

Medicinal plant biodiversity in India: Resource utilization and conservational aspects

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Abstract

India is among the world's richest countries in terms of plant biodiversity. Besides the abundant flora, containing some 17,500 taxa of vascular plants (Angiosperms, Gymnosperms & Pteridophytes), there is extraordinary ecosystem diversity as well as large pools of both wild and cultivated germplasms. India is also considered as one of the main centers of origin and diversification for plant diversity on Earth. The great British Botanist, Sir J.D.Hooker (1904) remarked that the flora of India is more varied than any other country of the equal area in the eastern hemisphere, if not on the globe. The medicinal plant biodiversity in India both, indigenous and introduced has been put at about 7,500 species. Out of these 1100 plants are frequently used in the Indian system of medicines and 500 plants are commonly used in the preparation of Ayurvedic, Unani and Homeopathic drugs. A tremendous increase in the production of herbal medicines and other products based on Ayurvedic, Unani and other traditional systems of medicines has also been witnessed in India. India has a well established natural drug and pharmaceutical industry making her a major exporter of the plant based products and raw materials. This has put a great pressure on the plant biodiversity of the country. There has been a gross depletion of the natural population of many medicinal plants. Quite few of these have become vulnerable while at least 20 are endangered. Although in recent years, efforts were done to conserve the plant biodiversity in India by various organizations at various levels but much work remains to be done. Past success in augmenting the resource through large scale cultivation of *Sassurea costus*, *Rauwolfia serpentina*, *Gloriosa superba* and many others and introduction of some valuable exotic/substitutive species are the inspiring steps in the stride for conservation of medicinal plant biodiversity in India. Various features of medicinal plant biodiversity of India, an account of resource utilization, prospects, concerns and conservational aspects are discussed in the present communication.

Keywords: *Indian Flora, Ayurvedic medicine, Unani medicines, Endangered, Exotic species*

Introduction

India is a treasure chest of biodiversity which hosts a large variety of plants and has been identified as one of the eight important Vavilorian centers of origin and crop diversity. Although its total land area is only 2.4% of the total geographical area of the world, the country accounts for 8% of the total global biodiversity with an estimated 49,000 species of plants of which 4,900 are endemic (Kumar and Asija, 2000). Medicinal plants which constitute a major segment of the flora provide raw materials for use in all the indigenous systems of medicine in India namely Ayurveda, Unani, Siddha and Tibetan medicine. According to the World Health Organization (WHO), 80% of the population in developing countries relies on traditional medicine, mostly in the form of plant drugs for their health care needs. Additionally, modern medicines contain plant derivatives to the extent of about 25%. On account of the fact that the derivatives of medicinal plants are non-narcotic having no side effects, the demand for these plants is on the increase in both developing and developed countries. There are estimated to be around 2500 effective plant based formulations available in Indian medicine. Over 1.5m practitioners of the Indian system of medicine in the oral and codified streams use medicinal plants in preventive, promotional and curative applications. It is estimated that there are over 7800 medicinal drug manufacturing units in India, which consume about 2000 tons of herbs annually (Singh, 2001).

