Chapter 6
Opportunities and Challenges in Ethnobotanical Studies of Indian Medicinal Plants

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Abstract Since the dawn of Ayurveda, the Indian healthcare system has been closely intertwined with plant-based medicines. Diverse Indian tribes and ethnic groups have knowledge of medicinal plants that yield pharmaceutically important biomolecules. Ethnobotanical study begins with understanding of the complex interaction patterns of both the biotic and abiotic factors of a habitat and moves on to Ethnopharmacology, the study of indigenous medicinal systems and aligning them with anthropological activities. Ethnobotanical studies focus on plant resource utilization for food, medicines, art, construction, music, aesthetics, rituals, etc. and play a pivotal role in Bio-prospecting of novel compounds, potent biomarkers, new crop foods, timber and non-timber product utilization, etc.

Thus, the scientific management of the Ethnobotanical database becomes a primary goal in amalgamating traditional and ethnobotanical medicinal knowledge with main stream medicine. This review discusses key points regarding the interrelationship between the biotic and abiotic factors with reference to medicinal plants and their management. Further, it also discusses the complex role of traditions, beliefs, and cohesive existence of stakeholders in plant conservation leading to the preservation of traditional and ethnic knowledge.

The article discourses a five-year database (2015–2020), compiling published literature about important ethnobotanical medicinal plants, listing of new plant species and plants utilized for ethnobotanical purpose with their conservation status and strategies. Based on the compilation, possible strategies and road map for effective conservation has been suggested. As an end-note, opportunities are mentioned that could serve governmental and non-governmental organizations to develop sustainable conservation practices for ethnobotanically important medicinal plants.

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6.1 Introduction

Ethnobotany, by definition, applies to the study of practical utilization relationship, including medicinal applications, between plant environment and humans in a natural setting (Harshberger 1896; Soejarto et al. 2005). The socio-economic-ecological interaction between nature and humans has evolved over time with plants governing a critical position. The knowledge of ethnobotany has been crucial for the survival of the species (Pathak and Bharati 2020; Albuquerque et al. 2017).

India, as a country, is not just rich in its culture and heritage, but is also home to the world's finest and rare flora and fauna. Over the centuries, the indigenous tribes of India have learnt to make these plants yield for them, and over the last 70–80 years science has played a strong role in studying these plants to understand their values and bringing them to crores of Indians who could benefit from it. India's large source of medicinal plants is used for traditional medicinal treatments. Therefore, documenting traditional and folklore knowledge of ethnobotanical plant resources plays an important role in compiling an inventory of newer and hitherto unknown sources of phytoconstituents and therapeutic usage (Chauhan 2020).

In recent times, the term ethnopharmacology has expanded the reaches of ethnobotanical knowledge to encompass a broader multidisciplinary approach (Soejarto et al. 2005). At the same time, with the rise and prominence of bio-prospecting, chemo-prospecting, and with the projected compound annual growth rate (CAGR) of 6.1%, i.e. from $29.4 Bn in 2017 to approximately $39.6 Bn by 2022 for the period of 2016–2024 of global market value for botanicals and plant derived drugs (Lawson 2017) (Nasr 2019), over-harvesting, degradation, loss of indigenous and traditional knowledge from local communities, non-acceptance of traditional systems of medicine in mainstream healthcare services and uncontrolled transboundary trading has become a grievous issue (Chauhan 2020).

The current chapter reviews the various aspects of ethnobotany in India with emphasis on studies on indigenous and traditional habitats, interaction of biotic factors, advantages of conservation and plant – human interactions. Further, threats and challenges to ethnobotanical resources due to anthropogenic influences, and roadmaps for better conservation have been discussed.

6.2 Status of Ethnobotany and Traditional Knowledge in India

Numerically speaking, the quantitative amount of published research in the field of ethnobotany in India has seen a constant incline despite the advent of newer avenues in research and a reported loss in the available pool of traditional and indigenous

knowledge (Pathak and Bharati 2020). On a quantitative basis, a review article by Pathak and Bharati in 2020 reports that around 2123 research articles have been published during 2007–2018 in the field of ethnobotany. Around 5458 authors affiliated to 1927 organisations have been contributors to this work (Pathak and Bharati 2020).

The current population of India is reported to be 1.388 billion (Worldometers 2020), out of which 104 million are tribal populace spread across approximately 705 communities with unique cultural diversification (Kumar et al. 2020). The reported botanical strength of the country is estimated at approximately 18,386 angiosperms, 79 gymnosperms, 1289 pteridophytes, 2748 bryophytes, 2511 lichens, 15,115 fungi, and 7357 algae (Dash et al. 2019) (Pathak and Bharati 2020).

It is interesting to note that the study of Ethnobotany in India began to see light in the early 1940s and since then, has seen a sustained growth in the number of studies being conducted. Knowledge about plants exists in both recorded and unrecorded formats; unrecorded knowledge usually gets handed down from one generation to another in sects, families, and tribes. According to a paper by Jain SK in 1994, there were 45,000 plant species that were recorded and many of these had medicinal values. India's knowledge of plants can be traced back to ancient Indian doctors; according to a study (Murthy et al. 2008), at least 8000 plants were known to have been used for treating various ailments without any known side-effects. A recent publication by Ministry of Environment of Forests (MoEF), Government of India, under All India Coordinated Research Project on Ethnobiology (AICRPE), reports that the ethnic communities of India use more than ten thousand wild plants for various therapeutic, edible, and miscellaneous uses (Gopal 2019).

