Medicinal and Aromatic Plants of the World

Ákos Máthé
Irfan Ali Khan *Editors*

# Medicinal and Aromatic Plants of India Vol. 1

Springer

# Medicinal and Aromatic Plants of the World

Volume 8

**Series Editor**
Ákos Máthé, Faculty of Agriculture and Food Science,
Széchenyi István University, Mosonmagyaróvár, Hungary

Medicinal and Aromatic Plants (MAPs) have been utilized in various forms since the earliest days of mankind. They have maintained their traditional basic curative role even in our modern societies. Apart from their traditional culinary and food industry uses, MAPs are intensively consumed as food supplements (food additives) and in animal husbandry, where feed additives are used to replace synthetic chemicals and production-increasing hormones. Importantly medicinal plants and their chemical ingredients can serve as starting and/or model materials for pharmaceutical research and medicine production. Current areas of utilization constitute powerful drivers for the exploitation of these natural resources. Today's demands, coupled with the already rather limited availability and potential exhaustion of these natural resources, make it necessary to take stock of them and enrich our knowledge regarding research and development, production, trade and utilization, and especially from the viewpoint of sustainability. The series Medicinal and Aromatic Plants of the World is aimed to look carefully at our present knowledge of this vast interdisciplinary domain, on a global scale. In the era of global climatic change, the series is expected to make an important contribution to the better knowledge and understanding of MAPs.

Budapest, Prof. Dr. Ákos Máthé.

Ákos Máthé • Irfan Ali Khan
Editors

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# Preface

Medicinal and aromatic plants (MAPs) have been utilized in various forms since the earliest days of mankind. They have maintained their traditional basic curative role even in our modern societies. Apart from their traditional culinary and food industry uses, MAPs are intensively consumed as food supplements (food additives) and in animal husbandry, where feed additives are used to replace synthetic chemicals and production-increasing hormones. Importantly, medicinal plants and their chemical ingredients can serve as starting and/or model materials for pharmaceutical research and medicine production. Current areas of utilization constitute powerful drivers for the exploitation of these natural resources. Today's demands, coupled with the already rather limited availability and potential exhaustion of these natural resources, make it necessary to take stock of them and enrich our knowledge regarding research and development, production, trade, and utilization, especially from the viewpoint of sustainability. The series Medicinal and Aromatic Plants of the World is aimed to look carefully at our present knowledge of this vast interdisciplinary domain, on a global scale. In the era of global climatic change, the series is expected to make an important contribution to the better knowledge and understanding of MAPs.

Mosonmagyaróvár, Hungary
October 2021

Ákos Máthé

# Preface

This book, as the eighth volume of the series Medicinal and Aromatic Plants of the World (MAPW), focuses on the medicinal and aromatic plants (MAPs) of India.

The vast country of India, which is frequently called a sub-continent, with its 15 agro-climatic zones, is one of the richest countries in the world regarding its wealth of biodiversity. Out of the documented flora of 17,000–18,000 flowering plant species, more than 7000 are estimated to have medicinal usage in folk and documented systems of medicine like Ayurveda, Unani, Siddha and Homoeopathy (AYUSH System of Medicine).

MAPs are a major resource base for traditional medicine and the herbal industry. In addition, they also provide livelihood and health security to a large proportion of the Indian population. About 242 species have annual consumption levels in excess of 100 metric tons/year.

In India, several attempts have been made to explore and best exploit this huge hidden wealth and to some extent undiscovered/unexplored biodiversity of the rich flora.

In view of the intensive and ever-increasing exploitation (frequently overexploitation) of natural resources of medicinal plants, an increasing number of species are becoming endangered, occasionally facing extinction.

In this scenario, headed by the Ministry of AYUSH, and in collaboration with numerous other relevant scientific institutions, intensive and innovative research and development activities have been launched in India. These are aimed at both exploration and sustainable utilization of natural resources.

The explicit aim of the present volume is to offer insight into the various aspects of these activities that are based on the rich knowledge of past of traditions, focusing on the sustainable utilization of the much-needed MAP resources.

The aim of this collective, comprising specialists working in the relevant fields of medicinal and aromatic plants, is to explore/collect/summarize and evaluate/validate the still-available information on these resources.

In the present volume (which is meant to be followed by further volumes), general aspects related to MAP use and research are introduced, while the next volume

will focus on the available knowledge on individual species that are promising success in their conservation/utilization and are native to India.

The editors wish to thank Springer and its editorial staff, in particular Melanie Overbeek, for their support of this daring project entitled *Medicinal and Aromatic Plants of the World*.

