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CONSERVATION STATUS AND THREATS PATTERN OF NARROW ENDEMICS: A CASE STUDY FROM TERICH VALLEY, HINDUKUSH RANGE, CHITRAL, NORTHERN PAKISTAN

Akhtar ZAMAN[1,*], Lal BADSHAH[2], Shariat ULLAH[3], Zahoor Ahmad SAJID[4], Ghulam JELANI[5]

[1]Phytoecology Lab, Department of Botany, University of Buner, KP, 19281, Pakistan
[2]Phytoecology Lab, Department of Botany, University of Peshawar, KP, 25120, Pakistan
[3] Phytoecology Lab, Department of Botany, University of Malakand, 23050, KP, Pakistan
[4]Department of Botany, University of Punjab Lahore, Punjab, 05422, Pakistan
[5]Plant Taxonomy Lab, Department of Botany, University of Peshawar, KP, 25120, Pakistan

Abstract

Endemic and endangered species of plants are critical components of plant conservation that need urgent human intervention to ensure long-term survival. Plant diversity conservation methods include in situ efforts like national parks, biosphere reserves, and gene sanctuaries, as well as ex-situ approaches like field gene banks, seed gene banks, and in vitro protection. The careful integration of various conservation measures can help not only to rescue endangered plant species but also to expand our knowledge of these species, paving the path for their long-term usage for humanity's benefit. This study reviews the current status of endangered and threatened plant species in Terich valley, followed by the different conservation strategies that are being or can be used to conserve these species in Pakistan along with potential prospects in this region.

Keywords*: Endemics; AOO; EOO; IUCN categories; Geographic maps; Terich valley*

Introduction

Wild plant diversity is quickly declining due to the unprecedented rise in human population, development, and habitat destruction [1]. In Pakistan, 31% of the population lives in rural areas and is entirely reliant on plant resources for their health and income [2]. Plants become extinct at a rate of one species per day as a result of anthropogenic stressors, which is 1000-10000 times faster than natural extinction [3]. If this rate continues, 60,000 to 100,000 plant species will be extinct in the next 50 years [4-6]. At the global level, 33,798 vascular plants (12.5% of the entire flora) are listed as threatened [7, 8]. Deforestation and commercial consumption are the main causing threats in Pakistan's forests and mountainous regions, which are diminishing at a pace of 1.5% per year [9]. The IUCN Red List of Threatened Species aims to assess the extinction risk of all species on the planet and serve as a "barometer of life" for the state of nature. The categories and criteria of the IUCN Red List are only relevant to wild plant populations within a taxon's natural range of ecological occurrence. The growing gravity of the current extinction problem has prompted a concerted effort to assess and track the threat of extinction faced by species all over the world. Over the last four decades, global, international, national, and local lists of endangered species have multiplied [10]. Recognize deteriorating

*Corresponding author: drakhtar@ubuner.edu.pk, akhtarzaman@uop.edu.pk

habitats or species on the verge of extinction as the first step in conservation efforts for endangered wildlife [11]. To define the status of a species, objective, quantifiable, and explicit criteria must be used. This research involves defining threats that are used to inform conservation actions where possible [12].

Terich Valley is home to a diverse range of vegetation. Per Wendelbo originally collected plants from this valley in 1952, according to the records of floristic investigations in Terich valley. The botany of the Chitral Relief Expedition [13]. Unfortunately, little research has been done on Pakistan's vulnerable plants, and there is very little information accessible [14-16]. However, anthropogenic activities such as habitat loss or modification (especially Deforestation and Urbanization), overexploitation of important medicinal plants, invasion of alien species, unregulated grazing, and tourist inflows have all put a large number of species at risk [17]. In addition, most plant species are restricted to subalpine and alpine ecosystems of limited scope and shortage, in order to tthreatenstatus in combination with various types of wild threat factors. Needed to be urgently investigated. From a threat perspective, these endemics are localized to a particular area and are not found anywhere else in the world, so the unique taxa of the area are important [18]. In addition, small populations of these plants occupy small geographical areas and particular habitats [19-21]. Its small population and single small distribution can prompt extinction. Therefore, endemic species need immediate attention [1]. This study is an attempt to assess the conservation status of nine valley endemic species according to the IUCN Category and Criteria 2010 Version 8.1 and according to the IUCN Regional Guidelines 2003 Version 3.1.

