,G,H	2781-3290	+	+
Pedicularis bicornuta Klotzsch ex Klotzsch	Lugru serpo	H	E,G,H,K	3160-3370	+	-
P. hookeriana Wall. ex Benth.	-	H	E	3370	+	-
P. pectinata Wall. ex Benth.	-	H	H,I	3160-3305	+	-
Scrophularia calycina Benth. and Scroph.	-	H	J	3225	+	-
Verbascum thapsus L.	Kolomasta,Jawarna Loudi, Tombru, Tamaku	H	A,C,G,K,L,N	2654-3290	+	+
Veronica biloba L.	-	H	O	2985	+	-
Tamaricaceae						
Myricaria germanica (L.) Desv.	Hombuk, Hombug	S	D,F,G,J,M	3225-3316	+	-
Urticaceae						
Urtica dioica L.	Bichhubooti	H	N	3134	+	-
Violaceae						
Viola biflora L.	Banaksha	H	A	2654	-	+

Abbreviations used: T= Tree; S= Shrub; H= Herb; F= Fern; A= Kukumseri; B= Jahlama; C= Sansa; D= Darcha-1; E= Darcha-2; F= Jispa-1; G= Jispa-2; H= Tinoo-1; I= Tinoo-2; J= Gamour-1; K= Gamour-3; L= Gamour-3; M= Gamour-4; N= Keylong; O= Beiling

there is need to check the long term ecological viability for better sustainability of Himalayan ecosystems. This species was selected for the present study due to its nativity, high economic potential and its ability to withstand extreme environment and biotic pressure. There is also a need to consider long term ecological viability for better sustainability. Sometimes, the dominant plant community inhibits growth of other plant species like a huge plantation of *Pinus* spp., which can bring threat to the survival of other plant in association. The huge plantation of this species without proper assessment can bring questionable mark on long term ecological viability. The study provides information of vegetation association with Seabuckthorn and compared with the other study at different habitat to understand the effect on long term ecological viability.

Phytosociological studies carried out in Lahaul valley to cover variety of habitats that is, riverside, dry slope, hill top, farmer fields and near home garden crops. These surveys show a wide range of plant species present under the canopies of Seabuckthorn. In Bhaga valley, physiographical condition favors the luxurious growth of Seabuckthorn and other plant species in comparison to Patan valley. Species richness shows a 'hump shaped' diversity pattern in the mid-altitudinal range from 3160-3266 m asl, which indicates favorable microclimate and habitat conditions of the area. Diversity indices show species richness of tree and shrub species is very less but the proportion of herb species is quite higher, which is even comparable to ecologically rich habitat. The natural Seabuckthorn stands have high plant diversity, but some of these are exploited by anthropogenic pressure and unscientific collection of fruits and leaves. The dominance of family Asteraceae, Poaceae, Lamiaceae and Rosaceae indicates alpine meadow nature of the study site. The overall diversity of plant species is much higher when compared to other survey reports in same area by different researchers.This indicates that Seabuckthorn plantation is an ecological viable option for sustainable development of the area and this will provide first input for the area and information to other parts of the world. Successful implementation of any programme can only be possible with general awareness, demarcation of ecologically rich area and proper management plan with the participation of local community and for this Himalayan ecosystem requires time to time biodiversity survey to develop effective conservation strategy.

RECOMMENDATIONS

The ecological benefits from the cold desert Himalaya are very peculiar due to the unique floral assemblage that brings high proportion of endemic plant species. Phytosociological studies provide information on the status of the plant species that help to understand the impact on ecological viability. Plant association pattern with Seabuckthorn show an ecologically rich habitat that have its benefit on long term ecological viability. For future this species can further be surveyed in more ecologically diverse habitats and can be tested in the laboratory for more result.

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