However, there has been a severe loss observed in the knowledge about traditional methods of plant cultivation, caretaking, and medicinal properties and also the traditional knowledge about flora. Most of this knowledge is part of the oral methods of information transfer. Hence, as healers and village elders grow old and succumb to the ravages of time, knowledge dies with them (Pandey and Tripathi 2017).

Currently, ethnobotany is predominantly concerned about traditional facts and has a multidisciplinary approach focussing mainly on plant resource utilization. Studies focussing on ecological evaluations and climate analysis, plant habitats and distribution, agricultural and cultivated design studies are slowly gaining fame among ethnobotanists (Ijaz et al. 2017). Thus, even in a modernized approach to scientific discoveries and innovations, the field of ethnobotany shall provide better results when viewed from the stand-point of the traditional healers and ethnic communities.

6.2.1 Relevance of Ethnobotanical Studies

Ethnobotany is reported to be a flourishing segment of research which appeals to the interests of a wide range of researchers from pure science and academic backgrounds to anthropological studies. Being predominantly linked to economic aspect

of botany, ethnobotany has also been pursued by many in order to benefit from the potential economic and resource benefits obtained from plant and plant-related products. The cross-cultural relevance and trade exchanges pertaining to plants and plant resources between communities, societies, and across nations, add significance to ethnobotanical studies and discoveries. Understanding the relation between plants, their medicinal potencies, their commercial values and human interactions and evolution has been a common focus for a wide variety of research endeavours in the interdisciplinary fields concerning ethnomedicine, ethnopharmacology, pharmacognosy, etc. (Leonti et al. 2020).

It is known that the ancient Indian medical system and medicines have been beneficial to treat thousands of chronic illnesses. According to Indian Ayurvedic monographs, reserpine (*Rauwolfia serpentina*) was used to treat high blood pressure (Vicker and Zollman 1999). *Decalepis arayalpathra*, more commonly known as 'Amritha Palam' in the regions of Tamil Nadu, is used for peptic ulcer, cancer-like afflictions, stomach ache, and other similar ailments (Mishra et al. 2015). Similarly, Sunthi (Ginger – *Zingiber officinale* Rosc), Ashwagandha (*Withania somnifera* (L.) Dunal), Guduchi (*Tinospora cordifolia* Miers) are commonly used for treating chronic illnesses.

The assimilation of a traditional or indigenous system is challenging not only because of the difficulties faced in transposition of unwritten and oral evidences into written scientifically valid studies but also due to the decontextualization of information that occurs in a scientific representation of ethnic data. This dissociates the ethnic knowledge from the socio-cultural background, which is necessary in order to understand the plant – human – society interactions (Berkes 2018; Albuquerque et al. 2019). Though inclusion of indigenous populace and community members as co-authors has been appreciated, it certainly does not guarantee legitimate representation of ethnobotanical, indigenous, and traditional knowledge (Zenderland et al. 2019).

6.2.2 Interdependence of Biotic and Abiotic Factors Influencing Human and Forest Relationship

One of the baseline results of an ethnobotanical study is the understanding of the complex interaction patterns of both the biotic and abiotic factors of a habitat. The interdependence is not limited only to other living things but extends to non-living factors too. Though such habitats and interactions have been reported by many to share similarities at a biosphere scale such as average productivity, nutrition turnover rate, soil parameters, etc., these micromanagement capacities of plant communities and interactions with abiotic factors can be held accountable for the wide variations with respect to the composition of plant community (Fujii et al. 2018).

With just tropical forest communities in reference, articles present a comparative scope of analysis between tree species community composition such as prominence of Leguminosae members vs. Dipterocarpaceae members or Combretaceae members, against soil types and other abiotic factors as a function of biodiversity.

Nevertheless, not all community interaction is competitive of nature, positive interactions like facilitation has also been well documented in plant communities (Ma et al. 2019).

Forests are currently the most threatened ecosystems all over the globe. The altercations to this ecosystem have been observed to damage it in ways which are at the core of the planet's atmospheric and climatic cycles (Roberts et al. 2017). The reported decreasing emotional and physical attachment to nature and natural elements post urbanization has further increased the risk of disconnect from nature and inability to understand the importance of ecosystem services that the current urban population benefits from (Palliwoda et al. 2017). Tribal and village population on the other hand are intricately involved with forest communities at a psycho-sociological level at times. Such a relation enables them a deeper and at times clearer understanding of the interactions among the forest species. Thus, *in-situ* conservation, if undertaken with the help and involvement of forest-based human communities, might be beneficial on both fronts i.e., conservation at a species level and indigenous knowledge level.

Further, as many of the social and ecological changes that affect a forest community occur on a much larger spatial and temporal dimension, with their effects visible after the observation of larger phytogeographical regions and accumulating in the order of decades, a longer, deeper, and community-based study using traditional and indigenous knowledge sources is most important to bridge the gap between reality and theories (Fischer 2018). Hence, study of forest and human interactions becomes a valid stepping stone in understanding ethnobotany and ethnic knowledge systems.

6.2.3 Tribes and Sacred Groves

A mystic approach to the concept of human – forest relation in the realms of conservation comes from the concept of sacred groves (Panda and Mund 2019). With the restrictions in place, sacred groves have been reported to act as treasure houses for rare species. Such a common property-based resource system embroidered with religious sentiments is a successful model for culture-based mode of biodiversity conservation in India (Parthasarathy and Babu 2019). Moreover, sacred groves further assist conservation in the form of ecological functions, unhindered progression of biological and cultural diversity and progress in renewal of ecosystem services (Parthasarathy and Babu 2019).