The number of medicinal plants in India, both indigenous and introduced, has been put at 7,500 by the Ministry of Environment and Forests, Government of India, through an All-India coordinated project on Ethno-biology in 1982 (Ahuja, 2001). Sixteen medicinal plants of exotic origin, introduced in India from time to time are under cultivation and are now considered as a part of the Indian medicinal plant resources. Notable among these are Senna, Psyllium, Belladonna, Cinchona, Eucalyptus, Ipecac, Digitalis and Mexican Dioscorea. In India the number of plants having confirmed therapeutic properties or yielding a clinically useful chemical compound, lies around 700 species. Out of these the plants providing largely and/or regularly used raw materials by Indian drug and pharmaceutical industry restricts to 300. India is also a major exporter of medicinal plant raw materials and their extracts. These include Senna leaf and pod, Psyllium husk and seed, Chebulic, Belleric and Emblic myrobalan and at least 100 other materials. The country exported a total of 42,000 tonnes of medicinal plant raw material to other countries during the year 2000-2001. Of this, Psyllium husk and seed (ex *Plantago ovata*), Senna leaf and pod (ex *Cassia angustifolia*), Vinca herb (ex *Catharanthus roseus*) and a few other sources of phyto-pharmaceuticals accounted for 32,209 tons. The export of materials employed in Indian System of Medicines (ISM) was 9,740 tons during the same period (Anon, 2001). Bulk of the later came from the plants occurring wild. A tremendous increase in the production of herbal medicines and other products based on Ayurvedia, Unani and other traditional systems has been witnessed in India also. The rich biodiversity of the country is yielding plant sources of various therapeutically valuable chemical compounds or their precursors which are in great demand in national as well international drug and pharmaceutical industry. This has put a great pressure on the raw materials, majority of which are obtained from plants growing in the forests or are associated with other forms of natural vegetation. There has been a gross depletion of the natural population of a number of medicinal plants. Quite a few of these have become vulnerable while at least 20 are endangered and are on the verge of extinction. Some note worthy previous works on the similar aspects of medicinal plants in India are by Adhikari, 2003; Ahuja, 2001; Jain, 1991; Kala *et al.*, 2006; Prakash, 2001; Said, 1969 and Sarin, 2003. However, there is not even a single publication exclusively giving an overview of different aspects of medicinal plants in India. The present study is thus made so as to bring together the otherwise scattered information on the various aspects of medicinal plants with a special focus on conservation and utilization in India.

Materials and Method

This study was conducted as an attempt to consolidate the scattered information lying with different sources regarding the Indian medicinal plants. The present paper is aimed at serving as an overview document on Indian medicinal plants covering a wide range of aspects like distribution, diversity, utilization, marketing conservation and future prospects.

The following institutes of national importance were used as sources for gathering information - Botanical Survey of India, Dehradun., National Botanical Research Institute, Lucknow., Central Institute of Medicinal and Aromatic Plants, Bangalore., Wild Life Institute of India, Dehradun., Jamia Hamdard University, New Delhi and Indian Institute of Sciences, Bangalore. The first author visited all these Institutes personally from September 2005 to January 2007 and gathered the information about various aspects of Indian medicinal plants biodiversity. The gathered information was compiled and critically analyzed to have an overview of the Medicinal plant biodiversity in India: Resource utilization and conservational aspects.

The Indian region (6° 45' to 37° 6' N and 68° 7' to 97° 25' E) with a total area of about 3029 million hectares is considered to be one of the twelve centers of origin and diversity of several plant species in the world. A significant feature of the Indian flora is the confluence of floras from the surrounding countries like Malaya, Tibet, China, Japan, Europe and even from wide separated continents like America, Africa and Australia. The Phytogeographers after critical analysis of flora have convincingly concluded that India has 5,725 endemic plant species (Ahmedullaha and Nayar, 1987). India's rich vegetational wealth and diversity is undoubtedly due to the immense variety of the climatic and altitudinal variations coupled with varied ecological habitats. There are almost rainless areas to the highest rainfall area in the world. The altitude varies from the sea level to the highest mountain ranges of the world. The habitat types vary from the humid tropical Western Ghats to the hot desert of Rajasthan, from cold desert Ladakh and icy mountains of the Himalayas to the long warm coast line stretches of Peninsular India. The extreme diversity of the habitats has resulted in such luxuriance and variety of flora and fauna that almost all types of forests, ranging from scrub forest to the tropical evergreen rain forest, coastal mangroove to the temperate and alpine flora occur in this region.

