academicJournals

Vol. 5(9), pp. 529-540, September 2013
DOI: 10.5897/IJBC2013.0580
ISSN 2141-243X © 2013 Academic Journals
http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

*Review*

# 'Biodiversity conservation of Himalayan medicinal plants in India: A retrospective analysis for a better vision'

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Accepted 15 July, 2013

**Ever-increasing demand of herbal medicines in the world market has put alarming threats to the existence of Himalayan medicinal plants, reported to be the richest source of active bio-molecules. Due to overexploitation, majority of these bear threatened status while some have become extinct. Various *in-situ* and *ex-situ* conservation efforts have been made by the Government of India through various bodies still situation seems to be pathetic. The present work was aimed at exploring the on-going efforts in order to understand the nature of challenges being faced and to design novel framework for improvement. Despite great efforts, cultivation of medicinal plants was not found popular because of several reasons, rendering it incapable for fulfilling the market demand. Consequently, supply of raw material to herbal industry is largely made through illegal harvesting from wild, which was observed as the greatest challenge. Various *in-situ* programs were found in a dire need of local people involvement at various stages, who can become a major taskforce for this. Micropropagation of many high value medicinal plants was found restricted to research papers only due to lack of commercial centers; while for many such plants micropropagation is yet to be standardized. The *in vitro* conservation efforts like gene banks, seed banks were not found extended to many high value plants. Different bodies involved in different conservation programs lacked proper coordination, documentation and dissemination of information. Suitable innovative and promising suggestions are made in the end. Establishment of extensive and organized network system, extending to every village for involving the local people is one suggestion. Development of an organized central pool of information to strengthen the on-going efforts, and establishment of Micropropagation Parks with special employment avenues to local people are also suggested. These suggestions if suitably implicated will go a long way for conserving this invaluable herbal wealth.**

**Key words:** *In-situ*, *ex-situ*, herbal industry, threatened, micropropagation, seed bank, gene bank.

## INTRODUCTION

Plants were being used as the main therapeutic agents during ancient times in India, as described in Susruta Samhita and the Charak Samhita (Prajapati et al., 2003) as well as by many other known cultures of the past like Egyptian, Babylonian, Jewish, Chinese etc. These herbal remedies are still the mainstay of about 70 to 80% of world population, mainly in developing countries for primary health care (Fransworth, 1988). Over the years,

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medicinal plants have come up as an irreplaceable entity in the modern drug discovery; nearly 20 to 30% modern drugs being derived from plants while many are synthetic analogues of natural compounds found in plants (Brower, 2008). India is one of the twelve mega biodiversity centers, having 45000 plant species due to 16 different agro-climatic zones, 10 vegetative zones and 15 biotic provinces (Singh and Chowdhary, 2000; Kala and Sajwan, 2007). The country has about 15000 medicinal plants species that include 7000 plants used in Ayurveda, 700 in Unani, 600 in Siddha, 450 in Homeopathy and 30 in modern medicines (Das, 2008). The Himalayas is credited all over the world as a trove of medicinal herbs, accounting for about 30% of the endemic species found in the Indian sub-continent (Nautiyal, 1998). Moreover, the medicinal plants found in the Himalayas include species of particularly high medicinal value (Anonymous, 2000a). The compression of thermal life zones and the fragmentation of the landscape make the Himalayas as hotspots of medicinal plant diversity (Kaul, 2010). Nearly 8000 species of angiosperms, 44 species of gymnosperms and 600 species of pteridophytes have been reported in the Indian Himalayas (Singh, 1996). Of these, 1748 species are identified as medicinal plants (Samant, 1998), some of these are found throughout the Himalayas (being altitude specific), while some are endemic to a particular physio-geographical location.

Amongst different climatic zones, the maximum medicinal plants diversity (1717 species) has been reported in the temperate zone (Kala et al., 2006). Many of the species have been enlisted in Appendix I of CITES (Convention on International Trade in Endangered Species of Flora and Fauna) and majority are under different threat status (Table 1).

## LOSS OF MEDICINAL PLANTS GENETIC RESOURCES

The annual demand of botanical raw drugs is quite high in domestic market in India (Ved and Goraya, 2007). The export value status of various herbal medicants and medicaments from India indicate towards the popular status of these in international market also (Table 2). At the national level, there are nearly two million practitioners of ISM (Indian systems of medicine) (Anonymous, 2000a), 9500 registered pharmacies of ISM and a number of unlicensed small-scale herbal pharmacy units (Ved and Goraya, 2007). The growing demand of medicinal plants is putting a heavy strain on the existing resources in India, particularly the temperate and alpine plants of Himalayas (Dhawan, 1997; Hazlett and Sawyer, 1998). Nearly all the Himalayan medicinal plants, which are traded in high volume (>100 MT/year), have come under immense threat of depletion (Ved and Goraya, 2007) (Table 1). The high trade value may be due to the presence of unique active bio-molecule or due to use in more than one formulation (Kala et al., 2006). It is estimated that more than 90% of raw material for pharmaceutical companies is drawn from wild, as less than 20 species of plants are under commercial cultivation (Ved et al., 1998; Uniyal et al., 2002). Collection of medicinal plants from the wild is generally being done without paying attention to the maturity of the plants, followed by storing at improper conditions (Anonymous, 2000a). More than 70% of the plant collections involve destructive harvesting because of the use of parts like roots, bark, wood, stem and the whole plant in case of herbs (Natesh, 2000). Since majority of medicinal plant species of Indian Himalayas are endemic to the region (Chatterzee, 1939), these are more vulnerable to extinction due to over-harvesting.

