Research Journal of Medicinal Plant

ISSN 1819-3455

Academic Journals Inc.

www.academicjournals.com

Research Journal of Medicinal Plant 5 (6): 685-694, 2011
ISSN 1819-3455 / DOI: 10.3923/rjmp.2011.685.694

Conservation Status of Medicinal Plants in Ladakh: Cold Arid Zone of Trans-Himalayas

G. Phani Kumar, Raj Kumar and O.P. Chaurasia
Medicinal and Aromatic Plant Division, Defence Institute of High Altitude Research (DIHAR), DRDO, C/o 56 APO, Leh-Ladakh, India

Corresponding Author: G. Phani Kumar, Medicinal and Aromatic Plant Division, Defence Institute of High Altitude Research (DIHAR), DRDO, C/o 56 APO, Leh-Ladakh, India

ABSTRACT

The study reveals that Ladakh is rich in medicinal flora and endemic diversity. The traditional knowledge on native plant species is highlights Amchi system of medicine and their traditional health-care system. The excessive extraction of medicinal plant resources for use in the pharmaceutical industry has resulted in ruthless destruction of natural populations of medicinal plants. Present study attempts to assess the current status of knowledge of medicinal plant resources and conservation status in Ladakh. An approach for prioritizing strategies for action is proposed which is a three step process, viz., technology development, technology dissemination, technology assessment and refinement. It also focuses on approach for prioritizing strategies for action is proposed.

Key words: Ladakh, medicinal plants, amchi system, trans-Himalayas, RET plants

INTRODUCTION

Many traditional healing herbs and their parts have been shown to have medicinal value and can be used to prevent, alleviate or cure several human diseases (Dhar *et al*., 1999). Consumption of herbal medicines is widespread and increasing in recent years and approximately 80% of the people in developing countries depend on traditional medicines for primary health care needs (Farnsworth *et al*., 1985). The global market for the medicinal plants and herbal medicine is estimated to be worth US$800 billion a year (Rajasekharan and Ganeshan, 2002). India is one of the leading countries in Asia in terms of the wealth of traditional knowledge systems related to herbal medicine and employs a large number of plant species includes Ayurveda (2000 species), Siddha (1121 species), Unani (751 species) and Tibetan (337 species). However, in order to avoid any toxicity caused by herbal plants; time and duration of dose should be chosen carefully (Karim *et al*., 2011).

The Himalayan region is a reservoir of a large number of medicinal and aromatic plants (MAPs) and designated as one of the global biodiversity hotspots, where ecological, phyto-geographical and evolutionary factors favour high species diversity. The Indian trans-Himalayas span over 186,000 km^2 above natural tree line zone and is known for its sparsely distributed vegetation and relatively low species diversity. This zone sustains more than 1000 plant species, 225 avian species and many rare and endangered mammalian fauna, including the snow leopard (Shiva, 1996). Ladakh region of Jammu and Kashmir contributes the highest geographical area in the trans-Himalayan region of India, followed by Lahaul-Spiti in Himachal Pradesh, northern part of Sikkin

and Uttaranchal. High-altitude Himalayan zone is full of fragile habitats and decline in tree-species richness, however, rich in representative (native) and endemic biodiversity elements (Kala and Manjrekar, 1999).

Keeping the above facts in view, the present article attempts to (1) identify medicinal plant resource base of Ladakh, (2) highlight the potential and role of medicinal plants in the Tibetan system of medicine, (3) assess the present state of knowledge on threatened medicinal plants of Ladakh, (4) cultivation and conservation implications and (5) suggest a coordinated plan for strengthening the medicinal plants sector in Ladakh. The results of the investigation will help in developing a strategy for conservation and utilization of the medicinal plants by promoting strong linkages among different types of institutions.

MATERIALS AND METHODS

Extensive field surveys (Jain, 1991) were undertaken since a decade to gather data on ethno-medico-botanical information on vegetation of Ladakh and the traditional uses of medicinal plant species across various localities in the Ladakh. Information was gathered using semi-structured questionnaires about the types of ailments treated by the traditional use of medicinal plants and the preparation of herbal medical formulations. The information related to traditional system of medicine given in the text was gathered from traditional healers living across the Ladakh (Changthang, Indus, Nubra, Suru and Zanskar valleys). Specimens of each species identified were maintained at DIHAR herbarium. Literature survey (Samant *et al*., 1998) was carried out for the compilation of various traditional practices, beliefs, raw materials used for curing different ailments, cultivation and conservation practices. Rarity of species is determined by field study, visual estimation, literature and herbaria. The criterion for categorization of threatened species is based on the IUCN (Nayar and Sastry, 1987; IUCN, 2001; Ved and Tandon, 1998).

