

STATUS OF PLANT BIORESOURCES UTILISED IN HERBAL INDUSTRIES AND THE NEED FOR CONSERVATION IN KERALA

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Abstract

Kerala, the capital of herbal drug industries in India, has 938 licenced manufacturing and cosmetic industries. The annual consumption of plant based raw materials by large and major herbal industries in Kerala reveals that about 562 species play a pivotal role in the industry both in raw and processed form, utilising over 4000 tonnes of biological materials. Two hundred thirty species of plants are consumed at the rate of over 1000 kilograms per year as dried leaf, flower, seed, stem, bark, root, rhizome, tuber, heartwood, grain, gall, exudate, extracts and even as a whole for specific preparations. High priority species with critical conservation status are included in the trade, and the demand for reproductive and root parts raise the question of sustainability where the level of sustainable harvest of these species are yet to be evaluated. The rich diversity of Medicinal and Aromatic Plants, its implication in sociocultural, health traditions and its potential of being the raw materials to plant based modern industries stresses the importance for conservation to these vital resources which need attention at a regional level to ensure a secure livelihood to the dependent communities and the expanding economy.

Keywords: *Traditional Medicine; Medicinal and Aromatic Plants; Indigeneous communities; Minor Forest Produce; Biological Diversity Act; Conservation; Access and Benefit Sharing.*

Introduction

WHO (World Health Organisation) defines traditional medicine as including diverse health practices, approaches, knowledge and beliefs incorporating plant, animal, and/or mineral based medicines, spiritual therapies, manual techniques and exercises applied singularly or in combination to maintain well-being, as well as to treat, diagnose or prevent illness [1]. Herbal medicines can be classified into indigenous herbal medicines, herbal medicine in (established) systems, modified herbal medicines and imported products with an herbal medicine based on criteria viz: origin, development or evolution of the system and the current form in practice [2]. According to WHO, 80% of the population in South Asia depends on plant-based medicines for maintaining and improving their health, and it is estimated that more than 2,400 higher plant species are used in the Indian systems of medicine and Western medicine systems [3]. The concept of 'Solution from Nature' has boosted the market for herbal medicines. Plant based raw materials have always been the backbone of Ayurveda and traditional medicines and have guided the development of potential drugs. Medicinal and Aromatic Plant (MAP) raw materials

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have a high demand for therapeutic, aromatic and culinary purposes. They are also the starting material for nutraceuticals, and in modern pharmacopoeia, nearly 25% of plant drugs are in use [4]. The ability of plant secondary metabolites in treating diseases have made them an indispensable part in the development of drugs for chronic diseases like cancer [5, 6].

China and India are two great producers of medicinal plantbased products, having more than 40% of global biodiversity [7]. India has a long history and cultural heritage in the field of traditional medicine and ethnic practices which has gained worldwide recognition. Lying within the Indo-Malayan ecozone India host one of the finest and richest plant diversity

in the world and boarding four (the Western Ghats, the Himalayas, Andaman and Nicobar Islands and the Indo-Burma region) of the thirtysix biodiversity hotspots of the world. It has been recognised as the home for about 7000 MAP species and many which are still to be explored. More than half a million tonnes of raw materials are harvested from the forests of India every year [8] resulting in enormous pressure on the medicinal plants that can gradually drive towards its extinction.

International and National Regulations

The Indian System of Medicine has adopted the Good Manufacturing Practices (GMP) for herbal products manufacturing units, intending to ensure quality covering all aspects of the manufacturing system. Though there exists Fairtrade Certification in India for various plant products to recognise and respect the rights of indigenous communities and Traditional Knowledge (TK), being an unorganized sector it has not been popular or accepted in the trade related with medicinal plants [9]. Schedule T of Drugs and Cosmetics Act, 1940 in India specifies that the raw materials should be of good quality for GMP certification. Drugs & Cosmetics Rules 1945 insists the herbal industry (Ayurveda, Siddha and Unani practices) maintain the record on their raw drug consumption in manufacture of their products to the State Drug licencing authorities and the National Medicinal Plants Board (NMPB) on an annual basis [10].

