



SCARCITY OF MEDICINAL PLANTS: A THREAT TO AYURVEDA-AN OVERVIEW

Akhilraj A.R^{1*}, Rukmini S² and Amalraj A.R³

¹Ethnomedicine & Ethnopharmacology Division, KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE - JNTBGRI), Palode, Thiruvananthapuram, Kerala, India

²Primary Health Centre (PHC), Ittiva, Kollam, Kerala, India

³Community Health Centre (CHC), Kallara, Thiruvananthapuram, Kerala, India

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ABSTRACT

Every country has its own traditional health care practices. These practices have evolved based on culture, philosophy, geographical conditions, flora, and mineral resources. Availability of Medicinal plants is the backbone of traditional health care practices like Ayurveda, Folk, Siddha, Unani, etc. India with its enormous natural flora is considered the 'Herbarium of World' and is one of the 12 mega biodiversity countries harboring two unique 'Biodiversity Hotspots' out of 18 in the world. But the overexploitation of these resources leads to depletion and scarcity of Medicinal plants. According to IUCN and WWF, about 50,000 - 80,000 flowering plant species are used for medicinal purposes worldwide. Among these, around 15,000 species are threatened with extinction from overharvesting and habitat destruction and 20 % of their wild resources have already been nearly exhausted with the exploitation from manhood. The current loss of plant species is around 100 to 1000 times above the expected natural extinction rate and it's said that the world is losing at least one potential major drug every 2 years. This eventually led to substitution or adulteration of the original plant source, which can adversely affect the quality, safety, and efficacy of the individual drug or formulations. The increasing demand for herbal products worldwide also pressurizes the pharmaceutical industry for overproduction of the same, which in turn drains out the natural resources to the maximum extent. So, it is the need of the hour to conserve the biodiversity of medicinal plant wealth for the present and forthcoming generations, by adopting suitable strategies and appropriate methods of conservation.

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INTRODUCTION

Medicinal plants always have a special place in Indian tradition. Lord Hanuman's leap from the battlefield to the Himalayan valley to fetch four lifesaving plants was no more than the dramatic assertion of a tradition that has echoed in the veda and classical literature. Ayurveda signifies "Na jagat yevamanou adham", that is, 'there is no substance in the world that cannot be used as medicine'; which means, everything that surrounds us, including plants can be used as medicine.^[1] Medicinal plants constitute one of the richest bioresources for herbal drugs, food supplements, natural cosmetics, complementary alternate medicine, phytoconstituents of industrial significance, and also as lead molecules for the development of allopathic drugs.

The word 'biodiversity' is a contraction of biological diversity. Diversity is a concept that refers to the range of variation or differences among some set of entities. Thus, biological diversity refers to variety within the living world.^[2] The term 'biodiversity' is indeed commonly used to describe the number, variety, and variability of living organisms. This very broad usage, embracing many various parameters, is actually a synonym of 'Life on Earth'. India has a rich treasure of

Medicinal plants due to the diversity of climatic and physiographic conditions spread all over the country. Medicinal plants occupy an important position in the spiritual and socio-cultural lives of our people, as they firmly believe that, the inherent properties of such plants can be used to ward off diseases and promote good health. India has 16 Agro-climatic zones, 45,000 different plant taxa, and 15,000 Medicinal plants of which 7,000 plants are used in Ayurveda, 700 in Unani, 600 in Siddha, 450 in Homoeopathy, and 30 in modern medicine.^[3] This makes India one among the 12 mega biodiversity hot spot countries of the world, harboring two unique biodiversity hot spots- the Eastern Himalayas and the Western Ghats. Despite India having only 2.5 % of the total land area of the world, the country accounts for over 8 % of the recorded species worldwide. The Indian System of Medicine has identified 1,500 Medicinal plants, of which 500 species are commonly used in the preparation of ISM&H drugs.^[4]