Results and Discussion

India has ten biogeographic zones namely Trans Himalayas, Himalaya, Desert, Semi Arid, Western Ghats, Deccan Peninsular, Gangetic Plain, North East India, Islands and Costs (Sharma, 2006). An account of some of typical Medicinal Plant representatives in each zone is presented in Table 1; and Table 2; shows the some most widely used plants in Indian Pharmaceuticals and Drug industry. Plant Name, Part used, Availability of resource and IUCN Status is also given there. Table 3; represents some important medicinal and aromatic plants grown as horticultural crops. Table 4; shows some other plants grown exclusively as medicinal crops a result of continuous and relate less extraction during the course of many decades, dozens of valuable species are facing danger to their survival in their natural abode in the absence of management practices for their regulated and scientific exploitation, protection, conservation and multiplication. Unregulated exploitation and disorganized trade practices are responsible for sharp decline in the herbal wealth of India. The study revealed that there are twenty eight medicinal plants species whose trade outside India (Export) has been banned under the minor forest produce category. Some of the prominent of these species are; *Aconitum sp.*, *Aquilaria malaccensis*, *Ceropegia sp.*, *Coptis teeta*, *Coscinium fenestratum*, *Cyathea sp.*, *Cycas beddomei*, *Nepenthes khasiana*, *Dioscorea deltoidea*, *Frerea indica*, *Gentiana kurroo*, *Kampferia galangal*, *Nardostachys grandiflora*, *Taxus wallichiana*, *Panax pseudoginseng*, *Paphiopedilum druryi*, *Picrrhiza kurooa*, *Podophyllum hexandrum*, *Rauwolfia serpentine*, *Renanthera pulcherrima*, *Saussurea costus*, *Swertia chirayta* and *Vanda coerulea*.

Critical analysis of occurrence of medicinal plants providing raw material for Indian pharmaceutical and drug industry reveals that *Ferula narthex* is almost extinct from the area of its natural distribution in Ladakh. Four are critically endangered, 20 are endangered and thirty two are vulnerable. There may be a decline in the supplies of another 30 raw materials within next 15 years if the collections at present rate are continued and no remedial steps are taken in near future (Sarin, 2003). Out of 30 medicinal plants under cultivation, at least 10 are being gradually abandoned or replaced by other crops which are more paying or have a regular market. Notable among these are *Atropa belladonna* in Kashmir, *Saussurea costus* in the Lahaul (H.P.), *Rauwolfia serpentine* in Hazaribagh (Jharkhand), *Coptis teeta* in Arunachal Pradesh, *Gloriosa superba* in Trichuraplli (Tamil Nadu) and *Dioscorea floribunda* in Darjeeling hills and Bangalore.

Table 1: Different biogeographic zones of India with some typical medical plant representative species

Biogeographic region	Names of some typical representative medicinal plant
Trans Himalayas	<i>Ephedra geradiana</i> Wall., <i>Hippophae rhamnoides</i> L., <i>Arnebia euchroma</i> (Royle) John
Himalayan	<i>Aconitum heterophyllum</i> Wall. Ex. Royle, <i>Ferule jaeschkeana</i> Vatke and <i>Saussurea costus</i> (Bale.) Lipsch., <i>Nardostachys grandiflora</i> DC., <i>Taxus wallichiana</i> Zucc. and <i>Rhododendron anthopogon</i> D. Don.
Desert	<i>Convolvulus microphyllus</i> Seib ex. Spreng., <i>Tecomella undulata</i> (Sm.) Seem., <i>Citrullus colocynthis</i> (L.) Schrader and <i>Cressa cretica</i> L.
Semi-Arid	<i>Commiphora wightii</i> (Arn.) Bhandari, <i>Caesalpinia bonduie</i> (L.) Roxb. and <i>Balanites aegyptiaca</i> (L.) Delilie.
Western Ghats	<i>Myristica malabarica</i> Lam. <i>Garcinia indica</i> (Thou.) Choisy, <i>Uleria salicifolia</i> Bedd and <i>Vateria indica</i> L.
Deccan Peninsula	<i>Pterocarpus santalinus</i> L.f., <i>Decalepis hamiltonii</i> Wigh & Arn, <i>Terminalia pallida</i> Brandis and <i>Shorea tumbuggaia</i> Roxb.
Gangetic Plain	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. Ex. DC., <i>Mallotus philippensis</i> (Lam.) Muell-Arg. and <i>Pluchea lanceolata</i> C.B. Clarke
North-East India	<i>Aquilaria malaccensis</i> Lam., <i>Smilax galbra</i> Roxb., <i>Abroma augusta</i> (L.) L.f. and <i>Hydnocarpus kurzii</i> (King) Warb.
Islands	<i>Cladophyllum inophyllum</i> L., <i>Adenanthera pavonina</i> L., <i>Barringtonia asiatica</i> (L.) Kurz, and <i>Aisandra buyracea</i> (Roxb.) Baehni.
Coasts	<i>Rhizophora mucronata</i> Lam., <i>Acanthus ilicifolius</i> L., <i>Avicennia marina</i> Vierth and <i>Sonneratia caseolaris</i> (L.) Engl.