The United Nations (UN)-Convention on Biological Diversity (CBD) came into force in 1993 with the objectives of conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. The CBD empowers the countries with sovereign rights over their genetic resources and the access to these are operated under Access and Benefit Sharing (ABS) mechanisms. Resource dependent communities of different regions depend either on wild or cultivated resources for local trade and exchange them to generate livelihood. The two supplementary agreements under the CBD - the Cartagena Protocol and the Nagoya Protocol seek to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology with a precautionary approach [11].

India's 'The Biological Diversity Act, 2002, and Rules, 2004' (Section 7) mandates prior intimation to the State Biodiversity Boards (SBB) for obtaining biological resources for commercial utilisation by corporates, associations or organisations registered in India, exemption allowed to local people or communities [9]. ABS is a way in which genetic resources are accessed, the benefits arise out of their use are shared between the people or the countries utilising the resource, wherein the benefit claimants may be the conservers of biological resources, their byproducts, creators and holders of knowledge and information relating to the use of such biological resources as per Section 2(a). Industries are accessing biological resources with different perspectives such as pharmaceutical, food and nutraceutical or cosmetic. Hence, the value additions on biological resources in different industrial sectors vary substantially. In some instances, similar biological resources may generate different values in different industrial sectors, which makes the ABS process more cumbersome. In this scenario, sectoral assessment of the utilisation of biological resources will be instrumental for framing effective ABS policy decisions [12]. The sector wise analysis of ABS applications received by

the National Biodiversity Authority (NBA) until October 2017 reveals that Pharmaceuticals occupy 54.5%, Research-18.9%, Nutraceuticals-15.1%, Cosmetics-2.6 & and others-8.9% [13].

Size and Nature of Herbal Medicines Market - India and Kerala

The diverse vegetation type of India supports the wide distribution of medicinal plant resources throughout the country. The rich source of MAPs used in drug, pharmaceutical, and cosmetic industries have always been an asset for India's nutraceutical & pharmaceutical industry. According to the All-India Ethnobiological Survey carried out by the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, over 8,000 plants were found to be used by traditional, folk and herbal medicine practitioners [14]. Among these medicinal plant species, only around 10% of them (880 species) are in active trade, around 48 species of them are exported, 42 species are imported, where 2,500 species are collected mainly from the wild [15,16].

Representing 11% of the world's flora, India has approximately 45,000 species of plants [17, 18]. Ayurveda, the most ancient and widespread system of healthcare practised in the country, depends on about 900 species of plants [12]. Indian systems of medicine utilise about 800 species at the industrial level, and approximately 25% of species cultivated while remaining are from the wild of which 178 species are consumed more than 100 tonnes annually [19, 20].

India ranks sixth in essential oil production and export of products derived from MAP [21]. The total production of essential oils in the world is estimated at 0.10 to 0.11 million tonnes. In terms of value, India stands in the second position with a world share of 21-22 per cent. To meet the demand of the herb-agro industries, about half a million tonnes of dry material is collected through destructive harvesting clearing 1.65 lakh hectares of forest. Upon analysing the nature of species that are active in trade, the highest is of herbs (41%), including grasses, followed by trees (26%), shrubs (17%) and climbers (16%). To meet the demands of herbal manufacturing units, 60 species are imported, 60 species are cultivated, and the lion share is collected from the wild [22]. Of the top traded medicinal plants, 54 are collected exclusively from the wild where habitat degradation and over-exploitation has forced 1,000 of medicinal plants under threat in India [23, 24]. Overall, around 90% of species are collected from the wild, of which 70% of the species are collected via destructive harvesting [24].

According to the IUCN Red List 2004, 297 plant species are included from India of which 16 are medicinal plants which include *Aconitum ferox*, *Picrorhiza kurroa*, *Nardostachys grandiflora*, *Panax pseudo-ginseng*, *Coptis teeta*, *Dioscorea deltoidea*, and *Costus sp* [19]. The highly traded species also include the threatened medicinal plants like *Aconitum heterophyllum*, *Coscinium fenestratum*, *Decalepis hamiltonii*, *Nardostachys grandiflora*, *Oroxylum indicum*, *Picrorhiza kurroa*, *Saraca asoca*, *Swertia chirayita*, *Vateria indica* among others. IUCN updated the Red List in June 2015 and have included 44 medicinal plants in the list from India, of which 18 are vulnerable, 16 are endangered and 10 are critically endangered. The status of the medicinal plants is highly alarming, and in the near future they may get extinct [25].