Methodology

Study area

Terich is a fascinating valley of Chitral that supports many wild plants. It is located in Chitral from 72º 07' to 73º 97' east longitude and 35º 20' to 36º 55' north latitude. It borders Tajikistan to the north, Badafshan to the west, Nuristan to the south, and the Ghizar district of Gilgit-Baltistan to the east (Fig. 1).

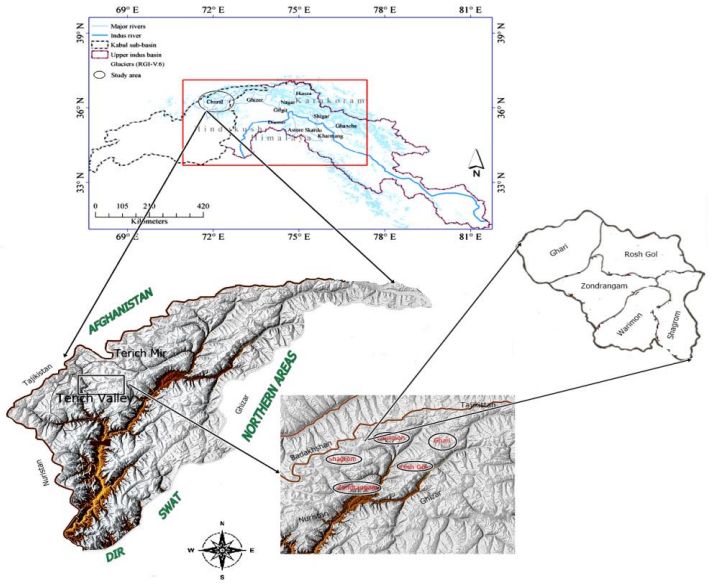

Fig. 1. Map of the study area showing surveyed sites

The valley is characterized by undulating terrain. The climate is cold. Temperatures range from an average minimum temperature of 12°C in winter to an average maximum temperature of 30°C in summer. Phytogeographically, the Terich Valley is located in the Irano-Turranian floristic area [22]. In terms of flora, the Iran-Turanian region is lush and contributes 45.6% to Pakistan's flora. Geologically and ecologically, the Terrich Valley is characterized by arid, temperate, sub-alpine, and alpine types [23]. Following the highest peak of the Hindu-Kush Mountains, Terich mir (7685m), there are Saraghr (7349m), Shakawar (7116m), Langer Peak (7100m) and many other lowland peaks [24].

Eco-geographic survey

Within the Terich Valley, Hindukush range, Chitral, an eco-geographic survey of selected endemics was conducted. The initial step was to learn more about these endemics' occurrence, distribution, and classification by researching relevant literature and examining herbarium specimens at Peshawar University Herbarium (PUH). The information gathered was utilized to create a rough distribution map for these endemics, as well as a schedule and route for field visits. At various times of the year, a complete field investigation was carried out in Terich Valley. The selected plant species were surveyed in five different locations throughout the valley. The physical coordinates of these sites were acquired using the global positioning system (GPS). The following is a list of the sites that have been surveyed (Tables 1 and 2).

Species evaluated

During in the present study, 9 endemic plant species (*Allium chitralicum, Astragalus chitralensis, Astragalus imitensis*, *Anaphalis chitralensis*, *Cuscuta reflexa*, *Delphinium chitralense*, *Delphinium nordhagenii*, *Tanacetum chitralense* and *Pedicularis stantonii*) were evaluated using IUCN Red List Categories and Criteria 2010 version 8.1 following Guidelines for Application of IUCN Red List Criteria at Regional Levels 2003 version 3.0.

Data collection

Record of population structure, habit and habitat

Following Ali and Qaiser, when a population of endemics was identified, the size, habit, habitat, extent, and life form were recorded during repeated field surveys (2010). Mature individuals of each endemic were also counted in each site, with mature individuals defined as those who produce flowers or fruits [25].

Identification of threat factors and population trends

Direct perceptions were made to survey the potential and genuine dangers to an endemic species populace in a given site. Various threats have been reported including overgrazing, deforestation, agricultural land expansion, habitat destruction, landslides, tourism, and over-exploitation.