With the total number of sacred grooves in India being vague at best ranging from as low as 13,720 reported in some publications (Parthasarathy and Babu 2019) to as high as 1,00,000 – 1,50,000 (CPREEC 2016a, b). Governmental databases further suggest a total of 2820 sacred grooves being documented in the state of Maharashtra (CPREEC 2016a, b). The pivotal backbone of traditions and beliefs based on ancestral spirits, myths, rituals, and taboos around these grooves have long preserved the sanctity and existence of sacred groves, which has in consequence played its part in conserving flora and fauna as if a natural museum of massive trees

and safe havens for medicinal species and fauna alike. For the tribes associated with such groves, these forests are an integral part of the life and, at times, livelihood. These indigenous tribal communities have a deep and intimate relationship with these forests and the conservation and maintenance of such an area is most often managed via voluntary cooperation and selfless communal efforts (Rath and Ormsby 2020).

In the state of Maharashtra, such sacred forests are called as 'Devrai' or 'Devgudi' or the forest of the God (Amirthalingam 2016). But with urbanization and western influences, these important traditional conservational strategies are being neglected, undermined, and at times terminated. Reports suggest that many such villages have sold off their lands to speculators because of urbanization and an enormous rise in land property prices. This has indeed triggered a cascade of breakdowns of socio-economic beliefs and cultural and traditional systems, which have led to significant losses to the protective sentiments towards sacred groves (Vipat and Bharucha 2014).

Some research articles present a substantial evidence regarding the relation of sacred groves and efforts of conservation. A 1998 study by Singh et al., around the Nagoni sacred forest in Himachal Pradesh reports a higher degree of species richness in comparison to non – sacred forest areas. Furthermore, density of medicinal plant species was reported to be twice in comparison to reserve forest areas wherein close to 40% medicinally important species were observed to be unique to sacred groves (Singh et al. 1998; Parthasarathy and Babu 2019). Similar reports of higher species richness have also been published from studies on sacred groves in Karnataka.

It is worth mentioning that, such reports are not confined to India; a similar study on sacred groves in Tanzania reported a higher woody species richness in comparison to state-managed forest (Mgumia and Oba 2003). Onyekwelu and Olusola (2014) report higher species richness and better conservation of endangered species in sacred groves of Nigerian forests (Onyekwelu and Olusola 2014). Many such comparative studies between sacred groves and non-sacred or state-managed forest land put forth evidence related to the success of the common property resource model of sacred groves in the conservation of forests. Thus, the need for promotion of community management forest schemes like social forestry, community forestry, and commercial forestry from the government is essential to reap the benefits of sacred groves in the modern setting.

6.2.4 Ethnobotanical Products and their Importance in Human Life

Numerous ethnobotanical studies focus on the discovery and utilization of plant resources of various applied fields like pharmacognosy, pharmaceutics, cosmeceutics, etc. In this reference, sacred groves not only provide plant resource but the never-ending strings of stories associated with these groves provide the much needed holistic in-sight required in designing an ethnobotanical product.

Many of the medicinally potent drugs used in society today have been a developed from medicinally important plants utilized in tribal communities under traditional systems of medicine (Heinrich 2003). Bio-prospecting for the discovery and utilization of novel compounds, potent biomarkers, new crop foods, non-timber product utilizations, etc. has always classically been dependant on ethnobotany. Because of the knowledge banks from traditional and indigenous sources behind ethnobotanical information, ethnobotanically directed bio prospecting has become a sought-after avenue in comparison to random assaying of plants in search of bioactive phytoconstituents (Garnatje et al. 2017). Numerous potent medical drugs such as Aspirin, Codeine, Colchicine, Vincristine and Vinblastine, Digoxin and Digitoxin are all examples of the same procedure. Though the practitioners of tradition schools of medicine may not be aware of the chemical structures and properties of individual phytocompounds, these same natural products do form the basis of numerous traditional treatment regimens. In the Indian setting, Ayurveda, other traditional schools of medicine and associated ethnomedicinal and indigenous knowledge is valuable components for workable bio prospecting and value addition processes. Equal benefit sharing among the prospector and the ethnic source of information as part of short-term processing, and in event of a discovery or commercialization of the product as long-term benefits with protection under Indigenous Intellectual Property Rights needs to be highlighted (Noorunnisa et al. 2020). The next section discusses the various strategies used by researchers towards achieving the goal of conservation of medicinal plant. The data presented in the tables namely Tables 6.1, 6.2, and 6.3 provided below is collected from the past 5 years of published work (2016–2020).

6.3 Roadmap for Conservation

Though over the past few years there is a focused attempt at promoting the sustainable use and conservation by the government, for example UNDP in partnership with the Ministry of Environment and Forests and the Global Environment Facility, the urban set up that utilize medicinal plants and their products are heavily dependent on their rural counterparts for providing more than 60% of the raw material that is forest-based. Some of the challenges faced by the wealth of knowledge regarding medicinal plants are manmade or natural calamities such as undocumented, unorganized or inappropriate cultivation practices and usage leading to over foraging and extinction of species, herbal health practitioners working in isolation and passing on their traditional knowledge only by word of mouth or on to family members. Also, resistance of the established mainstream medicinal practices to include herbal medicine, the rural-urban divide for the knowledge exchange and dissemination, the vagaries of fragile ecosystems resulting in habitat loss for the medicinal plants are also some of the challenges. Therefore, it is imperative for India to devise effective strategies for sustainable use and conservation of these medicinal plants. The value chain would include collection of germplasm, newer techniques of propagation, characterization and evaluation, disease resistance, effective storage and distribution to the manufacturer or the end user, with minimum post-harvest losses (IUCN 2011).