Tolerance to harvest further varies with the climatic conditions as the temperate herbs become highly vulnerable to harvest of individuals (Ticktin, 2004). Besides, human population growth, increased pollution, deforestation, urban development and other developmental activeties like hydroelectric projects and road lying also cause great loss of genetic diversity (Tandon et al., 2009). The threat status of medicinal plants of different states of Himalayan range has been assessed by various CAMP (conservation assessment and management plans) workshops, being organised by Foundation for revitalization of Local health and Traditions from time to time (Goraya, 2011) (Table 1).

## VARIOUS BODIES INVOLVED IN BIODIVERSITY CONSERVATION OF MEDICINAL PLANTS

The Government of India (GOI) is serious about the conservation of invaluable herbal wealth and is working through various Ministries, Departments, Institutes and Laboratories in this direction (Table 3). Besides, banking sector has also been developed for providing financial aids to various projects involved in medicinal plant conservation and cultivation programs. The National Bank for Agriculture and Rural Development (NABARD) is supporting development of medicinal plant sector in coordination with NMPB. NABARD is providing bankable models for some 50 medicinal and aromatic crops with the unit cost and the scale of finance at the state level (Kala et al., 2006) and is also assisting in the capacity building programs in this direction (Kumar, 2004; Prahalathan, 2004).

## PRESENT CONSERVATION SCENARIO: STATUS AND CHALLENGES

In the following sub-sections, a discussion is being made about various efforts being put forward for conservation of Himalayan medicinal plant species along with various challenges being faced by these efforts.

**Table 1.** Summarised description of some important threatened medicinal plant species of Indian Himalayas.

| | Scientific Name & Habit | Medicinal uses | Geographical Distribution | Trade Status[1] | IUCN Status[2] | Micropropagation Status |
|---|---|---|---|---|---|---|
| 1 | *Aconitum chasmanthum* Stapf ex Holmes (H) | Analgesic, diaphoretic, diuretic, sedative | 2100–3500m in Jammu-Kashmir | T | CR | * |
| 2 | *Aconitum deinorrhizum* (Stapf) (H) | Extremely poisonous | 3000–4500m in North-western Himalayas | T | EN | * |
| 3 | *Aconitum ferox* Wall. ex Seringe (H) | Anti-pyretic, anti-rheumatic, for treatment of paralysis, snake bite | 3000-4000m in Arunachal Pradesh, Sikkim | HT | EN | * |
| 4 | *Aconitum heterophyllum* Wall.ex Royle (H) | Anti-inflammatory, antipyretic, astringent, treatment of vomiting, cough, cold, astringent | 2000 – 4000m throughout Himalayas | HT | EN | (Giri et al., 1993) |
| 5 | *Angelica glauca* Edgew. (H) | Cordial stimulant in the treatment of dyspepsia and constipation. | 2600 - 3700m, Western Himalayas | T | EN | (Pandey et al., 2011) |
| 6 | *Aquilaria malaccensis* Lam. (T) | Agar-wood for aromatic preparation Anticancerous | 850-1000m in Eastern Himalayas | HT | CR | * |
| 7 | *Arnebia benthami* (Wall.ex G.Don) Johns (H) | In the treatment of diseases of tongue, throat, cardiac and cancer. | 2000-3000m in North-western Himalaya | T | CR | * |
| 8 | *Arnebia euchroma (*Royle*)*John.(H) | Root is antipyretic, used in the treatment of cancer, measles, burns, frost bite. | 3000 – 4200m, North-west Himalayas | T | CR | (Jiang et al., 2005) |
| 9 | *Atropa acuminate* Royle *ex* Lindl.(H) | Used as anodyne, diuretic, mydriatic, narcotic. | 1800-3000m, in Himachal Pradesh and Jammu-Kashmir | HT | CR | (Ahuja et al., 2002) |
| 10 | *Betula utilis* D.Don (T) | Antispasmodic, antidysenteric hemostatic | 2800-4200m North–West Himalayas, | T | EN | (Zaki et al., 2011) |
| 11 | *Cinnamomum tamala* (Buch.-Ham) Nees (T) | As Antispasmodic, antifungal, antibacterial, treating leucorrhoea | 900 – 2400m, throughout Himalayas | HT | EN | * |
| 12 | *Coptis teeta* Wall (H) | Rhizome is anti microbial and anti-inflammatory | 1500-3000m, Arunachal Pradesh | T | EN | (Tandon & Rathore 1992) |
| 13 | *Dactylorhiza hatagirea* (D.Don)Soo (H) | Used as a nervine tonic and aphrodisiac. | 2500 – 3500m North-western Himalayas. | T | CR | (Vij et al., 1995) |
| 14 | *Datisca cannabina* L. (H) | As diuretic, febrifuge and purgative, root is sedative | 1800-200m in Western Himalayas | NRT | EN | * |
| 15 | *Didymocarpus pedicellata* (H) | Treatment of renal stones, antimicrobial activity, anticancer | 600-1800m in Jammu-Kashmir | T | EN | * |
| 16 | *Dioscorea deltoidea* Wall.*ex* Griseli (C) | Used in modern medicine to prepare progesterone and other steroid drugs | 450-3100m throughout Himalayas | T | EN | (Chaturvedi et al., 1977) |
| 17 | *Epherda gerardiana* Wall.*ex.* Stapf. (S) | Instantaneous cure for asthma, useful in acute rheumatism, stimulant of heart. | 3700-5300m, North-Western Himalayas | HT | EN | (Watanabe et al., 1996) |