Mosonmagyaróvár, Hungary — Ákos Máthé

Hyderabad, India — Irfan Ali Khan
October 2021

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# About the Editors

**Akos Máthé** has a 40 years' background in teaching and research activities in plant ecophysiology and agricultural botany at the University of Horticulture and Food Industry, Budapest, and the Széchenyi István University, Győr, Hungary. Doctor of the Hungarian Academy of Sciences. Two times Fulbright Scholar at University of California Davis and University of Massachusetts, Amherst. Visiting professor also at University of Veterinary Medicine, Vienna (Austria). Courses on the production and ecology of Medicinal Plants, as well as Phytogenic Feed Additives, respectively. Teaching/Research/Consulting and Publication interest and activity include ecophysiology, plant domestication/introduction, production of MAPs, new crops and new uses of plants. International consultant and expertise (e.g.: FAO courses on MAP production – Antalya, Turkey, EU COST, IUCN, CBI committees, etc.). Member of editorial board/reviewer of international scientific journals, Ph.D. Theses, etc. Relevant activities include involvement in both Hungarian and EU funded research projects (e.g.: FEED SEG), education projects (CEEPUS, ERASMUS +, HERB AID, GOOD HERBS, Herbs and Youth, EOHUB, etc.). Founding secretary and Board of Directors member of Hungarian Medicinal Plant Association. President of International Council for Medicinal and Aromatic Plants (ICMAP http://www.icmap.org). Chairman of Section for Medicinal and Aromatic Plants, International Society for Horticultural Sciences (2006–2014), Member of Fair Wild Advisory Panel. Professor Máthé has authored some 100 publications in medicinal and

aromatic plant research and is series editor as well as editor/co-author of the book series Medicinal and Aromatic Plants of the World. He has been convener and speaker at several international scientific conferences (ISHS, ICMAP, and others), with invited and keynote speaker presentations. Network coordinator of FAO-related ESCORENA MAP (http://www.agroweb-cee.net/map/).

**Irfan Ali Khan** obtained his MSc from Aligarh Muslim University and PhD in botany from Osmania University, Hyderabad, specializing in genetics and plant breeding. Professor Khan is the former director of Nawab Shah Alam Khan Centre for Post Graduate Studies and Research (Affiliated to Osmania University), Anwarul Uloom College Campus, Mallepally, Hyderabad. Presently, he is the managing director of Ukaaz Publications, Hyderabad. He has published 163 research papers in reputed national and international journals and is now on the panel of "Experts on Mungbean" for all countries in South-East Asia and the Middle East. Professor Khan has been the editor of *Frontiers in Plant Science*, has edited 74 reference books, and has co-authored 3 textbooks with his wife, Professor Atiya Khanum. He is a Fellow of the Indian Society of Genetics (F.I.S.G.). Besides this, he is the editor-in-chief of *Annals of Phytomedicine* – an international journal. Professor Khan is the senior author of the famous textbook *Fundamentals of Biostatistics* by Khan and Khanum which has been released by world-renowned agricultural scientist Dr. M.S. Swaminathan on February 13, 1994, in Hyderabad. This book has been included as a textbook and also as reference book in more than 400 universities and research institutes in India and abroad. Besides this, he has given a formula of LSD (least significant difference) with suitable examples, which is more or less a substitute for Student's 't' test to compare two treatments.

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# Chapter 1
# Introduction to Medicinal and Aromatic Plants in India


**Ákos Máthé and Irfan Ali Khan**

**Abstract** Since the beginnings of known history of medicinal plants, the production and utilization of medicinal and aromatic plants has seen a tremendous, nearly indescribable progress. In an effort to provide quality healthcare to all, traditional medicine, in particular herbal medicine, has survived as a major healthcare provider, mainly in rural and remote areas.

Indian traditional system of medicine has a vast history that has been acknowledged also by modern research for their effectiveness. Indian traditional medicine or medicinal plants are also considered as vital sources for new drug development. Evidence based incorporation of Indian traditional medicine through clinical practice helps provide quality healthcare to all. In this context, the present chapter provides an insight into various basic aspects of medicinal and aromatic plant verticum spanning the product range - from the sustainable sourcing, conservation, cultivation and trade of raw-materials. Components or actors of the Indian Traditional Medicinal System largely depend on MAPs. The brief survey of the principal actors of Indian MAP sector provides an opportunity to assess the comprehensive and profound activities with which the present Ministry of AYUSH is engaged in promoting sustainable production and utilization of MAPs with the ultimate goal of integrating it into clinical practice to provide safe, efficient and quality healthcare to the people.

**Keywords** India · Medicinal and Aromatic Plants · Biodiversity hotspots · Flora · Natural conservation · Official and public participants of legal regulation

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## Abbreviations

| | |
|---|---|
| ASU | Ayurveda, Siddha and Unani |
| CCRAS | Central Council for Research in Ayurvedic Sciences |
| CCRH | Central Council for Research in Homeopathy |
| CCRIMH | Central Council for Research on Indian Medicine and Homoeopathy |
| CCRUM | Central Council for Research in Unani Medicine |
| CCRYN | Central Council for Research in Yoga and Naturopathy |
| GMP | Good Manufacturing Practices |
| ISM & H | Indian System of Medicine and Homeopathy |
| ISM | Indian System of Medicines |
| NAM | National Ayush Mission |
| NCEs | New Chemical Entities |
| NMPB | National Medicinal Plant Board |
| RET | Rare, Endangered, Threatened |
| VCSMPP | Voluntary Certification for Medicinal Plant Produce |
| WHO | World Health Organization |

## 1.1 Introduction

The known history of medicinal plants in India dates back to the early times before Christ. According to Atal and Kapur (Atal and Kapur 1977) the earliest mention of medicinal plant use can be found in the so called "Rigveda", one of the oldest repositories of human knowledge, written between 4500 and 1600 B.C.