Measurement of Area of Occupancy (AOO) and *Extent of Occurrence (EOO)*

Geographic coordinates were mapped on a geo-referenced map search engine in ArcView 9.2 (Google Earth, 2018). The α-hull method [26] was used to calculate the Extent of Occurrence. A polygon was drawn by spanning line overall taxons and known sites, omitting those within the polygon boundary, to indicate the breadth of endemic taxa occurrence (EOO) (eq. 1). The existence of endemics was determined using a grid size of 2km (a cell area of 4 km^2). Likewise, the (AOO) was calculated by (eq. 2) with counting the number of occupied grid cells compared to the individual cell area in a uniform grid encompassing the full habitat range [25].

$$\text{Extent of Occurrence EOO} = \frac{\text{Numer of locations of endemic species}}{\text{Subpopulation \& decline number of mature individuals}} \quad (1)$$

$$\text{Area of occupancy (AOO)} = \text{No. of occupied cells x Area of individual cell} \quad (2)$$

Grazing index

The grazing indexes calculated for each endemic species were counted per unit area following [27].

Table 1. Grazing index of individuals

Percentage of grazed individuals	Symbol	Grazing index
1-20 %	+	Less grazed
21-50 %	++	Moderate grazed
51-80 %	+++	Extensively grazed
81-100 %	++++	Critically grazed

Results and discussion

Distribution of selected endemics

In this study, 9 species were evaluated using the IUCN Red Data List categories and criteria [25] version 8.1, with 5 taxa being classified as critically endangered and the other 4 taxa being classified as endangered. The described endemics are found in subalpine and alpine sections of Terich Valley, Chitral, according to the current study. *Allium chitralicum* is a small endemic taxon that grows in temperate and subalpine environments, preferring fairly humid, shaded, and stony undulating crevices of Shagrom between 1480 and 1900 metres. *Anaphalis chitralensis* can be found in the foothills, sub-alpine, and alpine regions between 1975 and 3471 metres (Ghari, Rosh Gol, Warimon, and Zondrangam). This plant grows in the company of junipers, on steep and open terrain, in rock crevices, and in sunny locations. *Astragalus chitralensis* is found in moderately moist, less shady areas between or between rocks in the Warimon, Shagrom, Rosh Gol, and Zondrangam ranges between 2300 and 3200 metres. While *Astragalus imitensis* prefers damp areas in open or shady loose dirty patches, it can also be seen growing with junipers. At Zondrangam and Rosh Gol, the species is found in a typical sub-alpine zone between 2200 and 2590 metres. *Cuscuta villosa* grows in small groups amid the rocks or in rock crevices on very steep, least stable, moist shaded, or open slopes at a height of 2400-3350 meters Rosh Gol. *Delphinium chitralense* grows in the valleys of Warimon, Rosh Gol, and Zondrangam in damp locations between 2000 and 3300 meters in open or shaded settings, rock outcroppings, and rocky crevices, loose soiled, and less pebbly patches. *Delphinium nordhagenii* is found in the subalpine and alpine zones at heights of 3657 meters (Rosh Gol, Ghari). *Pedicularis stantonii* is an alpine endemic taxon that grows inately in humid, shaded, and sandy slopes at an altitude of 3000-4300 meters at Ghari above sea level. *Tanacetum chitralense*, on the other hand, has been found in the valley's Rosh Gol, Ghari, and Zondrangam, and grows in damp locations in open or shaded areas with stony cracks between 2620 and 3700 meters (Fig. 2).

The total number of mature individuals, sub-populations, EOO, AOO, and decline/fluctuations in the number of mature individuals were all recorded throughout the current examination of endemics throughout the Terich valley. In the case of *Allium chitralicum*, there were one sub-population and 39 mature individuals, with 17 mature individuals in 2016, 12 mature individuals in 2017, and 10 mature individuals in 2018, whereas the number of mature individuals declined to 12 and the grazing index was classified as moderate. This species' EOO and AOO were calculated to be 7km^2 and 4km^2, respectively. *Anaphalis chitralensis* was detected in four subpopulations in the Terich valley. This species' AOO and EOO were assessed to be 430km^2 and 22km^2, respectively. There were 619 mature individual plants in total, with 264 in 2016, 233 in 2017, and 122 in 2018, for an average of 206 mature individual plants each year with a grazing index of heavily grazed. In the valley, there are four separate sub-populations of *Astragalus chitralensis*. This species' EOO and AOO were measured at 80km^2 and 7km^2, respectively. In 2016, there were 99 mature individual plants in these sub-populations, but only 60 mature individuals were found in 2017, and only 34 mature

individuals were found in 2018 at an average of 64 individuals per year, and the grazing index was recorded as extensively grazed.