**Table 1**. Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | *Ferula jaeschkeana* Vatleant (H) | For treatment of tumors, chronic wound, ulcers | 2800-3500m, Western and North-western Himalayas. | T | VU | * |
| 19 | *Fritillaria cirrhosa* D.Don (H) | For treatment of cough and bronchial problems | 3000 – 4600m in North-eastern Himalaya | T | EN | (Wang et al., 2010) |
| 20 | *Gentiana kurroo* Royle (H) | Root is anthelmintic, antiinflammatory, antiseptic, bitter tonic, cholagogue, | 3200-4000m North–west Himalayas. | T | CR | (Sharma et al., 1993) |
| 21 | *Gymnocladus assamicus* Kanjilal (T) | As soap substitute, protection from leech infection. | 1800-2700m, North-east Himalayas | NRT | CR | * |
| 22 | *Habenaria intermedia* D.Don (H) | Tubers for rejuvenation purpose, | 1500-2500m, North-western Himalayas, | NRT | EN | * |
| 23 | *Hyoscyamus niger* L. (H) | Antispasmodic, hypnotic, mild diuretic | 1500-3700m, In western Himalayas | T | EN | (Uranbey, 2005) |
| 24 | *Jurinea dolomiaea* Boiss (H) | Used for Colic & Puerperal fever, root extract as incense | 3200-4000m, in western Himalays | HT | EN | * |
| 25 | *Lilium polyphyllum* D.Don ex Royle (H) | Tuberous roots as tonic | 2200 -3200m North West Himalayas | NT | CR | * |
| 26 | *Malaxis musifera* (Lindl.)Kuntze (H) | Antimicrobial activity | 2500 – 3700m in Western Himalayas | NRT | CR | * |
| 27 | *Meconopis aculeate* Royle (H) | Poisonous, Help to heal broken bones, treat inflammation | 3000-4000m in Western Himalayas | NRT | EN | * |
| 28 | *Nardostachys jatamansi* DC. (H) | Rhizome as tonic, stimulant, anti-spasmodic, diuretic | 3000-4000m, from throughout Himalayas | HT | EN | (Mathur 1992) |
| 29 | *Panax pseudoginseng* Wall (H) | Tonic to mind and body, in curing a number of diseases | 2500-3400m, Eastern Himalayas | NRT | EN | * |
| 30 | *Paris polyphylla* Sm. (H) | Analgesic, antipyretic antispasmodic, antitussive, narcotic. | 1400 – 4300m, North-west Himalayas | T | EN | (Chang et al.,2009) |
| 31 | *Picrorhiza kurroa* Royle ex Benth. (H) | Antibacterial, cathartic (in large doses), laxative (in smaller doses). | 2700 – 4500m, Throughout Himalayas. | HT | EN | (Lal et al., 1988) |
| 32 | *Pleione maculata* (Lindl.) Lindl. & Paxton (C) | Pseudobulbs used in liver complaints and stomach ache. | 1000–2700m, Eastern Himalaya | NRT | EN | * |
| 33 | *Podophyllum hexandrum* Royle (H) | In treatment of lung and testicular cancer, leukaemia and rheumatoid arthritis. | 2000-4500m, Western Himalayas | T | EN | (Chakraborty et al., 2010) |
| 34 | *Polygonatum cirrhifolium* (Wall.)Royle (H) | Used as Carditonic, Sialagogue, antitussive, carmative | 1700–4600m, Western Himalayas | T | EN | (Qazi et al. 2005) |
| 35 | *Rauvolfia serpentia* (L.)Benth.ex Kurz (H) | As tranquilizer, for treatment of high blood pressure, schizophrenia, as antidote | 1200-2000m, Western and eastern Himalayas | HT | CR | (Bhattacharya et al., 2008) |