Mentions on the use of plants for curing diseases can be traced back to the times around 1600 B. C. (Sharma et al. 2021). Some western scholars feel that Ayurveda developed somewhere about 2800–600 B.C. This was in the form of a supplement to Vedas that records definite properties of drugs and their uses, in some details. The eight divisions of the Ayurveda were followed by two books written later by Susruta and Charka, near about 1000 B.C.

According to early records, the primary needs of the sick were met from plants. Since then, the therapeutic value of the plants has become so highly respected that the "holy basil" is still worshipped by Hindus.

Indian traditional medicine and medicinal plants are also considered as vital sources for new drug development. In order to make traditional a mainstream system, several measures have been taken to incorporate traditional medicine in evidence based clinical practice.

In view of above-mentioned, the present chapter aims to offer an introduction to the Indian medicinal and aromatic plant scenery. This is a relatively short insight, that will be farther broadened by the individual chapters that follow.

## 1.2 Geographic Characteristics of India

India is a country in South Asia. With its 3,287,263 km$^2$ territory and an estimated population of ca. 1,352,642,280 (2018 census). It is the seventh-largest country by land area, second-most populous country, and the most populous democracy in the world.

India is situated North of the Equator between 66°E to 98°E long. and 8°N to 36°N lat. Border surrounded by Nepal, China and Bhutan in the North; Bangladesh and Myanmar in the east; the Bay of Bengal in the South-East; the Indian Ocean in the South; the Arabian Sea in the West; and Pakistan in the North-West.

India is a quasi "sub-continent": 2933 kms wide and 3214 kms long. In the North, the ranges of the Himalaya mountains separate the "Indian sub-continent" from the rest of Asia. Southwards, the Indo-Gangetic plains are further crossed over by the Vindhyachal mountains. The next-lying Deccan Peninsula is bounded by the Arabian sea to the South-West and the Bay of Bengal to the South-East. The southern-most tip of the country projects into the Indian Ocean.

Mountains cover an area of around 100 million ha. Arid and semi-arid zones are spread over 30 million hectares and the coastline is about 8000 km long (MoEF 2009). The three great rivers of Northern India – the Indus, the Ganges and the Brahmaputra, have their sources in the Himalaya.

## 1.3 Biogeographic Diversity in India

### *1.3.1 Biographic Regions of the Indian Subcontinent*

The bio-geographic position of India is so unique that all known types of ecosystems can be found in its territory: these can range from coldest places, like the Nubra Valley, dry cold deserts of Ladakh, temperate and Alpine and subtropical regions of the North-West and trans-Himalayas, rain forests with the world's highest rainfall in Cherrapunji in Meghalaya, wet evergreen humid tropics of Western Ghats, arid and semi-arid conditions of Peninsular India, dry desert conditions of Rajasthan and Gujarat to the tidal mangroves of the Sunderban which harbors about 47,000 plant species of which 17,000 are angiosperms (S. Sharma and Thokchom 2014) (Fig. 1.1). India is also rich in medicinal plant diversity with all the three levels of biodiversity - such as species-, genetic- and habitat diversity represented (Mukherjee and Wahile 2006).

According to the Indian Medicinal Plants Factsheet (NMPB 2020), out of the ca. 17,000 flowering plant species in India, more than 7000 plants species are known to have been used traditionally, as medicinal plants. Ayurveda, more than 3000 years old system of medicine has widespread acceptance. More than 90% formulations used in the Ayurveda, Siddha and Unani systems of medicine are plant based and about 22% of the MAP-production is sourced through cultivation.

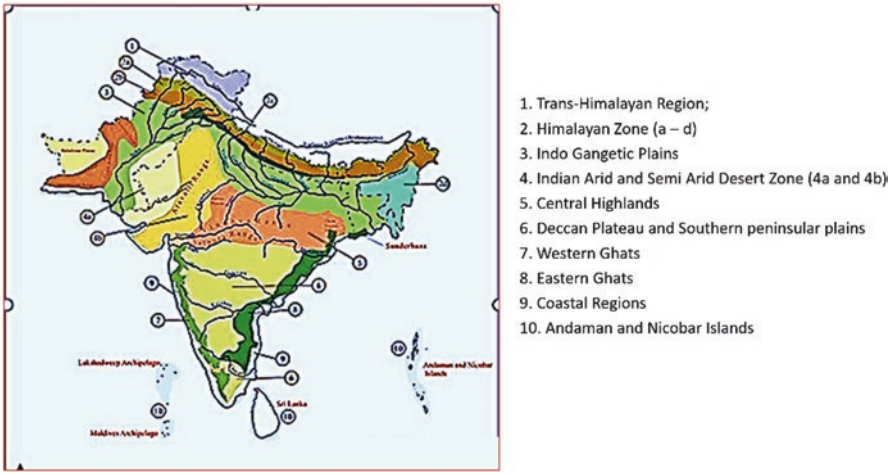


**Fig. 1.1** Biogeographic regions of India (After: Manakadan and Khan (2019) Birds of the Indian Subcontinent—In a Nutshell (researchgate.net))

### *1.3.2 Biogeographic Diversity of Medicinal Plants, in India*

For a better understanding of her vegetation diversity, based on their distinct and unique vegetation, India has been divided into 10 biogeographical regions Singh (2020). The biogeographical regions and their relevant characteristical medicinal plant species are summarized in Table 1.1.

