Sustainable utilization of moist temperate Himalayan medicinal plants in Pakistan

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Abstract

The moist temperate Himalayas, as one of the major ecological zones of Pakistan, invites specific attention to the conservation of environment and the sustainable development of natural resources. During the last hundred years, the area has been subjected to major structural changes leading to a decrease of about fifty per cent of the potential forest area. The decrease in forest cover, combined with major changes in community structure has been responsible for the decline of indigenous medicinal plant resources and as well as traditional knowledge of their use. Ayubia National Park has been identified as a priority area for medicinal plant conservation.

The study aimed to analyze traditional knowledge including local names, general distribution, flowering period, part used, medicinal and other uses, market values and taxonomic diversity of the medicinal plant of the area. Traditional knowledge of about 117 indigenous medicinal plants (including 8 cultivated ones) has been collected from 140 informants. Women followed by children have been identified as the principle gatherers of medicinal plants. About 44 species were found to be market oriented. The field surveys were conducted by adopting predefined questionnaires through guided and transect walks. The market oriented indigenous species have been subjected to IUCN criterion for evaluation of their conservation status. According to this criterion, eleven species including two trees (*Juglans regia*, *Taxus wallichiana*), one shrub (*Berberis lycium*) and eight herbaceous species (*Asparagus adscendens*, *Atropa acuminata*, *Colchicum luteum*, *Dioscorea deltoidea*, *Podophyllum hexandrum*, *Rheum australe*, *Saussurea costus* and *Valeriana jatamansi*) have been found endangered. Ex situ cultivation trials have been conducted on all of the endangered herbaceous species. Two cultivated species (*Carum copticum* and *Nigella sativa*) have been trailed as crop substitutes by involving local communities in the low land Himalayas in demonstration plots.

It has been concluded that in up land Himalayas, where availability of cultivated land is significantly reduced, the establishment of botanical gardens, home gardens or kitchen gardens may be the best ex situ conservation strategy for sustainable utilization of medicinal plants. While clearly defined land tenure systems and community participation in park management will be the best in situ conservation measure, medicinal plants as crop substitute can bring better results in low land Himalayas.

Introduction

Around 90% of the medicinal species are used by people, who are native to the area in which the plants occur. This is indicative of the vast repository of knowledge of plant medicine that is still available for global use, provided of course that it does not get lost before it can be tapped or documented. Traditional and indigenous medical knowledge of plants, both oral and codified, is undoubtedly eroding. The main reason for this erosion of indigenous knowledge is the global domination of a monoculture which exclusively promotes those knowledge systems that are a part of this dominant culture. (Shankar, 1998). Documentation of traditional knowledge prevailing in different areas of the world will leads towards its conservation. Considerable work is going on in several parts of the world e.g., there is a study, which documents the abundance, distribution and knowledge of medicinal plant species in a Ransa Dayak village and the adjoining forest in West Kalimantan, Indonesia. Over

250 medicinal plant species from 165 genera and 75 families were utilized by the local healer (Caniago & Siebert, 1998). Eighty-one herbal drug species in 51 families and 77 genera have been documented from Nepal (Manandhar, 1995). The results of ethnobotanical fieldwork between two Yanomami communities have been presented. In addition to the 113 species already known to be used by the group, a further 85 species were documented. The origins and significance of this knowledge have been discussed, with particular reference to the use of plants in the treatment of malaria (Milliken & Albert, 1997).

Little is known about traditional knowledge and practices, which have been developed by the transhumance society on available plants, animal resources, medicinal herbs and other technologies of high altitude Himalayas, where resources are scarce. Traditional knowledge of some important herbs in their society, traditional cattle breeding achievements, and the traditional handicrafts of high altitude Himalayan has been documented and the immediate need for value addition in these sectors in order to save them from extinction and to add to the income of the people has been suggested (Farooquee & Nautiyal, 1999). An inventory of wild edible plants of Indian Himalaya used by local communities has been formulated. Over 675 wild plant species, representing 384 genera and 149 families, are used as food or edible matter(Samant & Dhar, 1997). By studying the biodiversity of a protected area of West Himalaya (Askot Wildlife Sanctuary), it was reported that plant diversity has been represented by 1262 species of vascular plants, of which about 70 species were found to be used as medicine (Samant *et al.,* 1998).

A checklist of the cultivated plants (581 species belonging to 111 families and 381 genera) of the whole Korean peninsula has been produced (Hodzun *et al*., 1997). Diversity of medicinal plants in West African habitats has also been studied (Cole, 1996). Medicinal plants of the Western Usambara Mountains in Tanzania have been inventoried for the first time as an analysis of medicinal plants used in Africa. A total of 328 taxa have been collected, yielding 2260 individual use reports. The most popular species were *Myrica salicifolia* and *Toddalia asiatica* (Schlage *et al.,* 2000).

In the recent years, more efforts have been made to document traditional knowledge,with particular emphahsis on the Himalayas. In this regard, traditional utilization of 160 plants has been described, collecting the knowledge from Margalla Hills National Park. The conservation status of the plants has also been discussed (Shinwari & Khan, 1998; 1999; 2000). About 58 species of medicinal plants from Ayubia National Park-Galliat have had a preliminary listing (Shah, 2001). Indigenous knowledge of about 25 medicinal herbs from Kahuta-Rawalpindi district has been reported (Qureishi & Khan, 2001). Similarly traditional uses of about 77 species have been recorded from the Shogran valley, Mansehra (Matin *et al.*, 2001). Ethnobotanical importance of about 48 species has been documented from the Kaghan valley, Mansehra (Shinwari *et al*., 1996). Traditional knowledge of about 69 medicinal plants found in Machyara National Park, Azad Kashmir has also been documented (Bukhari, 1996). Indigenous knowledge of about 85 medicinal plants has been described from Northern Chitral (Khan & Le Feure, 1996). Folk utilization of medicinal plants found in Khair pur district, Nara desert and Cholistan has also been explored (Chaudhri & Arshad, 1987; Ansari *et al.,* 1993; Batti *et al*., 2000).

The moist temperate Himalayas in Pakistan extend all along the entire length of the outer Himalayan ranges. They usually form a zone between 1450-3500 meters (4500-10,000 ft) depending upon the aspect, configuration, habitat and soil conditions. They merge with the sub tropical pine forests below and sub-alpine/alpine forests in their upper limits. This forest is typified by most of the Murree hill range (including the Gallies), the lower Neelum and Kaghan valleys extending westwards to parts of eastern Swat bordering on Indus Kohistan (Hussain & Ilahi, 1991). These forests are predominately coniferous with some broad-leaved species. Dominating species are few, forming pure or mixed associations. The occurrence of species depends upon the aspect, altitude and local habitat conditions. *Abies pindrow* Royle in northern aspects or moist slopes, *Pinus wallichiana* Jackson with *Taxus wallichiana* Zucc. as an understorey and occasional *Cedrus deodara* (Roxb. ex D. Don G. Don) on dryer hotter slopes. Broadleaved trees include *Ulmus wallichiana* Planchon, *Juglans regia* L., *Quercus floribunda* Lindl. ex A. Camus, *Acer caesium* Wall. ex Brandis, *A. stercuuliaceum* Wall. and *Prunus cornuta* (Wall. ex Royle) Steud., the shrub layer comprises *Viburnum grandiflorum* Wallich ex DC., *Berberis lycium*

Royle, *B. ceratophylla* G. Don, *Rosa brunonii* Lindl., *Skimmia laureola* (DC.) Sieb. & Zucc. ex Walp. and *Lonicera webbiana* Wall. ex DC. Forbes includes many species of *Impatiens* and *Euphorbia* as well as *Viola*, *Fragaria* and *Gentiana*. Creepeers include *Hedera nepalensis* K. Kock and *Clematis montana* Buch.-Ham. ex DC (Afzal, *et al.,* 2001).