**Table 1**. Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| 36 | *Rheum emodi* Wall.ex Meissn.(H) | Used as diuretic, liver stimulant, purgative, cathartic, stomachic, antitumor, antiseptic | 3300 – 5200m, throughout Himalayas | HT | EN | (Lal and Ahuja 1993) |
| 37 | *Rheum moorcroftianum* Royle (H) | Used in treatment of diarrhoea, dysentery, liver diseases. | 3600-6400m, Central Himalayas, | HT | EN | * |
| 38 | *Rhododendron anthopogon* D.Don (S) | Anti-tussive, diaphoretic, its oil reduce cancer growth | 500 – 1500m, Western Himalayas | HT | EN | * |
| 39 | *Saussurea obvallata* (DC.)Edgew. (H) | Used to treat paralysis of the limbs & cerebral ischemia. | 3500-4000m, throughout Himalayas, | NRT | CR | (Joshi and Dhar 2003) |
| 40 | *Saussurea costus* (Falc.) Lipsch (H) | Used in asthma, inflammatory disease, anti-ulcer, anti-cancer drugs | 2800-3000m, North-West Himalayas, | HT | CR | * |
| 41 | *Smilax glabra* Roxb. (C) | Anti-inflammation, anti-cancer | 1800-3000m, Eastern Himalayas | HT | CR | (Zeng et al. 2005) |
| 42 | *Swertia chirata* (Buch-Hams. ex Wall.(H) | Antipyretic, hypoglycemic, Anti-microbial | 1200 – 3000m, throughout Himalayas | HT | CR | (Balaraju et al. 2009) |
| 43 | *Taxus wallichiana* Zucc. (T) | Antifungal, antibacterial and antitumor | 1800 – 3300m, throughout Himalayas | HT | EN | (Datta et al. 2006) |
| 44 | *Zanthoxylum armatum* DC. (S) | In treatment of tumors, headache, hepatitis, fever, leukoderma, skin diseases, cough, asthma, paralysis, arthritis, diabetes, | 1100 – 2500m, Western Himalayas | | EN | * |

1: from www.frlhtenvis.nic.in
*: not available to the best of our literature survey.
Abbreviations in table: H (Herb), S (shurb), T (tree), C (climber), T (traded), HT (highly traded that is, >100 MT/year), NRT (not recorded in trade), EN (endangered), CR (critically endangered), VU (vulnerable).

**Table 2.** Export status of medicants and medicaments of various Indian system of medicine from India* (value in US $ million).

| | | 2007-2008 | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 | 2012-2013 (April to December) |
|---|---|---|---|---|---|---|---|
| Medi- cants | Ayurveda | 31.19 | 51.07 | 25 | 38.09 | 33.03 | 17.13 |
| | Unani | 0.05 | 0.1 | 0.02 | 0.05 | 0.09 | 0.01 |
| | Siddha | 0 | 0 | 0.01 | 0.04 | 0 | 0.10 |
| | Homeopathy | 0.32 | 0.56 | 1.17 | 0.2 | 0.65 | 0.24 |
| Medica-ments | Ayurveda | 48.74 | 70.23 | 117.15 | 115.52 | 137.2 | 90.26 |
| | Unani | 0.23 | 1.02 | 0.07 | 0.21 | 10.21 | 0.99 |
| | Siddha | 0.1 | 0.02 | 0.08 | 0.24 | 0.15 | 0.18 |
| | Homeopathy | 0.44 | 0.47 | 0.42 | 0.78 | 0.59 | 0.7 |

*Source: Export-import Data Bank, Department of Commerce, Government of India.

## Implementation of conservation strategies

The world conservation strategy (IUCN, UNEP and WWF, 1980) defines conservation as "the management of human use of the biodiversity so that it may yield the greatest sustainable benefit to present generation while