The percentual distribution of bio-geographic zones of India are summarized in Fig. 1.2.

## 1.4 Biodiversity Hotspots in India

The notion of global biodiversity hotpots can be traced back to the year 2000, when Myers et al. (Myers et al. 2000) identified 25 global biodiversity hotspots in the world, for the first time. Biodiversity hotspots are characterized by exceptional concentrations of **endemic species** that are undergoing exceptional loss of habitat. To qualify as a biodiversity hotspot, a region must have **at least 1500 vascular plants as endemics** and **30% or less of its original natural vegetation**. (In other words, it must be threatened.) In 2009, another 9 hotspots were added to the list of global hotspots).

India accommodates parts of four global biodiversity hotspots, i.e.: the **Himalaya**, the **Western Ghats**, **Indo-Burma** and **Sundaland** (Table 1.2).

- **The Himalaya**, which runs across India's northern tier, is the boundary between two of the Earth's great **biogeographic realms** — the Palearctic, which covers

**Table 1.1** Biogeographic zones of India with characteristic medicinal genera/species (Singh 2020)

| | Biogeographic zone | Characteristic Medicinal Plants |
|---|---|---|
| 1. | Trans- Himalayan- Ladakh, Lahaulspiti | *Ephedra gerardiana, E. intermedia, Fritillaria roylei, Geranium sibricum, Meconopsis aculeata, Hippophae rhamnoides, Jurinea dolomiaea, Hyoscyamus niger, Juniperus communis, Podophyllum hexandrum, Saussurea gossypiphora, S. lappa, S. obvallata, Rheum webbianum, Bergenia stracheyi, Bunium persicum, Colchicum luteum* |
| 2. | Himalayans- Jammu and Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam and West Bengal. | *Rheum, Saussurea, Gentiana, Maconopsis, Cotoneaster, Polygonum, Anemone, Primula, Saxifraga, Allium, Cremanthodium, Corydalis, Juniperus, Ephedra, Hippophae, Aconitium, Podophyllum, Skimmia, Rhodiola, Ainsliaea, Dolomiaea, Dactylorhiza* |
| 3. | North-east India– Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim | *Oroxylum indicum, Smilax glabra, Paris polyphylla, Berginia cilate, Podophyllum hexandrum, Illicium griffithii, Coptis teeta, Swertia chiryata, Aconitum ferox, Aconitum heterophyllum, Vanda coerulea, Renanthera imschootiana, Rauvolfia serpentine, Aquilaria mallaccensis, Hibiscus Manihot, Abies spectabilis, Acorus calmus, Abutilon indicum, Abroma augusta* |
| 4. | Indian Desert – Thar and Kutch. | *Glycyrrhiza glabra, Tinospora cordifolia, Plantago ovata, Asparagus racemosus, Cassia angustifolia, Withania somnifera, Achyranthes aspera, Barleria prionitis, Boerhaavia diffusa, Eclipta alba, Euphorbia caducifolia, Evolvulus alsinoides, Pergularia daemia, Sida cordifolia, Solanum surattense* |
| 5. | Western Ghats- Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat | *Anona squamosa, Buchanania lanzan, Aphanamixis polystachya, Rauvolfia serpentine, Gymnema sylvestre, Gloriosa superba, Phyllanthus neruri, Tridax procumbens, Leucas aspera, Dioscorea bulbifera, Rhicanthus nasuta, Momordica dioica, Mimosa pudica, Hibiscus angulosus, Calotropis gigantea, Parthenium hysterophorus, Saraca asoca, Gloriosa superba, Strycnos nux-vomica, Phyllanthus neruri, Semcarpus anacardium* |
| 6. | Semi-Arid regions- Punjab plains, Rajasthan, Haryana, Gujarat, Maharashtra | *Bacopa monnieri, Calotropis gigantea, Cannabis sativa, Centella asiatica, Acorus calamus, Cassia fistula, Cardiospermum helicacabum, Bauhinia vahlii, Asparagus racemosus, Asparagus adsecendens, Cyperus rotundus, Datura metel, Justicia adhatoda, Eclipta alba, Ricinus communis, Piper betle, Phyllanthus fraternus, Rauwolfia serpentina* |
| 7. | Deccan Peninsular- Telangana, Maharashtra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu | *Azadirachta indica, Centella asiatica, Celastrus paniculatus, Chlorophytum tuberosum, Chlorophytum arundinaceum, Curcuma pseudomontana, Cycas circinalis, Drosera burmanii, Gloriosa superba, Oroxylum indicum, Santalum album, Terminalia arjuna, T. chebula, Tinospora cordifolia, Vitex negundo, Withania somnifera, Bixa orellana, Entada pursaetha, Zanthoxylum alatum* |

(continued)