Fig. 2. Images of plants of the valley's Rosh Gol, Ghari, and Zondrangam:
a) *Allium chitralicum, b) Anaphalis chitralensis*; c) *Astragalus chitralensis;*
d) Astragalus imitensis; e) Cuscuta villosa; f) Delphinium chitralense;
g) Delphinium nordhagenii; h) Pedicularis stantonii; i) Tanacetum chitralense

In Terich Valley, *Astragalus imitensis* is found in two sub-populations. In these sub-populations, the total number of mature individual plants was 57 in 2016, 40 in 2017, and only

13 mature individuals were found in 2018, with an average of 37 individuals each year and a moderate grazing index (Table 1).

The species' (AOO) and (EOO) were 6 and 5km^2 respectively. During the research, one sub-population of *Cuscuta villosa* with a confined endemic nature was discovered (Table 2).

Table 2. Conservation status of endemics

Taxa	***Sub-populations***	***Population size***			***Grazed individuals /year***			***AOO (km^2)***	***EOO (km^2)***	***Altitude (m)***
		2016	2017	2018	2016	2017	2018			
Allium chitralicum Wang & Tang.	Shagrom	17	12	10	7	5	-	4	7	1480-1900
	Total		39		12					
	Grazing index	Moderate grazed								
Anaphalis chitralensis Qaiser & Rubina.	Ghari	146	86	62	22	17	9	22	430	1975-3471
	Rosh Gol	87	56	-	12	-	-			
	Warimon	-	68	45	-	13	6			
	Zondrangam	31	23	15	16	9	-			
	Total	264	233	122	50	39	15			
	Grazing index	Extensively grazed								
Astragalus chitralensis Ali.	Shagrom	34	24	16	14	10	-	7	80	2300-3200
	Warimon	27	12	9	7	4	3			
	Zondrangam	20	14	9	9	5	-			
	Rosh Gol	18	10	-	8	4	-			
	Total	99	60	34	38	23	3			
	Grazing index	Extensively grazed								
Astragalus imitensis Ali.	Zondrangam	23	16	9	10	4	4	5	6	2200-2590
	Rosh Gol	34	24	5	9	5	-			
	Total	57	40	13	19	9	4			
	Grazing index	Moderate grazed								
Cuscuta villosa L.	Rosh Gol	56	42	36	12	10	6	3	3	2400-3350
	Total		134			28				
	Grazing index			Less grazed						
Delphinium chitralense H. Riedl.	Rosh Gol	37	22	16	11	4	3	36	460	2000-3300
	Warimon	40	18	8	8	6	5			
	Zondrangam	22	14	6	10	5	-			
	Total	99	54	30	29	15	8			
	Grazing index	Moderate grazed								
Delphinium nordhagenii Wendelbo.	Rosh Gol	45	36	23	14	6	-	5	11	3657
	Ghari	56	32	24	-	9	6			
	Total	101	68	47	14	15	6			
	Grazing index	Less grazed								
Pedicularis stantonii Y. Nasir.	Ghari	46	33	24	14	9	6	3	7	3000-4300
	Total		103			29				
	Grazing index	Moderate grazed								
Tanacetum chitralense (Podlech) K.	Ghari	56		45	26	8	-	5	3	443	2620-3700
	Rosh Gol	45		39	22	6	3	-	2		
	Zondrangam	32		21	14	12	8	7			
	Total	133		105	62	26	11	12			
	Grazing index	Less grazed								

In 2016, 56 mature individuals were observed, 42 in 2017, and only 36 mature individuals were sighted in 2018, with an average of 44 individuals each year and grazing Index was calculated which show less grazed pattern of grazing for this endemic taxon. EOO and AOO were calculated to be 3 km^2 and 3 km^2, respectively. Three subpopulations of *Delphinium chitralense* have been identified. The species' EOO and AOO were 460km^2 and 36km^2, respectively. In 2016, there were 99 mature individuals; in 2017, there were 54 mature individuals; and in 2018, there were 183 mature individuals, with an average of 61 mature individual plants every year. In Terich Valley, two *Delphinium nordhagenii* sub-populations were discovered. In 2016, 101 mature individual plants were spotted, followed by 68 in 2017, and 47 in 2018, for an annual average of 72 mature individual plants. The Endemics AOO and EOO were calculated to be 5km^2 and 11km^2, respectively (Figs 3-5). The total number of sub-populations in the case of *Pedicularis stantonii* was recorded as one, with a limited endemic pattern, and the total number of mature individuals was reported as 103, with 46 in 2016, 33 in 2017, and 24 in 2018, respectively, while the grazing index was recorded as moderate. The species' EOO and AOO were calculated to be 3km^2 and 7km^2, respectively. *Tanacetum chitralensis* was also found in the Terich valley but in three different sub-populations. The species' AOO and EOO were assessed to be 443km^2 and 32km^2, respectively. There were 300 mature individual plants in total, with 133 in 2016, 105 in 2017, and 62 in 2018, for an average of 100 mature individual plants per year and a moderate grazing index (Table 2, Figs. 6-7).