The use of plant resources in the preparation of medicines is towards an increasing trend both in developed and developing countries, due to the growing concern about the side-effects of chemicals and synthetic substances. Medicinal plant-based drugs have the added advantages of being simple, effective,

*Corresponding author: Akhilraj A.R

Research Fellow (Ayurveda), Ethnomedicine & Ethnopharmacology Division, KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE - JNTBGRI), Palode, Thiruvananthapuram, Kerala, India

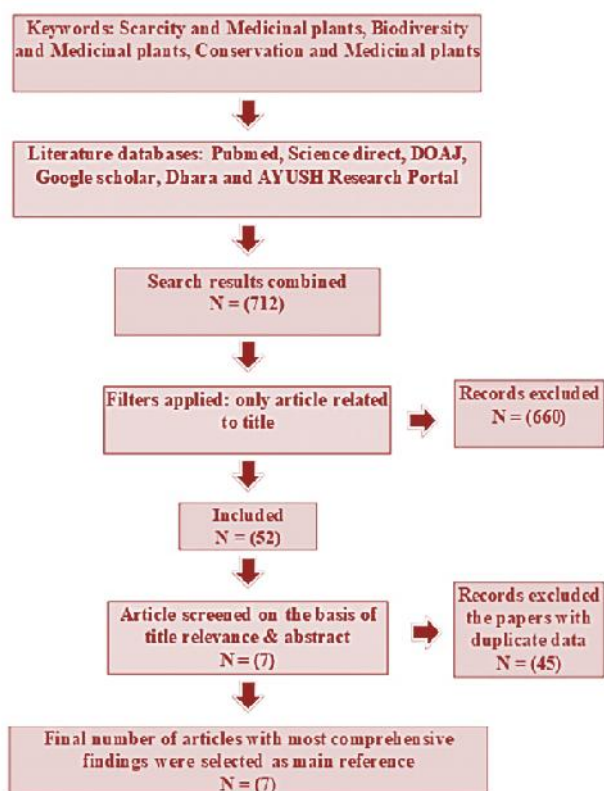
and offering a broad spectrum of activity with an emphasis on the preventive action of drugs.^[5] Because of these factors, the demand for plant-based medicines is increasing worldwide. WHO's forecast is that the global market for herbal products is expected to reach around US\$ 5 Trillion by 2050.^[6]

A large part of plant species used in the Indian System of Medicine like Ayurveda, Unani, and Siddha are still collected from forests and natural vegetation. With the rapid rise in the national and global understanding of the importance of herbal medicine, the pace of exploitation of Medicinal plants from the wild state also has increased. Consequently, several important medicinal plant species occurring in forest canopies are being threatened with extinction and are listed in the Red Data books of IUCN.

The country needs to urgently shift the harvestation of Medicinal plants with high industrial demand (especially those having harvestation with habitat destruction), from their wild habitats to cultivated sources only. Several species of conservation concern have been reported in significant trade. Special attention needs to be paid to such threatened species to ensure their sustainable harvest, perpetuation, and genetic conservation. This has been an active area of study in recent times. Such an understanding is essential to guide the conservation and management of these Medicinal plant resources.

MATERIALS AND METHODS

The literary research was done through various databases such as published journals, research articles, and contemporary texts. Various electronic databases like PubMed, Science direct, DOAJ, Google scholar, Dhara, and AYUSH Research Portal were searched by using the MESH Terms Scarcity and Medicinal plants, Biodiversity and Medicinal plants, Conservation and Medicinal plants, and Conservation and Medicinal plants.



From the obtained 712 combined results, 660 records were excluded because of the filters applied on articles related to the title and included only 52 of them. Then the articles were screened based on title relevance and abstract, from which the most comprehensive 7 articles were selected.