**Table 1.1** (continued)

| | Biogeographic zone | Characteristic Medicinal Plants |
|---|---|---|
| 8. | The Coastal zone- Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Goa, Maharashtra, Odisha, West Bengal, Lakshadweep | *Xylocarpus mekongensis, Xylocarpus granatum, Heritiera fomes, Excoecaria agallocha, Avicennia marina, Avicennia alba, Avicennia officinalis, Acanthus bolubilis, Acanthus ilicifolius, Sonneratia caseolaris, Clerodendron inerme, Rhiziphora mucronata, Rhizophora apiculate, Salicornia brachiate, Ipomoea pescaprae, Bruguiera gymnorhiza* |
| 9. | Indo- Gangetic planes- Gujarat, Sindh, Punjab, Bihar, Bengal and Assam | *Acacia arabica, Holoptela integrifolia, Madhuca indica, Launaea procumbens, Phyllanthus amara, Rosa centifolica, Solanum surattense, Tephrosia purpurea, Tinospora crispa, Tribulus terrestris, Terminalia bellerica, T. chebula, Cassia angustifolia, Cassia occidentalis, Centella asiasatica, Crotolaria burhai, Eclipta alba* |
| 10. | The Indian Islands- Andaman and Nicobar islands | *Semecarpus kurzii, Strobilanthes andamanensis, Uvaria andamanica, Artabotrys nicobarianus, Calamus andamanicus, Aristolachia tagala, Phyllanthus andamanicus, Glochidion calocarpum, Daemonorops manii, Alstonia kurzii, Dichapetalum gelonioides, Dripetes andamanica* |

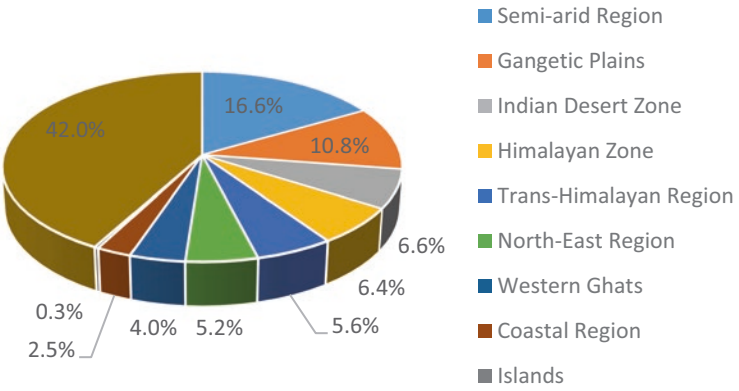


**Fig. 1.2** Biogeographic zones of India. (After: Sunit Singh 2020)

most of temperate-to-arctic Eurasia, and Indomalaya. This covers most of the Indian subcontinent and extends into Indochina, Sundaland (Malaysia and western Indonesia) and the Philippines.

The rich plant diversity of the Himalaya numbers over 8000 angiosperms, 44 gymnosperms, 600 pteridophytes, 1737 bryophytes, 1159 lichens etc. (Singh and Hajra 1996) and has been a source of medicinal plant species.

- **Western Ghats** is stretching some 1600 km from the north of Mumbai to the southern tip of India. This biodiversity hotspot contains a large proportion of the country's plant and animal species; many of which are only found here and

**Table 1.2** Biodiversity hotspots of India and the number of endemic plant species

| Hotspot | Endemic plant species (% of Global total, 300,000) |
|---|---|
| Tropical Andes* | 20,000 (6.7%) |
| Sundaland* | 15,000 (5.0%) |
| Madagascar* | 9704 (3.2%) |
| Brazil's Atlantic Forest* | 8000 (2.7%) |
| Caribbean* | 7000 (2.3%) |
| **Sub-Total** (% rounded) | 59,704 (19.9%) |
| Mesoamerica | 5000 (1.7%) |
| Mediterranean Basin | 13,000 (4.3%) |
| Indo-Burma | 7000 (2.3%) |
| Philippines | 5832 (1.9%) |
| **Totals** | 90,536 (30.1%) |

* Hotspots with at least 2% of the world's endemic plants and vertebrates? comprising only 0.4% of the Earth's land surface (all nine amount to 1.7% of the Earth's land surface)
† This would total 30.2% but for rounding of numbers in the individual hotspots.

nowhere else in the world. The Western Ghats are one of the world's biodiversity hotspots with over 5000 flowering plants. It is estimated that at least 325 globally threatened species occur here. At 2695 m, Mt. Anamudi in Kerala, India is the highest peak in the Western Ghats. The Western Ghats are being considered as a UNESCO World Heritage Site.

Once covered by dense forests, today, a large part of the Western Ghats-range has been logged or converted to agricultural land area for tea, coffee, rubber and oil palm production, or simply cleared for livestock grazing, reservoirs and roads.

According to Suja (Suja 2005), out of the large variety in the Western Ghats, about 50 species hold a very high value for traditional medicine. The most common species include e.g. *Mimosa pudica, Hibiscus angulosus, Leucas aspera, Phyllanthus neruri, Calotropis gigantea, Tridax procumbens, Parthenium hysterophorus.*

Farther important species are *Anona squamosa, Buchanania lanzan, Semecarpus anacardium, Dioscorea bulbifera and Aphanamixis polystachya* (recommended for various forms of tumors), Pepper (fruit) and Cinnamom bark mixed together (recommended for curing Migraine), *Rhincanthus nasuta, Momordica dioica, Cinnamomum zeylanicum, Ophiorhizza mungos (used to* relieve cancer patients).

- **Indo-Burma:** In terms of species diversity and endemism, the Indo-Burma Biodiversity Hotspot is biologically one of the most important regions of the planet. It comprizes all non-marine parts of Cambodia, Lao PDR, Myanmar, Thailand and Vietnam, plus parts of southern China (Tordoff et al. 2012).

