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ANTHROPOGENIC THREATS AND THEIR IMPACT ASSESSMENT ON MEDICINAL FLORA OF WESTERN HIMALAYA-NEELUM VALLEY (AZAD JAMMU & KASHMIR)

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Abstract

The goal of this study was to observe anthropogenic (human) threats and evaluate their Overall Threat Impact (OTI) on 44 high-valued medicinal plants of Neelum Valley, located in the Western Himalayan range (Azad Jammu & Kashmir). According to the findings, there are currently 28 anthropogenic threats to medicinal plants that belong to the 10 primary threats categories. The major threats observed in the local ecosystem were traditional uses, commercial uses, weak law enforcement, social issues, deforestation, habitat loss, soil erosion, over grazing by livestock, water deficit, and development. Among the total (44) examined species, 14 species are endemic to the Himalayas; of these, 2 species show the narrow distribution and are restricted to W. Himalayas. All reported medicinal taxa were assessed for their Overall Threat Impact (OTI). Of these, 23 species (52.27%) were facing very high OTI, followed by 11 species (25%) in high OTI, 8 species (18%) with low OTI, 2 species (4.5%) with medium OTI. Among all observed threats, the leading threats to plants were unsystematic overcollection, social issues and habitat loss respectively. The medicinal flora, which is graded from high to very high OTI, requires more attention on a priority basis for their long-term survival and sustainable utilization.

Key words: Anthropogenic threats, Medicinal plants, Conservation, Neelum Valley, Himalaya, Issues.

Introduction

Plants have been used as a source of medicines globally from time immemorial. World Health Organization (WHO) stated that 80% of the world's population depended on traditional medicine for their primary health care needs. Whereas, 30% of the world's drugs are prepared by plants (Anwar *et al.*, 1979). Pakistan has rich flora and varied climate having about 6000 flowering plant species, of which around 700 from the Himalayas are used for medicinal and aromatic purposes (Shinwari, 2010). Almost 80% of the endemic flowering plants of the country (of a total of 410 taxa) are confined to the northern and western mountains of Pakistan and Kashmir (Ali, 2008). Mountainous regions provide a naturally conducive environment for the growth of the flora including medicinal plants. In the Himalayan ranges, at least 70% of the medicinal plants and animals are wild, most of the population (70-80%) depends on traditional medicines healthcare (Pie and Manadhar; 1987; Shaheen *et al*., 2012; Shaheen & Shinwari, 2012).

It is estimated that four medicinal plants out of five from the wild are used in medicine (Srivastava *et al*., 1995). Globally, about 15,000 medicinal plant species are estimated to be threatened facing extinction due to overexploitation (Anon., 2007). Many medicinal plants of the Himalayas are endemic (Dhar *et al*., 2000) many of them are economically important (Ijaz *et al.*, 2021). The local communities have been using these plants for various ailments and for a long time they have been dependent on plant resources for their food, health, shelter, fuel, and other purposes also. Therefore, the extensive use of plants in pharmacological therapies and livelihood by local communities, exert heavy biotic pressure. Some other anthropological activities such as deforestation and overexploitation are proliferating agents leading threat to plant diversity, which may cause loss of medicinal plants (MPs) by gradual thrilling into a threatened or rare category and eventually may become extinct. Furthermore, unscientific and unsustainable approaches are implied to collect the MPs for various purposes which are another major cause of plant diversity loss from the area (Hussain & Khaliq, 1996; Ahmad *et al*., 2009). In the present study, a priority ranking (PR) was conducted to know the severity of different threatening factors on the medicinal flora. However, the conservation status of plants is not completely known due to a lack of data for their sustained survival.

The plant hotspot of Pakistan is scattered into 13 natural regions viz., alpine to mangrove forest, but the information on conservation status is limited due to a lot of ambiguity in the available data (Ahmad *et al.*, 2012). In many countries, the range of use of medicinal plants is 4% to 20% while, around 2500 plant species are taken in global trade (Schippman *et al*., 2002). About 60% of people of remote areas are engaged in the collection and processing of different medicinal plants. They do not known the proper timing of collection nor the processing, storing, and marketing procedure. Resultantly such types of activities cause loss of biodiversity (Qamar *et al.*, 2010). Ibrar (2003) examined the conservation status of eight medicinal plants from Himalaya (Pakistan) and his approach was based on the availability of medicinal plants in markets and consumption instead of quantitative data on population size, the extent of occurrence, and area of occupancy. To determine the conservation status of a taxon, it is necessary to monitor population size, determine the extent of occurrence and area of occupancy, and the nature and extent of any threats (Anon., 2001).

As there are no comprehensive research reports available from the area under consideration, therefore, a present attempt is made to compile the detailed information following the IUCN criteria regarding the impacts of anthropogenic activities on the medicinal plants.

Materials and Methods

Study area: Himalaya has been divided by many workers into Western Himalaya, Central Himalaya, and Eastern Himalaya with varied climatic zones ranging from subtropical to alpine zone based on elevation (Rana and Samant, 2010). Azad Jammu & Kashmir (AJ&K) is located in the foothills of Western Himalaya between 73º to 75º east (longitude) and 33º to 35º north (latitude) with an area of 13,269 km^2 and can be divided into two distinct geographical zones; North and East are mostly hilly and mountainous while South and West are valleys and plains. Azad Jammu & Kashmir (AJK) is rich in plant diversity because of the diversified habitats, such as lakes, rivers, streams, springs, meadows, steep mountain slopes, cultivated fields and wastelands, etc. Extensive topographical variations in the area support variety of plant species ranging from subtropical flora of plains to alpine flora of higher altitudes (Afshan *et al*., 2011).