RESULTS

Major causes for the loss of Biodiversity

General threat to Phyto-diversity in India

Apparently, the quick decline of the vegetation cover of a country is directly linked with the rapid population growth with an ever-increasing need. The major causes of the loss of biological diversity in India both within the hills and plains are anthropogenic. The eight major causes for the loss of biodiversity identified were namely - (1) Habitat loss and fragmentation (2) Introduced species (3) Overexploitation of plant and animal resources (4) Pollution of soil, water, and atmosphere (5) Global climatic change (6) Expansion of industries, agriculture, and depletion of natural forest (7) Want of pollinating vectors (8) Unisexual flowered species.

Threat to Medicinal plants in particular

All these factors as described, threatening the Phyto-diversity in India broadly cover most of the threats to Medicinal plant species. Over-exploitation and indiscriminate use of wild resources in commercial demand nowadays play a great role not only behind the quick decline of the species concerned but also develop into a threat for the survival of other related species, thus acting as the major factors disturbing the entire ecosystem.

For Medicinal plants, like other plant parts in commercial demand, premature exploitation is another factor that is additionally responsible for the rapid destruction of wild stock. Whenever a plant is in high demand, premature exploitation is expected to threaten the next season's propagation and regeneration of the species.

In India, so far little work has been done to assess the level and extent of exploitation of plant species for medicinal purposes in commercial demand. The inventory also is neither comprehensive nor updated. Species locally endangered or the area-specific threats to these plants are yet to be studied.

Going for Medicinal plant cultivation in response to the growing demand for certain species can be a lucrative agricultural option in India. A timely attempt to do so, would not only save some of the wild species from possible extinction but also feed the country's economy with an assured and sustained financial benefit in near future.

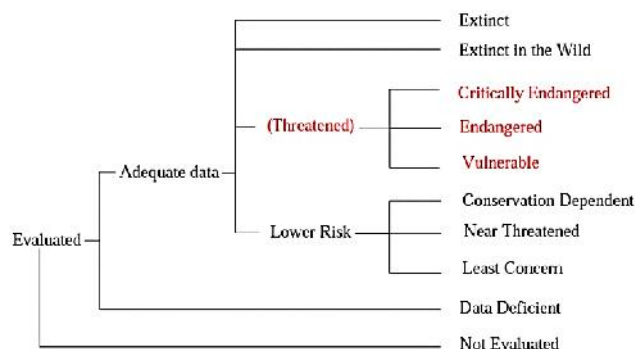


Fig 1 IUCN threat categories

Table 1 Threat assessment criteria

Criteria for assessing threat status	Critically Endangered	Endangered	Vulnerable
A2 to A4-population reduction	80% (in 10yrs or 3 generation)	50% (in 10yrs or 3 generation)	30% (in 10yrs or 3 generation)
B1-extent of occurrence	<100 sq.km	<5000 sq.km	<20000 sq.km
B2-area of occupancy	<10sq.m	<500sq.km	-
C-small population size	<250	<2500	<10000
D-very small or restricted population size	<50	<250	<1000
E-quantitative analysis (population decline)	>50% (in 10yrs or 3 generation)	>20% (in 20yrs or 5 generation)	>10% in 100yrs

Trade market in Medicinal plant parts: The National Scenario

The markets dealing with Medicinal plant part trading in India is a highly disorganized and less studied sector. So far, very little idea has been generated on the nature and quantum of trade in medicinal plant parts. The need, supply, and price structures are highly fickle. Even today, India lacks a total and updated inventory on which particular plant parts are being traded in the market. There are many confusions and controversies regarding the names of the items in trade. Moreover, there are practices of adulteration and merchandising totally different items as inferior substitutes.

Fig 2 Threatened Medicinal plants of Himalaya, Eastern ghats and Western ghats

Fig. 2.1: Himalaya - Threatened Medicinal plants



2.1a- Jeevaka
Malaxis acuminata D. Don



2.1b- Rishbhaka
Malaxis muscifera (Lindley) O. Kuntze



2.1c-Kakoli
Roscoeia procera Wall.

Fig. 2.2:Eastern ghats - Threatened Medicinal plants



2.2a- Sweta chandana
Santalum album L.