The focal area of the present study, Ayubia National Park, is located in Lesser Himalayas three hours drive north of Islamabad in the Galliat Hills (North West Frontier Province). It was declared a national park in 1984 with the aims of preserving its beautiful landscapes, forests and biodiversity for scientific research, education and recreation. The average altitude is 2300 m (maximum 3000 m at Mushkpuri Top). The initial area of the park was 1684 ha, expanded through a northern extension in 1998 to make a total of 3312 ha. The park supports one of the best remaining examples of moist Himalayan temperate forest in Pakistan and is surrounded by seven major villages and three small towns (Nathiagali, Ayubia and Khanspur) (Aumeeruddy *et al*., 1998).

According to Census latest Report of 1998, since 1981 the population has increased by 35.96%. The population of the communities living around Ayubia National Park has increased from 32,547 in 1981 to 50,073 in 1998. However, since independence in 1947 an overall cumulative growth of 176.18% has been recorded in the population of the area (Shah, 2001). As a matter of chance, the population of woman has increased more rapidly than men of the area. This severe increase in human population along with its increasing number of livestock has posed a serious threat to the integrity of the Park in particular and forests of the area in general. The villages are surrounded by terraced agricultural land located mostly at the valley's base. Grassland and forest occur on steeper slopes and are proportionally more extensive. Most forest outside the park is gazetted as either Reserved Forest (in which the local people have no legal rights of use) or Guzara Forest (which is owned by individuals or communities). Ayubia National Park is a Reserved Forest as well as a park. Guzara Forest can be used by its individual or communal owners for various purposes - such as to graze livestock and collect deadwood and grass for fodder, but the cutting of timber, in particular conifers, remains under the control of the Forest Department. Some areas designated legally as Reserved or Guzara Forest have been degraded through illegal harvest and mismanagement of trees and other processes, and are now either grasslands or wastelands.

Various factors such as altitude, topography, climate, soil moisture, exposures, and altitudinal variation determine the particular vegetation types and specific habitats. These habitats have been altered over the years by biotic and other factors (which include overpopulation, urbanization, deforestation, terracing of land for agriculture, overgrazing, and forest fires). Various National Parks have been established to counter such disasters and Ayubia National Park is one of those natural reserves. In the park area generally three vegetation types have been observed: Subtropical Pine Forests, moist temperate Forests, and Sub alpine Scrubs and Scattered Tree line

Methods

The research work was initiated in February 2000 and continued up to December 2002. The sites selected to carry out research work on medicinal plants were; Ayubia National Park (Nathia Gali), Burban (Murree), Margalla Hills (Kotla Village), Kaghan Valley and Hilkot Valley (Mansehra). All these areas selected are medicinal plant hotspots of the moist temperate Himalayan region. Ayubia National Park (ANP) has been taken as a focal reference point. A comprehensive review of the relevant literature has been conducted which included the subject matter as well as regional studies. Specific review on the species selected for conservation trials has also been conducted.

Field surveys:

The time for field surveys was selected in accordance with the life cycle of the plants, the season of collection, processing and utilization of the plant products by the local community. The study trips were arranged from

March to May 2000. The fieldwork was totally based on interviews; observations and guided field walks/transect walks during the fieldwork.

In order to study field conditions, keen observations have been made during the walk in the upland during the growth period. In the meantime all the voucher specimens have been collected during the flowering stage, pressed and preserved. Thus two files of local plant voucher specimens have been developed. One set was submitted to the Herbarium of Quaid-e-Azam University, Islamabad and the other set to Pakistan Forest Institute, Peshawar.

Survey of traditional knowledge:

Interviews have been conducted with the local inhabitants, selected informants, the herbalists (Hakims) and the local authorities and societies. About 150 informants have been interviewed on a random basis. A questionnaire has been adopted during the survey; designed to elicit a quantitative and participatory approach about the status of indigenous medicinal plants and their utilization by the people. A female student has been involved to interview the female community of the area.

First of all, the focal area; Ayubia National Park was surveyed. Indigenous medicinal plants which are utilized by the traditional knowledge of the people have been selected as reference specimens. Traditional knowledge about the indigenous medicinal plants of Ayubia National Park has been checked from other sites (Kaghan, Hilkot, Murree, Margalla and Machyara) selected within the moist temperate Himalayas by conducting the same exercise.

Market surveys:

The economic and commercial value of the indigenous medicinal plants utilized in the study area has been tested in market surveys. In this regard, a questionnaire has been adopted to interview the local plant collectors and , medicinal plant sellers (Pansaries) in local markets i.e., Rawalpindi and Lahore. Regarding the quantitative approach, a questionnaire has been devised about the quantity of plant resources, uses, rate of sale, consumption, availability, economic and market value etc. (Phillips and Gentry, 1993). Intensive surveys have been conducted.

The outcome of the interviews of the surveys have been rechecked and compared with results of the other sites. The variations among information obtained from different sites have been noted.

Criterion for the selection of species:

According to the Red Data Book of IUCN, the status of commercially important indigenous species (in terms of threatened condition) in the study area have been determined by using the following four parameters; Availability, Collection, Growth and Part used providing a total score for each species. Based on this analysis, the relative importance of specific medicinal plants has been classified into the following categories: Endangered, Vulnerable, Rare, Infrequent and Dominant species (IUCN, 1970-2002). The adopted key was as follows:

Availability	**Collection**
0=Uncommon or very rare	0=More than 1000 Kg/year
1=Less common or rare	1=Consumed from 500-1000Kg/year
2=Ocassional	2=Consumed from 300-400Kg/year

3=Abundant	3= Consumed from 100-200Kg/year
Growth	**Part Used**
0=Regrowth in more than 3 years	0=Root, Rhizome, Whole plant
1=Regrowth within 3 years	1=Bark
2=Regrowth within 2 years	2=Seeds, Fruits
3=Regrowth in 1 year	3=Flowers
4=Regrowth in a season	4=Gum, Latex, Leaves