Table 3. IUCN threat categories to selected endemics

Species evaluated	***Total no of mature individuals***	***Total no of sub-populations***	***EOO $(km)^2$***	***AOO $(km)^2$***	***Major threats***	***Criteria met***	***Category assigned***
Allium chitralicum Wang & Tang.	39	1	7	4	Overgrazing, Landslides	B 1 a b (v) 2 a b (v); C 1 2 a (i) (ii); D	Critically Endangered
Anaphalis chitralensis Qaiser & Rubina.	619	4	430	22	Overgrazing, Landslides, overexploitation for local use	A 2 a; B 1 a b (v) c (iii) (iv) 2 a b (v) c (iii) (iv); C 2 b	Endangered
Astragalus chitralensis Ali.	193	4	80	7	Overgrazing, Landslides	C1 2 a (i) b	Critically Endangered
Astragalus imitensis Ali.	110	2	6	5	Overgrazing, Landslides	B 1 a c (i) (ii) (iv); C 2 b	Critically Endangered
Cuscuta villosa L.	134	1	3	3	Overgrazing, Landslides	B 1 a c (i) (ii) (iii) (iv) 2 a c (i) (ii) (iii) (iv); C 2 a (i) b	Endangered
Delphinium chitralense H. Riedl.	183	3	460	36	Overgrazing, Landslides	B 2 a c (i) (ii) (iii) (iv) C 2 a (i) b	Endangered
Delphinium nordhagenii Wendelbo.	276	2	11	5	Overgrazing, Landslides, overexploitation for local use	C 1 2 b	Critically Endangered
Pedicularis stantonii Y. Nasir.	103	1	7	3	Overgrazing, Landslides	B 1 a b (v) c (iv) 2 a b (v); C 1 2 a (i) (ii) b; D	Critically Endangered
Tanacetum chitralense (Podlech) K.	300	3	443	32	Overgrazing, Landslides	A 2 a; B 1 a b (v) c (iii) (iv) 2 a b (v) c (iii) (iv); C 2 b	Endangered