2.2b- Kampillaka
Mallotus philippinensis Muell. Arg



2.2c-Asoka
Saraca asoca (Roxb.) de Wilde

Fig. 2.3:Western ghats - Threatened Medicinal plants



2.3a-Keerikkizhangu
Anaphyllum wightii Schott



2.3b-Amrithapala
Decalepis arayalpathra (Joseph & Chandras.) Venter.



2.3c-Kaliyaka
Coscinium fenestratum (Gaertn.) Colebr.

There is no specific system of quality control. There are items banned for export without cultivation certificate, but a majority of the enforcement staff does not have any idea of these existing laws or the identification of such items. The trade routes and sources of most of the items are not exactly known or studied. Transit amenities and tax format is not uniform in different states and major wholesale markets. The overall situation demands immediate attention from the Central Government, respective State Governments, and other sectors dependent on the market. A mercantile database on the trade has to be framed and carrying out a comprehensive analytical survey on the market economy is an urgent necessity.

Major Stakeholders

The major stakeholders in the field are drug manufacturers, traders in herbs and crude drugs, medical practitioners in Ayurveda, Folk, Siddha, Unani, Homeopathy, Hakami, Sowa-Rigpa, and other alternative medicine dependent mostly on medicinal plants or their derivatives, cultivators, collectors of these Medicinal plants, Co-operative sectors associated with cultivation and collection of them, Central and State government departments, Scientists, Research institutions, Universities, and NGOs.

Ongoing Initiatives

Protection and Conservation strategies

Regulation of 'Wildlife Trade' is the most effective measure to protect the wild potential resources for their sustainable use. Using IUCN methods, BSI - the nodal organization responsible for monitoring and preparation of the list of plants to be included in the negative list of export has so far listed 53 species for restriction in trade.

Detection of different threat groups/categories is the primary data source for taking effective measures of protection and conservation of potential plant resources. It is roughly estimated that about 10 % of higher plants are under different threat categories. BSI has already published 4 volumes of RDB of Indian plants accounting for relevant information of more than 800 species. CITES is the international treaty to monitor the international trade of wild species.

The legal and policy framework includes various Acts such as the Forest Act 1927; the Indian Wildlife (Protection) Act 1972 and Wildlife (Protection) Amendment Act 1991; the Forest (Conservation) Act 1980; the Environment Protection Act 1986; the National Forest Policy 1988; the National biodiversity Act 2002; the Scheduled tribes and other traditional forest dwellers Act 2006 etc. In addition, there are various international treaties like CITES, Ramsar-CMS, etc. directly related to the conservation of biological diversity, which came into force in December 1993; India ratified and joined in February 1994. It has been decided that for in-situ conservation, the involvement of indigenous people and local ethnic communities is of utmost importance.

In-Situ Conservation

Conservation of a given species in its natural habitat or within the area where it grows naturally is understood as In-situ conservation.^[7] The recorded forest area of India is about 77.01 million hectares, but as reported by Landsat imagery, the area shielded by forests is about 64.01 million hectares. Today India has less than 2 % of the total forest area in the world but supports 15 % of the world's population. Most Medicinal

plants are endemic species and their medicinal properties are mainly due to the presence of secondary metabolites that answer stimuli in natural environments which cannot be expressed under culture conditions.^[8]

Habitat Conservation

India has a large network of 104 National Parks and 551 Sanctuaries covering about 4.9 % of the total land surface as well as 4 marine ecosystems, such as the Gulf of Mannar, the Gulf of Kutch, Andaman and Nicobar Islands, and Lakshadweep. It has also been proposed to increase these protected areas, to reduce the significant gaps in between various bio-geographic units. However, the critical problem is not merely the conservation of a particular species or habitat, but, the continuation of the very process of evolution of all microorganisms, plants, and animals as an integral part of the natural ecosystem. To achieve the objective, the Govt. of India has designated 18 biosphere reserves (categories roughly correspondingly to IUCN category V protected areas) to protect larger areas of natural habitat.^[9]