Total Score

0-4=Endangered

5-8=Vulnerable

9-12=Rare

12-14=Infrequent

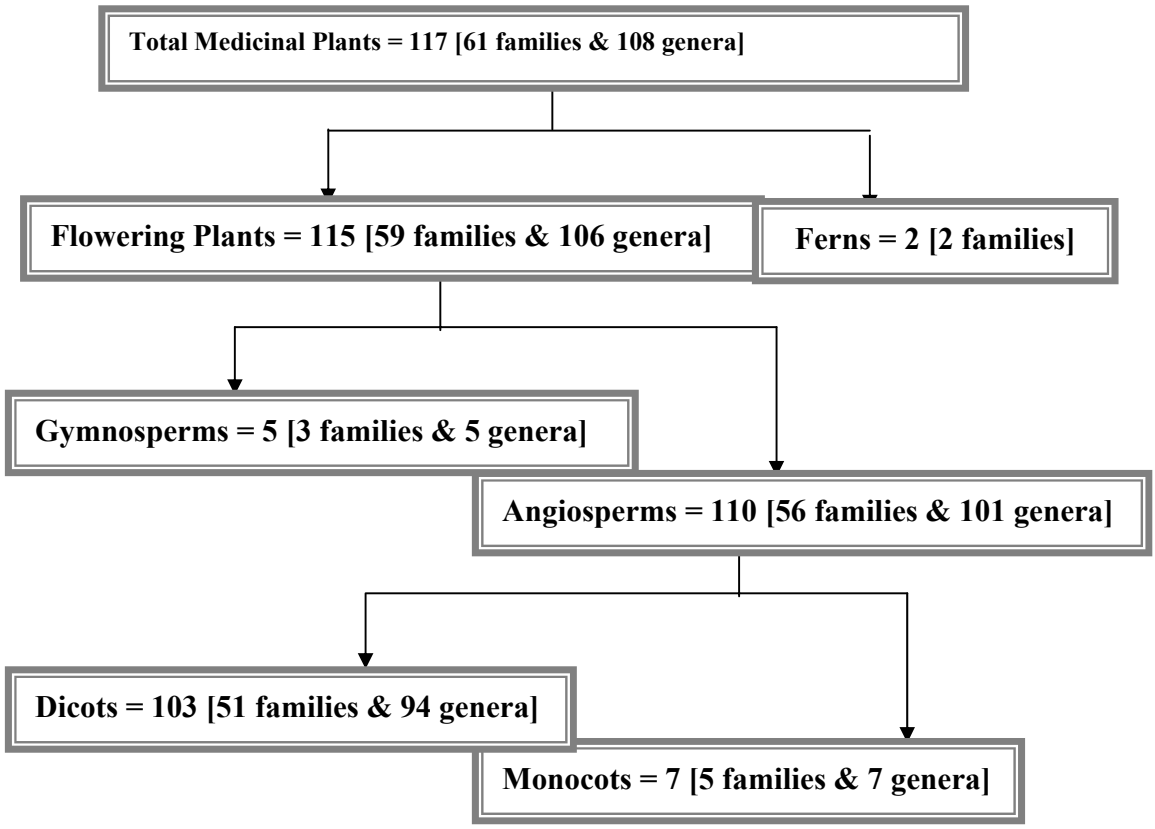
15-16=Dominant

Results

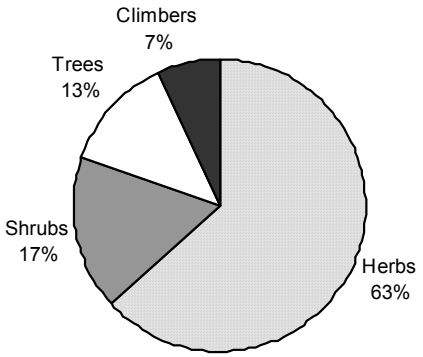
Traditional knowledge about medicinal plants of Ayubia National Park has been collected and also verified from other moist temperate Himalayan regions of Pakistan i.e., Kaghan, Murree, Machyara, Hilkot.

It is found that usually plants are harvested by the application of certain picking tools as knife, digging stick, 'kudal' and sometimes manually. Flowers and leaves are dried in the shade. They are placed under the sun for a very brief period to prevent fungal attack. Barks, woods and twigs are dried under the sun or in thin layers in the open air. Fibrous roots are dried under the sun. Transversely cut fleshy roots and rhizomes have been dried and stored in a cool dry place. A number of traditional methods were used to make herbal remedies, such as infusion, decoction, tincture, syrup, jelly, oils, creams, ointment, pills, compress, poultice, steam inhalants, and juice.

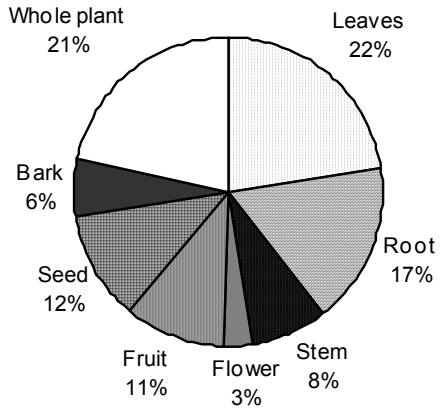
Chart 1: Indigenous medicinal plants diversity at ANP



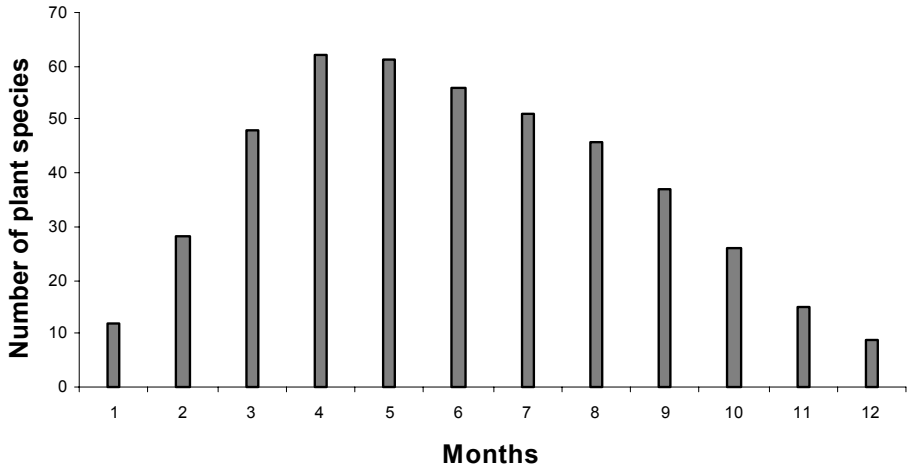
Graph 1: Proportional Representation of Life Forms



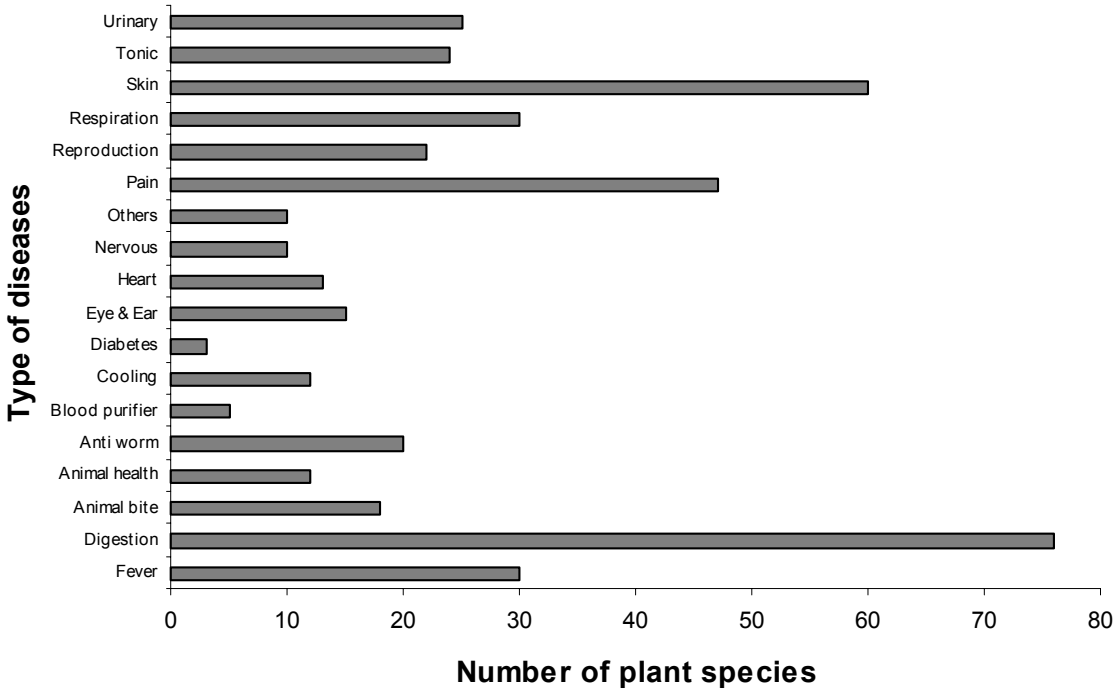
Graph 2: Diversity of Medicinal Plant Part Used