Neelum district (Neelum Valley) is the largest district of Azad Jammu Kashmir by area and is situated north-east of Muzaffarabad district (Fig. 1). The valley extending approximately 200 kilometers along the Neelum River, covering an area of 3737 km2, lies between 73˚-75˚ E (longitude) and 32˚-35˚ N (latitude) with altitude of 900-6325 meters above sea level (a.s.l). During summer, the maximum daily temperature varies 20-30^{o}C while in winter it is 4-0^{o}C (Mahmood *et al*., 2011). Phytogeographically the area belongs to Sino-Himalayan region (Ali & Qaiser, 1986), and the area is dominated by moist temperate forest, sub-alpine scrubs followed by dry temperate forest, and alpine pastures.

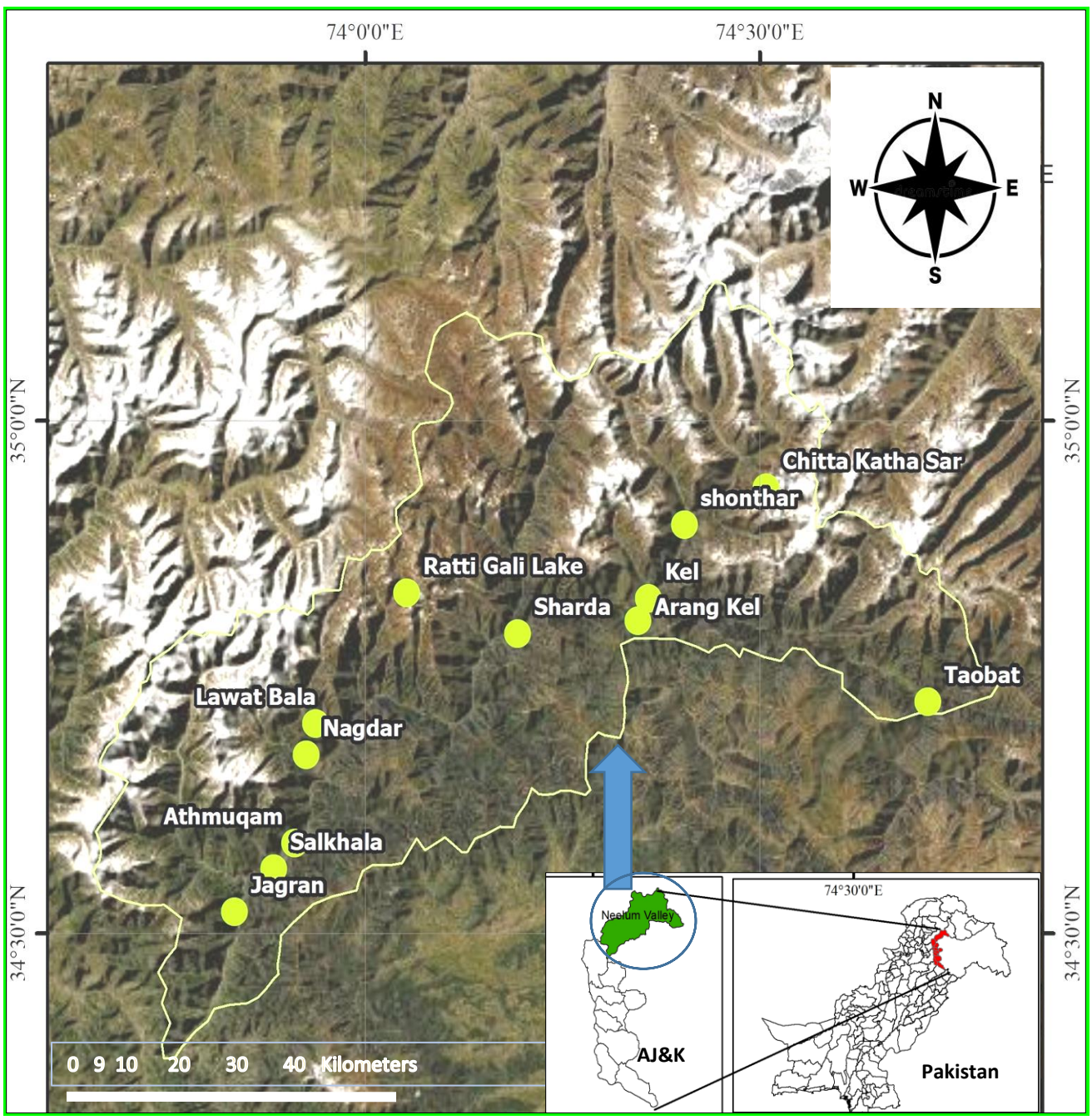

Fig. 1. Map of the study area Neelum Valley Azad Kashmir.

Plant collection: Excursion trips of the study area were undertaken in different seasons from the year 2015-2020 to observe existing threats and collect the plant specimens from the sampling sites which were randomly marked. List of high-valued medicinal plants of the Neelum Valley was prepared from literature (Dar, 2003; Shinwari *et al*., 2006; Mahmood *et al*., 2011) as well as conformed from locals. When plant population sites were marked, 2-3 days were spent there, to determine the loss of medicinally important plant population density. Anthropogenic threats were examined thoroughly in the field of the natural environment. Plants were identified with the help of "Flora of Pakistan" (Nasir & Ali, 1973-1989; Ali & Nasir, 1989-1992: Ali & Qaiser, 1993-2021) and Voucher specimens were deposited in the Prof. Dr. S. I. Ali Herbarium (KUH), Centre for Plant Conservation, University of Karachi.