**Table 3.** List of various bodies involved in medicinal plants biodiversity conservation programs in India.

| | Working body | Work related to medicinal plants biodiversity conservation |
|---|---|---|
| 1 | Department of Ayurveda, Yogs and Naturopathy, Unani, Sidha and Homeopathy (AYUSH), Established by Ministry of Health and Family Welfare (MOHFW), Govt. of India (GOI). | Included the medicinal plants biodiversity conservation in its national policy. |
| 2 | National Medicinal Plants Board (NMPB), Set up by AYUSH | To co-ordinate all matters relating to medicinal plants including conservation and cultivation.<br>Has established 35 State Medicinal plants Board for taking concerned issues in respective states. |
| 3 | Ministry of Environment and Forests (MoEF), GOI. | Has well defined 'National biodiversity Action Plan' for biodiversity conservation of Indian fauna and Flora. |
| 4 | Jawahar Lal Nehru Tropical Botanic Garden and Research Institute (TBGRI), Thriuvananthapuram, Kerala Identified as 'Center of Excellence for Biodiversity conservation of Medicinal Plants' by MOEF | It is an autonomous Institute established by the Government of Kerala in 1979. It functions under the umbrella of the Science, Technology and Environment Department, Government of Kerala.<br>Has very large Botanic Garden and carries out various *ex-situ* conservation programs. |
| 5 | Institute of Ayurvaeda and Integrative Medicine (I-AIM), initiated by Foundation for revitalization of Local Health Traditions (FRLTH), Bangalore (a registered trust) | Identified as 'Center of Excellence on Medicinal Plants and Traditional knowledge' by MOEF,<br>Designated as 'ENVIS Centre on Medicinal Plants' by MOEF as carries out extensive activites for medicinal plants conservation. |
| 6 | The Botanical Survey of India (BSI), Supported by MoEF. | Has established experimental botanical gardens at different geo-graphical locations of India, namely:<br>Dehradun (Northern circle),<br>Allahabad (Central Corcle),<br>Shillong (Eastern Circle),<br>Pune (Western Circle),<br>Coimbatore (Southern Circle),<br>Port Blaire (Andeman and Nicobar),<br>Jodhpur (Arid Zone),<br>Gangtok (Sikkim-Himalayan Circle)<br>Itanagar (Arunachal field station). |

**Table 3** Contd.

| | | |
|---|---|---|
| 7 | The Indian Council of Forest Reserve (ICFRE), supported by MoEF | To develop reserve forests and support cultivation of medicinal plants. |
| 8 | Indian Council of Agricultural Research (IARI) along with National Bureau of Plant Genetic Resources (NBPGR), National Research Center for Medicinal and Aromatic Plants (NRCMAP) and Indian Institute of Horticulture Research (IIHR) | Implements 'All India Coordinated Project on Medicinal and Aromatic Plants', the project also includes biodiversity conservation as an important aim. |
| 9 | Various Institutes and laboratories of 'Council for Sientific and Industrial Research (CSIR)' namely:<br>Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow.<br>Institute of Himalayan Bioresource Technology (IHBT), Palampur.<br>National Botanic Research Institute (NBRI), Lucknow.<br>Central Drug Research Institute (CDRI), Lucknow.<br>Indian Institute of Integrative Medicine (IIM), Jammu-Tavi<br>Regional Research Laboratories (RRLs) at Bhubneshwar, Jorhat, Palampur, Bhopal and Thriuvananthapuram. | These are involved in various activities of medicinal plants including biodiversity conservation |

maintaining its potential to meet the needs and aspirations of future generations". The conservation strategies being implemented, so far for the Himalayan medicinal plants, fall in two categories: *in-situ* conservation and *ex-situ* conservation and the choice of method for a species depends on propagation cycle of species concerned, seed behaviour of the species, objectives of a particular conservation effort and technologies as well as funds available.

### *In-situ conservation*

It refers to conserving the plants in their natural habitats either as wild plant communities or crop cultivars in farmers' fields as components of traditional agricultural system. At present, about 10 million hectares (4.5% of the geographical area of India) of area are under the *in-situ* conservation (Kala and Sajwan, 2007). Different Himalayan states have established biosphere zones, national parks (for example, 4 in Jammu and Kashmir, 5 in Uttarakhand, 1 in Sikkim) and wildlife sanctuaries (15 in Jammu and Kashmir, 5 in Uttarakhand, 6 in Sikkim) for the conservation of wild flora and fauna of the respective area (Singh et al., 2000). Such areas are always vulnerable to natural calamities, extreme weather conditions and sudden outburst of forest fires. Illegal harvesting from these conserved zones is also a big challenge for example, collection of medicinal plants from 'Himalayan National Park' in Kullu Valley, is a vital source of income for nearly 11000 people living around due to scarcity of other livelihood options (Alam, 2004). The governments are coming up with new policies to combat with the illegal harvesting but situation is still pathetic. Domestication and cultivation of medicinal plants is another way of *in-situ* conservation. Despite being one of the policy issues of both the Central and State governments, the response of farmers is not encouraging. Medicinal plant species generally have long gestation period and exhibit high dependency on natural pollinators, unpredictable seed germination patterns and poor seed viability (Kala and Sajwan, 2007). Agro-technology for large scale cultivation is available for only few of rare and endangered medicinal plant species