Table 6.1 Scientific basis for conservation of select ethnobotanical plants

Sr. No	Botanical name	Reason for conservation	Assays/screening	References
1.	*Decalepis hamiltonii* Wight & Arn.	It is being exploited for its nutraceutical and medicinal properties; root specific flavor metabolite 2-hydroxy-4-methoxy benzaldehyde	*In-vitro* propagation, bioactive potential, *in-vitro* production of flavour metabolite	Pradeep et al. (2016)
2.	A total of 108 plants belonging to 51 families have been identified,	Needs to be conserved for commercial benefit of tribal populace	Soliga tribal community residing at Biligiriranga Swamy Temple Tiger Reserve (BRTTR) uses plants for curing various ailments.	Nautiyal et al. (2016)
3.	The present study reported 51 medicinal plants belonging to 37 families.	Needs to be conserved for commercial benefit of tribal populace	Survey on medicinal plants in southern Western Ghats of Virudhunagar district, Tamil Nadu,	Suresh et al. (2016)
4.	Calamus vattayila Renuka (A study of 3 populations)	Needs to be conserved for commercial benefit of tribal populace	Genetic differentiation and total gene diversity among the population was significantly high, therefore conservation of each population is required as a representative. Possibility of in breeding is indicated.	Priya et al. (2016)
5.	*Saraca asoca* (Roxb.) Willd	Medicinally important tree and hence needs to be conserved	To understand genetic variation, ISSR markers were used and RP-HPLC of selected phytocompounds were analysed. No significant trends indicating in-situ and ex-situ conservation is required.	Hegde et al. (2018)
6.	*Saraca asoca (Roxb.) De Wilde*	Commercial herbal preparations, traditional medicine.	RAPD employed to understand genetic diversity; results reveal good genetic diversity; therefore, gene pool is not under immediate threat.	Saini et al. (2018)
7.	*Arenga wightii* Griff	Commercial applications such as food, fiber, medicinal properties etc.	Genetic variability was assessed in 32 natural populations using ISSR markers that showed similarity more than diversity; this data will help in determining the conservation strategies for the future.	Madar et al. (2019)

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Table 6.1 (continued)

Sr. No	Botanical name	Reason for conservation	Assays/screening	References
8.	*Ensete superbum* (Roxb.) Cheesman	The endosperm is used for various human disorders	Exomorphic characters were examined by SEM. This indirectly unveils the genetic diversity of the plants as the size and phenotype varied across the latitudes	(Kumar et al. (2019)
9.	*Garcinia indica* (Thouars) Choisy	High value medicinal plant.	Determine genetic diversity using ISSR markers. IT revealed genetic diversity; this information will help conservation of potential germplasm	Palkar and Sellappan (2019)
10.	*Saraca asoca* (Roxb.) Willd	Medicinally important plant.	Determining genetic diversity using ISSR markers and metabolic studies using HPLC. This was done to help develop conservation strategies.	Hegde et al. (2019)
11.	*Gnetum ula* Brongn	Medicinally important plant of western ghats	Its phytochemical profile is reported as a review; it is not considered classical drug; therefore, these studies are required for implementing proper conservation policies	Irfan et al. (2020)
12.	*Decalepis salicifolia* (Bedd. Ex Hook.f.) venter	Steno-endemic and critically endangered species	Genetic diversity assessed using ISSR markers- 62% variance detected. GC analysis of 2 HMBA showed significant variation. This allows for planning of in situ conservation strategies for maximum preservation of genetic resources	Gokul et al. (2020)
13.	Genus *Calamus*	Economically important	Genetic diversity assessed using 26 microsatellite markers	(Kurian et al. (2020)
14.	*Garcinia imberti* Bourd	Endemic species	Genetic diversity assessed using ISSR markers; revealed less or moderate genetic diversity but all has its own characteristic which should be conserved	(Anto et al. 2020)