Graph 3: Phenological Variations



Graph 4: Variation Among Treatment of Different Diseases



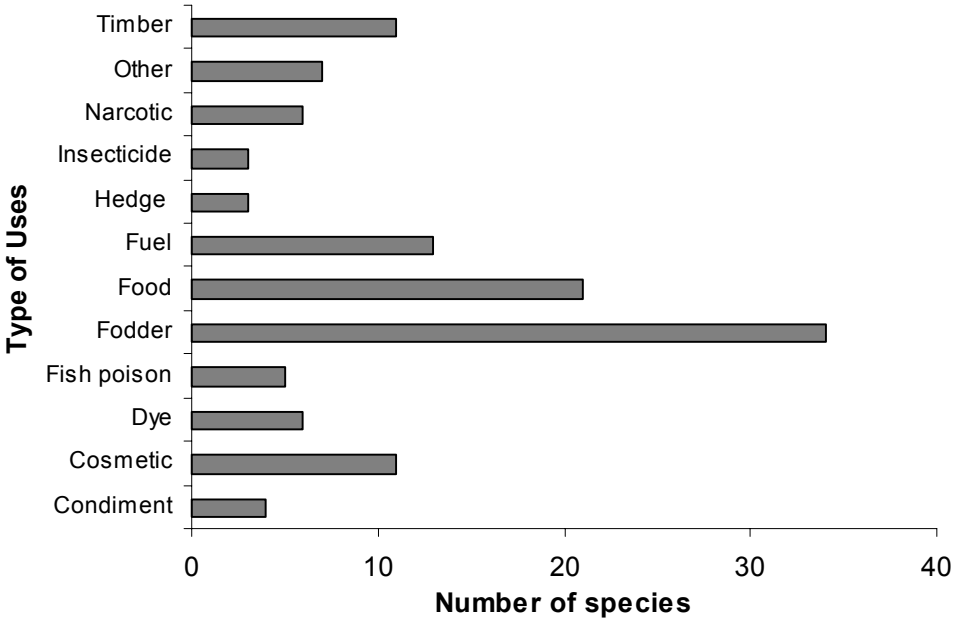
Sr. no.	Name of species	Family	Local Name	Type
1	*Acorus calamus*	Araceae	Bach	Insect & Snake
2	*Amaranthus viridis*	Amaranthaceae	Chaleri	Scorpion & Snake
3	*Arisaema flavum*	Araceae	Obais	Snake
4	*Barleria cristata*	Acanthaceae	Tadrelu	Snake
5	*Boerhavia procumbens*	Nyctaginaceae	Itsit	Scorpion
6	*Cissampelos pariera*	Menispermaceae	Bili/Pilligar	Snake
7	*Datura stramonium*	Solanaceae	Dhatura	Fish
8	*Ficus carica*	Moraceae	Anjir	Bee
9	*Jasminum officinalis*	Oleaceae	Chambeli	Scorpion
10	*Murraya koeniji*	Rutaceae	Kamni	Insect
11	*Pinus roxburghii*	Pinaceae	Chir	Scorpion & Snake
12	*Rubia cordifolia*	Rubiaceae	Manjit	Scorpion & Snake
13	*Sauromatum venosum*	Araceae	Sap ki booti	Snake
14	*Saussurea heteromalla*	Asteraceae	Butt peva	Horse
15	*Verbena officinale*	Verbenaceae	Karanta/Pamukh	Scorpion & Snake

Table 1: Medicinal Plants Used against Different Animal Bites

Sr. no.	Name of species	Family	Local Name	Remarks
1	*Aesculus indica*	Hippocastenaceae	Bankhor	Fever& cough
2	*Arisaema flavum*	Araceae	Obais	Rani khait
3	*Cannabis sativa*	Cannabinaceae	Bhang	Appetizer
4	*Carisa oppaca*	Apocynaceae	Garanda	Sore
5	*Cynodon dactylon*	Poaceae	Talla	Milk & butter
6	*Fumaria indica*	Fumariaceae	Pitpapra	Diarrhea
7	*Hedera nepalensis*	Araliceae	Kurie/Albumber	Milk supply
8	*Morus alba*	Moraceae	Toot	Milk supply
9	*Plantago major*	Plantaginaceae	Batti	Mavakhar
10	*Saussurea heteromala*	Asteraceae	Butt peva	Dyspepsia
11	*Verbascum thapsus*	Scrophulariaceae	Geedar tamaku	Diarrhea
12	*Zanthoxylum armatum*	Rutaceae	Timber	Give warmth

Table 2: Medicinal Plants Used in Veterinary Medicines

Graph 5: Magnitude of Pressure of Utilization Other than Medicinal Value



Sr. no.	Name of species	Family	Local Name	Habit
1	*Abies pindrow*	Pinaceae	Partal/Palundar	Tree
2	*Cedrus deodara*	Pinaceae	Deodar/Diar	Tree
3	*Diospyros lotus*	Ebenaceae	Kala Amlok	Tree
4	*Dodonaea viscosa*	Sapindaceae	Sanatha	Shrub
5	*Ephedra gerardiana*	Ephedraceae	Asmani	Shrub
6	*Ficus carica*	Moraceae	Anjir	Tree
7	*Juglans regia*	Juglandaceae	Akhrot	Tree
8	*Morus alba*	Moraceae	Toot	Tree
9	*Pinus roxburghii*	Pinaceae	Chir	Tree
10	*Punica granatum*	Punicaceae	Anar/Darunna	Shrub
11	*Pyrus pashia*	Rosaceae	Batangi	Tree
12	*Quercus leucotrichophora*	Fagaceae	Ban/Reen	Tree
13	*Taxus wallichiana*	Taaxaceae	Burmi	Tree

Table 3: Medicinal Plants Used as Fuelwood

Sr. no.	Name of species	Family	Local Name	Habit
1	*Abies pindrow*	Pinaceae	Partal/Palundar	Tree
2	*Aesculus indica*	Hippocastenaceae	Bankhor	Tree
3	*Arisaema flavum*	Araceae	Obais	Herb
4	*Berberis lycium*	Berberidaceae	Kashmal	Shrub
5	*Bistorta amplexicaule*	Polygonaceae	Maslun	Herb
6	*Cichorium intybus*	Asteraceae	Kasni	Herb
7	*Convolvulus arvensis*	Convolvulaceae	Lehli/Hiran padi	Herb
8	*Cynodon dactylon*	Poaceae	Talla	Herb
9	*Diospyros lotus*	Ebenaceae	Kala Amlok	Tree
10	*Ephedra gerardiana*	Ephedraceae	Asmani	Shrub
11	*Euphorbia helioscopia*	Euphorbiaceae	Dhodal	Herb
12	*Euphorbia wallichii*	Euphorbiaceae	Harvi	Herb
13	*Ficus virgata*	Moraceae	Phagwara	Shrub
14	*Fumaria indica*	Fumariaceae	Pitpapra	Herb
15	*Fragaria nubicola*	Rosaceae	Panjakha	Herb
16	*Galium aparine*	Rubiaceae	Kochan	Herb
17	*Geranium wallichianum*	Geraniaceae	Rattanjot	Herb
18	*Hedera nepalensis*	Araliaceae	Albumber	Climber
19	*Jasminum humile*	Oleaceae	Peeli Chambeli	Shrub
20	*Jasminum officinalis*	Oleaceae	Chambeli	Shrub
21	*Juglans regia*	Juglandaceae	Akhrot	Tree
22	*Morus alba*	Moraceae	Toot	Tree
23	*Plantago major*	Plantaginaceae	Chamchipatra	Herb
24	*Podophyllum hexandrum*	Podophyllaceae	Bankakri	Herb
25	*Punica granatum*	Punicaceae	Darunna	Shrub
26	*Pyrus pashia*	Rosaceae	Batangi	Tree
27	*Rubus fruticosus*	Rosaceae	Gharacha	Shrub
28	*Rumex nepalensis*	Polygonaceae	Hula	Herb
29	*Quercus leucotrichophora*	Fagaceae	Ban/Reen	Tree
30	*Swertia angustifolia*	Gentianaceae	Chirayita	Herb
31	*Taxus wallichiana*	Taxaceae	Burmi	Tree
32	*Valeriana jatamansi*	Valerinaceae	Mushkbala	Herb
33	*Veronica melissifolia*	Scrophulariaceae	Mashkanna	Herb
34	*Viola canescens*	Violaceae	Banafsha	Herb