The collection from forest area is usually done by local villagers and tribals staying in the vicinity of forests. They collect the material in small lots in their spare time and store it till sold or bartered at a nearby shop. The local shopkeeper, in majority of cases acts as a middleman between the collectors and drug dealers or sometimes the consumer himself. The material so collected from an area is sent out of forest after payment of a nominal fee. Sometimes large scale collections are organized by crude drug dealers or the drug manufactures themselves. The collection of some selected raw material is also handled by the forest department, forest corporations or co-operative societies. In the process, the collection rules are frequently flouted, the life cycle of plant is broken and the quality of the material so collected gets deteriorated. There is a flourishing market of crude medicinal plant materials in India. The traders at local markets also act as procurement and forwarding agents for regional or central markets. The regional markets, such as Baramulla, Srinagar and Udhampur in J&K state, Chamba and Kulu in Himachal, Bhuj and Rajkot in Gujarat, Varanasi in U.P., Haridwar and Dehradun in Uttarakhand and Mysore in Karnataka procure the produce of a particular region and constitute the main supply line for main markets located at Calcutta, Mumbai, Chennai, Kochi, Tuticorin, Delhi and Amritsar. These markets also handle bulk of exports and imports and pharmaceutical industry. This makes the estimation of requirements a difficult task. Such information emanating from various sources differs widely from each other. Chemical and Pharmaceutical Export Promotion Council has estimated the annual demand of raw materials from 55 species at around 32,000 MT (Prakash, 2001). Ayurvedic Drug Manufacturers Association puts such demand at 30,000 MT from 110 species of plants (Unial, 2002). Out of 160 or so plants listed in Tables 3 to 5 of this paper, 100 are having a large demand in the preparation of medicines, around 18 are processed for isolating various phyto-pharmaceuticals or their precursors and 10 such as Psyllium seed and husk and Chebulic and husk, Sena leaf and pod and Chebulic myrobaian fruit are exported in large quantities. Presumptions based on data collected from accurate data is available regarding annual requirements of the plant raw materials by the Indian drug. A large number of sources, indicate that the present requirements of the raw materials lies between 1, 50,000 and 2, 00,000 MT per annum. This include the materials coming from certain largely cultivated sources, such as Cinchona, Psyllium, Senna, Ashwagandha, Tea, Tobacco