Study area: Ladakh, 'the land of high-rising passes', is located in the state of Jammu and Kashmir, India (32°15'-36° N; 75°15'-80°15'E). It is bounded on the north and east by China and in the north-west by Gilgit and Skardu (Pakistan). Siachen is the largest glacier located in the extreme northwest of Ladakh. The barren mountain landscape of Ladakh is broken by a series of rivers, notably the Indus and tributaries including Zanskar, Markha, Shyok, Nubra and Suru. The high-altitude (8000 ft to 24000 ft), harsh natural environment of Ladakh is characterized by extreme temperature (-30°C to +30°C), high radiation, strong winds, low precipitation (<100 mm year^{-1}), low humidity; and desert-like extensive barren landscape, rugged topography, steep and vertical glaciated slopes, minimal forest cover and few pasture lands at high elevations (Kumar *et al*., 2009a,b, 2010). The Tibetan science of healing, Sowa rigpa (gSo-ba Rig-pa), is an integrated system of health care contains elements of Ayurveda and Chinese medicine. Since *amchis* are the practitioners of this system it is also known as Amchi medical system (Namgyal and Phuntsog, 1990) 60% of the public health of Ladakh is looked after by this system (Chaurasia and Singh, 1996; Kala, 2005). Some of the Tibetan medicines were made up of purely plant species and their parts. Gradually, Tibetan medicine has gained considerable momentum in Western countries due to the growing awareness about the side effects of allopathic medicines (Kala, 2002).

RESULTS AND DISCUSSION

Vegetation and medicinal flora of Ladakh: Flora and vegetation at the landscape level are an important component in the study of the diversity of life forms and ecological patterns in spatial

variability (Farina, 1998). The flora of Ladakh comes under alpine and high alpine zones and differs significantly from the rest of the Himalayas due to prevailing unique climatic conditions and physiography. Tree line is more or less absent in this zone, however, annual and perennial herbs followed by stunted shrubs and bushes dominate the flora which counts more than 750 plant species (Chaurasia *et al*., 2007): 540 dicots, 65 monocots and two gymnosperms (Kachroo *et al*., 1977). The dominant families of the study area are Asteraceae, Brassicaceae, Fabaceae, Graminae, Ranunculaceae, Lamiaceae etc. and followed more or less same sequence with North-west trans-Himalayan vegetation (Aswal and Mehrotra, 1994) (Fig. 1). The distribution vegetation is adhered to particular altitude range and sometimes to particular valleys. Maximum number of plant species (429) were identified in between 11000-12000 ft asl and then decreased number of species with increased altitude (Fig. 2). Many of the high altitudinal plants have shown potent medicinal values (Kumar *et al*., 2010, 2011).

Medicinal plants of Ladakh can open avenues of economic growth in the emerging world market. Further, it has been realized that medicinal plants of the trans-Himalayan region offer an advantage in having much greater possibilities of providing novel bio-molecules in view of the environmental stress (Mani, 1994). In the present study medicinal plants of Ladakh are being grown under three categories, alpine mesohytes, oasitic vegetation and desert vegetation. The parts of Suru valley is characterized by high humidity, more rainfall and shows the characteristic of alpine mesophytes. The common mesophytic medicinal plant species are *Podophyllum hexandrum*, *Lavetera kashmiriana*, *Lotus corniculatus*, *Astragalus rhizanthus* etc. The habitation nearby river beds Zanskar, Indus, Nubra and Shyok represented by Oasitic vegetation. The medicinal plants of this zone are *Hippophae rhamnoides*, *Dactylorhiza hatagirea*, *Allium przewalskianum*, *Peroveskiana*, *Mentha longifolia*, *Potentilla cuneata*, *Sedum ewersii*, etc. Desertic flora found

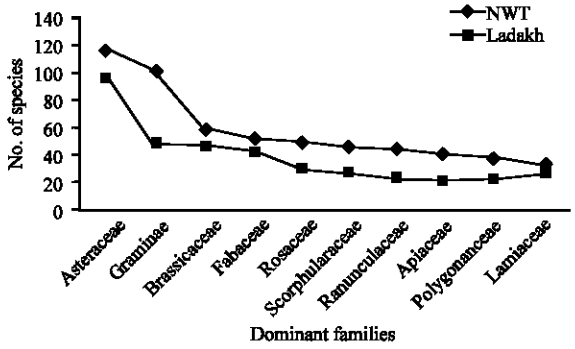

Fig. 1: Comparison of dominant families of Ladakh and North-west Trans-Himalayas (NWT)

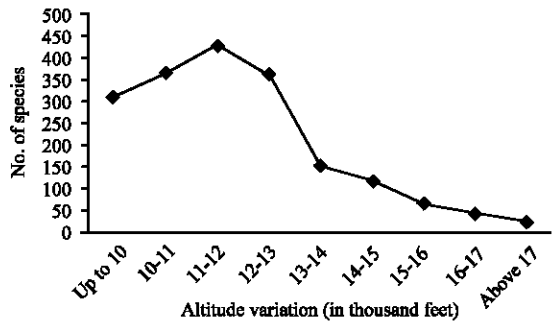

Fig. 2: Distribution of plant species in different altitudes of Ladakh

growing around high passes like Khardungla (18,380 ft), Changla (17,342 ft) and Tanglangla (17,240 ft). The same vegetation also found in the barren lands of *Indus* and *Changthang* valleys characterized by little rainfall, low humidity, extreme fluctuation of diurnal temperature and high velocity winds etc. Many of the plant species are distributed with altitude, latitude and longitude, spatial distribution pattern of MAP's is given in Fig. 3. Some earlier researchers were also found effect of altitudinal variations on physiological or morphological parameters of the plant species (Gupta *et al*., 2011).