Table 6.2 Identification of new species and their conservation status

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
1	Endemic riparian angiosperm	Floral diversity of Netravati River system in Western ghats; threatened status. In-situ and ex-situ conservation was proposed	Korse (2017)
2	*Henckelia lyrate* (Wight) A.Weber & B.L.Burtt	Enumeration and conservation assessment has been reported as critically endangered.	Geethakumary et al. (2016)
3	*Phyllagathis indica* J.Mathew, Yohannan & Kad.V.George	Conservation status is updated as critically endangered	Mathew et al. (2016a, b)
4	*Strobilanthes malabarica* Josekutty, P.Biju & Augustine	Large population is found in the windward side of Paithalmala along the slopes in the evergreen forests and bordering the grasslands, but not protected from human interactions.	Josekutty et al. (2016)
5	A total of 132 plant species (included Pteridopytes) belonging to 101 genera under 45 families; the present study listed 52- plant species of medicinally important plants utilized by the ethnic people to address their daily healthcare needs	Biodiversity of the Sathuragiri hills in the southern Western Ghats of Tamil Nadu, India	Gurusamy et al. (2016)
6	*Andrographis megamalayana* Gnanasek, Karupp. & G.V.S.Murthy.	It is a new species from western ghats. It is evaluated as vulnerable using IUCN red list categories and criteria version 3.1	Gnanasekaran et al. (2016)
7	*Ceropegia ravikumariana* Kambale & Gnanasek.	Data deficient and explorations from similar habitats are required to determine its exact IUCN threat status	Kambale and Gnanasekaran (2016)
8	*Miliusa sahyadrica* G.Rajkumar, Alister, Nazarudeen & Pandur. a Paleotropical genus	A new species in western ghats. A total of 23 species and 1 genus is recorded in India. 15 species and one variety are reported from western ghats. Except 4 species, all are endemic to that region. It has been treated as critically endangered.	Rajkumar et al. (2016)
9	Medicinal Flora and Related traditional knowledge of Western Ghats	An article reporting the plants for community-based malaria management	Prakash et al. (2016)
10	*Piper rukshgandhum* J.Mathew	A new species from Achankovil forest, Kerala section. Categorized as critically endangered.	Mathew et al. (2016a, b)

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Table 6.2 (continued)

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
11	*Pseudoglochidion anamalayanum* gamble	One of the few collections of Anamalais, Coimbatore district. ITS taxonomic position using matK and ITS markers reveals it to be nested among the Phyllanthus species of subgenus Isocladus.	Pagare et al. (2016)
12	A total of 3896 individuals comprising 97 species, 79 genera and 45 families were reported to be present in sholas in the Nilgiri Mountains	This study aimed at providing descriptive information on the floristic composition of the sholas in the Nilgiri Mountains	Mohandass et al. (2016)
13	Two hundred and eighty-five genera of 41 families of climbers were identified in southern western ghats of Tamil Nadu	These are listed as rare, endangered and threatened species (RET). Conservation strategies are required for the same.	Sarvalingam and Rajendran (2016)
14	163 species of plants were reported to be used as ethnomedicinal plants by local traditional healers of Irulas tribes	Ethnobotanical survey among the Irulas tribes in Maruthamalai hills	Tamilselvi et al. (2016)
15	Ethnobotanical survey in Karnataka along the western ghats	A book chapter dedicated to the uses of plants by the indigenous community along the western ghats	Somashekhar (2016)
16	Ethnoveterinary medicines and practices of western ghats	A chapter describing the ethnoveterinary practices and the medicinal plants used along the western ghats.	Nair and Punniamurthy (2016)
17	Tropical reeds: Bamboo genus Ochlandra (endemic to Western ghats)	Ecological function, its unscientific usage, demands and a need for conservation is mentioned in this review	Siji Mol et al. (2016)
18	*Litsea floribunda* (Blume) gamble	Ratio of male trees are lower and needs conservation of the same.	Srinivas and Krishnamurthy (2016)
19	Ethnomedicinal assessment of riparian vegetation of Bhavani river in Pillur beat, Karamadai range, Western Ghats,	A total of 112 plants were recorded and leaves were the most frequently used part for disease treatment.	Dhivya and Kalaichelvi (2017)
20	*I. mankulamensis* sp. *nov. and I. pandurangani sp. nov.*	New taxa of impatiens identified in southern parts of western ghats; classified as critically endangered	Mambetta Prabhukumar et al. (2017)

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Table 6.2 (continued)

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
21	88 species of medicinal plants identified from Ratnagiri of which 5 plants were found to be endemic	This study is an ethnobotanical survey of selected sample villages in Ratnagiri. Conservation of biodiversity of study area is suggested.	Patil and Satyawan (2017)
22	*Liparis sanamalabarica* P.M.Salim	A new species found in the forests of Wayanad district in Kerala; conservation status is vulnerable	Salim (2017)
23	*Anisochilus petraeus* Mathew & Yohannan	A new species collected from Achankovil Forests of southern Western Ghats, India. Conservation status assigned as "Critically endangered"	Mathew et al. (2017)
24	*Eriocaulon govindiana* Nov.	A new species from from marshy areas in the Wayanad wildlife Sanctuary, Kerala. It is categorized as "Data deficient"	Sunil et al. (2017)
25	*Dendrocalamus stocksii* (Munro) M.Kumar, Remesh & Unnikrishnan	Preservation, sociocultural aspects of this species was studied from Sindhudurg district, south Konkan region of Maharashtra	Digambar Patil (2017)
26	*Cucumis silentvalleyi* (Manilal, T. Sabu & P.Mathew) Ghebret. & Thulin *and Cucumisindicus* Ghebret. & Thulin	Both are rare, narrow endemics of western ghats. Both are reported to be highly vulnerable and needs in situ as well as ex situ strategies of conservation	Kattukunnel et al. (2017)
27	A total of 1142 angiospermic taxa was reported at Bhimashankar wildlife sanctuary, northern Western Ghats	Of these 53 taxa are under different threat categories according to IUCN.	Rahangdale and Rahangdale (2017)
28	A total of 99 orchids were reported in a survey in western ghats of Kerala	The survey was carried out to identify the orchis with horticultural and commercial importance, thereby proposing its conservation strategies to protect the gene pool	Ajithkumar et al. (2017)
29	*Hopea glabra* Wight & Arn. And *Hopea utilis* (Bedd.) bole	They were located in Silent Valley National Park and Shankili forests in Kulathupuza range respectively for the first time. They are reported to be threatened species	Sreekumar et al. (2017)
30	*Strobilanthes sainthomiana* Augustine, Josekutty & P.Biju	A new species reported from Paithalmala hills, Kannur District. Population quite large but now protected from anthropogenic disturbances	Augustine et al. (2017)