Table 4: Medicinal Plants Used as Fodder

Sr. no.	Name of species	Family	Local Name	Type
1	*Amaranthus viridis*	Amaranthaceae	Chaleri	Vegetable
2	*Daphne mucronata*	Thymeliaceae	Kuttilal	Edible fruit
3	*Diospyros lotus*	Ebeanceae	Kala amlok	Edible fruit
4	*Dryopteris ramosus*	Pteridaceae	Pakha	Vegetable
5	*Ficus carica*	Moraceae	Anjir	Edible fruit
6	*Ficus virgata*	Moraceae	Phagwara	Edible fruit
7	*Flacourtia indica*	Flacourtiaceae	Kokoh	Edible fruit
8	*Foeniculum vulgare*	Umbelliferae	Sonf	Condiment
9	*Fragria nubicola*	Rosaceae	Panjakha	Edible fruit
10	*Grewia asiatica*	Tiliaceae	Falsa	Edible fruit
11	*Hypericum perforatum*	Hypericaceae	Balsana	Vegetable
12	*Juglans regia*	Juglandaceae	Akhrot	Edible fruit
13	*Morus alba*	Moraceae	Toot	Edible fruit
14	*Murraya koenniji*	Rutaceeae	Kamni	Condiment
15	*Pinus roxburghii*	Pinaceae	Chir	Edible fruit
16	*Podophyllum hexandrum*	Podophyllaceae	Bankakri	Edible fruit
17	*Punica granatum*	Punicaceae	Darunna	Condiment
18	*Pyrus pashia*	Rosaceae	Batangi	Edible fruit
19	*Rubus fruiticosus*	Rubiaceae	Garacha	Edible fruit
20	*Solanum miniatum*	Solanaceae	Mako	Vegetable
21	*Sonchus asper*	Asteraceae	Hind	Vegetable
22	*Taxus wallichiana*	Taxaceae	Burmi	Edible fruit
23	*Viburnum grandiflorum*	Sambucaeae	Guch	Edible fruit
24	*Zanthhoxylum armatum*	Rutaceae	Timber	Condiment

Table 5: Medicinal Plants Used as Food

Scientific name	Local Name	Quantity in Kgs			
		Hilkot	*Kaghan	Ayubia	Murree
1) *Aconitum heterophyllum*	Atis		80	64	
2) *Acorus calamus*	Bach	1200			
3) *Adiantum capillus-veneris*	Persioshan			24	
4) *Berberis lycium*	Kashmal	1000	25		
5) *Bergenia ciliata*	Zakham-e hayat			10	40
6) *Bistorta amplexicaule*	Maslun		780		
7) *Dioscorea deltoidea*	Angoor-e-shifa		4480		
8) *Geranium wallichianum*	Rattanjot	1200		16	
9) *Juglans regia*	Akhrot			80	100
10) *Justicia adhatoda*	Bhekar		50	56	
11) *Lavetera kashmeriana*	Raisha khatmi		2760		
12) *Mentha longifolia*	Pudina			240	45

13) *Paeonia emodi*	Mamekh	4000	520	75	
14) *Podophyllum hexandrum*	Bankakri		13960		
15) *Punica granatum*	Darunna		10	140	160
16) *Rheum australe*	Chutial	2000			
17) *Saussurea costus*	Kuth		8000	80	
18) *Skimmia laureola*	Ner	160			64
19) *Swertia angustifolia*	Chirayita			32	
20) *Taxus wallichiana*	Burmi		5920		
21) *Valeriana jatamansi*	Mushkbala	500	18920	40	
22) *Viola canescens*	Thandi-booti	2000		48	40
23) *Zanthoxylum armatum*	Timmer	200	10		56

*Table 6: Extraction of Indigenous Medicinal Plants from Area (Source: Survey of local crude drug dealers and community collectors)(*Source: Kaghan Forest Division, Forestry Department, Government of NWFP)*

Market Value of Indigenous Medicinal Plants

No.	Botanical Name	Trade Name	Part used	Rawalpindi & Lahore	
				Price/Kg	Consumption (Tons/year)
1	*Achillea millefolium*	Baranjasif	Whole	50	01.56
2	*Aconitum heterophyllum*	Atis	Root	800	05.00
3	*Acorus calamus*	Bach	Rhizome	375	25.00
4	*Adiantum capillus-veneris*	Persioshan	Whole	40	04.32
5	*Asparagus adscendens*	Musli sufaid	Root	260	1.135
6	*Atropa acuminata*	Angoor-e-shifa	Root	12	10.00
7	*Berberis lycium*	Rasout	Sap	240	01.02
8	*Bistoria amplexicaulis*	Bekh-e-anjabar	Root	24	00.44
9	*Boerhavia diffusa*	Tukhm-e-aspat	Seed	120	00.10
10	*Cichorium intybus*	Bekh-e-kasni	Root	40	02.64
	Cichorium intybus	Tukhm-e-kasni	Seed	60	06.54
11	*Colchicum luteum*	Suranjan-e-talkh	Rhizome	400	02.76
12	*Coriandrum sativum*	Dhaniya	Fruit	40	10.08
13	*Cusuta reflexa*	Afsitamone	Shoot	120	00.61
	Cusuta reflexa	Tukhm-e-kasoos	Seed	100	0.84
14	*Dioscorea deltoidea*	Kanis sabz	Root	25	00.12
15	*Ficus carica*	Anjir zard	Fruit	140	03.80
16	*Foeniculum vulgare*	Badyan	Fruit	50	07.00
	Foeniculum vulgare	Bekh-e-badyan	Root	40	02.34
17	*Fumaria indica*	Burg-e-shahtra	Leaves	24	02.94

18	*Geranium wallichianum*	Rattanjot	Root	50	28.00
19	*Hyocyamus niger*	Ajwain khurasani	Fruit	60	00.40
20	*Juglans regia*	Maghz-e-akhrot	Seed	170	20.00
21	*Justicia adhatoda*	Berg-e-bansa	Leaves	121	00.88
22	*Lavetera kashmeriana*	Tukhm-e-khatmi	Seed	50	54.40
23	*Mallotus philipensis*	Kamila	Fruit	120	00.27
24	*Mentha longifolia*	Podina desi	Whole	20	17.20
25	*Ocimum basilicum*	Tukhm-e-rehan	Seed	120	2.540
26	*Paeonia emodi*	Ud-e-salep	Root	50	50.42
27	*Plantago major*	Tukhm-e-panwar	Seed	40	00.82
28	*Plantago ovata* *Plantago ovata*	Ispaghol musullum Bhosi ispaghol	Seed Seed	60 160	53.50 19.58
29	*Podophyllum hexandrum*	Bankakri	Rhizome	90	30.00
30	*Punica granatum*	Anardana	Seed	50	120.04
31	*Quercus leucotrichophora*	Juft-e-baloot	Seed	24	00.41
32	*Rubia cordifolia*	Majheet	Root	70	01.22
33	*Rheum australe* *Rheum australe*	Asarat-e-revand Revandchini	Root Sap Root	400 100	00.21 00.12
34	*Saussurea costus*	Qast-e-talkh	Root	140	00.76
35	*Sida cordifolia*	Beejband siah	Seed	80	00.40
36	*Sisymbrium irio*	Khaksi	Seed	70	00.44
37	*Skimmia laureola*	Berg-e ner	Leaves	12	24.00
38	*Smilax aspera*	Chobchini	Root	240	00.61
39	*Solanum nigrum*	Mako khushk	Fruit	40	00.20
40	*Swertia angustifolia*	Charaita shirin	Shoot	30	00.30
41	*Taxus wallichiana*	Zarnabad	Leaves	30	02.04
42	*Tribulus terristris*	Gokhrokhurd	Fruit	30	02.04
43	*Trigonella foenum-graecum*	Tukhm-e-methi	Seed	32	01.35
44	*Valeriana jatamansi*	Mushkbala	Root	50	100
45	*Viola canescens* *Viola canescens*	Burg-e-banafsha Gul-e-banafsha	Leaves Flower	25 200	03.14 02.94
46	*Vitex negundo*	Tukhm-e-sumbhaloo	Seed	30	00.70
47	*Withania sominifera*	Asgand nagori	Root	150	11.18
48	*Zanthoxylum armatum*	Timmer/Timber	Seed	10	31.00