Experiential estimation of overall threat impact: Field observations were undertaken to identify the current and potential risks to the population of medicinal plant species. The direct and indirect threat of various plants and their habitats were assessed in different seasons of the year at regular intervals of 10-15 days. Threat impact on 44 medicinal plant species was observed through counting the loss of the species from the marked area. The selected size of the area was different for different species depending on the habitat specificity and life form of the species. $50m^2$, $100m^2$, $500m^2$ and $1000m^2$ areas were marked for small herbs and the plants with dense population, $0.5km^2$-$2km^2$was marked which were randomly distributed/found in a large area. The number of individuals of each species were regularly counted during the month of August from 2015-2020 and percentage was determined according to the method proposed by (Master *et al*., 2009; 2012). Two locations (Lawat and Kel situated in Athmuqam and Sharda tehsils respectively) were investigated for overall threat impact.

The Overall Threat Impact (OTI) measures the degree to which a species is directly or indirectly threatened in the study area (global, national, or regional) The threats that have been identified are described as follows "the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes (Salafsky *et al*., 2008). The "Impact"/ "Magnitude" was determined using the approach "Scope" and "Severity" described by Master *et al*., (2009; 2012) and IUCN-CMP (World Conservation Union–Conservation Measures Partnership) (2006). Scoring of the "scope" of threats, as given below, was followed.

Pervasive: Affects all or the majority of the population or occurrences (71–100%). **Large:** Affects a large percentage of the population or occurrences (31–70%). **Restricted:** Affects a small percentage of the population or occurrences (11–30%). **Small=**Affects only a small (1–10%) percentage of the total population. Within the "scope", "severity" is the rank of destruction/damage to the species from the threat that can reasonably be estimated with continuation of current circumstances/ trends. For a taxon, "severity" is usually calculated as the level of reduction of the species' population. The recommended IUCN-CMP ranking of threat "severity," as listed below was followed. **Extreme:** within the scope of the threat, the threat is likely to destroy or eliminate the occurrences of an ecological community, system, or species, or lower the population of the species by 71–100%. **Serious:** within the extent of the threat, the threat is anticipated to seriously degrade/decrease the affected occurrences or habitat, or, in the case of species, to reduce the population by 31–70%. **Moderate:** Within the extent of the threat, the threat is likely to moderately decrease the afflicted occurrences or habitat, or, in the case of species, to lower the population by 11-30%. **Slight:** Within the scope of the threat, the threat is only likely to degrade the afflicted occurrences or habitat, or, in the case of species, to lower the species population by 1–10%.

The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the region of concern is known as threat "impact" (or "magnitude"). The relationship between assigned scope and severity values determines the threat's impact. "Very high," "High," "Medium" and "Low" are the four levels of threat. The connection of threat impact and population degradation and guidelines for assigning overall Impact value has been well-defined in the guidelines of (Anon., 2006) and Master *et al*., (2009; 2012).

Results and Discussion

Plants are frequently facing multiple threats from their environment such as habitat loss, introducing invasive species, deforestation, over-collection, pollution, ground demand for natural resources, grazing, lack of adequate training, and illegal trading (Alam & Ali, 2009). Qamar *et al*., (2010) discussed some other threats to medicinal plants such as soil erosion, poverty, weak law enforcement, fires, and habitat degradation. According to the study conducted by (Ganie *et al*., 2019) argued that the medicinal flora of the Kashmir Himalaya had been exposed to 13 different type of threats and these threats had a significantly bad impact on plant species as well as their habitats. Currently, in the study area, we observed 28 threats that have bad impact on medicinal flora caused by human activity directly or indirectly categorized into following 10 major categories (Tables 1, 2 and 3).

Traditional uses: Overharvesting of natural wealth (plants) for multiple purposes had damaged plant diversity; around 15,000 medicinal plants were accounted to be threatened with extinction globally owing to overexploitation (Anon., 2007; Ganie *et al.*, 2019). We observed most of the medicinal plants are being locally used as food and also preserved for consumption in the off-season. The pressure of overcollection on most of the medicinal plants not only reduces the population size of these plants it may also cause species extinction as well. Because the most ideal mode of reproduction in all studied plants is asexual/vegetative reproduction which means these plants replicate through underground rhizome, bulb, and tuber; on the other hand, consumption of these parts in medicine is very high. That's why asexual reproduction has been rapidly decreased and cause loss of population, but propagation through seed occurrence is very low. A plant completely matures during the time of three years or more. It is owing to harsh climatic conditions, low seed viability, long time seed dormancy and unavailability of seeds in the soil (due to improper time of collection and excessive use). We observed that the population density of 22 plants-*Aconitum heterophyllum, Allium humile, Allium carolinianum, Allium schoenoprasum*, *Allium victorialis*, *Angelica archangelica*, *Angelica glauca*,

Arnebiabenthamii, *Bergenia stracheyi*, *Campanula latifolia, Dipsacusinermis*, *Dolomiaea macrocephala, Dryopteris crassirhizoma, Geranium wallichianum*, *Lindelofia longiflora, Megacarpaea polyandra, Polygonum affine, Potentilla eriocarpa, Pteridium aquilinum*, *Rheum australe, Rheum webbianum* and *Aucklandia costus* was badly affected owing to excessive use as food and medicine both.