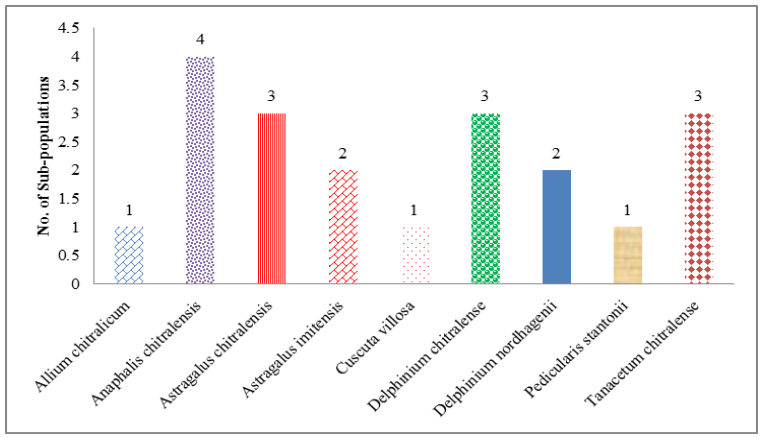

Fig. 3. No. of sub-populations of selected endemics

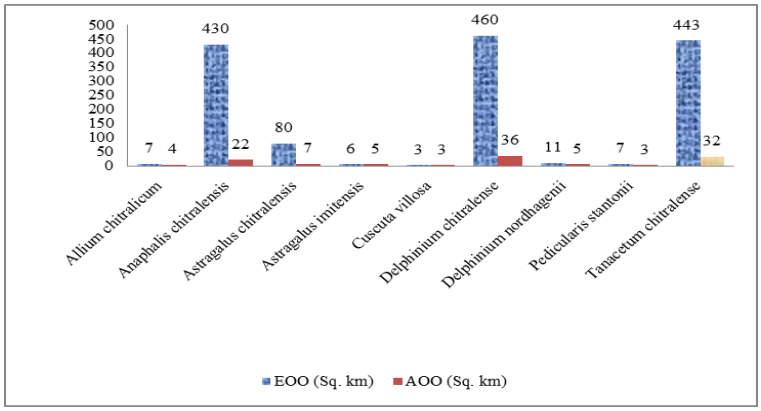

Fig. 4. EOO and AOO of selected endemics

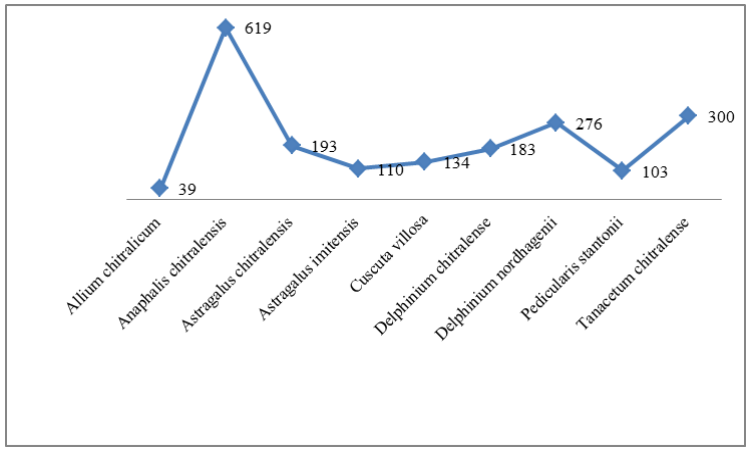