Table 7: Market Value of Indigenous Medicinal Plants

Conservation Status

No.	Botanical name	Availability	Consumption	Growth	Part Used	Score
1	*Achillea millefolium*	2	0	3	0	5
2	*Aconitum heterophyllum*	2	0	3	0	5
3	*Acorus calamus*	3	0	4	0	7
4	*Adiantum capillus-veneris*	4	0	4	0	8
5	*Asparagus adscendens*	2	0	2	0	4
6	*Atropa acuminata*	1	0	0	0	1
7	*Berberis lycium*	3	0	1	0	4
8	*Bistorta amplexicaulis*	3	2	1	0	6
9	*Boerhavia procumbens*	3	3	3	2	11
10	*Cichorium intybus*	3	0	3	0	6
11	*Colchicum luteum*	0	0	1	0	1
12	*Cuscuta reflexa*	3	1	3	2	9
13	*Dioscorea deltoidea*	1	3	0	0	4
14	*Fumaria indica*	3	0	3	0	6
15	*Geranium wallichianum*	3	0	4	0	7
16	*Hyocyamus niger*	2	2	3	2	9
17	*Justicia adhatoda*	3	1	2	3	9
18	*Lavetera kashmeriana*	1	0	3	2	6
19	*Mallotus philipensis*	3	2	0	2	7
20	*Mentha longifolia*	3	0	4	3	10
21	*Paeonia emodi*	1	0	1	3	5
22	*Plantago major*	2	1	4	0	7
23	*Plantago ovata*	3	0	4	2	9
24	*Podophyllum hexandrum*	1	0	3	0	4
25	*Punica granatum*	3	0	0	2	5
26	*Quercus leucotrichophora*	3	2	0	2	7
27	*Rubia cordifolia*	3	0	0	2	5
28	*Rheum australe*	1	3	1	0	5
29	*Saussurea costus*	0	1	1	0	2
30	*Sida cordifolia*	3	2	3	0	8
31	*Sisymbrium irio*	3	2	3	2	10
32	*Skimmia laureola*	3	0	3	4	10
33	*Smilax aspera*	2	1	3	0	6
34	*Solanum nigrum*	3	3	3	3	12
35	*Swertia angustifolia*	3	2	4	0	9
36	*Taxus wallichiana*	1	0	0	0	1

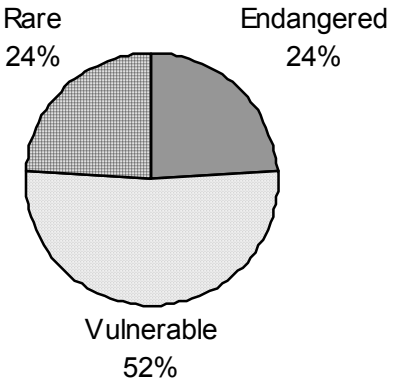
37	*Tribulus terristris*	2	0	3	2	7
38	*Valeriana jatamansi*	3	0	1	0	4
39	*Viola canescens*	3	0	4	0	7
40	*Vitex negundo*	3	1	3	0	7
41	*Withania sominifera*	3	0	2	0	5
42	*Zanthoxylum armatum*	3	0	3	1	7

*Table 8: Status of Commercially Important Indigenous Medicinal Species (**Total Score**=0-4=Endangered, 5-8=Vulnerable, 9-12=Rare, 13-14=Infrequent, 15-16=Dominant)*

No.	Species	Demand	Harvesting Month	Collector rate Rs. per Kg	Market rate Rs. per Kg			
					Local Market	Whole sale	National Market	International Market
1	*Asparagus adscendens*	Increase	August September	50	80	150	200	2600
2	*Atropa acuminata*	Normal	September October	3	7	10	12	-
3	*Colchicum luteum*	Increase	March May	60	150	250	360	600
4	*Dioscorea deltoidea*	Decrease	July September	30	60	100	150	-
5	*Podophyllum hexandrum*	Normal	July September	30	40	50	90	400
6	*Paeonia emodi*	Decrease	July September	20	25	35	50	200
7	*Saussurea costus*	Decrease	July September	40	45	55	75	300
8	*Valeriana jatamansi*	Normal	June September	60	70	150	200	500
9	*Carum copticum*	Increase	May June	10	20	30	50	400
10	*Nigella sativa*	Increase	May June	20	30	50	70	320

Table 9: Average Price per Kg of plants at Different Market Levels

Graph 6: Conservation Status of Marketable Species



Discussion

In Pakistan, although adequate data is not available about medicinal plants that require conservation, there is overwhelming agreement among experts in the country that the most threatened ecosystems are the alpine and temperate Himalayan forests in the north of the country. There is also agreement that almost all the forest of Pakistan has been exploited heavily during the last two decades, medicinal plants included.

In fact, previous attempts to list threatened species of plants are either fragmentary or out-dated and deposited with different agencies; as such, they need to be re-evaluated and updated. The use of these earlier lists as a conservation tool is limited by the fact that the status of many species remains unclear; this is particularly true of threatened species. It is therefore, very important to have a comprehensive survey of the important vegetation zones. It is important to prepare National Red Data Book based on recent IUCN criteria.

To initiate in-situ conservation efforts, Pakistan has established a network of national parks, wildlife sanctuaries and game reserves covering about 10 million hectares. Ex-situ conservation of medicinal and aromatic plants seeds has recently been initiated at the plant Genetic Resource Institute (PGRI) at NARC in Islamabad, where a special corner called the Hakim Said Chamber has been established.

Ecological and social changes produced by economic and technological development have led to a deep transformation of attitudes and values regarding plants (Hynes et al., 1997). Most cultural changes in rural communities are associated with increasing interactions with modern social systems. Consequently, much of the

knowledge and use of plant resources, as well as the resources themselves, are disappearing in many regions (Berg, 1994; Boom, 1987). Therefore long term conservation of plant resources and the knowledge associated with them is necessary for the benefit of local people and for their potential use by communities at large. As a science of documenting traditional knowledge on the use of plants by indigenous people and assessing human interaction with the natural environment, ethnobotany has great potential for contributing to biodiversity conservation in the Himalayas.

For developing countries like Pakistan, medicinal plants are of great value in the treatment of various kinds of diseases and disorders. They are also more accessible and affordable than allopathic medicines. Thus the systematic documentation of indigenous knowledge about the use of these plant resources by local people and their chemical and biological examination would be useful for the discovery of new therapeutic agents.

As a part of the moist temperate Himalayas, Ayubia National Park is rich in diverse medicinal plants, which are distributed in its sub-tropical, moist temperate and sub-alpine forests. These plants are highly valued since they are used in both traditional medicines and by modern pharmaceutical companies. The ethnobotanical survey also reveals a rich local knowledge of these medicinal plants. About 63% of the respondents reported that they prefer herbal treatment by an herbalist (Hakim) or self-treatment with locally available medicinal plants. In remote villages like Lahure Khas, where access to modern medicine is limited, traditional healing systems play an indispensable part in providing healthcare to the people. Among them the Unani medical system is the most highly practiced.

The current ethnobotanical survey shows that out of 129 plants of economic value (Shah, 2001), 117 species (108 indigenous, and 9 cultivated) were found to be of traditional medicinal value. These medicinal species belongs to 61 families and 108 genera (Chart 1). People use medicinal plants to cure more than 50 ailments. Maximum treatment was found to be given against digestive complaints (c. 77 plants) and skin problems (c. 60 plants) (Graph 4). The medicinal plants include 15 trees, 20 shrubs, 74 herbs and 8 climbers (Graph 1). About 38% of the plants were used either in the form of roots or whole. This triggers the dire need of conserving such medicinal species through cultivation and regeneration (Graph 2).Medicinal species bloom preponderantly during April to July (c. 58 plants) while least from November to January (c. 12 plants). So field trips arranged for collection purposes would be beneficial during these months (Graph 3). Similarly maximum harvesting pressure has been noted against fodder utilization (29 per cent i.e., about 34 plants of the total 117) (Graph 5).

The moist temperate Himalayas are one of the major ecological zones from which medicinal plants are collected. It also provides most of the country's timber requirements. During the last hundred years, these forests have been subjected to major structural changes leading to a decrease of about 50% of the potential forest areas. The decrease in the forest cover, combined with major changes in community structure, has also been responsible for the decline in medicinal plant populations resulting from disturbances of habitats (Siyal, 2003).