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Table 6.2 (continued)

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
31	31 plants were found to be reported as ethnomedicinal which were used by Sholaga tribes of Kathri hills.	Ethnobotanical survey of Sholaga tribes	Yogeshwari and Kumudha (2018)
32	*Cinnamomum goaense* Kosterm.	Rediscovery at Idukki District of Kerala after a lapse of 57 years, and termed as data deficient to determine the conservation status	Geethakumary et al. (2018)
33	*Hedyotis beddomei* Hook. f.	Rediscovery after 144 years from Elivalmala of Muthikulam forests, Palghat district; assessed as 'critically endangered	Mambetta Prabhukumar et al. (2018)
34	*Distimake rhynchorhiza* (Dalzell) Simões & staples	Was found to be widely distributed in western ghats; also, it is proposed that the status be decreased from "endangered" to "vulnerable"	Rita Simões and More (2018)
35	*Kingiodendron pinnatum* (DC.) harms	17 populations mapped to 13 forest location in Kerala; based on their economic and medicinal values, isolated and fragmented population, irregularities in flowering and fruiting period, in situ conservation strategies are proposed	Jose et al. (2018)
36	*Peperomia ekakesara (Piperaceae)* Syam Radh & Nampy	A new species identified from Mathikettan shola National Park in southern Western Ghats; conservation status is "near threatened"	Syam Radh and Nampy (2018)
37	*Strobilanthes orbiculata* Sinj. Thomas B.Mani & Britto	A new species was found in southern parts of the Western Ghats, India	Thomas et al. (2018)
38	*Memecylon travancorense* Sivu, N. S. Pradeep, Pandur. & Ratheesh	A new species from Agastyamala Biosphere reserve; it is categorized as "data deficient"	Raghavanpillai Sivu et al. (2018)
39	*Crotalaria suffruticosa* S.Subraman. & A.K.Pandey *and C. multibracteata* S.A.Rather & A.K.Pandey	Two new species were found in the Karul Ghat and Panhala region of Maharashtra respectively. matK and ITS markers were used to assess the phylogenetic relationship. Both are considered under "endangered" category	Rather et al. (2018)
40	*Micromitrium vazhanicum sp.* C. N. Manju, V. K. Chandini, and K. P. Rajesh	It was identified in Peechi-Vazhani wildlife sanctuary and its conservation status is discussed	Manju et al. (2019)

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Table 6.2 (continued)

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
41	*Humboldtia bourdillonii* Prain	A new population was discovered in Vagamon Hills of Kottayam District which is quite distant from original location. The new location witnesses many environmental calamities therefore conservation measures are required	Balan et al. (2019)
42	33 species were documented as ethno – botanical plants from Salher and Mulher and adjoining areas in western ghats	The list was generated as a result of ethnobotanical survey. Bhil, Kokana and Mahadeo koli tribes were interviewed for the same.	Sonawane (2019)
43	*Capillipedium parviflorum* (R. Br.) Stapf.	Occurrence reported for first time in Chitramoola, Karnataka	Abhijit and Krishnamurthy (2019)
44	*Trichopus zeylanicus ssp. travancoricus Burkill ex K. Narayanan*	Ethnomedicinal plant. Fragmented population was found in Agasthyamalai Hills. Has been included under endangered category, therefore conservation and propagation techniques are encouraged	Sasikala and Ramasubbu (2019)
45	*Eugenia velliangiriana* Murug., V. Ravich., Murugan & Arum.	New species reported from Velliangiri hills, Coimbatore. Designated as data deficient	Maruthakkutti et al. (2019)
46	*Strobilanthes tricostata* Sinj. Thomas, B.Mani, Britto & Pradeep	New species is reported in Megamalai hills, Tamil Nadu. It is termed as critically endangered	Thomas et al. (2019)
47	*Boswellia serrata* Roxb.	Ethnobotanical plant of Soliga tribes in the Western Ghats. Gum-resin extraction is carried out by these tribes. The cultural practices, beliefs of these tribes can help conservation plans of these trees in its natural habitat	Kori et al. (2019a, b)
48	*Boswellia serrata* Roxb.	Gum resin harvest in the western ghats. Used for religious practices. Currently threatened by *L. camara* invasion and also the harvesting, therefore management is required for viability of this tree.	Kori et al. (2019a, b)
49	Eighty-one climbing plant species and 12 species are threatened in	Distribution of climber in Courtallam hills was carried out. In situ conservation and protection by involving local community is proposed.	Elumalai and Perumal (2020)

(continued)

Table 6.2 (continued)