Fig. 5. Total no of mature individuals during 2016-2018

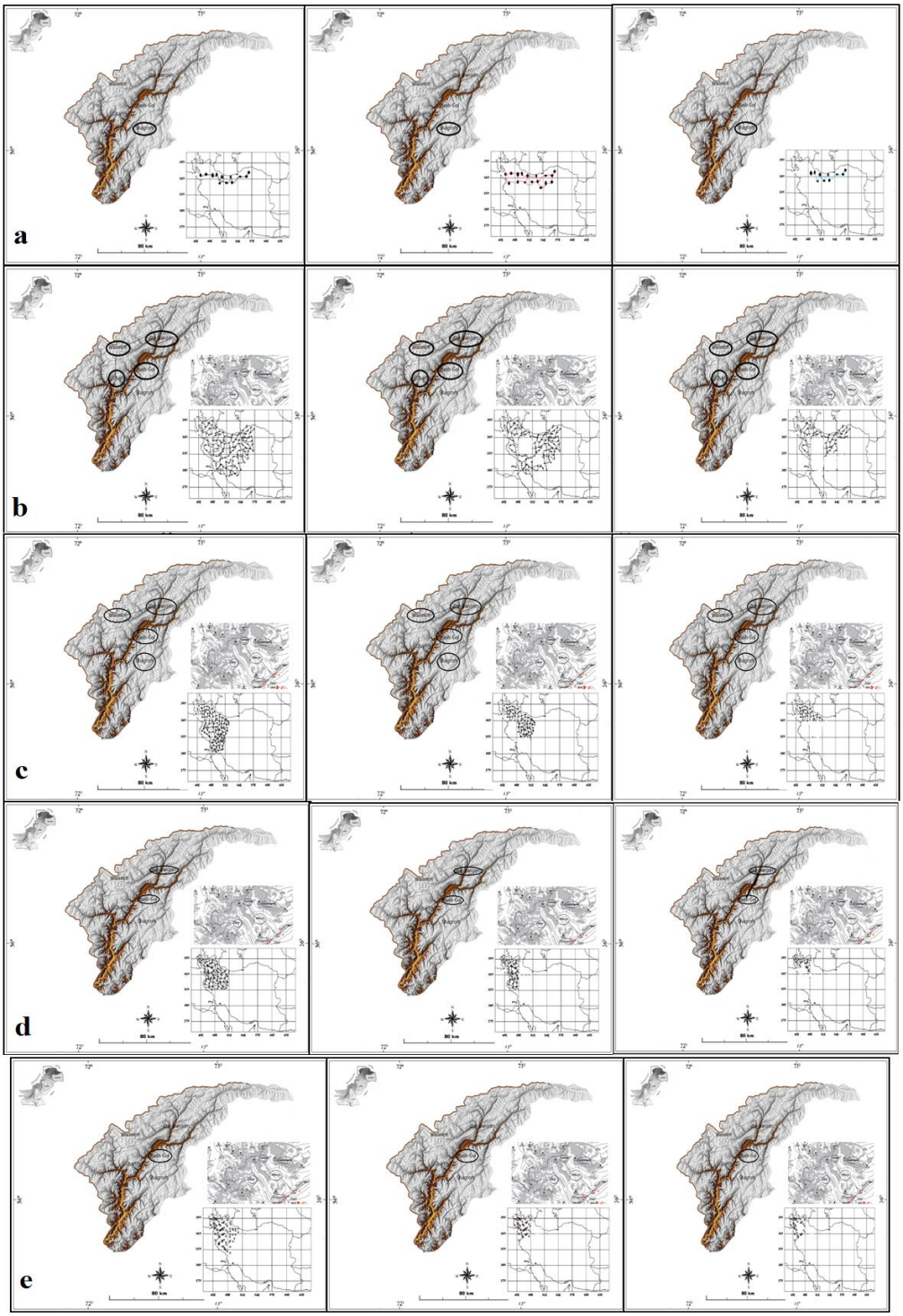

Fig. 6. EOO and AOO on 2016-2018 period for: a) Allium chitralicum; b) Anaphalis chitralensis; c) Astragalus chitralensis; d) Astragalus imitensis; e) Cuscuta villosa