Social issues: There are many social issues in the area; one of them is poverty (Qamar *et al*., 2010). Which causes lot of problems such as unemployment, corruption, illegal trade, food crisis, lack of contemporary health facilities, lack of a loyal leader, etc., of them, the most dangerous threat to medicinal plant diversity is unethical overexploitation. Usually, women (90%) are involved in the collection of medicinal plants while 10% are male, and they are unaware of suitable time for the collection.

Commercial uses: The unchecked commercialization of wild medicinal plants is threatening the future of vital resources, as well as the beauty, diversity, and natural heritage of our planet (Kulik & Roberson, 2008). Moreover, they also reduce resources of the medicinally important plant due to which these plants are inaccessible and unaffordable for the local communities or human population as they relied on these plants. The traditionally important medicinal plant species are over-exploited legally or illegally in the wild for sale or trading in the local, national or international markets (Ganie & Tali, 2013). In our reported plants, the underground parts of some medicinal plants such as *Aconitum heterophyllum*, *Aucklandia costus*, *Fritillaria cirrhosa, Trillium govanianum* and *Valerina jatamansi*are sold in the market and are source of revenue generation. Due to high industry demand the extraction of their underground parts for revenue generation is a serious threat to their survival.

Weak law imposition: Checking and monitoring system of wild medicinal plants is not very effective in the area under consideration (Qamar *et al.,* 2010). In upper areas of the Neelum Valley, people are free to collect as well as harvest medicinal plants from natural habitats for revenue generation or local use. Many inhabitants in the area are involved in illegal trade and they have no permit for collection. Therefore, they can easily collect medicinal plants in huge quantities and sell them in the market. On the other hand, the reforestation process on the wide range areas by locals and government level is very slow.

Human influence: The practice of overharvesting of traditionally important medicinal plants along with grasses or other herbs by inhabitants and their bad activities in natural habitats has severely rendered the plant population. It was noticed that when people go to the field for collecting the plants they trample the population of associated/neighbor plants. Sometimes the natural area is also affected by playing games by locals or temporary settlements of nomads/tourists. Many plants such as *Aconitum chasmanthum, Allium humile, Allium carolinianum, Allium schoenoprasum, Allium victorialis, Arnebia benthamii, Trillium govanianum, Delphinium pyramidale, Polygonum affine*, and *Lindelofia longiflora* are highly sensitive to direct human influence as well as cattle. Outer nomads which are hundreds in number go to the area during summer for feeding their sheep and goat and stay temporarily (usually in tents) at high altitudes where medicinal plants are abundant and are badly impacted by them.

Table 1. Different observed anthropogenic threats to wild medicinal plants of Neelum Valley, Azad Kashmir.

Anthropogenic threats	Sub-categories	Acronym	Threat no.
Traditional uses	Overcollection for food use	OFU	1
	Overcollection for medicinal use	OMU	2
	Preservation for local use in off-season	PFO	3
Commercial uses	Revenue generation	RG	4
	Excessive industry demand	EID	5
Social issues	Unsystematic way of collection/illiteracy/poverty	UIP	6
	Illegal trade	IT	7
Weak law imposition	Lack of proper supervision	LPS	8
	Slow process of forest restoration	SPR	9
	Out listing of plant from priority conservation list	OPC	10
Human influence	Unregulated tourism	UT	11
	Temporary visits by locals for plant collection/ lallygag/excursion	TV	12
	Bad activities of the local people	BA	13
	Seasonal settlement of nomads	SA	14
Development	Road making	RM	15
	Unregulated seasonal accommodation for tourists	USA	16
Deforestation	Cutting as fuelwood	CF	17
	Cutting forests for furniture and house making	CFH	18
Livestock	Overharvesting for treatment of cattle diseases	OTD	19
	Grazing effect	GE	20
	Cattle influence	CI	21
	Collection for stock (forage)	SFO	22
Water deficit	Flood change the water direction	FCD	23
	Water direction changes toward another side through the pipeline	WDC	24
Habitat loss	Soil erosion/Flood/Landslides	SFL	25
	Deforestation	DE	26
	Forest fire	FF	27
	Land misuse caused flash flood/soil erosion	LMF	28

Table 2. The overall threat impact (OTI) of anthropogenic threats on the medicinal plants in Neelum Valley Azad Kashmir, Pakistan.