Ex-Situ Conservation

To complement the in-situ conservation, considerable attention also has been paid to ex-situ methods of conservation. Ex-situ conservation is that the conservation and maintenance of plant samples outside their natural habitat, either within the sort of the entire plant, or as a seed, pollen, and tissue or cell culture.^[10] The collection (from within and outside the country), preservation, multiplication, and supply of genetic resources (for research only) is done through the National Bureau of Plant genetic resources, New Delhi for wild relatives of crop plants. In addition to 123 botanical gardens, the Department of Biotechnology has initiated germplasm facilities also. India is that the overall supervisor for the establishment of Gene Bank of Medicinal and Aromatic plants among 6-15 countries.

For large-scale multiplication of forest tree species, two tissue culture pilot plants were established at National Chemical Laboratory, Pune, and at Tata Energy Research Institute, New Delhi. Plant tissue culture laboratories have also been setup in different National institutes.

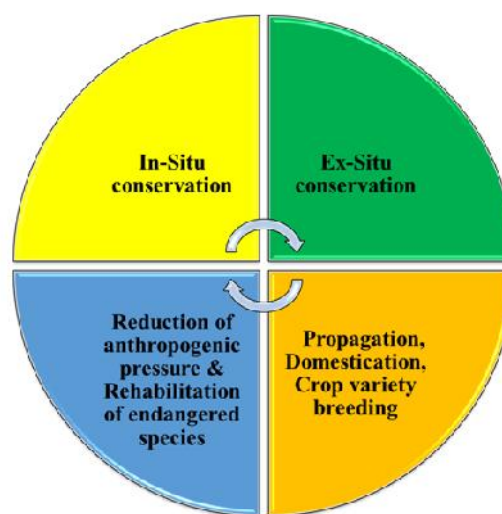


Fig 3 Complimentary strategies for Biodiversity conservation

Table 2 Conservation status of selected Medicinal plants in India

Botanical name	Common name	Systems of Medicine	Distribution & Habitat	Cause of extinction	Red list category	Conservation strategies
<i>Acorus calamus</i> L.	<i>Vacha</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	North temperate hemisphere and Tropical Asia; throughout India; occasional in certain hill tracts of Kerala	No information is available on threats to the species or its habitats	Least concern	No conservation measures have been undertaken specifically for this species
<i>Justicia beddomei</i> (Clarke) Bennet	<i>Vasa</i>	Ayurveda	Endemic to Southern Western Ghats	No information available	Critically endangered	Conservation status unknown
<i>Boerhaavia diffusa</i> L.	<i>Punarnava</i>	Ayurveda, Folk, Homoeopathy, Siddha and Unani	Pantropical. Moist and dry deciduous forests and also plains	No information available	Not accessed	Conserved at several MPCAs
<i>Picrorhiza Kurroa</i> Royle ex Benth.	<i>Katuki</i>	Ayurveda, Folk, Tibetan and Unani	Grows in Himalayan regions from Kashmir to Sikkim at the height of 7,000 to 14,000 ft.	No information available	Endangered	Conservation status unknown
<i>Piper longum</i> L.	<i>Pippali</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	Indo-Malaysia. Semi-evergreen, ever-green and moist deciduous forests	Habitat loss	Endangered	Conservation status unknown
<i>Rouwolfia serpentina</i> (L.) Benth. ex Kurz	<i>Sarpagandha</i>	Ayurveda, Folk, Homoeopathy, Siddha, Tibetan and Unani	South and South East Asia. Moist deciduous forests and plains	Habitat destruction	Extinct in wild	Conservation status unknown
<i>Withania somnifera</i> (L.) Dunal	<i>Aswagandha</i>	Ayurveda, Folk, Homoeopathy, Siddha, Tibetan and Unani	Found throughout the drier part of India, grows in semitropical areas receiving 500-750 mm rainfall	Over exploitation for preparation of medicines on large scale	Extinct in wild	Conservation status unknown