Table 2: Some widely used medicinal plants of India

Name of the Plant	Part used	Resources availability and IUCN status	Name of the Plant	Part used	Resources availability and IUCN status
<i>Acacia nilotica</i>	STBK/GM	Good	<i>Acorium chusmantium</i>	RT	Rare (CR)
<i>Acorium heterophyllum</i>	RT	Rare (CR)	<i>Aethiodes vesica</i>	LF	Good
<i>Aegle marmelos</i>	FR-RT	Good	<i>Albizia lebbek</i>	STBK	Good
<i>Astoria scholaris</i>	STBK	Good	<i>Andropogon paniculata</i>	HB	Fair (VU)
<i>Aristolochia indica</i>	RT	Fair	<i>Artemisia maritima</i>	HB	v.poor
<i>Asparagus racemosus</i>	RT	Poor	<i>Asarum indicum</i>	LS/STBK/SD	Good
<i>Bambusa arundinacea</i>	Marra	v.poor (EN)	<i>Bauhinia variegata</i>	STBK	Good
<i>Berberis aristata</i>	RT	Poor (VU)	<i>Berberis asiatica</i>	RT	Poor (VU)
<i>Bentla utilis</i>	STBK	v.poor (VU)	<i>Boerhaavia diffusa</i>	RT	Good
<i>Cissia occidentalis</i>	SD	Good	<i>Catharanthus roseus</i>	HB/RT	Fair
<i>Centella asiatica</i>	WP	Good	<i>Cinnamomum zeylanicum</i>	LS/BK	Good
<i>Colchicum autumnale</i>	Com	Poor (VU)	<i>Commiphora wightii</i>	GM	v.poor (EN)
<i>Corchorus microrhizus</i>	HD	Good	<i>Coptis teeta</i>	RT	Poor (VN)
<i>Coscinum fenestratum</i>	ST	Poor (VN)	<i>Cuculigo orchoides</i>	RT	Fair (VU)
<i>Curcuma aromatica</i>	Com	Good	<i>Cyperus rotundus</i>	Tuber	Good
<i>Dactylorhiza hatagirea</i>	RT	Rare (CR)	<i>Datura stramonium</i>	LS/SD	Good
<i>Dioscorea deltoidea</i>	RH	V.poor (EN)	<i>Eclipta prostrata</i>	WP	Good
<i>Embelia ribes</i>	FR	Fair (VU)	<i>Embelia tjeriancotton</i>	FR	Good
<i>Entella officinalis</i>	FR	Good	<i>Ephedra Gerardiana</i>	ST	Fair (VU)
<i>Erythrina variegata</i>	STBK	Good	<i>Ficus religiosa</i>	GM	Extinct
<i>Ficus racemosa</i>	STBK	Good	<i>Gaultheria fragrantissima</i>	LS	Poor (VU)
<i>Gloriosa superba</i>	RT/SD	Good	<i>Gynocardia odorata</i>	SD	Good
<i>Hedyotis spicata</i>	RH	Good	<i>Helicteres isora</i>	FR	Good
<i>Holarrhena anandisenterica</i>	STBK	Good	<i>Hydnocarpus pentandra</i>	SD	Good
<i>Ipomoea hederacea</i>	SD	Good	<i>Lepidium sativum</i>	SD	Good
<i>Leptocarpus reticulatus</i>	RT	Fair	<i>Madraca longifolia</i>	FR, SD	Good
<i>Melastoma philippinensis</i>	FR/ind	Good	<i>Mimosa pudica</i>	SD	Fair
<i>Mitrasaccharum</i>	SD	Fair	<i>Nardostachys grandiflora</i>	RT	Poor (VU)
<i>Nymphaea stellata</i>	FL	Poor (VU)	<i>Ocimum basilicum</i>	HB	Fair
<i>Ocimum sanctum</i>	SD	Good	<i>Oreocaulum turpe</i>	RT	Fair
<i>Phyllanthus amarus</i>	HB	Good	<i>Picrorhiza kurroo</i>	RT	Poor (VU)
<i>Piper longum</i>	FR/RT	Fair	<i>Pistacia integerrima</i>	Call	Poor (VU)
<i>Plantago zeylanica</i>	RT	Good	<i>Podophyllum hexandrum</i>	RT	Poor (VU)
<i>Prunella vulgaris</i>	WP	Fair	<i>Prunus cerasoides</i>	STBK	Fair
<i>Psoralea corylifolia</i>	SD	Fair	<i>Pterocarpus santalinus</i>	WD	V.poor (EN)
<i>Parica grandis</i>	SD	Good	<i>Rauwolfia serpentina</i>	RT	Fair
<i>Santalum album</i>	WD	Fair	<i>Sapindus mukroosi</i>	FR	Good
<i>Saussurea costus</i>	RT	Poor	<i>Sida cordifolia</i>	SD	Fair
<i>Solanum nigrum</i>	WP	Good	<i>Solanum surattense</i>	WP, RT	Good
<i>Sweetia chirata</i>	WP	v.poor (EN)	<i>Symplocos racemosa</i>	STBK	Good
<i>Tamarix gallica</i>	Galls	Fair	<i>Taxus wallichiana</i>	STBK	Fair (VU)
<i>Terminalia arjuna</i>	LS, STBK	Fair	<i>Terminalia chebula</i>	Fp	Good
<i>Thespesia populnea</i>	FL, FR	Fair	<i>Tinospora cordifolia</i>	ST	Good
<i>Tribulus terrestris</i>	FR, RT	Good	<i>Valeriana jatamansi</i>	RT	Good (VU)
<i>Viola pilosa & others</i>	FL	Fair (VU)	<i>Vitex negundo</i>	LS/FR	Good