S. No.	Species, Family	Origin	Anthropogenic threats	Current threat(s)	Scope	Severity	Impact	Overall threat impact
1.	*Achillea millefolium* L., Compositae	Native	Traditional uses	2◘	Small	Slight	Low	Low
			Social issues	6♦	Small	Slight	Low	
			Weak law imposition	10♦	Large	Moderate	Medium	
			Livestock	20♦, 22◘	Small	Slight	Low	
2.	*Aconitum chasmanthum* Stapf ex Holmes., Ranunculaceae	Native	Traditional uses	2♦	Small	Slight	Low	High
			Weak law imposition	10●	Large	Serious	High	
			Human influence	11●, 12●, 14●	Large	Serious	Medium	
			Development	15●, 16●	Large	Serious	Medium	
			Livestock	21♦	Small	Slight	Low	
			Water deficit	24◘	Small	Slight	Low	
			Habitat loss	25♦, 28◘	Restricted	Moderate	Medium	
3.	*Actaea spicata* L., Ranunculaceae	Native	Weak law imposition	10◘	Large	Moderate	High	High
			Human influence	12●, 13●	Restricted	Moderate	Medium	
			Habitat loss	25♦,26●, 27♦, 28◘	Restricted	Moderate	Medium	
4.	*Aconitum heterophyllum* Wall. ex Royle., Ranunculaceae	Endemic to W. Himalaya	Traditional uses	2●, 3●	Pervasive	Extreme	High	Very high
			Commercial uses	4●, 5●	Pervasive	Extreme	High	
			Social issues	6●	Large	Serious	High	
			Weak law imposition	7●, 8●	Restricted	Moderate	High	
			Livestock	21◘	Small	Small	Low	
			Habitat loss	25♦, 28◘	Small	Small	Low	
5.	*Allium humile* Kunth., Amaryllidaceae	Endemic to W. Himalaya	Traditional uses	1●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	12◘,13◘, 14◘	Small	Moderate	Moderate	
			Livestock	20●, 21●	Large	Serious	High	
6.	*Allium carolinianum* DC., Amaryllidaceae	Endemic to Himalaya	Traditional uses	1●,2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	13◘, 14●	Large	Moderate	Medium	
			Livestock	20●, 21●	Large	Serious	High	
7.	*Allium schoenoprasum* L., Amaryllidaceae	Endemic to Himalaya	Traditional uses	1●,3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	13◘, 14●	Restricted	Small	Medium	
			Livestock	20●, 21●	Large	Serious	High	
8.	*Allium victorialis* L., Amaryllidaceae	Native	Traditional uses	1●, 3◘	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Livestock	20◘	Small	Slight	Low	
			Habitat loss	25♦, 26●, 27♦	Large	Slight	Low	

Table 2. (Cont'd.).

S. No.	Species, Family	Origin	Anthropogenic threats	Current threat(s)	Scope	Severity	Impact	Overall threat impact
9.	*Angelica archangelica* L., Apiaceae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	13◘	Small	Slight	Low	
			Livestock	19●	Large	Serious	High	
			Habitat loss	25◘	Small	Slight	Low	
10.	*Angelica glauca* Edgew., Apiaceae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	9●, 10●	Large	Serious	High	
			Livestock	19●, 21◘, 22●	Large	Serious	High	
			Habitat loss	25♦, 26●, 27♦, 28♦	Restricted	Slight	Low	
11.	*Aquilegia fragrans* Benth., Ranunculaceae	Native	Traditional uses	3◘	Small	Slight	Low	Low
			Weak law imposition	8♦, 9♦, 10♦	Small	Slight	Low	
			Human influence	14♦	Small	Slight	Low	
			Habitat loss	25♦,26♦, 27♦, 28♦	Small	Slight	Low	
12.	*Artemisia annua* L., Compositae	Native	Traditional uses	2♦	Small	Slight	Low	Low
			Social issues	6♦	Small	Slight	Low	
			Weak law imposition	10♦	Small	Slight	Low	
			Livestock	20◘, 22●	Restricted	Moderate	Low	
			Habitat loss	25◘	Small	Slight	Low	
13.	*Arnebia benthamii* (Wall. ex G.Don) I.M.Johnst., Boraginaceae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	13◘, 14♦	Small	Slight	High	
			Livestock	20◘	Small	Slight	Low	
			Habitat loss	25◘	Small	Slight	Low	
14.	*Bergenia stracheyi* (Hook.f. & Thomson) Engl., Saxifragaceae	Endemic to W. Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Habitat loss	25♦	Small	Slight	Low	
15.	*Betula utilis* D. Don., Betulaceae	Endemic to W. Himalaya	Traditional uses	1◘, 2◘	Small	Slight	Low	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10◘	Large	Serious	High	
			Deforestation	17●, 18●	Large	Serious	High	
			Habitat loss	25♦	Small	Slight	High	
			Livestock	22●	Large	Serious	High	
16.	*Campanula latifolia L., Campanulaceae*	Native	Traditional uses	1●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Livestock	20●	Large	Serious	High	

Table 2. (Cont'd.).

S. No.	Species, Family	Origin	Anthropogenic threats	Current threat(s)	Scope	Severity	Impact	Overall threat impact
17.	*Delphinium pyramidale*Royle., Ranunculaceae	Native	Traditional uses	2♦	Small	Slight	High	Very high
			Livestock	20●	Large	Serious	High	
			Habitat loss	25♦	Small	Slight	Low	
			Human influence	11●,12●, 13●, 14●	High	Slight	High	
18.	*Dipsacus inermis* Wall., *Caprifoliaceae*	Native	Traditional uses	1●, 2●, 3●	Restricted	Slight	Low	Low
			Social issues	6●	Restricted	Slight	Low	
			Weak law imposition	10●	Restricted	Slight	Low	
19.	*Dolomiaea megacephala* Qaiser, A. Ghafoor& R. Abid., Compositae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Habitat loss	25♦	Small	Slight	Low	
20.	*Dryopteris crassirhizoma Nakai., Dryopteridaceae*	Native	Traditional uses	1●, 3●	Large	Serious	High	Very high
			Social issues	6●	Restricted	Serious	High	
			Weak law imposition	10●	Restricted	Serious	High	
21.	*Euphorbia helioscopia* L., Euphorbiaceae	Native	Traditional uses	2♦	Small	Slight	Low	High
			Weak law imposition	10●	Small	Slight	Low	
			Human influence	13●, 14●	Large	Moderate	Low	
			Development	15♦	Restricted	Slight	High	
			Livestock	21◘	Small	Slight	Low	
22.	*Fritillariacirrhosa* D.Don., Liliaceae	Native	Traditional uses	2♦	Large	Serious	High	Very high
			Commercial uses	4●, 5●	Pervasive	Extreme	High	
			Social issues	6●	Large	Serious	High	
			Weak law imposition	7●, 8●	Restricted	Slight	High	
			Livestock	21◘	Small	Slight	Low	
23.	*Geranium wallichianum* D.Don ex Sweet., Geraniaceae	Native	Traditional uses	1♦, 2●, 3●	Large	Serious	High	High
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	9●, 10●	Restricted	Slight	Low	
			Human influence	13♦	Small	Slight	Low	
			Habitat loss	25♦, 26●, 27♦	Restricted	Slight	Low	
24.	*Inularoyleana* DC., Compositae	Native	Traditional uses	2♦	Small	Slight	Low	Low
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Small	Slight	Low	
			Human influence	13♦	Small	Slight	Low	
25.	*Iris hookeriana* Foster., Iridaceae	Native	Traditional uses	2◘	Small	Slight	Low	High
			Weak law imposition	10●	Large	Serious	High	
			Human influence	14♦	Restricted	Slight	Low	
			livestock	21◘	Small	Slight	Low	
26.	*Juniperus communis* L., Cupressaceae	Native	Traditional uses	2◘	Small	Slight	Low	Medium
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	9●, 10●	Small	Slight	Medium	
			Deforestation	17●	Large	Serious	High	
			Human influence	14●	Small	Slight	Low	