**Table 4.** Herbal garden/Vanaspati vans for *ex-situ* conservation in Himalayan states of India.

| Name of state | Name of herbal garden |
|---|---|
| Himachal Pradesh | Kasturba Sewa Smiti Nursery, Deothi, Solan<br>Herbal garden Dumreda<br>Herbal garden, Jogindernagar<br>Botanical Garden, Nauni-Solan<br>Herbal garden of YS Parmar University, Nauni-solan<br>Herbal garden, Neri<br>Herbal garden at IHBT, Palampur |
| Assam | Medicinal Plant garden RRI, Guwahati<br>North-east ecological Park, Jorhat |
| Meghalaya | Medicinal Plant Garden cum Gene Pool Conservation Plot (MPGGPCP), East Khasi Hills.<br>MPGGPCP, Rongrenggiri<br>MPGGPCP, Sangmein.<br>MPGGPCP, Umkhuti.<br>MPGGPCP, Umsaw Nongladew. |
| Arunachal pradesh | Medicinal Plant Garden, Itanagar |
| Uttarakhand | SMP Garden, RRI (Ayurveda), Tarikhet (Ranikhet) |
| Sikkim | Kitam Herbal garden, Maruni Taar Reserve Forest<br>Kitam Herbal garden, Tayoung Reserve Forest<br>Kitam Herbal garden, Karthok Reserve Forest<br>Kitam Herbal garden, Chuba Reserve Forest<br>State Biodiversity Park Herbal garden<br>Samdruptse Harbal garden, Tendong Nature reserve<br>Maenam Haerbal garden, Maenam Sanctuary<br>Ratey Chu Herbal garden, Ratey Chu Reserve Forest |
| Jammu and Kashmir | Herbal Garden-Trikuta Hills, School of Biotechnology, Sh Mata Vaishno Devi University, Kakryal, Katra |

(Anonymous, 2003b).

Majority of medicinal plants, if cultivated, are cultivated without any specific guidelines resulting in poor harvest. Though one of the ongoing activities of NMPB is the development of monographs on agro-technology of medicinal plants, not many monographs have been developed for threatened ones of Himalayas. The efforts need to be fastened for this. Another reason for less interest of farmers is the great fluctuation in demand and prices of medicinal plants. With the release of good agricultural practices for medicinal plants by NMPB, GOI in collaboration with World Health Organization (WHO) in 2009 the exports are expected to rise substantially which may make cultivation of medicinal plants a profitable business; the consequences are yet to be assessed. The complex procedure of acquiring the permit for cultivating medicinal plants, from the Government agencies, is another hurdle in popularisation of medicinal plants cultivation. Generally, farmers fall prey to middlemen for this and if, somehow, the Farmers are not granted permit, they are left with no option but to sell the produce illegally, exposing them to action by government agencies and the exploittation by middlemen (Kala, 2000; Alam and Belt, 2004). No national level statistics on the species wise cultivation of medicinal plants and production of botanical raw materials from such cultivated sources is available (Anonymous, 2008c). NMPB hasprioritized 34 medicinal crops across the country for large scale cultivation including nearly 14 medicinal plants of Himalayas (Kala and Sajwan, 2007). Besides prioritization, intensive efforts are also needed for training and guidance of farmers to motivate them towards medicinal plants cultivation.

### *Ex-situ conservation*

It includes methods which involves conservation outside the native habitat like seed storage, DNA storage, pollen storage, *in vitro* conservation, field gene banks and botanical gardens. Of these, presently, the establishment of herbal gardens/Vanaspati vans is the most largely

implemented *ex-situ* effort (Table 4). The gene banks (TBGRI, NBPGR, CIMAP, IIIM), set up by the DBT, GOI are conserving nearly a thousand accessions of important species from different bio-geographic regions of the country in the seeds banks, *in vitro* repository, DNA bank and under cryopreservation. Of these, IIIM is focussing particularly on the threatened plants of North-western Himalayas; however, the list of species does not include many and there is a lack of proper information of the species under *ex-situ* conservation. One such gene bank in Eastern Himalayas is also needed. The species which are sterile or do not easily produce seeds, or produce recalcitrant seeds or crop plants which are clonally propagated are usually conserved in the field gene banks at IHBT and IIIM. Although, field gene banks provide easy access to the conserved material for use, they run the risk of destruction by natural calamities, pests and diseases and are associated with problems in terms of required land space and labour input during annual and perennial replanting, testing and documentation.

The biotechnology has provided some effective tools namely, micropropagation and cryopreservation, for the conservation of plant genetic resources (Pence, 1999). During the last decade, numerous efforts have been made towards the development of *in vitro* propagation protocol for many threatened medicinal plants of Indian Himalayas but majority of such plants still wait for a suitable one (Table 1). The *in vitro* propagation methods so standardized have remained confined to publications and scientific discussions only. There is no proper documentation of the commercial large scale production using micropropagation, to the best of our search. The DBT, GOI has set up two Micropropagation Technology Parks at National Chemical Laboratory (NCL), Pune and Tata Energy Research Institute (TERI), New Delhi. There is a need of establishing such centres at different locations in Himalayan states also. Biotechnology also provides the possibility of large scale production of bio-active compounds through suspension cultures or hairy root cultures. Unfortunately, these techniques have not been adopted for large scale commercial production of high value bio-active compounds rather extraction is largely done from the natural tissue.