During the field investigations twenty three indigenous medicinal plants species (Table 6) were recorded as being extracted from Ayubia, Kaghan, Murr ee and Hilkot which are the gateways through which these plants have been supplied in considerable amounts to various national trading centres including Peshawar, Rawalpindi, Quetta, Lahore, Karachi and also abroad.

Analysis of the nearest national market (Rawalpindi and Lahore) survey revealed that 4 species (Acorus calamus, Aconitum heterophyllum, Colchicum luteum and Rheum australe-root sap) have a maximum price of. Rs. 300 to 800 per Kg, followed by Asparagus adscendens, Berberis lycium and Smilax aspera (Rs. 200-300 per Kg) and about 47 species have average price below Rs. 200 per Kg. The data shows that only two species (Punica granatum and Valeriana jatamansi) reach a maximum annual consumption of more than 100 tonnes per annum followed by Lavetera kasmeriana, Plantago major and Paeonia emodi at 50 to 100 tonnes per annum while the rest are consumed at below 50 tonnes per annum (Table 7).

The post harvest processing of the material is one of the most important stages in the manufacture of herbal medicines. Collectors can add value to their material and make it more acceptable for well informed buyers, by adopting scientific procedures. Properly packed, clean and good quality herbal material receives a higher price in herbal markets. The price of Pakistani Podophyllum hexandrum is Rs. 90/Kg in the national market while the Indian Podophyllum hexandrum fetches Rs. 190/Kg in the national market of Pakistan; this is due to effective value addition technology. In case of Asparagus adscendens, the price of the Pakistani species is Rs. 260/Kg on the national market. But the Indian Asparagus adscendens achieves Rs. 2200/Kg on the national market of Pakistan due to the effective value addition technology.

In the international market, especially in European herbal markets, there is a growing demand for organically grown medicinal plants. This certified plant material receives a 3-4 times higher price in the international market. All the selected species collected from the wild fulfil the requirements of organic produce, if presented in acceptable form with proper certification. In-situ conservation and rotational harvesting from natural areas will ensure organic plant materials.

Crude herbal material realizes little monetary returns in both national and international markets. Often these materials are collected in the developing world and exported to western countries for processing. The manufacturers of finished products in western countries sell them at very high prices worldwide. The major part of this money goes to the processing companies in the west, and not to the collectors in the developing world.

Ayubia National park is heavily exploited for fuel wood and fodder (herbaceous and from broad-leaved trees). The collectors of fuel wood and fodder are women, hundreds of whom visit the park daily, except in winter. There is also considerable illegal release of cattle into the park during the summer months. It is reported that there is an official system of fees to allow access to collect fuel wood and fodder and to graze stock. Relatively minor items collected by villagers include medicinal plants, food plants and mushrooms (Morchella esculenta & M. conica species etc.) that are dried and exported, fetching a high price in the European market. There is evidence regarding the extent of collection of medicinal plants. A general survey of the use natural resources by the local people suggests that the use of medicinal plant is on a small scale and declining, but a detailed study revealed a higher prevalence of medicinal plant use and even some commercial collecting in the park.

From the point of view of conservation objectives, the unauthorized collection of plant materials, notably medicinal plants, fuel wood and fodder, in Ayubia National Park is undesirable, as is the unregulated grazing of cattle. About 35.7 per cent cases were registered against fuel wood collection, followed by 22.60 per cent for tree cutting and 16.77 per cent for fodder collection during nine years between 1993-2001. However it is found that only small fractions of these cases, perhaps not more than 10 per cent of the actual cases have been registered. The rate is more or less constant and is perhaps sustained by the same offenders (Shah, 2001).

With no link between use and responsibility, and high and probably ever-growing local demands for fuel wood, fodder and grazing land, it can safely be predicted that the quality of the forest will decline unless systems of local resources management are improved. In the long run, there will be no benefits from resource depletion. Fewer resources will be available to the local people, leopards and rare pheasants will be lost, and the quality of catchments will deteriorate. This will have serious consequences because millions of people in the lowlands rely on the steady flow of rivers from this and other forested area in the Himalayas.

The main threats to the conservation of medicinal plants in the area are unsustainable harvesting by the local people, illegal collection inside the national park, grazing in high pastures, collection of premature plants and collection of whole underground parts. Previous ecological studies have also revealed the vulnerability of important medicinal plants to over harvesting and grazing.

Out of 42 indigenous marketable species, 10 medicinal plants have been found endangered, 22 species were found vulnerable and 10 were rare to the area according to the proposed IUCN criteria (Table 8, Graph 6).

The ten endangered species include one tree i.e., Taxus wallichiana and a shrub Berberis lycium. Due to their long life cycle, these two endangered woody species have been excluded from ex-situ cultivation trials. The rest of the 8 endangered herbaceous species has been selected for ex-situ cultivation trials. These species include Asparagus adscendens, Atropa acuminata, Colchicum luteum, Dioscorea deltoidea, Paeonia emodi, Podophyllum hexandrum, Saussurea costus and Valeriana jatamansi.

Taxus wallichiana (Burmi) has come into prominence in recent times due to its uncontrolled harvesting from the Himalayan wilds for the extraction of the anticancer drug 'taxol'. This tree has also been reported as endangered from Indian Himalayas. It is found only in some undisturbed locations mixed with fir, spruce and blue pine. It is a very slow growing tree with poor regeneration and the extent of canopy damage is likely to have serious consequences on biomass yield, plant survival and natural regeneration by affecting seed output (Rikhari et al., 1998). During the last four years about 5920 Kgs needles/twigs along with bark worth Rs. 1,77,600 have been extracted from Kaghan valley alone (Table 6). This tree species has been observed to be a victim of an unknown pathogenic disease. It is also under pressure due to its use as timber, fuel wood and fodder. This species has been declared as endangered in the area under the proposed criteria. This tree needs cultivation study and its propagation and processing needs standardization. The demand for the species is very high and market supply is very low. It is very important to evaluate the genetic diversity of the sub-species. It has been reported that significant quantities of taxol have been not only located inside the needles but also on their surface also (Zobel et al., 1996). Use of bark must be substituted with needles to release harvest pressure on bark in order to stimulate sustainable utilization of this critical species.

The only medicinal shrub found endangered was Berberis lycium. The whole plant was found to be used for different disorders. Its cultivation requires further study. It is usually grown from seed; vegetative propagation needs study. Its fruit was collected by men, women and children for domestic use and often eaten on the spot. The wild fruit was collected by grazers in the forest. Occasionally, small quantities appear on the local market. The moderate rate of supply is not adequate to the high demand. Study of genetic diversity is required. It can be recommended to cultivate the shrub as live hedges.

Asparagus adscendens cultivation techniques are known but standardization is required. Propagation has been done by seeds and rhizomes but needs refining. Primary processing methods have been discovered but needs standardization to avoid colour change. Genetic diversity needs to be studied. Further research has been required for the improvement of cultivation techniques. The demand for the plant is high while supply has been found to be moderate.

Atropa acuminata cultivation techniques are known but further study is required. The roots of the plant are used as anti asthmatic and analgesic treatments. The demand for the plant material is high and supply is poor. Its population sample requires evaluation. Cultivation trials are needed to be done. Roots of *Colchicum luteum* are used for Colchicine. Its cultivation and propagation techniques have not been fully discovered and it needs study. The processing techniques also require study. The demand for the plant material is considered very high and supply is poor. There is a need to evaluate its population diversity. Priority should be given to cultivation and selection of genotype in research.

Dioscorea deltoidea has also been described among threatened plants of economic value from India (Jain, 1997). Cultivation of D. deltoidea has been achieved but needs further standardization. The propagation of the plant has been done by pieces of rhizomes. The local demand of the plant material is high while supply is poor. Processing techniques are identified Evaluation of the population needs to be done. While conducting research on this plant, priority should be given to its cultivation based on its regional trials.

Paeonia emodi is used in the treatment of rheumatic pain and backache. Demand is high while supply is poor. The germplasm evolution is reported to be crucial, especially in relation to rhizome production and time of

harvest. Cultivation of the plant as crop under shade is needed. This species prefers to grow in sandy loam and loamy silt soil having slightly acidic properties (Sher, 2002).