Table 2. (Cont'd.).

S. No.	Species, Family	Origin	Anthropogenic threats	Current threat(s)	Scope	Severity	Impact	Overall threat impact
27.	*Juniperus squamata* Buch.-Ham. ex D.Don., Cupressaceae	Native	Traditional uses	2◘	Small	Slight	Low	Medium
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	9●, 10●	Large	Serious	High	
			Deforestation	17●	Large	Serious	High	
			Human influence	14●	Restricted	Slight	Low	
28.	*Lindelofia longiflora* (Benth.) Baill., Boraginacea	Native	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	13♦, 14●	Restricted	Slight	High	
			Livestock	20●	Large	Serious	High	
29.	*Meconopsis aculeata* Royle., Papaveraceae	Endemic to Kashmire	Traditional uses	2◘	Small	Slight	Low	Low
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Large	Slight	Low	
30.	*Megacarpaeapolyandra*Benth ex Madden., Brassicaceae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
31.	*Polygonum affine* D.Don., Polygonaceae	Endemic to Himalaya	Traditional uses	1●, 2●, 3●	Large	Slight	Low	High
			Social issues	6●	Large	Slight	Low	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	14♦	Restricted	Slight	Medium	
			Development	15♦, 16♦	Small	Slight	Medium	
			Livestock	20●	Large	Serious	High	
32.	*Potentilla eriocarpa* Wall. exLehm., Rosaceae	Native	Traditional uses	1●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
33.	*Pteridium aquilinum* (L.) Kuhn., Dennstaedtiaceae	Native	Traditional uses	1●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
			Habitat loss	25♦, 28●	Restricted	Slight	Low	
34.	*Rheum australe D. Don., Polygonaceae*	Native	Traditional uses	1●	Small	Slight	Low	High
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Large	Serious	High	
			Human influence	14♦	Small	Slight	Low	
			Habitat loss	26♦, 27●	Small	Slight	Low	
35.	*Rheum webbianumRoyle., Polygonaceae*	Native	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Social issues	6●	Large	Serious	High	
			Weak law imposition	10●	Large	Serious	High	
36.	*Rhodiola heterodonta* (Hook.f. & Thomson) Boriss., Crassulaceae	Native	Traditional uses	1♦, 2♦, 3♦	Small	Slight	Low	Low
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Large	Moderate	Low	

Table 2. (Cont'd.).

S. No.	Species, Family	Origin	Anthropogenic threats	Current threat(s)	Scope	Severity	Impact	Overall threat impact
37.	*Rhodiola wallichiana*(Hook.) S.H.Fu., Crassulaceae	Native	Traditional uses	1♦, 3●	Small	Slight	Low	High
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Large	Moderate	High	
38.	*Aucklandia costus*Falc. (syn. *Saussurea costus* (Falc.) Lipsch)., Compositae	Native	Traditional uses	1●, 2●, 3●	Large	Serious	High	Very high
			Commercial uses	4●, 5●	Large	Serious	High	
			Social issues	6●	Large	Serious	High	
			Weak law imposition	7●,8●	Large	Serious	High	
			Habitat loss	26◘, 27◘, 28♦	Small	Slight	Low	
39.	*Sinopodophyllum hexandrum* (Royle) T.S. Ying., Berberidaceae	Endemic to Himalaya	Traditional uses	1◘, 2◘	Small	Slight	Low	High
			Social issues	6●	Small	Slight	Low	
			Weak law imposition	10●	Large	Moderate	High	
			Livestock	21◘	Small	Slight	Low	
40.	*Skimmia laureola* (DC.) Sieb. &Zucc. ex Walp., Rutaceae	Native	Traditional uses	1♦, 2♦, 3◘	Small	Slight	Low	Low
			Weak law imposition	9●, 10●	High	Moderate	Low	
			Habitat loss	25♦, 26♦, 27◘	Small	Slight	Low	
41.	*Swertia ciliata* (D. Don ex G. Don) B.L. Burtt., Gentianaceae	Native	Traditional uses	2♦, 3◘	Small	Slight	Low	High
			Social issues	6♦	Small	Slight	Low	
			Weak law imposition	10●	Large	Serious	High	
			Habitat loss	28◘	Small	Slight	Low	
42.	*Swertia speciosa* Wall., Gentianaceae	Native	Traditional uses	2♦, 3◘	Small	Slight	Low	High
			Social issues	6♦	Small	Slight	Low	
			Weak law imposition	10●	Large	Serious	High	
			Development	15●, 16●	Large	Serious	High	
			Water deficit	23♦, 24♦	Small	Slight	Low	
43.	*Trillium govanianum* Wall. ex Royle., Melanthiaceae	Native	Traditional uses	1◘, 2◘	Large	Serious	High	Very high
			Commercial uses	4●, 5●	Pervasive	Extreme	High	
			Social issues	6●	Large	Serious	High	
			Weak law imposition	7●, 8●, 9●	Restricted	Moderate	High	
			Human influence	12♦,	Small	Slight	Medium	
			Livestock	21◘	Restricted	Moderate	High	
			Habitat loss	26●, 27●	Large	Moderate	High	
44.	*Valeriana jatamansi* Jones., Caprifoliaceae	Native	Traditional uses	2◘, 3◘	Small	Serious	Low	High
			Commercial uses	4●, 5●	Restricted	Serious	Medium	
			Social issues	6●	Large	Serious	High	
			Weak law imposition	7●, 8●, 9●	Restricted	Moderate	Medium	
			Human influence	14♦	Small	Slight	Low	
			Habitat loss	26●, 27●, 28♦	Large	Moderate	High	