### Documentation and dissemination of information about conservation of Himalayan medicinal plant species

There is a lack of proper documentation of the outcome of various schemes being implemented for biodiversity conservation by respective bodies. For certain areas like the *in vitro* conservation of various threatened plants (pollen banks, slow growth, DNA banks, cryopreservation), mass multiplication by micropropagation and herbal formulations from *in vitro* regenerated plant sources, the information is completely/partially unavailable on the concerned website. The inadequate management system, related to plant germplasm information, in India has been emphasized from time to time and building up of a national medicinal plant conservation database is need of the hour (Prajapati et al., 2003; Sobral, 2001). Detailed information related to conservation, such as names of the plant under conservation, the types of measures followed, places where the practices are carried on, the names of the units (organisations) involved in the various programmes and the addresses of the contact persons for correspondence are all necessary to those working in this field (Bhattacharyya, 2006). Recently, several institutes and organisations, involved in different aspects of medicinal plant conservation have initiated a network program namely, Indian Medicinal Plants National network of Distributed Databases (INMEDPLAN) to pool their resources; the request is provided on request to the network secretary at FRLHT, Bangalore.

A number of online databases have been offered by many institutes (Bhattacharyya, 2006) but in all the available databases of the threatened medicinal plants of Himalayas do not find a satisfactory place. Documentation and dissemination of the information on various conservation efforts of these plants will in a way encourage many groups to initiate conservation efforts for those plants which have not been covered yet. Further modifications in the existing strategies will be greatly benefitted by availability of such information.

## SOME SUGGESTIONS FOR STRENGTHENING THE ON-GOING EFFORTS

### Developing an extensive network system in every state for efficient dissemination and documentation of information among the local communities

Since its establishment, NMPB is doing excellent job for conservation of country's invaluable herbal wealth. As to mobilize and meet the objectives of its various schemes, it has set up 35 SMPB across the country; likewise SMPB should establish nodal office at every district with extension office in each village of the Himalayan states to disseminate maximum information about various schemes directly to the people and document information regarding various aspects of biodiversity conservation from them. The village extension office, besides carrying out dissemination of NMPB and SMPB schemes, can have the many additional activities as explained in Figure 1. The SMPB should organize all the information from the districts nodal offices and develop suitable databases.

### Developing an organized central pool of information by documenting various medicinal plants conservation activities and their outcome, across the country

Presently, the biggest challenge to medicinal plants biodiversity conservation program is the lack of coordination among various bodies involved in such activities. There