Rare, endangered and threatened (RET) species of ladakh: Threat is more difficult to characterize since it may be a natural consequence of biological or geological processes or be the result of past or present human activities directly or indirectly influencing the plant populations or their environment. The populations keep changing size and density over a period of time and such changes may make plant species rare, endangered and threatened, eventually leading in the extinction (Maikhuri *et al*., 1998; Bisht and Badoni, 2009). During the study, it has been observed that the frequency of some of important medicinal and aromatic plant of Ladakh with which it was earlier abound, have considerably declined due to their unscientific exploitation, natural calamities, road construction, uprooting for fuel, overgrazing and other activities (Dar *et al*., 2006). This destruction has rendered many species endangered and threatened. In recent years it was also observed that the population size and number are decreasing in higher elevations. Many species found in Ladakh are considered 'critically endangered' and many more are 'endangered' or 'vulnerable'. The following villages and areas are famous across Ladakh for their medicinal plant wealth and diversity; Sapi, Kanji, Kardhungla, Changla, North Pullu, South Pullu, Hunder and Summur etc. Many amchis from all over Ladakh travel to these hot spots to collect MAPs and they are thus sites of intense collection. Many plant species like Saussurea, Rheum, Artemisia, Thylacopsermum can see hanging along roadside near Khardungla 18,380 ft. and other high motorable passes. The forest department has also made extensive exercises to protect natural habitats and notified three protected areas (Hemis National Park, Karakoram Wildlife Sanctuary and Changtang Wildlife Sanctuary), five wildlife reserves (Randum, Sabu-Chakur, Rizong basgo, Gya-Miru and Kangri) and three game reserves (Boodh Karbu, Tongri and Lung lang) in the region. The field observations on Rare, Endangered and Threatened (RET) medicinal and aromatic plants have been made and compared (Samant *et al*., 1998; Nayar and Sastry, 1987; IUCN, 2001) with are tabulated in Table 1. Overall situation of medicinal plants in Ladakh is under pressures and many wild species are threatened.

Cultivation of medicinal plants: Consumption of herbal medicines is widespread and increasing day by day. There is now wide recognition of the contributions that medicinal and aromatic plants make to the global economy and human welfare (WHO/IUCN/WWF, 1993). Many of the medicinal plants in developing countries are extracted from the wild, it may the result of loss of genetic diversity and has led to rapid depletion of a number of MAPs from their natural habitats (Maikhuri *et al*., 1998; Singh, 2002). Domestication and cultivation of MAPs is one of the viable options to meet the growing demands from the industries and to reduce the extraction pressures in the natural habitats of MAPs. Several researchers were studied on high altitudinal medicinal plants and observed that they were highly potent and required cultivation (Sultan *et al*., 2006; Hwang *et al*., 2009; Prakash *et al*., 2011). In Ladakh, Defence Institute of High Altitude Research (DIHAR) being conducted several workshops and field demonstrations on conservation practices of MAP species. Some important medicinal plant's cultivation techniques for the region of Ladakh has presented in Table 2 which includes germination%, type of vegetative propagation,