<i>Andrographis paniculata</i> (Burm.f.) Wall. Ex Nees.	<i>Kiratatika</i>	Ayurveda, Folk, Homoeopathy, Siddha and Unani	Peninsular India and Sri Lanka; scrub jungles, open forests, also in plains	No information available	Least concerned	Conservation status unknown
<i>Aegle marmelos</i> (L.) Corr.	<i>Bilva</i>	Ayurveda, Folk, Homoeopathy, Tibetan and Unani	India, Myanmar and Sri Lanka; throughout India	No information available	Vulnerable	Conservation status unknown
<i>Cedrus deodara</i> (Lamb.) G. Don	<i>Devadaru</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	High mountain tree, grows in Himalayan region	Deforestation and Unscientific collection	Least concern	Several protected areas across its range
<i>Mimosa pudica</i> L.	<i>Lajjala</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	Native of South America; now pantropical. Weed in plains	This taxon is not considered to be threatened or in decline	Least concern	Protected areas network and seeds have been collected and stored by Millennium Seed Bank Project
<i>Nardostachys jatamansi</i> (D. Don) DC.	<i>Jatamansi</i>	Ayurveda, Folk, Tibetan and Unani	Grows at great elevations up to 17,000 ft. on the Alpine himalayas	No information available	Endangered	Conservation status unknown
<i>Pterocarpus santalinus</i> L.	<i>Raktachandana</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	Grows naturally in South Indian states like, Karnataka, Tamilnadu and Andhra Pradesh up to an elevation of 3,000 ft. attitude	Over exploited in the past	Endangered	International trade in now monitored through a CITES
<i>Punica granatum</i> L.	<i>Dadima</i>	Ayurveda, Folk, Homoeopathy, Siddha, Tibetan and Unani	Central and West Asia, West Himalaya; Cultivated	Threatened by livestock grazing	Least Concern	Conservation status unknown
<i>Santalum album</i> L.	<i>Chandana</i>	Ayurveda, Folk, Homoeopathy, Tibetan and Unani	Peninsular India and Malaysia. Dry deciduous forests	Fire, grazing and most importantly exploitation of the wood for fine furniture and carving and also oil is threatening the species	Vulnerable	Export of the timber is banned from India
<i>Tribulus terrestris</i> L.	<i>Goksura</i>	Ayurveda, Folk, Homoeopathy, Siddha, Tibetan and Unani	Tropical and warm temperate regions of the world. Dry deciduous forests and waste lands	Habitat destruction and occurrence in very low frequency	Extinct in wild	Conservation status unknown
<i>Pongamia pinnata</i> (L.) Pierre.	<i>Karanja</i>	Ayurveda, Folk, Siddha, Tibetan and Unani	Indo-Malaysia. Dry deciduous, moist deciduous forests and Mangroves	Not considered to be affected by any major threats at present	Least Concern	Protected areas network, seeds have yet to be collected As a method of ex-situ conservation
<i>Centella asiatica</i> (L.) Urban.	<i>Mandukaparni</i>	Ayurveda, Folk, Homoeopathy, Modern, Siddha, Tibetan and Unani	Tropical Asia and Africa. Generally found near reservoirs and streams of water	This species is not likely to be threatened	Least Concern	No conservation actions are required

DISCUSSION

In recent years, the growing demand for herbal products has led to a quantum jump within the number of plant materials traded within and across the countries. Though India features rich biodiversity, the growing demand is putting a crucial strain on the prevailing resources.