There are 309 globally threatened plant species in Indo-Burma (IUCN 2011), comprising two-fifths of the hotspot's globally threatened species. It is estimated that this figure probably represents only a fraction of the plant species of global conservation concern, because of the limited extent of comprehensive global threat

assessments. (Gymnosperms are generally better assessed than angiosperms. Within angiosperms, tree species and particularly commercially valuable timber species are generally better assessed than other groups.)

A total of 40 ethnomedicinal plant species from 35 genera and 25 families have been documented for the first time from Mizoram. *Ardisia polycephala (VU), Begonia inflate (NT), Blumea lanceolaria (VU), Canarium strictum (NT), Cautleya gracillis (EW), Claoxylon khasianum (NT), Curcumorpha longiflora (VU), Dalbergia pinnata (CR/VU), Dendrobium ariaeflorum (EN), Garcinia lancaeafolia (EN), Gelsemium elegans (VU), Helicia excelsa (NT), Lepionurus sylvestris, Millettia piscidia (NT), Musa glauca (NT), Pajenela longifolia (NT), and Raphidophora hookeri (NT). C. gracillis* was extinct in the wild, two were endangered, five were vulnerable, and maximum of nine plant species were of the nearly threatened status (P. K. Rai and Lalramnghinglova 2011).

- **Sundaland:** The Sundaland biodiversity hotspot region covers Indo-Malayan islands (Indonesia and Malaysia). It includes the Nicobar group of Islands–Borneo, Java and Sumatra, Singapore, Philippines.

Sundaland holds about 25,000 species of vascular plants, 15,000 of which are found nowhere else. There are at least 117 endemic plant genera in the hotspot; 59 of these endemic genera are found in Borneo, 17 in Sumatra, and 41 on the Malay Peninsula.

Borneo boasts a spectacular diversity of trees. There are about 3000 species, including more than 265 species of dipterocarps; no less than 155 of these are endemic to the island. The island also has more than 2000 species of orchids.

Notable plants in the hotspot include members of the genus *Rafflesia*, represented by 16 species with very large flowers. One of these, *Rafflesia arnoldii*, has the largest flowers in the world, measuring up to one meter in diameter.

## 1.5 Flora of India

It is estimated that from the *ca.* 4,65,688 known plant species of the world, 49,441 species, including the bacteria, algae, lichen, virus and fungi, are present in India, with 28% of these species being endemic.

Due to the vast extent of the country and the most varied **topographic/ecological conditions**, as well as the resulting wide range of **habitats,** the flora is extremely diverse. Both these factors and the fact that India – as a country, in the political sense - cannot be defined by only one geographic unit (see: **World Geographical Scheme for Recording Plant Distributions** "Flora of India - Wikipedia" 2021) seem to have made it necessary for botanists to apply a special approach in floristic exploration, i.e.: the Flora of India has been divided into a number of regions.

When surveying the history of Botany of India, it is hard to create a precise picture of the floristic work that had been done in the course of centuries. This dilemma was expressed by Santapau (Santapau 1956), who - whilst holding the post of Chief

Botanist of the Botanical Survey of India - tried to find out the extent of botanical exploration in India. He stated: "It is clear that very few places have been explored methodically in the past; by this I mean that very few areas have been so explored that we may say that we know the complete flora of the area…".

It seems that most of the floristic exploratory work can be traced back to the establishment of Botanical Survey of India (BSI), the apex taxonomic research organization of the country, established in 1890. The organization's mandate was to explore, collect, identify and document the rich plant resources of the erstwhile British India.

In a historical perspective, however, it should be mentioned that the fundamental work "The Flora of British India", by Sir J.D. Hooker and his co-workers included is still instrumental when dealing with plant species of the Republic of India. The following data are meant to illustrate the extent of the exploratory work achieved by Hooker and co-co-workers: 171 families, 2325 genera and 14,312 species of flowering plants described in the Flora of British India (7 volumes, 1872–1890) covering the areas of present day India, Pakistan, Afghanistan, Nepal, Tibet, Bangladesh, Burma (Myanmar), Ceylon (Sri Lanka) and Malayan Peninsula (Hooker 1875).

### *1.5.1 Botanical Survey of India (BSI)*

The Botanical Survey of India (BSI) was established in 1890 with the main objectives to explore the plant resources of the country and to identify plant species with economic virtues ("Botanical Survey of India" 1891). Following a reorganization by the Government, in 1954, the main objectives of BSI were determined to include: (a) undertaking intensive floristic surveys and collecting accurate and detailed information on the occurrence, distribution, ecology and economic utility of plants in the country, (b) collecting, identifying and distributing materials that may be of use to educational and research institutions and c) acting as the custodian of authentic collections in well planned herbaria and documenting plant resources in the form of local, district, state and national flora.

In 1978, Indian botanists started the publication series, the new National Flora of India. It was published in the form of Fascicles dealing with families, tribes and large genera of flowering plants, as a Series 1 which also includes Flora of India, Series 2 for State Flora, Series 3 for District Flora and Series 4 for Miscellaneous publications on floristic account of special habitat or groups and other aspects dealing with plants ("Flora" n.d.).