Key: ●=Highly exposed to existed threat, ♦=Fairly exposed to existed threat, ◘= Low exposed to existed threat

Table 3. Medicinal plant species affected by various anthropogenic threats observed in the Neelum Valley, AJ&K.

Species ↓ Threats →	LMF	FF	DE	SFL	WDC	FCD	SFO	CI	GE	OTD	CFH	CF	USA	RM	SA	BA	TV	UT	OPC	SPR	LPS	IT	UIP	EID	RG	PFO	OMU	OFU
Achillea millefolium	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Aconitum chasmanthum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Actaea spicata	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Aconitum heterophyllum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Allium humile	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Allium carolinianum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Allium schoenoprasum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Allium victorialis	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Angelica archangelica	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Angelica glauca	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Aquilegia fragrans	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Artemisia annua	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Arnebia benthamii	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bergenia stracheyi	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Betula utilis	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Campanula latifolia	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Delphinium pyramidale	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Dipsacus inermis	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Dolomiaea megacephala	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Dryopteris crassirhizoma	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Euphorbia helioscopia	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Fritillaria cirrhosa	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Geranium wallichianum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Inula royleana	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Iris hookeriana	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Juniperus communis	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Juniperus squamata	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Lindelofia longiflora	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Meconopsis aculeata	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Megacarpaea polyandra	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Polygonum affine	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Potentilla eriocarpa	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Pteridium aquilinum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rheum australe	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rheum webbianum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rhodiola heterodonta	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Rhodiola wallichiana	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Aucklandia costus	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Sinopodophyllum hexandrum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Skimmia laureola	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Swertia ciliata	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Swertia speciosa	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Trillium govanianum	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Valeriana jatamansi	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Key: = No affect, = Moderate threat, =High threat, = Low threat

Development: The unplanned development may also cause negative impacts and lead towards the declination of plant diversity (Tali *et al*., 2014). The habitats of most plants have been badly harmed in contemporary times due to the rise of the tourist industry (Ganie *et al*., 2019). Urbanization is considered as the major factor, causing forests to be cleared to allow for housing projects. Similarly, unplanned roads making, tourist spots (picnic points), cutting forests for furniture and house making, clearing the forests for agriculture, seasonal accommodation for tourists especially near the lakes, waterfalls, and grassy plains in the natural areas (especially in the upper areas of the Valley) are those activities responsible for the decline of many plants population and habitats such as *Aconitum chasmanthum, Delphinium pyramidale, Iris hookeriana, Euphorbia helioscopia, Polygonum affine* and *Swertia speciosa.*

Deforestation: Deforestation leads to habitat fragmentation, shrinking patch size and core area, and isolation of appropriate habitats, in addition to habitat loss (MacDonald, 2003). Due to the unavailability of natural gas facilities, the local communities use wood as the main source of fuel. The fuelwood mainly comes from trimming of lower branches or by cutting the whole tree from forest, which is easier to collect and this generally meets the requirements of households, and local use causes major damage to habitat. The frequent chopping of shrubs, lower branches, and trees for fuel and cooking also caused habitat degradation including the increased possibility of soil erosion. Deforestation in the Himalayan regions is normally accredited to demographic demands and its associated effects i.e., increase in demand for farming, development of livestock, utilization of native forest for fodder, fuelwood, and timber (Saira & Iqbal, 2017). Forest fire erodes many plants especially when fire damage forests many other plants which grow under the trees are also badly affected or sometimes even vanish from the area. Some species such as *Actaea spicata, Allium victorialis, Angelica archangelica, A. glauca, Dipsacus inermis, Geranium wallichianum, Skimmia laureola, Trillium govanianum, Valeriana jatamansi* are found in the forests or bushes with healthy growth. The deforestation not only reduces density of trees and shrubs but also under stony population of herbaceous plants also decline.