Table 3: Some medicinal and aromatic plants of India grown as horticulture crops

Plant	Crop	Medical Part	Demand
<i>Allium sativum</i>	Garlic (Lahsoon)	Bulb/Oil	V. High
<i>Amomum subulatum</i>	Large cardamoms	Fruit, Seed	Med
<i>Amorphophalus campanulatus</i>	Sooran	Corm	Mar
<i>Anethum sowa</i>	Indian Dill (Sowa)	Seed, Seed oil	V. High
<i>Apium graveolense</i>	Calery	Seed, seed Oil	Med
<i>Areca catechu</i>	Betelnut (Supari)	Seed	Med
<i>Cinnamomum verum</i>	Cinnamon (Dalchini)	Stem bark	Med
<i>Coriandrum sativum</i>	Coriander (Dhania)	Fruit	Med
<i>Crocus sativus</i>	Saffron (Kesar)	Pistil	Mar
<i>Cuminum cyminum</i>	Cumin (Zira)	Fruit	High
<i>Curcuma Longa</i>	Turmeric (Haldi)	Root	High
<i>Elettoria cardamomum</i>	Cardamom	Fruit, Seed	High
<i>Foeniculum vulgare</i>	Fennel (Saunf)	Fruit	Med
<i>Lausonia inermis</i>	Mehndi (Henna)	Leaf	High
<i>Linum usitatissimum</i>	Alsi (Linseed)	Seed; Oil	Med
<i>Momordica charantia</i>	Karels	Leaf, Seed	Low
<i>Myristica fragrans</i>	Jaiphal, Javitri	Seed and Aril	Med
<i>Nigella sativa</i>	Kalsunji	Seed	Low
<i>Papaver Somniferum</i>	Opium poppy	Opium	V. High
<i>Piper nigrum</i>	Black pepper	Fruit	V. High
<i>Prunus amygdalus</i>	Badam (Almond)	Kernel/Oil	Med.
<i>Ricinus communis</i>	Eranda (Castor)	Root/Oil	High
<i>Sesamum indicum</i>	Sesamum (Til)	Seed, Oil	High
<i>Syzygium aromaticum</i>	Cloves (Lavanga)	Flower bud	High
<i>Trachyspermum ammi</i>	A jawain	Seed	High
<i>Trichosanthes dioica</i>	Patol, Parval	Leaf/Fruit	Low
<i>Trigonella foenum-graceum</i>	Fenugreek (Methi)	Seed	Low
<i>Zingiber officinalis</i>	Ginger (Soonth)	Rhizome	V. High