To-date, the floristic surveys of many of the Indian states have already been conducted by BSI. Similarly, surveys of Union territories have been completed and the rest are in progress. The floristic survey of 68 protected areas, 26 sacred groves, 01 Ramsar site, 12 fragile ecosystem and 23 Tiger Reserves have also been completed.

About four million plant specimens of different groups are lodged in different herbaria of the BSI. Since the inception of Botanical Survey of India, scientists of BSI have discovered one new family, 43 new genera and more than 1666 new

species and infraspecific taxa including many botanically interested taxa. Population study of about 900 RET taxa of the family Orchidaceae and Sapotaceae have been completed in Eastern Himalayas (BSI n.d.) (Botanical Survey of India (bsi.gov.in).

Keeping pace with the modern times, requirements and technologies, the present activities of BSI include the development of a digital platform 'Indian Plant Diversity Information System (IPDIS)'. It has also initiated the web launching of all BSI publications (such as books, records, periodicals, newsletters, reports, archival correspondences, rare books (even not available in any of the Biodiversity library portal) and herbarium specimens.

Farther cutting-edge initiatives are: the development of e-Flora of India and Plant Checklist database, digitization of all BSI publications. The launching of NELUMBO (http://nelumbo.biocloud.net/), the online portal of BSI's official journal, has already been completed.

Till date, BSI has published 10 volumes of Flora of India, 29 volumes of Fascicles, 29 volumes of State Flora for 9 states, 34 volumes of District Flora for 26 District and 140 numbers of Miscellaneous publications.

#### 1.5.1.1 Medicinal Plants in the Botanical Survey of India

Regarding Medicinal and Aromatic Plants, the Environment Information System (ENVIS) hosted by BSI is of great importance. The mandate of ENVIS covers the systematic collection and compilation of data (mainly secondary data) on "Floral Diversity" including the medicinal and aromatic plants. ENVIS collects, collates and disseminates the data through its website (http://envis.nic.in/).

## 1.6 Conservation of MAPs vs. Loss of Natural Diversity

Until relatively recently, medicinal plants were generally lumped into the broad category of Minor Forest Produce (MFP). This terminology was used even by the progressive 1988 Forest Policy Resolution. Remarkably, it was adopted in the very same year, as the Chiang Mai Declaration that internationally recognized the need and called for the sustainable use of natural resources.

### *1.6.1 Impact of Chiang Mai Declaration*

The **Chiang Mai Declaration (1988)** expressed alarm over the consequences in the loss of plant diversity and highlighted "the urgent need for international cooperation and coordination to establish programs for the conservation of medicinal plants to ensure that adequate quantities are available for future generations". It also called

for a need to coordinate conservation actions based on both *in situ* and *ex situ* strategies (Máthé 2015).

The decades to follow were marked by several declarations and sets of recommendations calling for the Conservation and Sustainable use of biodiversity. In India, also a similar trend could be observed.

In 1999, a Task Force was established to provide policy directives, measures for sustaining the resource base, achieving an equitable marketing system and thriving pharmaceutical industry (Indian System of Medicine and Homeopathy - ISM&H), regulation of domestic and international trade, besides facilitating protection of patent rights and IPR of medicinal plants (Singh 2006). The Task Force emphasized that medicinal plants represent not only a valuable part of India's biodiversity but also a source of great traditional knowledge. Medicinal plants can be viewed as a possible bridge between sustainable economic development, affordable health care and conservation of vital biodiversity. For ensuring sustainable and equitable development of medicinal plants sector, the report recommended the establishment of 200 **Medicinal Plants Conservation Areas** (MPCA), 200 'Vanaspati Vans', in degraded forest areas. The Task Force also recommended the establishment of the **Medicinal Plants Board** for the integrated development of this sector.

Since the publishing of the Chiang Mai Declaration, in 1988, the conservation of medicinal plants has been receiving much more attention in India. This is illustrated by the upsurge in the number of publications detected in the SCOPUS database, under the search term "Conservation + medicinal + plants + India (Fig. 1.3).

Despite of all measures, the majority of supplies continue to be met from wild sources. In an effort to meet the increasing demand for medicinal plants, therefore one of the main aims of NMBP is to focus on both *in-situ* and *ex-situ* conservation of genetic resources (Sharma and Thockhom 2014).

In the course of initiatives, the list of threatened taxa of the Indian flora has been established. It is maintained by the Botanical Survey of India**:** https://bsi.gov.in/uploads/documents/research-program/Threatened-plants-of%20India.pdf. In this database, each plant entry contains information about the purported medicinal values of the species. As an example and just in order to rightly assess the magnitude of the danger plants (including medicinal plants) are facing, it should be mentioned that a total of 560 plant species of India have already been included in the International Union for Conservation of Nature and Natural Resources (IUCN) Red

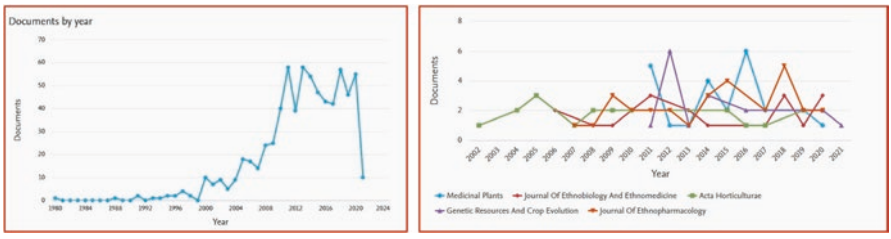


**Fig. 1.3** Distribution of records detected in SCOPUS database, under the search term "Conservation of medicinal plants in India"

List of Threatened species: out of these, 247 species have been ranked into the threatened category (Venkatasubramanian et al. 2018).