Sr. No	Species of plants/ethnobotanical surveys	Conservation status	References
50	*Desmodium velutinum* (Willd.) DC	A review which lists the ethnobotanical uses and pharmacological properties of this plant	Aswathi et al. (2020)
51	*Genus anemone L.*	One species reported in western ghats. Has medicinal properties; needs assessment of conservation status therefore.	Rajput and Agnihotri (2020)
52	*Wendlandia angustifolia* Wight ex. Hook.f.	Presumed to be extinct but should be assigned to endangered based on new data from western ghats	Muthumperumal et al. (2020)
53	*Impatiens saulierea* B.Mani, S. Thomas & Britto and *I. josephia* Sinj.Thomas, B.Mani & Britto	New species from Idukki district in Kerala. Classified as endangered	Mani et al. (2020)
54	*Cryptocarya sheikelmudiyana* A.K.H. Bachan & P.K. Fasila, sp. nov.	New species from Kerala; endangered status	Fasila et al. (2020)
55	*Impatiens nidholapathra* Vishnu & Nampy, sp. nov *and I. grandispora Impatiens grandispora* Nampy & Vishnu, sp. nov.	New scapigerous species found in Idukki district in Kerala; assessed critically endangered	Mohan et al. (2020)
56	*Goniothalamus sericeus* Sujana & Vadhyar, sp. nov	New species found in Western Ghats of Tamil Nadu; provisionally termed critically endangered	Sujana and Vadhyar (2020)
57	Genus *Salacia*	Reported as endangered and this study assesses the chromosome number of these species.	Kamat et al. (2020)
58	138 species representing ethnomedicinal plants used by Kani tribe	Ethnobotanical survey was carried out amongst the Kani tribe of Pechiparai hills of Kanyakumari wildlife sanctuary, Western Ghats	Sukumaran et al. (2020)

Table 6.3 Opportunities via conservation practices

Sr. No.	Botanical nomenclature	Plant and metabolite/ property of interest	Other reasons of interest	Conservation strategy	References
1	Fruits of *Syzygium travaccouricum* gamble.	Economic importance	Critically endangered species of southern western ghats. Infested with insect pests	Application of pheromone (methyl eugenol) during the time of fruit setting in the natural habitat of the plants.	Hussain and Anilkumar (2016)
2	*Dysoxylum malabaricum* Bedd. Ex C. DC. *(white cedar)*	Economically important endemic tree; genetic diversity in the trees from northern and southern western ghats	–	Variation at ten nuclear simple sequence repeat loci; reduced genetic diversity observed; forest conservation especially in the northern region is required	Bodare et al. (2017)
3	Rattans, or canes	NTFP – Supports many forest dwelling communities	–	High species richness of rattans in western ghats detected using niche-modelling tools; conservation values for 21 economically important endemic rattans identified	Joshi et al. (2017)
4	*Impatiens naimudica Impatiens anaimudica* C. E. C. Fisch., *I. elegans* Bedd., *I. disotis* Hook. f. *and I. phoenicea* Bedd.	Endemic and rare balsams	–	Ex situ conservation by vegetative propagation using stem cuttings	Prasad et al. (2017)
5	*Ceropegia karulensis* Punekar, Tamhankar, Lakshmin., Kumaran, Raut, S.K.Srivast. & Kavade	Exploitation of tubers and poor regeneration from seeds	Endemic, endangered	Callus induction, somatic embryogenesis and microtuberization as one of the conservation strategies as the secondary metabolites produced by *in-vitro* callus tissues and native wild plants varied slightly.	Meena et al. (2017)

(continued)

Table 6.3 (continued)

Sr. No.	Botanical nomenclature	Plant and metabolite/ property of interest	Other reasons of interest	Conservation strategy	References
6	*Anoectochilus elatus* Lindl	Economic importance	Endangered	Micropropagation and genetic stability assessment by ISSR molecular markers as conservation strategy	Sherif et al. (2017)
7	*Spathoglottis plicata* Blume.	To protect plant genetic resources by in situ conservation	–	*In-vitro* asymbiotic seed germination.	Aswathi et al. (2018)
8	*Nothapodytes nimmoniana* (J. Graham) Mabb.	Camptothecin (CPT)	Red listed species	Assessed CPT content by HPTLC from five different ecotypes. This leads to identification of "chemical hot spots" that ultimately leads to monoculture of these species, as a step towards conservation	Hannah et al. (2018)
9	*Garcinia gummi-gutta* (L.) N.Robson	Medicinally important	Declining populations	Reproductive biology studies done for proper conservation strategies; highest percentage of fruit set was found in hand cross pollination than natural which is wind pollination.	Aswathi et al. (2018)
10	Endangered anticancer medicinal plants of western Ghats	Therapeutic and medicinal properties	–	A chapter reviewing the plant conservation strategies using key biotechnological tools	Swamy et al. (2018)
11	Threatened medicinal plants of western Ghats	Therapeutic and medicinal properties	–	This chapter addresses the *in-vitro* multiplication and conservation strategies	Radha (2020)
12	*Ceropegia media* (Huber) M. Y. Ansari	Medicinal value	Difficulty in germination, slow growth	*In-vitro* propagation protocol and subsequent phytochemical profile, for conservation of this RED listed plant	Pandey et al. (2020)

Although the Convention of Biological Diversity had set a goal for all participant countries, including India, to reduce the rate of biodiversity deterioration by 2010, along with additions such as the Nagoya Protocol and COP – 10 strategic plans for biodiversity 2011–2020 i.e., Aichi Targets, it should be accepted with stable all around evidences that the targets have not been met (CBD, UN). The inter-governmental Science policy platform on Biodiversity and Ecosystem Services warns us about the unprecedented degradation and decline of natural equilibrium with accelerated rates of species extinction (Dash et al. 2019).