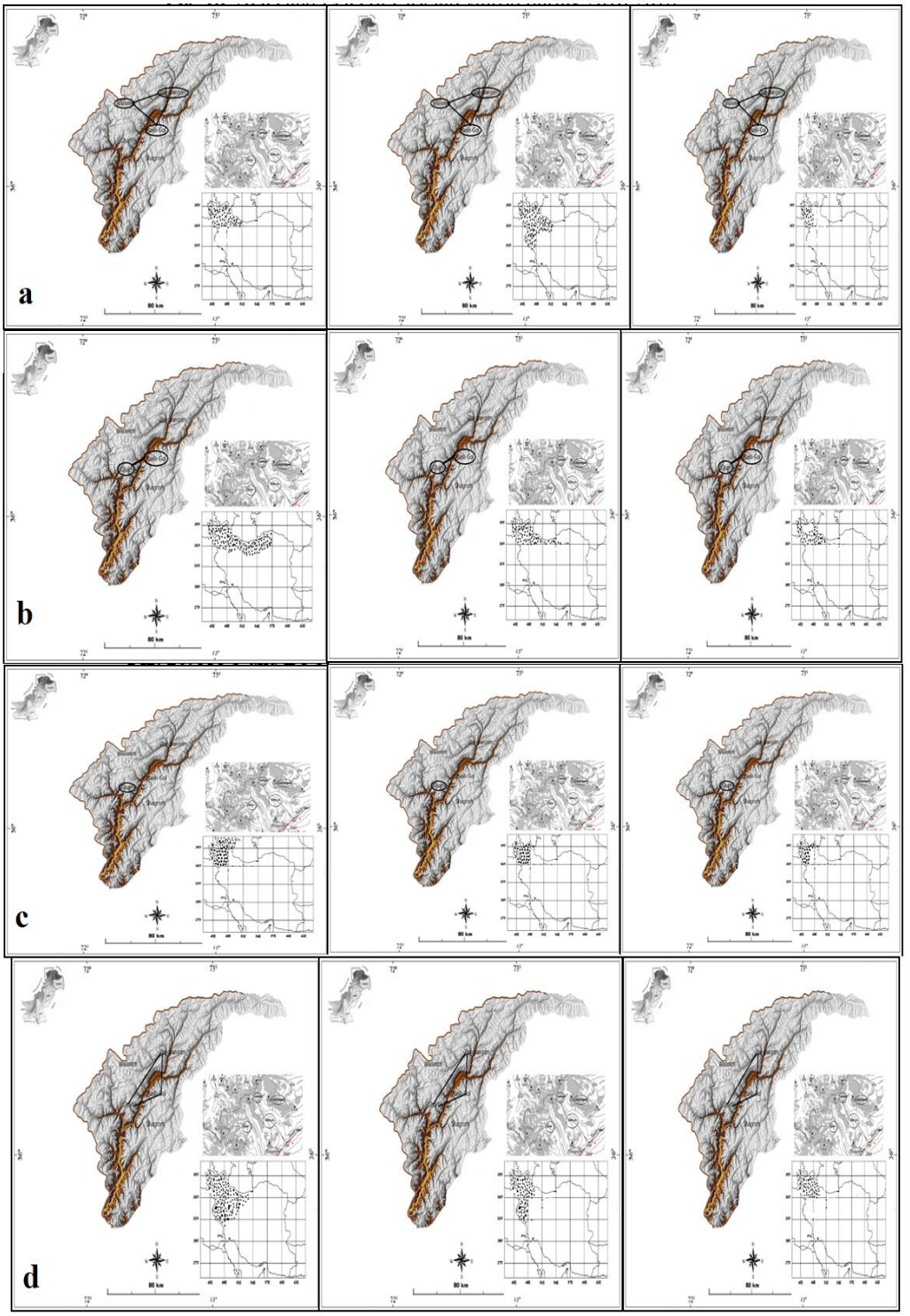

Fig. 7. EOO and AOO on 2016-2018 period for: a) Delphinium chitralense
b) Delphinium nordhagenii; c) Pedicularis stantonii**;** d) Tanacetum chitralense

Anaphalis chitralensis, *Cuscuta reflexa*, *Delphinium chitralense*, and *Tanacetum chitralense* are classified as endangered (EN), whereas *Allium chitralicum*, *Astragalus chitralensis*, *Astragalus imitensis*, *Delphinium nordhagenii*, and *Pedicularis stantonii* are classified as critically endangered (CR) (Table. 3). The obligation of an appropriate threat category to a species is critical for its conservation, however, in the Terich valley, Hindukush range, such categories have been assigned to vulnerable species relatively rarely in accordance with IUCN recommendations.

Operative threats to endemics

The current research illuminates the many dangers that afflict chosen endemics in their natural habitats and are accountable for their demise. The main risks to the population of these endemics in their natural habitats were uncontrolled grazing, over-exploitation for local use, habitat degradation, deforestation, landslides, and uncontrolled visitor movement (Table 3). These taxa's natural habitat is heavily grazed alpine pastures [28], such as *Anaphalis chitralensis* and *Astragalus chitralensis*, which were largely devoured by overgrazing. Because they were unable to set their seeds due to grazing animals, these species were only found at two locations (Rosh Gol and Ghari). Overgrazing and trampling have reduced the number of plant species in a given area [29-31]. *H. Sher et al.* [32] studied that overgrazing is the primary threat to the destruction of vegetation and dissemination of species through direct use as well as through truly changing their normal territory. The amount of jeopardized species is growing as a result of normal debasement and overgrazing [33]. Over-browsing likewise made land disintegration due to which a decrease in phytodiversity that happens nearby. The round about impacts of over-grazing incorporates mechanical wounds to seedlings, soil piecese and soil microorganisms. These practices increment the helplessness of soil to disintegration conditions Landsliding was one more danger to the regular natural surroundings of *Anaphalis chitralensis* and *Astragalus chitralensis* in Rosh Gol and Ghari. *Anaphalis chitralensis* favors clammy slants which are inclined to landsliding peculiarity. The avalanches not simply impact the part of the populace size yet additionally goal the discontinuity of living space. A significant piece of the vegetation in Terich valley was presented to landsliding. *L. Lapcha et al.* [34] accepted that land sliding push plants of an area towards weakness. The occupants of Terich valley generally rely upon the plant assets for their different homegrown uses and in this manner, many plants were close to elimination. Protection and feasible utilization of plant assets in the valley should be started. In the viewpoint of the above-expressed circumstances, it was felt vital to do broad field studies all through the Terich valley to get the total image of the plant abundance to enlist the threatened plants and, propose strategies for their conservation [35, 36].

Conclusions

The risk status of 9 endemic plants was carried out for the first time in this valley in understanding with IUCN territorial rules. The present study highlighted the danger status of these endemics and the nature of the variables that debilitate them. Suggestions include arranging plans for the prompt support of their economical generation.

A comprehensive program must be planned by including nearby masses, traditionalists, Governmental and Non-Governmental Organizations to require valuable measures for undermined plants and their preservation with an uncommon center on endemic species to

moderate their termination hazard. The propelling of nurseries, seeds, and quality banks for endemic species at town levels was vital for the preservation of threatened species. Also, solid measures ought to be taken to play down the general effect of current dangers.

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