The population of *Podophyllum hexandrum* is small in size. It is also over exploited in high altitude Himalayas at in natural environment (Choudhary, et al., 1998). The natural populations of P. hexandrum have also been decreasing since 1982 in Garhwal Himalaya (Bhadula et al., 1996). It has been propagated from seeds and rhizome parts. There is an urgent need for sampling evaluation. Demand for the plant is high and supply is poor. In research priority should be given to its germplasm exploration, cultivation, regional trials, harvest time reduction.

Saussurea costus roots are used for respiratory problems due their aromatic properties. It has also been reported among Indian threatened plants of economic value (Jain, 1995). Its cultivation, propagation and processing techniques have been identified. Demand for the plant material is high and supply is considered poor. It is very important to evaluate its shelter growth cycle. Genetic diversity study needs to be done as the plant has two forms, one from Kashmir and other from Ayubia.

Valeriana jatamansi rhizomes and roots are known to be used as mild sedative, in leprosy and as a tonic. The same plant has also been reported as endangered from Nepal (Bhattarai, 1996). Cultivation and propagation techniques are known but further study is required. Its demand is very high and supply is low. Germplasm evaluation is crucial, especially in relation to rhizome production and time of harvest.

Conclusion

Given the importance of medicinal plants for sustaining livelihoods in Ayubia and the pressure on these resources due to trade, the conservation status of medicinal plants is endangered inside the national park. There is evidence that people living outside the national park are already collecting medicinal plants within the boundary of the park. The national park lacks sufficient manpower to efficiently monitor all illegal activities. On the other hand, communities living inside the park have been traditionally managing their pastures and other resources according to customary systems. Knowledge about distribution, abundance, harvesting and management techniques of medicinal plants is thus community based, while National Park staff has little precise knowledge about these subjects. It ensues from this that local communities are in the best position to protect and manage medicinal plants if an agreement, which confers appropriate rights on them, is reached with the park authorities. In order to reach this agreement, a precise management plan needs to be established with each community which includes conservation and sustainable management systems. This community management plan can then be submitted to the park authorities for further consideration and ultimate integration in the park management plans for buffer zones situated inside the park.

Tentative guidelines for work to improve local systems of management for medicinal and other plant resources, emerging from the Ayubia experience, include:

1. Local medicinal plant issues should be placed within wider local contexts e.g., consider all plant resources used, and all land use and resource ownership categories, including the roles that the latter might play in conservation efforts.

2. Good management depends partly on making it worthwhile for people to be good managers. The system of land tenure and resource ownership, and decision-making processes within communities (including between the genders) are key considerations.

3. The people who actually harvest and locally use wild plant resources must be included within management systems. Often, harvesters of wild medicinal plants are among the most disadvantaged members of communities' e.g., women and the land less.

4. Valuable alliances can be forged with local people and conservationist each bringing their particular perspective and knowledge to the identification and resolution of conservation and development problems (subject areas include identification of plants; knowledge of plant use; values assigned to plants and their products; perspectives on rarity and threatened status; methods of management; perspectives on marketing).

Where there are protected areas, agreements are necessary between local people and agencies specifying rights and responsibilities. Medicinal plants can be significant components of such agreements, since they are often culturally valued, vital for local healthcare and sometimes-important sources of income.

Natural regeneration of medicinal plants is adversely affected also by a number of climatic and edaphic factors. The period of growth at higher elevation is generally very short i.e., (April, May to October), any change or disturbance in the climatic factors i.e., prolonged drought in the initial stages of growth (April to June) or excessive rains resulting in low temperature during the month of July and August may result in the poor regeneration and growth of the plants during that year.

Disturbance in the regeneration patterns is also caused due to heavy grazing and intensive felling of trees in particular area. Due to increase in population and simultaneously of animals the grazing pressure has increased tremendously and though unpalatable or even poisonous plants may not be eaten, they are trampled so heavily that regeneration and survival of the plants become extremely difficult.

Moreover the extraction of important medicinal plants by the grazers, collectors and interested drug dealers continues without any consideration of age and size of the plants, which results in the depletion of this natural resource. Generally the plants occurring at higher elevation acquire perennial nature and require a prolonged period of growth i.e. 6-8 years depending upon the plant species concerned. Some plants require at least three to four years to reach the flowering stage. Most of the time, they are extracted by the collectors before reaching the flowering and fruiting stage and thus minimizing their regeneration possibilities. Further, where the roots of the plants are to be collected, the plant has to be destroyed in the process of extraction. Being long duration plants these important medicinal plants are at the verge of extinction in some of the accessible areas, while in far-flung areas, the plants are found sparsely and widely scattered.

Collection of medicinal plants carried out by collectors can be streamlined to provide ample regeneration time for the plants, keeping their optimum period of growth in view. The area once used for collection may be declared as protected area and no more extraction may be allowed for a period of six to eight years.

Seeds of important medicinal plants may be collected according to their time of maturity and after proper cleaning, drying and garbling be stored in glass-jars for regeneration in the next season.

It is suggested that reseeding of important medicinal plants in their natural habitats may be carried out during rainy season in depleted areas where these plants have become scarce. The regeneration area may later be closed for six years by imposing ban on the extraction of herbal drugs. This practice would help to conserve germplasm resources and ensure future sustained supply of this renewable resource from the forest area.

Study of modes of propagation, regeneration, cultural and agronomical issues carried out in the moist temperate Himalayan region indicated that endangered plants like *Asparagus adscendens*, *Atropa acuminata*, *Colchicum luteum*, *Dioscorea deltoidea*, *Paeonia emodi*, *Podophyllum hexandrum*, *Saussurea costus* and *Valeriana jatamansi* could be successfully regenerated and propagated in the depleted areas where the population of these species have become scarce. While short-term annual plants like *Carum copticum* and *Nigella sativa* can be introduced as crop substitutes in low land Himalayas.

In the light of observations and experience of the present study the following recommendations have been formulated for future considerations:

1. Local communities can only take more responsibilities for sustainable harvest of medicinal plants if they have the choices afforded by adequate income, control over the resource, and the knowledge and skill required.

2. A medicinal plant conservation strategy should be designed at government level that includes land-use planning, habitat protection and species-specific in-situ and ex-situ conservation measures.

3. Industry and consumers should assume greater responsibility for the conservation of medicinal plant and should bear a greater share of the cost of conservation directly.

4. Medicinal plants produce is governed by the law of supply and demand and therefore only those plants may be cultivated which have a constant demand in the market and could provide a reasonable cash return to the farmer.

5. Plants requiring long period of growth and specific ecological conditions and elevations may be regenerated in their natural habitats in case of their scarcity, otherwise the demand may be met from natural resources by adopting a systematic rotation for exploitation on a sustained yield basis.

6. Pharmaceutical concerns interested in the cultivation of specific plants should take up their cultivation on a large scale by developing their own research and development facilities.

7. To preserve the medicinal plant species, gene pools may be created in the natural habitats of various plants.

8. A procedure may be evolved to streamline the marketing of medicinal plants. Unstable market fluctuation in prices is the main cause of low production of medicinal plant produce.

9. Research needs to be undertaken on the selection of fast growing, high active ingredients yielding cultivars of commercially important species.

10. It is economically viable that smallholder farmers should play a greater role in medicinal plant cultivation, by introducing home yard gardens or a kitchen garden concept.

11. Core conservation areas should be recognized as control sites for comparison with the forest where exploitation of wild population of medicinal plants continues to take place. Disturbed sites should be used to monitor recovery and regeneration.

12. Provenance collection in secure field banks should be established for medicinal plant genotypes.

13. Sustainable limits of harvesting from wild population should be set over a period until enriched plantings are established.

14. To raise awareness, campaigns like “plants for health” or “plants are wealth” should be designed. Understanding of the importance of habitat and medicinal plant conservation should be promoted in the area.

Fresh quantitative survey should also be conducted in this area to monitor the effectiveness of the recommendations, as well as the status and recovery of populations; permanent plots or transect lines need to be set up outside and within core conservation areas.

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