One of the major rationales behind promotion of In-situ conservation is to enable continuous evolution of the ethnobotanical target species and ethnomedicinal plant resources in the face of changing selection pressures, both natural of origin due to climatic changes and induced effects of human interventions (Bellon et al. 2017). As, notwithstanding their indubitable value, ex-situ conservation strategies have an elementary drawback of essentially being a 'frozen snapshot' of the phenological and genetic make-up of species at collection.

Taking into account the bio-diverse nature of the medicinal plant species found in India, there are huge opportunities for developing strategies for the creation of above value chain by the Government in close association with rural communities. Ministry of Environment and Forests and the Global Environment Facility, Ministry of AYUSH, National Medicinal Plant Board (NMPB), CSIR – Central Institute of Medicinal and Aromatic Plants (CIMAP), Indian Institute of Integrative Medicine, ICAR- Directorate of Medicinal Aromatic Plant Research and many more agencies are involved in research and development of medicinal plants.

The possible conservation strategies have been illustrated in the Fig. 6.1:

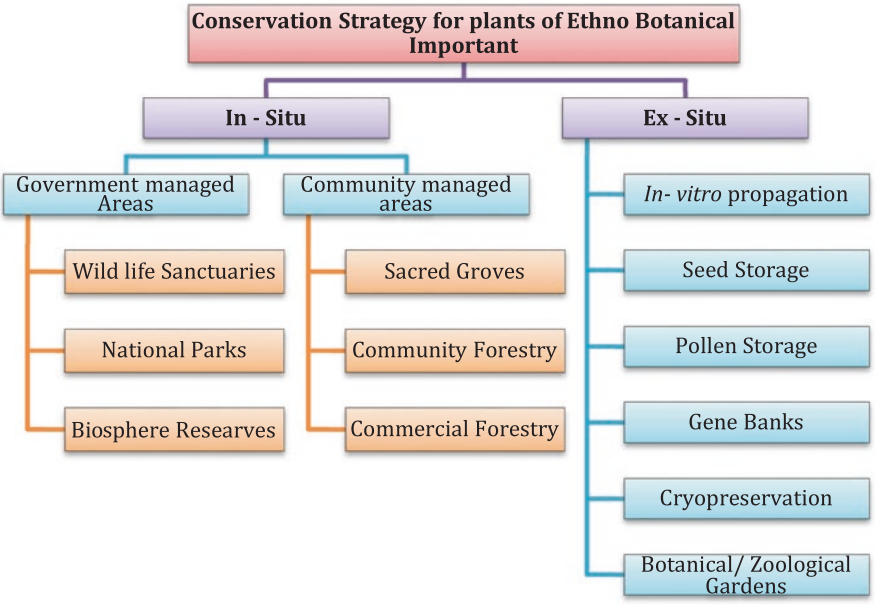

Fig. 6.1 Conservations strategies of medicinal plants

Most of the conservation strategies implemented by NMPB involve capacity building through trainings, raising awareness through promotional activities like the creation of Home/School herbal gardens, support programs for quality assurance and standardization through development of Good Agricultural and Collection Practices (GACPs), development of monographs laying down standards of quality, safety and efficacy; development of agro-techniques and credible institution a mechanism for certification of quality of raw drugs, seeds and planting material (Joshi 2008). The community level efforts of educating the rural farmers regarding sustainable harvesting techniques, discouraging cutting down of native and medicinally important trees, celebrating National Tree planting day, have improved the quality of the produce and increased the incomes of the villagers.

Another effective strategy is the setting up of Medicinal Plant Conservation Areas (MPCAs) which are natural forest areas established and managed by the State Forest Departments in collaboration with local communities to conserve threatened medicinal plants. Technological advances in Biotechnology as well as GIS mapping system have played a pivotal role in conservational success stories, especially ethnobotanical regions. Foundation for Revitalization of Local Health Traditions (FRLHT) has been working on Medicinal Plants knowledge documentation and conservation efforts since 1993 (Utkarsh 2006).

According to a latest report by United Nations Developmental Program (UNDP), 16 Biodiversity Management Committees have been created; and close to 500 women have been trained to document the biological resources found in the forests and local knowledge associated with it (UNDP 2021). If these efforts continue to develop confidence in the traditional healers of safeguarding their knowledge against misappropriation and bio-piracy and ensure their share in the profit incurred by technology driven value addition to the final product, it will add further in conserving the ethnobotanical wealth of our country.

6.4 Conclusion

In conclusion, it can be stated that, there are adequate opportunities for developing the sound practice of sustainable conservation of ethnobotanically important medicinal plants. Successful attempts have already been made by government agencies in some states and an effective public private partnership model can further boost the cultivation and exports of Indian medicinal plants, thus making India the number one country in medicinal plant exports. The following strategies can be adopted for sustainable development of medicinally and economically important plant species:

- Updatable Geo mapping for identification of sacred groves, unprotected forests and other ecotypes for evaluation of actual and factual data.
- Developing tribal leaders and sacred grove managers as mentors to promote sacred groves for younger populations.

- Linking forest or tribal communities with Scientific Community and development of a common nationwide repository for newly discovered tribal and indigenous knowledge.
- Providing adequate funding and infrastructure for promoting Research and Development for Ethnobotanical based bio-prospecting in India.
- The evaluation of Tribal Knowledge and implementation of the same to main stream medicine after scientific evaluation of data.
- Establishment of a value chain from protector/grower to consumers for ecological and economical sustainability.
- Establishment of a regulatory authority to develop norms to prevent misuse and bio-piracy and compensation to all legitimate stake holders.

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