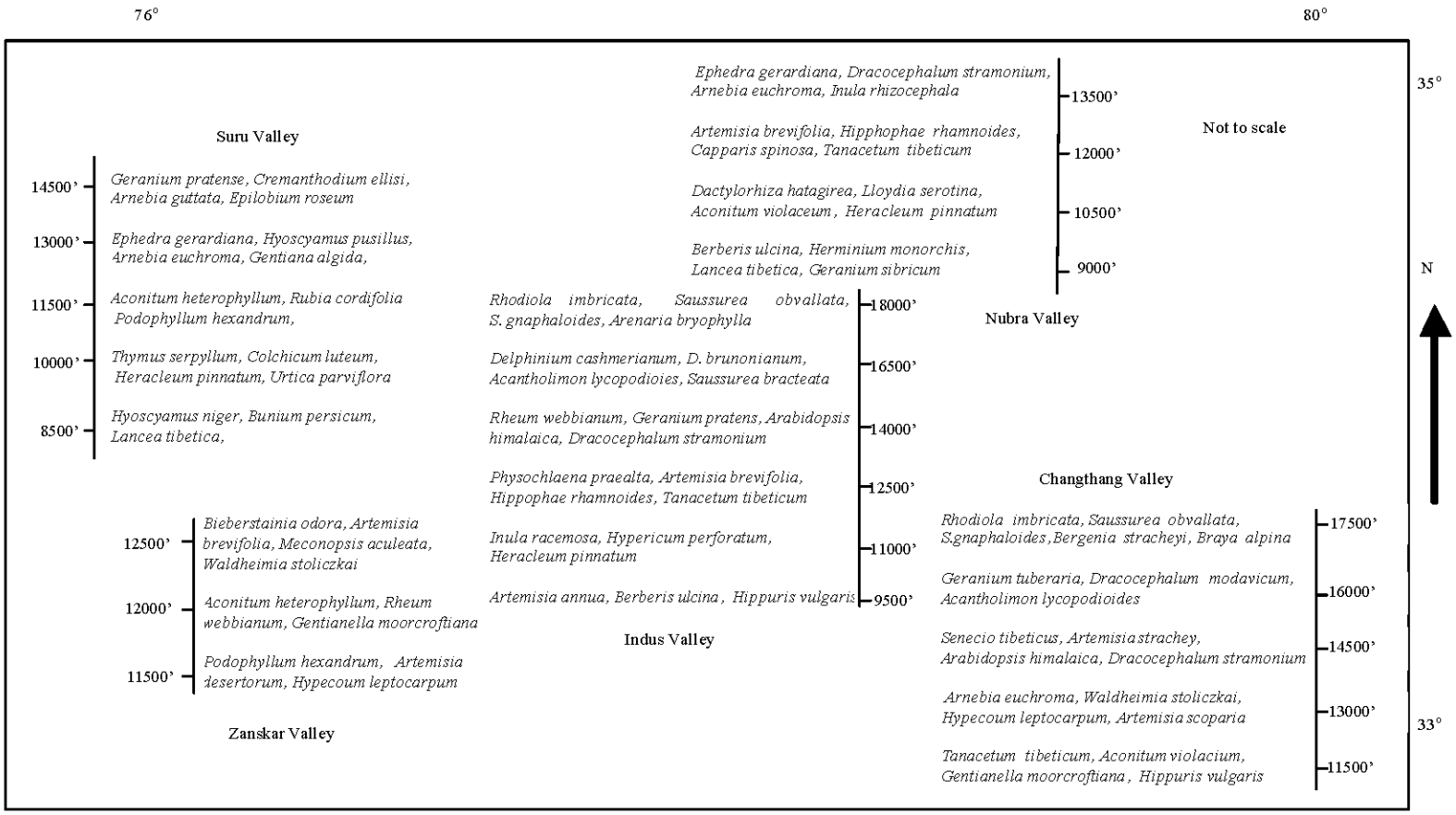

Fig. 3: Spatial distribution of MAP's in different valleys of Ladakh (altitude in feet asl)