Livestock: Although most medicinal plants are not eaten by livestock, however, the impact of grazing becomes high and more serious at the end of the summer season (Alam & Ali, 2009). Overgrazing inhibits the spread of species not just via direct consumption but also by modifying their microhabitats (Sher *et al.*, 2010). The plant populations particularly in the forests, alpine and sub-alpine pastures are also disturbed. The pressure on medicinal plants of livestock specifically livestock of outer nomads declines the plant diversity at a broad scale. Plants like *Allium humile, A. carolinianum, A. schoenoprasum, A. victorialis, Betula utilis, Campanula latifolia, Lindelofia longiflora, Polygonum affine* have been highly affected by overgrazing and largely eaten by cattle. Similarly, the extraction of roots of *Angelica archangelica* and *A. glauca* for the treatment of cattle disease cause ample damage to these plants.

Water deficit: Climate change is rapidly becoming the greatest threat to plants (Seaton *et al*., 2010). Moreover, variation in temperature and availability and consumption of water are the main factors that disturb the plant's habitat. Sometimes the direction of the water change toward another side (water supply through pipeline or water storage to another side for human and cattle consumption) resultantly water levering plants disappear from their habitats. Deforestation is also another reason for water shortage, in such a situation *Swertia speciosa* is highly affected.

Habitat loss: Globally habitat loss is recognized as the major threat to biodiversity with an extensive area of vegetation (Brummitt *et al*., 2015).

Along with mountain slopes, the rising frequency of landslides is another threat to the survival of the medicinal plants (Ganie *et al*., 2019). A range of the medicinal plants of Western Himalaya are facing serious threats owing to land-use change (Pandey *et al*., 2019). Habitat loss was recorded owing to many reasons like deforestation, flood, and misuse of land, forest fire, landslides, and soil erosion. It was observed that as other growing association plants are also useful for plant growth it is owing to an allelopathic effect, provide shade for shade-loving plants, increase the organic matter, provide suitable microbes, increase soil moisture and perforation. Such types of association of plants were seen almost in all ecological zones. Likewise, under the forests and shrubs-*Actaeaspicata, Allium victorialis, Angelica glauca, Trillium govanianum, Valerina jatamansi* and *Geranium wallichianum* were observed with healthy growth. Thus, their habitats are interlinked with the dense forests and shrubs growth. The healthy growth of many other plants-*Aconitum heterophyllum, Campanula latifolia, Sinopodophyllum hexandrum, Fritillaria cirrhosa* were observed in association form with many other herbs in the subalpine pastures. Unplanned land use/soil erosion cause major damage to habitat loss of many medicinal species. Dar & Naqshi (2002) argued that soil erosion could wash away into the nearby water sources, caused to increase sedimentation levels creating detrimental effects on the plant diversity. The landslides not only affect the large expanse of the natural population but also cause fragmentation of habitat.

Immediate required conservation measures: An appropriate method of conservation amplification on a wide scale for conserving the medicinal flora is in-situ conservation, which covers biosphere reserves, sanctuaries, woodland, and other natural habitats. Production of medicinal plants will be maintained under such activities because plants grow without any influence and are undisturbed (Natesh, 2000). The Himalayas region of Pakistan demands tremendous concentration for the conservation and sensible use of natural riches. Propagation of medicinal plants on a scientific basis will be profitable to reduce pressure on plants. In this regards public support and awareness through training should be mandatory (Saira & Iqbal, 2017).

Currently, no conservation strategy has been implemented by Government, local and NGOs level, and nobody propagates these plants in agricultural land. The local inhabitants indiscriminately collect these medicinal plants from natural habitats, which is quite alarming. Therefore we must have to pay attention to our precious medicinal plants to prevent them from extinction. For conserving and sustaining the beauty of nature, the following recommendations must be applied on an immediate basis to guarantee sustainable uses.

- Ensure sustainable harvesting, it would be possible through (i) Whole aerial part of the entire plant population in the same habitat should not be picked; (ii) avoid collecting where there are few plants. (iii) It is important to save some plants from the collection sites, (iv) plant from sensitive habitats should not be collected, (v) collection should be done at the right time.
- Alternate energy choices such as solar panels and LPG should be provided to reduce their reliance on fuelwood. Another option would be to provide these rural inhabitants with subsidized gas stoves and cylinders, reducing their dependency on forest resources for fuelwood.
- Grazing of livestock should be stopped in susceptible areas.
- Tree and shrubs which are essential for the growth of other herbaceous plants should be protected.
- To improve techniques for production, storage and harvesting.
- Increase the number of honest, well-trained, and well-paid custodians/staff for the protection of wildlife.
- Increase in employment and income of the local people.
- Most plants can be protected by applying strong law enforcement.
- To ensure targets and techniques for monitoring and keeping complete records on medicinal plants of protected areas as well.
- Awareness should be created among locals through introducing formal courses, conducting programs, and educational campaigns.
- Barrication or signage is mandatory for the flora which is at high risk of extinction.

Conclusion

In the Neelum Valley, most medicinal plants meet various combinations of threats; these anthropogenic threats are highly involved in declining the medicinal plant diversity in the area. Locals rely on forest (*Abies pindrow, Cedrus deodara, Pinus wallichiana* and *Picea smithiana*) to meet fuel needs and build houses. Deforestation not only reduces the tree diversity rather responsible for the habitat loss of many other herbs. On the other hand, overexploitation of medicinal herbs for revenue generation and local use is another major threat to most plants. Checking and monitoring policies are weak and the area is highly under pressure by overgrazing. Among the all studied plants almost 77% medicinal plants are under huge pressure owing to human-caused threats. For the protection of the rich diversity of the Neelum Valley short and long-term conservation measures should be immediately implemented.

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