Table 4: Some widely cultivated medicinal plants of India

Plant	Part Used	Demand	Plant	Part Used	Demand
<i>Acorus calamus</i>	RH	High	<i>Dioscorea floribunda</i>	RH	High
<i>Alpinia galanga</i>	RH	Med	<i>Embolia officinalis</i>	FR	V. High
<i>Aloe vera</i>	LF	V. High	<i>Eucalyptus globules</i>	LF/Oil	High
<i>Ammi majus</i>	FR	Med	<i>Gloriosa superba</i>	RT/S	Med
<i>Asparagus racemosus</i>	RT	High	<i>Inula racemosa</i>	RT	Low
<i>Atropa belladonna</i>	RT/LF	Low	<i>Kaempferia galangal</i>	RH	Low
<i>Carum carvi</i>	FR	High	<i>Piper longum</i>	FR/RT	High
<i>Cassia angustifolia</i>	LF:FR	High	<i>Plantago ovata</i>	SD/Husk	V. high
<i>Catharanthus roseus</i>	RT; HB	V. High	<i>Rauwolfia serpentina</i>	RT	High
<i>Cinchona sps.</i>	STBK	High	<i>Saussurea costus</i>	RT	High
<i>Digitalis lanata</i>	LF.OIL	High	<i>Withania somnifera</i>	RT	High

Abbreviations and legends to Tables 2-4.

Vegetative parts used : RT- Root; RTBK-Root bark; ST-Stem; STBK-Stem bark; LF-Leaf; FL-Flower; FR-Fruit; SD-Seed; GM-Gum, oleoresin; WP-Whole plant; HB-Herb (aerial parts).

Resources: Good-No declines foreseen; Fair-May decline if there is increase in current rate of collection; Poor-Already declining; V. Poor-Declining sharply and may exhaust shortly; Rare-Almost exhausted in the wild; Threat categories (IUCN): CR-Critically Endangered; EN-Endangered; VU-Vulnerable

and Poppy. The demand of the raw material may increase substantially in coming years due to enhanced production of medicines, phyto-pharmaceuticals, extracts and over the counter products by the Indian drug and pharmaceutical industry.

Conclusion

The observations made in the foregoing discussion indicate that medicinal plant raw material resource in India though facing problems, there is enough scope for its development to meet the requirements of drug and pharmaceutical industry. Concerted multi-disciplinary efforts are required to execute large scale production of materials from both wild and cultivated sources. The augmentation and supplies of raw materials obtained from the plants growing in forests, especially those originating from trees and shrubs may better be left with the foresters who may undertake in-situ conservation, restocking and forestation with desirable species. Steps for systematic census of medicinal plants associated with different types of forest vegetation and quantitative evaluation of the raw material available will also have to be undertaken by the forest department.

Large scale cultivation of medicinal plants, both indigenous and exotics will be a desirable solution for ensuring unrestricted supply of the raw material in required quantities. Research and development studies on domestication of wild plants and introduction of certain exotics have been going on at a number of government, non government and academic agencies since long, but the success in large scale cultivation could be obtained in only few cases. The causes of failures need critical investigation in the light of the fact that India is blessed with a wide spectrum of agro-climatic conditions, a chain of research institutions with competent workers in the field of biology, biotechnology and agricultural sciences and a hard working and enterprising farmer. There appears to be a lack of coordination among various workers and between organizations engaged in the development of medicinal plant resources. Cultivation of medicinal plants is inversely linked to prevalence of easy and cheap collection of medicinal raw materials from the wild, cornering of the profits by a vast network of traders and middlemen and absence of industry's interest in providing buyback guarantee to the grower. These problems require immediate solutions to ensure the involvement of the farmers in this task. A lot of work has been done in various fields of development of medicinal plant resources of India. Valuable data on botany, distribution pattern, occurrence, chemistry, pharmacology and agro-technologies has been lying accumulated with various research institutions, universities and non-government organization. Such data retrieved and consolidated at one place, critically examined and documented will greatly help in devising strategies for proper development and conservation of medicinal plant raw material resources of the country. A collaborative work involving scientist, government, institutions, NGO's and forest dwellers is suggested for preserving the traditional indigenous knowledge and practices and conservation of medicinal plants and upliftment of rural economy of the country.

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