Table 1: List of threatened medicinal plants of Ladakh

Name of the Taxa	Family name	Local name	Altitude (ft.)	Part used	IUCN status	
					NWH	JK
Acantholimon lycopodioides (Girad) Boiss.	Plumbaginaceae	Longze	14500-16000	Whole	EN	EN
Aconitum heterophyllum Wall. Ex. Royle	Ranunculaceae	Bona-karpo	10500-12500	Root	CR EN	CR EN
Aconitum violaceum Jac. Ex Stapf	Ranunculaceae	Bona-nagpo	10000-12500	Root	CR EN	VU
Arnebia benthamii (Wall. Ex G. Don) John.	Boraginaceae	Balchar	9000–12000	Root	CR EN	CR EN
Arnebia euchroma (Royle ex benth.) Johnston	Boraginaceae	Demok	13000-16000	Root	EN	EN
Arnebia guttata Bunge	Boraginaceae	Demok	11000-14500	Root	VU	
Artemisia maritima L.	Asteraceae		10000-12000	Leaf	EN	VU
Bergenia stracheyi (Hk.f. and Th.) Engl.	Saxifragaceae	Gatikpa	11000-13000	Root, flower	VU	VU
Betula utilis D.Don.	Betulaceae	-	10000-13000	Root	EN	CR EN
Bunium persicum (Boiss) Fedtsch.	Apicaceae	-	9750-12000	Fruit	NL	EN
Colchicum luteum Baker.	Liliaceae	Tukapa	10500-12000	Rhizome	NL	R
Cremanthodium ellisii Hk. F. Kitam	Asteraceae	Lukumentok	14750-16000		NL	R
Dactylorhiza hatagirea (D.Don) Soo.	Orchidaceae	Ambolakpa	9500-11000	Tuber	CR EN	EN
Delphinium cashmerianum Royle.	Ranunculaceae	Lunde-kaown	14500-16500	Seed, stem, flower	R	NL
Ephedra gerardiana Wall. ex Stapf.	Ephedraceae	Chhapat	10000-11600	Stem, root	VU	EN
Ephedra intermedia Schr and Mey.	Ephedraceae	Chhapat	9300-11000	Root, leaf	NL	VU
Ferula jaeschkeana Vatke	Apiaceae		9500-11200	Root	VU	VU
Fritillaria roylei Hk.	Liliaceae	Abhisa	11200-12000	Bulb	CR EN	EN
Geranium sibricum L.	Geraniaceae	Eyamlomentok	9600-10500	Leaf	CR EN	R
Herminium monorchis (L.) R. Br.	Orchidaceae	Peo	10250-11500	Tuber	VU	NL
Hippophae rhamnoides L.	Elaegnaceae	Sastalulu	9000-13500	Whole	LR-NT	VU
Hyoscyamus niger L.	Solanaceae	Gay-lantang	8500-10000	Fruit	LR-NT	VU
Juniperus communis L.	Cpressaceae	-	9500-12000	Fruit, leaf	R	NL
Jurinea dolomiaea Boiss.	Asteraceae	-	10000-12000	Whole	NL	EN
Lancea tibetica Hk.f. and Th.	Scrophulariaceae	Chagna	9500-11000	Seed	R	R
Lloydia serotina (L.) Reichenb.	Liliaceae	Rtsa-awa	9600-10400	Tuber	NL	R
Meconopsis aculeata Royle	Papaveraceae	Achatsarmum	14000-15200	Leaf, flower, fruit	CR EN	EN
Physochlaena praealta (Decne.) Miers	Solanaceae	Langthang	10,000-16,000	Seed, flower	VU	VU
Podophyllum hexandrum Royle	Berberidaceae	Demokusu	12000-13700	Root	EN	EN
Polygonatum multiflorum (L.) All.	Liliaceae	Ra-mnye	10200-12000	Root	VU	VU
Polygonatum verticillatum (L.) All.	Liliaceae	Ra-mnye	10000-12500	Root	VU	VU
Rheum spiciforme Royle	Polygonaceae	Lachhu	10000-16000	Root	VU	VU
Rheum webbianum Royle	Polygonaceae	Chu-rtsa	11250-13400	Root	VU	VU
Rhodiola heterodonta (Hk. f. and T.) A. Boiss.	Crassulaceae	Solo-marpo	16500-18380	Root	NL	NL
Rhodiola imbricata Edgew.	Crassulaceae	Solo-carpo	16500-18380	Root	NL	EN
Rhododendron campanulatum D. Don	Ericaceae	-	9000-12500	Leaf, flower	VU	VU
Saussurea bracteata Decne.	Asteraceae	Jar-bag	17000-18380	Flower, leaf	R	NL
Saussurea gnaphalodes (Royle) Sch-Bip.	Asteraceae	Yuliang	17500-18380	Whole	R	NL
Saussurea gossypiphora D.Don	Asteraceae	-	15000-17000	Flower	EN	R
Saussurea lappa (Decne.) Sch-Bip.	Asteraceae	Rustha	10000-13000	Root	CR EN	CR EN
Saussurea obvallata (DC.) Edgew.	Asteraceae	Spanrtsa-Dobo	16500-17500	Root	VU	NL

IUCN status abbreviations: CR EN: Critically endangered; EN: Endangered, VU: Vulnerable; R: Rare; LR Nt: Low risk-near threatened; NL: Not listed; NWH: North west Himalayas; JK: Jammu and Kashmir