The resources of Medicinal plants are getting scarce day by day due to overexploitation and unscientific harvesting practices. While the demand for Medicinal plants is growing, variety of them are being more threatened in their natural habitat. Sustainable management and harvesting of Medicinal plants can conserve biodiversity, promote environmental health, generate employment opportunities, provide affordable drugs and augment exports. The acceptable use of Medicinal plants and good harvesting practices must be implemented for fewer the available Medicinal plants having slow growth because overexploitation often leads to resource exhaustion and species extinction. Root and whole-plant harvesting of Medicinal plants are more destructive methods than collecting their leaves and flowers or buds alone. For herbal drugs made from whole plants or roots, using their leaves as an alternate can function an honest solution. For instance, Wang *et al.* discovered that extracts from ginseng leaf-stems and roots have similar pharmacological activities, but ginseng leaf-stem has the advantage of being a more sustainable resource.^[11] Conservation not only provides protection of the species in certain ecological areas but also gives enough period of time for their propagation of next generation. Thereby, we can achieve the goal of conservation of plant resources, especially the rare and endangered species. Cultivation of Medicinal plants also can provide handsome returns to farmers and cultivators giving them the economic advantage as a motive. India, with its diversified biodiversity, has tremendous potential and natural advantage during this emerging area.

The Medicinal plant's sector at this isn't well organized and needs special attention. Although different Ministries and Departments within the Government sector, NGOs, and individuals within the private sector are making efforts in several directions, there's a requirement to coordinate and systematize these efforts. An appropriate mechanism for coordination and implementation of policies concerning Medicinal plants is important to facilitate inter-ministry, inter-state and institutional collaboration and to avoid duplication of efforts.

Table 3 Summary of the responsibilities of the various Ministries and Departments of Government of India regarding Medicinal plants

Ministry/Department	Subject/Area of Work
Dept. of Indian Systems of Medicine	1. Preparation of list of Medicinal plants in ISM. 2. Documentation of local health traditions and Indian System of Medicine and Homeopathy. 3. Encouragement to ex-situ cultivation. 4. Development of agro technologies.
Dept. of Biotechnology	1. Tissue culture and preservation of Medicinal plants.
Dept. of Science and Technology	1. Biotechnologies, agro-technologies, CSIR germplasm preservations etc.
Ministry of Agriculture	1. Ex-situ propagation of Medicinal plants. 2. Development of agro-technologies. 3. Tissue culture and preservation of Medicinal plants.

Ministry of Environment and Forests	1. Conservation of Medicinal plants. 2. Identification and notification of threatened species and advice to the Ministry of Commerce to regulate their export. 3. Documentation of ethno-botanical use of Medicinal plants. 4. Studies on ethno-biology, survey and identification of plants including Medicinal plants by Botanical Survey of India.
Ministry of Commerce	1. Regulation of export of Medicinal plants, plant products or their derivatives as per the advice of MoEF.
State Governments	1. Collection of Medicinal plants from the wild. 2. Ex-situ cultivation of priority species.

CONCLUSION

Over-exploitation and indiscriminate use of wild resources led to depletion and scarcity of Medicinal plants. The habitat loss by overharvesting and destructive methods for meeting the increased demand resulted in a severe and irreplaceable loss of plant resources, leading to their dwindling availability and threatening their survival. In this alarming situation, the need of the hour is to develop appropriate methods of conservation along with sustainable use of these resources, to combat the depletion and extinction of Medicinal plant reserves. The country needs a revolutionary change in their cultivation methods, that is, to urgently shift the harvestation of Medicinal plants with high industrial demand, from their wild habitats to cultivated sources only. This will ensure the sustainable harvest, perpetuation, and genetic conservation of the threatened species.

Conflict of interest

The authors have no conflict of interest.

Abbreviations

BSI - Botanical Survey of India
CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSIR - Council of Scientific and Industrial Research
DOAJ - Directory of Open Access Journals
ISM - Indian System of Medicine
ISM&H - Indian System of Medicine and Homoeopathy
IUCN - International Union for Conservation of Nature
MoEF - The Ministry of Environment and Forests
MPCA- Medicinal Plant Conservation Area
NGO - Non-Governmental Organization
RBD - Red Data Book
US\$ - United States Dollar
WHO - World Health Organization
WWF - World Wildlife Fund

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