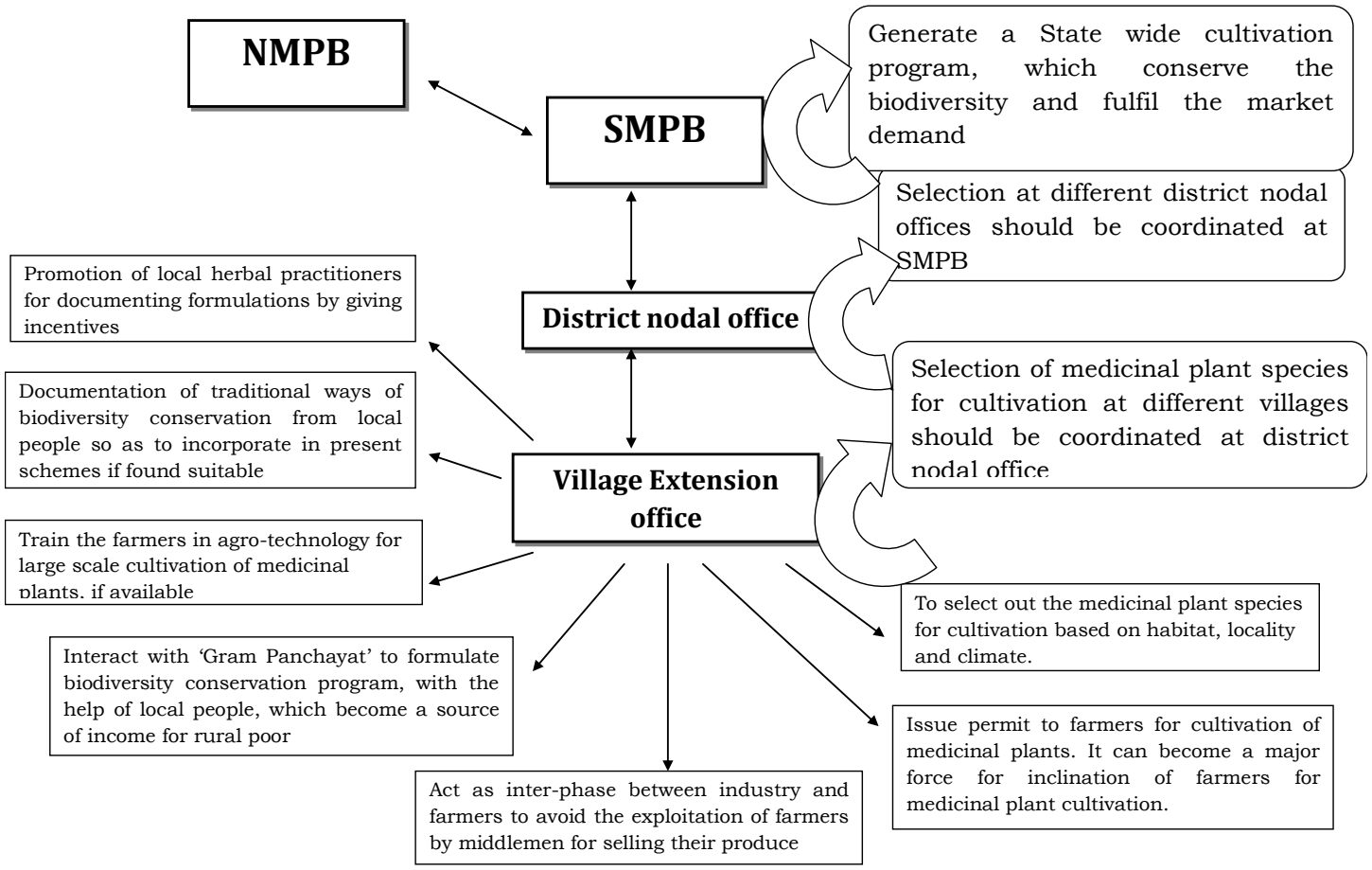


**Figure 1.** Schematic representation of various proposed activities of State Medicinal Plant Board (SMPB).

is a need to develop the coordinated effort at each stage (for example, research, cultivation, collection, storage, processing, manufacturing and marketing) which need to be supported by an appropriate policy framework. Development of an organized Central Pool of information, under the umbrella of NMPB, for documenting the nation-wide activities related to medicinal plant sector, without disturbing the independence of various bodies, can offer the solutions. The executing body (person/groups/ institutes/universities/NGOs/Forest Departments) and the supporting body (like SMPB, DBT, DST, UGC, State Governments and Forest Departments) involved in any activity of medicinal plant sector should send a copy of detailed information of that to this central pool. Implementation of such policy should be made mandatory by some legalized option. With the pooled information, different databases should be developed with detail information of conservation scenario of various medicinal plants across the country which should be updated annually. Such an effort will avoid duplicity of the work and will also encourage the persons/organisations to initiate conservation efforts on medicinal plants which have remained ignored till that time.

**Micropropagation parks with employment avenues for local people**

Though, micropropagation can play significant role in commercializing plants, the high operating cost and the deficit of skills and infrastructure have been limiting research and development. Some cost effective methods have been developed for *in vitro* propagation of some plants (Santana et al., 2009). Further, the *in vitro* propagated plants have also been found to generate more income when compared to propagation by conventional means (Das et al., 2010). Development of the large scale 'micropropagation units', at different locations of the Himalayas, is required for accelerating the on-going conservation programs. These units can be attached to herbal gardens/Vanaspati vans/Forest zone/Field gene banks. Such units will produce the healthy clonal plants of various threatened medicinal plants of that area/zone in large amount. These plantlets can be sold to farmers/ private companies/institutes/Forest departments for large scale cultivation with a license specific to tissue cultures raised plants. As these plants will have a very good quality and will be clonal in nature, they will enjoy a good

price in market and will be best suited for drug manufacturing. A separate unit can be established by the SMPB for taking care of license for cultivation of tissue cultures raised plant and for making their availability to farmers. Further, these plantlets can be introduced in various herbal gardens for- *ex-situ* conservation, seed production and subsequent storage in seed banks, pollen collection for storage in banks. A number of local people can be employed on daily wages for plantation and taking care of these plants.

The plantlets can be introduced in the permissible forest zone, involving the local people. The price of planting these plantlets followed by protection should be considerably high than what they get by illegal harvesting to attract the local people. The Micropropagation Park can have a centre for production of identified high value bioactive compound through suspension cultures or hairy root cultures in large fermenters. Such a step will ensure the quality of herbal drugs as well as lighten the heavy burden on natural resources.

## Conclusions

The use of herbal medicines is enormously increasing due to fewer side effects, easy availability, low cost, longer shelf life and the possibility of finding some novel molecule. This has put a heavy pressure on the biodiversity of the medicinal plants, particularly on native plants of Himalayas. Various bodies have formulated very effective schemes, policies and programs for conservation of the medicinal plant wealth of the country but the situation is still out of control. The various *ex-situ* as well as *in-situ* conservation efforts need to be geared up to combat the existing challenges. *In vitro* conservation, the promising tool of biotechnology, need to be harnessed to its full potential. Large scale production of medicinal plants through cost effective micropropagation for commercial supply can reduce the existing ever-growing burden on natural populations of these plants. The paper reveals that proper dissemination of various schemes and incentives of various conservation programs is not up to the remotest area, paving a way to cropping up of a vicious network of middlemen at every stage. To combat this, the paper has suggested the development of the extensive network system to every village so that information be exchanged directly with the local community. Further, the paper stresses that the various *in-situ* as well as *ex-situ* conservation programs can give more satisfactory results if these are co-ordinated by mutual exchange of information and are able to involve the local community by taking care of their interests.

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