Table 2: Conservation techniques of some important MAP's for Ladakh climate

Name of the plant	Seed germination and requirement	Vegetative propagation	Manure and Irrigation	Part used and harvesting period	Total production
Aconitum heterophyllum	62-65%; 1.5 kg ha^{-1}	Root divisions/tubers; Req: 95,000 cuttings ha^{-1}	FYM and compost (1:2) @ 7 t ha^{-1}; irrigation in every 48 h	Root; Oct-Nov	93 kg ha^{-1} (after 2nd year)
Allium carollinianum; A. prezuwalskianum	67-75%; 7 kg ha^{-1}	Division of bulbs; Req: 1,25,000 bulbs ha^{-1}	FYM @ 5 t ha^{-1}; irrigation in every 24 h	Bulbs, leaves; Aug- Sep	110 kg ha^{-1}/year
Podophyllum hexandrum	50-60%; 3.5 kg ha^{-1}	Rhizomes cuttings; Req: 11,000 cutting ha^{-1}	FYM / green manure @ 5 t ha^{-1}; Irrigation in every 24 h.	Rhizome; Oct-Nov	5 t ha^{-1} (after 4th year)
Dactylorhiza hatagirea	Very less % of germination and not recommended	Tuber division; Req: 50,000 tubers ha^{-1}	FYM @ 8 t ha^{-1}, mulching is required; irrigation every 12 h	Tubers; Sep-Oct	1.5 t ha^{-1} (after 3rd year)
Arnebia euchroma A. benthami	60-70%;5kg ha^{-1}	Root cuttings; Req: 50,000 cuttings ha^{-1}	FYM @ 6 t ha^{-1}; Irrigation in every 48 h	Roots; Sep-Out	1.2 t ha^{-1} (after 4th year)
Rubia cordifolia	80%; 1.5-2 kg ha^{-1}	Root cuttings; Req: 22,000 cuttings ha^{-1}	FYM @ 10 t ha^{-1};Irrigation in every 3rd day	Root; Sep-Oct	3 t ha^{-1} (after 3rd year)
Polygonatum verticillatum	70%; 2 kg ha^{-1}	Rhizome cuttings; Req: 42,000 cuttings ha^{-1}	FYM @ 15 t ha^{-1}; Irrigation in every 48 h	Rhizome; Sep-Out	1.3 t ha^{-1} (after 3rd year)
Rheum webbianum	50-60%; 600 g ha^{-1}	Rhizome cuttings; Req: 16000 cuttings ha^{-1}	FYM @ 4 t/ ha; Irrigation in every 24 h.	Rhizome; Oct- Nov	4 t ha^{-1} (after 3rd year)
Inula racemosa	70-80%; 200 g ha^{-1};	Rootstocks; Req: 40,000 cuttings/ha	FYM @ 15 t ha^{-1} at the time of land preparation; light irrigation in every 3-4 weeks	Root Oct- Nov	8 t ha^{-1} (after 2nd year)
Hippophae rhamnoides	80-90%; 50 g ha^{-1}	Root cuttings, suckers or stem cuttingsReq: 1,500 cuttings/ha	FYM @ 20 t ha^{-1}; Plantation of male:female ratio should be 20:80; light irrigation at initial stage	Leaves, fruits and seed Aug-Oct	Fruit: 10-15 t ha^{-1}/ year Leaf: 30 t ha^{-1}/ year (after 4th year onwards)
Rhodiola imbricata	5-10% can be increased by cold treatment upto 60%	Rhizome cuttings; Req: 30,000 cuttings ha^{-1}	FYM @ 40 t ha^{-1}; Irrigation is required weekly twice	Rhizomes Sea: Sep - Oct	2 t ha^{-1} (after 5th year)
Sasuurea lappa	85%; 1.25 kg ha^{-1}	Root cuttings; Req: 15,000 cuttings ha^{-1}	FYM/ green mannure @ 15 t ha^{-1}; Excessive watering at initial stages and later on every 4th day.	Root Sea: Oct-Mar	3 t ha^{-1} (after 2nd year)

FYM: Farm yard manure

requirement of seed and manure and approximate production ha^{-1}. Recently, some NGO's are showed their interest on encouraging medicinal plant cultivation in Nubra, Indus and Zanskar valleys.

It is surprising that most of the local people do not know the economical importance (market value) of highly medicinal value plant species like *Podophyllum, Hippophae, Dactylorhyza* etc. Besides lack of knowledge, there is a certain lack of co-ordination among the villagers about the importance of several species in modern systems of medicine and so, they are not willing to cultivate these herbs. Therefore, these people need to be made aware of the importance and to receive information collectively, so that they can discuss themselves, accompanied by their knowledge of technology for cultivation. Cultivation of MAPs could provide an opportunity to enhance incomes of people residing in harsh environments, such as high elevation zones of the Ladakh.

Strategies for conservation: Convention on Biological Diversity (CBD) states that the systematic approach of medicinal plant conservation plays a vital role in environment management and development through traditional as well as scientific practices (Uniyal *et al*., 2006). Documentation and preservation of high altitudinal medicinal plant species of Ladakh and their traditional knowledge system are the most important aspect for the benefit of humankind, before it lost forever. This will require a systematic approach contains technology development, technology dissemination, technology assessment and refinement (Fig. 4). It's a three directional process interlinked each step