Farther information on the endangered species can be obtained from the MAPs the database maintained on-line by the ENVIS Centre on Medicinal Plants (http://envis.frlht.org/implad). This innovative, search based database stores 7637 botanical names out of which 6198 are medicinal plants.

### *1.6.2 Germplasm Conservation of MAPs in India*

Based on the recognition that traditional medicines are still means of health care for about 65% of the population and there is a need to revitalize local health conditions, the UNDP (United Nations Development Program) and in India the GOI (Government of India) have launched an initiative on 'Conservation of Medicinal Plants for Health and Livelihood Security'. The project started in 2005 is being implemented in the following eight states: Karnataka, Tamil Nadu, Andhra Pradesh, Kerala, Maharashtra, West Bengal, Rajasthan and Orissa. In Bangalore, the Foundation for Revitalization of Local Health Traditions (FRLHT), is the local partner that has undertaken several efforts through this initiative to strengthen India's traditional medicine system.

Among the numerous attempts aimed at the conservation of the rich MAPs, the project "Mainstreaming Conservation and Sustainable Use of Medicinal Plant Diversity in Three Indian States" is worth highlighting. This project is jointly funded by the Government of India, National Medicinal Plant Board (NMPB) and the State Governments of Arunachal Pradesh, Chhattisgarh and Uttarakhand. The results that have been reached so far include the Demonstration of replicable models of *in-situ* and *ex-situ* conservation of medicinal plants, the establishment of twenty Medicinal Plant Conservation Development Areas (covering 24,047 hectares, in three project states). The three project states have undertaken plantation of various medicinal plants on 13,130 hectares (United Nations Development Program 2021).

The biogeographic position of India is very unique that has resulted in a wide range of ecosystems and habitat such as forests, grasslands, wetlands, deserts, coastal and marine ecosystems. India is rich in all the three levels of biodiversity viz. species diversity, genetic diversity, and habitat diversity (Mukherjee and Wahile 2006).

India has 426 biomes representing different habitat diversities that gave rise to one of the richest centers for plant genetic resources in the world (Pushpangadan and Narayanan Nair 2001).

In India, similarly to other MAP producing countries, medicinal plant resources are getting depleted at an alarming rate. Today, 90% of the medicinal plants consumed domestically and for export are collected from the wild, and only 70 out of the *ca*. 700 traded species are obtained purely from cultivated sources (Soumya 2012). The continuously increasing demand on herbal products has put the valuable MAP resources under great stress and brought many medicinal plants to the verge

of extinction. MAP natural resources are facing also other threats, like climate change, deforestation, destructive/inexpert harvesting, extensive industrialization, forest fire, etc. It is estimated that in India about 246 plants species are threatened: most of them possess medicinal values (IUCN 2011TAb). These figures have been constantly increasing, so that there is an urgent need to conserve the wild populations of medicinal plant diversity (Ved et al. 2001; Dhar et al. 2000).

### *1.6.3 The role of Medicinal Plant Conservation Areas (MPCA)*

As part of its efforts for biodiversity conservation, the Indian Ministry of Environment and Forestry (MoEF) has set up eight biosphere reserves, 87 national parks and 448 sanctuaries, under Wildlife (Protection) Act, 1972. These cover more than four and half percent geographical area of the country (Singh 2006).

In 2003, Katwal et al. (2003) reported that State Forest Departments (SFDs) of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra, in consultation with the Foundation for Revitalisation of Local Health Traditions (FRLHT) and with the support of DANIDA and UNDP have established 54 forest genebank sites called Medicinal Plant Conservation Areas (MPCA). The network of 54 MPCAs, measuring 200 ha to 500 ha each, has been established gradually since 1993 and represents all forest types with large bio-climatic and soil regime variation. These "gene banks" harbor 45% of recorded populations of flowering and medicinal plants of Peninsular India, including 70% of the red-listed species. The intra-specific diversity of MAP-germplasm conserved in the MPCA network can be used to provide authenticated quality planting material for commercial cultivation to meet rising demands of the herbal industry.

### *1.6.4 National Medicinal Plant Board Consortia in India*

NMPB (NMPB 2021d) has recognized the necessity to maintain connectivity between stakeholders in the both supply and value chain of medicinal plants, while supporting end-to-end conservation and cultivation activities including good post harvesting. In order to establish the desired linkage between the farmers and manufacturers, a 'Seed to Shelf' approach is being introduced. In this activity, aspects related to Quality Planting Materials (QPM), Good Agriculture Practices (GAP's), Good Post Harvest Practices (GPHP's) are addressed.

In order to meet the ever-increasing demand for medicinal plants, there is a need to focus on both *ex-situ* cultivation and *in-situ* conservation.

In pursuit of above aims, NMPB encourages the foundation of consortia that will engage in the following activities: Production of Quality planting material, Research & Development, Cultivation and Trade of medicinal plants/market linkage.