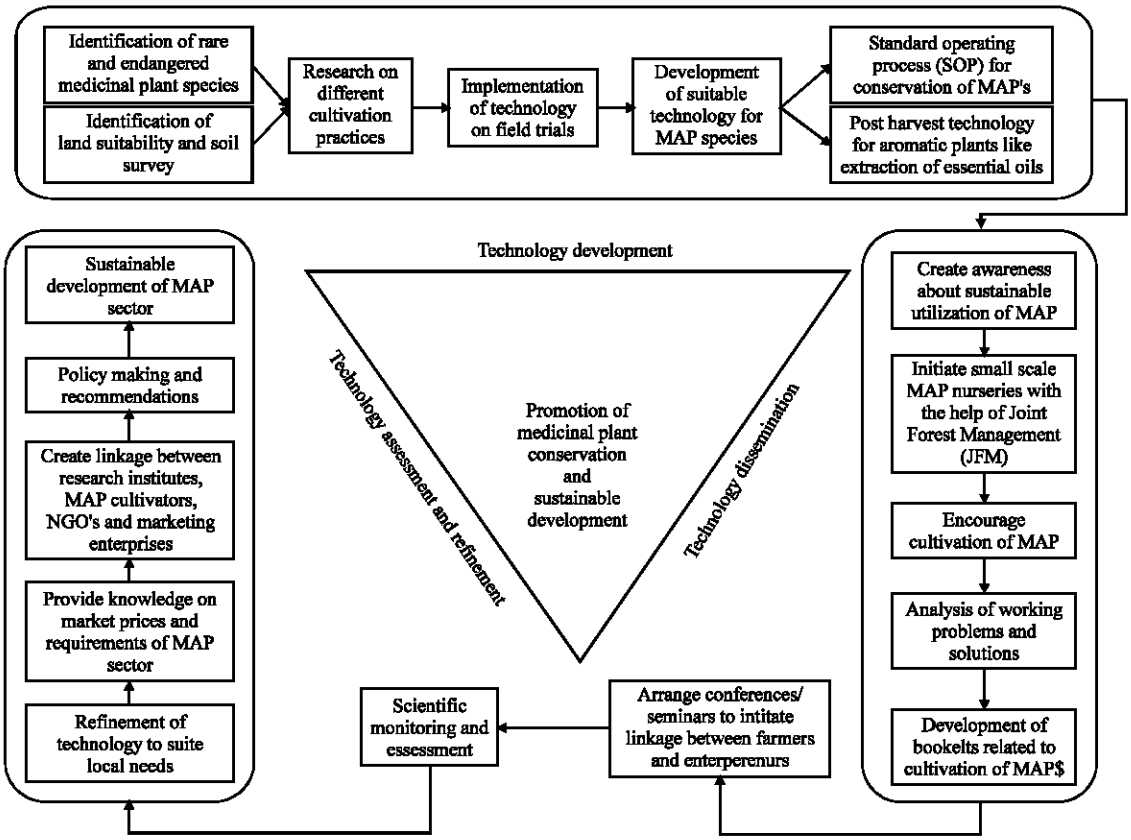

Fig. 4: A model plan for Conservation and sustainable development of MAP

with other. Research and development institutions are having the role in development of suitable and sustainable technology; state govt and forest agencies have the role to implement the technology into field level and entrepreneurs have the role to make a sustainable market for the sector. However, no single institution/agency can meet all the challenges involved in this sector. The problems can only be overcome by building effective partnerships between farmers/ growers, extension agents, private sector, NGOs/GOs, researchers, policy makers and, more importantly by enhancing information exchange.

ACKNOWLEDGMENTS

We thank all Amchies for sharing their traditional knowledge and also thankful to forest officials who co-operated in the extensive field surveys and all fellow colleagues at the DIHAR lab for help and support. We also thank the anonymous reviewer for valuable comments on the earlier version.

REFERENCES

Aswal, B.S. and B.N. Mehrotra, 1994. Flora of Lahaul-Spiti (A cold desert in North West Himalaya). Bishen Singh Mahendra Pal Singh, Dehradun, India.

Bisht, C. and A. Badoni, 2009. Medicinal strength of some alpine and sub-alpine zones of western Himalaya India. New York Sci. J., 2: 41-46.

Chaurasia, O.P. and B. Singh, 1996. Cold Desert Plants. V. I-IV, Field Research Laboratory, Defence Research and Development Organisation, Leh, India.

Chaurasia, O.P., Z. Ahmed and B. Ballabh, 2007. Ethnobotany and Plants of Trans-Himalaya. Satish Serial Publishing House, Delhi.

Dar, A.R., G.H. Dar and Z. Reshi, 2006. Recovery and restoration of some critically endangered endemic angiosperms of the Kashmir Himalaya. J. Boil. Sci., 6: 985-991.

Dhar, U., R.S. Rawal, S.S. Samant, S. Airi and J. Upreti, 1999. People's participation in himalayan biodiversity conservation: A practical approach. Curr. Sci., 76: 36-40.

Farina, A., 1998. Principles and Methods in Landscape Ecology. Chapman and Hall, London, UK.

Farnsworth, N.R., O. Akelere, A.S. Bingel, D.D. Soejarto and Z. Guo, 1985. Medicinal plants in therapy. Bull World Health Org., 63: 965-981.

Gupta, S., G. Bhaskar and H.C. Andola, 2011. Altitudinal variation in essential oil content in leaves of *Zanthoxylum alatum* Roxb. A high value aromatic tree from uttarakhand. Res. J. Med. Plant, 5: 348-351.

Hwang, S.F., H.U. Ahmed, K. Ampong-Nyarko, S.E. Strelkov, R.J. Howard and G.D. Turnbull, 2009. Causal agents of root rot and the effect of vesicular-arbuscular mycorrhizal fungi in seedlings of *Rhodiola rosea* in Alberta, Canada. Plant Pathol. J., 8: 120-126.

IUCN, 2001. IUCN Red List Categories and Criteria: IUCN Species Survival Commission. Version 3.1. IUCN, Gland, Switzerland and Cambridge, UK., pp: 2-30.

Jain, S.K., 1991. Dictionary of Indian Folk Medicine and Ethnobotany. Deep Publications, New Delhi.

Kachroo, P., B.L. Sapru and U. Dhar, 1977. Flora of Ladakh. Bishen Singh Mahendra Pal Singh, Dehradun India.

Kala, C.P. and N. Manjrekar, 1999. Ethno-medicobotany of Indian trans-Himalaya: A case study from Spiti. J. Econ. Taxon. Bot., 23: 177-183.

Kala, C.P., 2002. In Medicinal Plants of Indian trans-Himalaya: Focus on Tibetan Use of Medicinal Resources. Bishen Singh Mahendra Pal Singh, Dehradun.

Kala, C.P., 2005. Health traditions of Buddhist community and role of *amchis* in trans-Himalayan region of India. Curr. Sci., 89: 1331-1338.

Karim, A., M. Nouman, S. Munir and S. Sattar, 2011. Pharmacology and phytochemistry of Pakistani herbs and herbal drugs used for treatement of diabetes. Int. J. Pharmacol., 7: 419-439.

Kumar, G.P., A.A. Murkute, S. Gupta and S.B. Singh, 2009a. Carbon sequestration with special reference to agroforestry in cold deserts of Ladakh. Curr. Sci., 97: 1063-1068.

Kumar, G.P., S. Gupta, P.M. Murugan and S.B. Singh, 2009b. Ethnobotanical studies of Nubra Valley-a cold arid zone of Himalaya. Ethnobot. Leaf., 13: 752-765.

Kumar, G.P., M.P. Murugan, A.A. Murkute and S.B. Singh, 2010. A carbon sequestration strategy involving temperate fruit crops in the trans-Himalayan region. J. Hortic. Sci. Biotechnol., 85: 405-409.

Kumar, R., G.P. Kumar, O.P. Chaurasia and S.B. Singh, 2011. Phytochemical and pharmacological profile of sea buckthorn. Res. J. Med. Plant, (In Press).

Maikhuri, R.K., S. Nautiyal, K.S. Rao and K.G. Saxena, 1998. Medicinal plant cultivation and biosphere reserve management: A case study from the Nanda Devi Biosphere Reserve Himalaya. Curr. Sci., 74: 157-165.

Mani, M.S., 1994. The Himalaya, its Ecology and Biogeography: A Review. In: High Altitudes of the Himalaya. (Biogeography, Ecology and Conservation), Pangtey, Y.P.S. and R.S. Rawal (Eds.). Gyanodaya Prakashan, New Delhi, pp: 1-10.

Namgyal, G. and S.T. Phuntsog, 1990. In Amchi Pharmaco-therapeutics Central Council for Research in Ayurveda and Siddha. Cambridge Printing Works, New Delhi.

Nayar, M.P. and A.R.K. Sastry, 1987. Red Data Book of Indian Plants. Vol. 1, Botanical Survey of India, Calcutta.

Prakash, V., H. Bisht and P. Prasad, 2011. Altitudinal variation in morpho-physiological attributes in *Plantago major*: Selection of suitable cultivation site. Res. J. Med. Plant, 5: 302-311.

Rajasekharan, P.E. and S. Ganeshan, 2002. Conservation of medicinal plant biodiversity in Indian perspective. J. Med. Arom. Pt. Sci., 24: 132-147.

Samant, S.S., U. Dhar and L.M.S. Palni, 1998. Medicinal plants of Indian Himalaya: Diversity, Distribution, Potential Values. Gyanodaya Prakashan, India.

Shiva, M.P., 1996. Inventory of Forestry Resources for Sustainable Management and Biodiversity Conservation. Indus Publishing Company, New Delhi.

Singh, J.S., 2002. The biodiversity crisis: A multifaceted review. Curr. Sci., 82: 638-647.

Sultan, P., A.S. Shawl, P.W. Ramteke, A. Jan, N. Chisti, N. Jabeen and S. Shabir, 2006. *In vitro* propagation for mass multiplication of *Podophyllum hexandrum*: A high value medicinal herb. Asian J. Plant Sci., 5: 179-184.

Uniyal, S.K., A. Kumar, B. Lal and R.D. Singh, 2006. Quantitative assessment and traditional uses of high value medicinal plants in Chhota Bhangal Area of Himanchal Pradesh, Western Himalaya. Curr. Sci., 91: 1238-1242.

Ved, D.K. and V. Tandon, 1998. CAMP report for high altitude medicinal plants of Jammu-Kashmir and Himachal Pradesh. Foundation for Revitalization of Local Health Traditions Bangalore India.

WHO/IUCN/WWF., 1993. Guidelines on Conservation of Medicinal Plants. IUCN, Gland, Switzerland.