Industry and commerce of manufacturing units in India and Kerala – The Ministry of AYUSH has estimated there were 8954 AYUSH manufacturing units in India during 2019-20, out of which 7718 units were into Ayurveda products, 625 into Unani and 397 Homeopathy [26]. The Confederation of Indian Industry (CII) concluded that only around 50 companies have revenue above 100 crore rupees which account for over 85% of the revenue generated by this sector. Based on Ayurvedic Drug Manufacturers Association (ADMA), top 50 Ayurveda companies (both food and non-food products) reported having revenue of 22,500 crore rupees during the financial year April 2017-March 2018 from sales. The size of the natural/Ayurveda, veterinary, and feed supplement market is estimated to be 700 crores rupees, with nearly 150 crores rupees from exports [27]. As cosmetic sectors rely on different kinds of botanical materials, the dependency on traditional knowledge in this sector is high.

CII estimates a USD 3 billion market size for Indian Ayurveda industry viz Ayurveda products (ethical, classical, over the counter (OTC), personal care and beauty products) and

services (medical, well-being, and medical tourism services). The CII recently reported gross market size of USD 4.4 billion, or roughly 30,000 crore rupees during 2018 and recording a Calculated Compound Annual Growth Rate (CAGR) of 16% until 2025. CII also pointed out that 77% of Indian households are using Ayurvedic products as against 69% in 2015. The industry whose total worth was USD 3.4 billion in 2015 is expected to reach USD 9.7 billion by 2022 [27].

Companies involved in Ayurvedic medicine production had declined, and 1000 companies of the total 9000 have gone out of business from 2005-2010. Ayurvedic medicines fall under two main categories - classical products and proprietary products. The market shares of proprietary products are ever increasing with the decline in classical medicinal products. The turnover of proprietary products is 5500 crore rupees compared to 500 crore rupees for classical medicines. The major share of exports is raw materials when compared to finished products. The export earnings in total have increased from USD 39 million to USD 150 million during the period 2000-2010 even though finished product share in this stake has increased only 4% (39% to 43%) [28]. This preference for raw materials over finished products is leading to a huge fall in revenue for India. A similar trend was observed in Kerala, as 1,121 pharmaceutical production units (2007) reduced to 1,177 in 2010, only about 713 valid industries were registered [29].

The analysis of secondary data on industries reveals that 12% of the nation's formal ayurvedic industrial units are established in Kerala and owns an annual turnover of about 650 crores rupees [27]. Of these, the majority are privately owned units, and among the government sector, the noted one is Oushadhi. 70% of production under Oushadhi fulfils Kerala's 90% needs and the remaining 30% of the products are exported (20%) and marketed (10%) through retail outlets of the company. The consumption pattern by the manufacturing units and local medical practitioners varies considerably, and the ayurvedic pharmaceutical units consume 90 to 95 per cent of medicinal plants traded in the state [14].

Kerala has been one of the leaders of ayurvedic drugs in India. Almost 70% of the herbal plants used in the formulation of Ayurvedic remedies are native to Kerala. The annual consumption of about 230 raw drugs in Kerala is 20,517 tonnes, of which 48% is consumed by the large units [16]. *Sida sps.* and amla are the most abundantly consumed items and analysis on annual consumption with regard to plant parts show that roots/tubers/rhizomes constitute 45% of the total quantity. Fruits and seeds constitute 18%; whole plants (herbs) 12%; leaves 7%; bark 6%; stem 5%; wood 5%; flowers and resin 1% each. The nature or the type of analysis of the medicinal plants shows the majority of them are angiosperms consisting of 33% trees followed by herbs, shrubs, climbers and lower groups of plants [30]. The trend analysis of parts indicates the bulk of plant material from roots, whole plant, fruits, seeds and bark whose extraction could question the survival and regeneration of medicinal plants in nature [25]. Of the material sourced by the manufacturers from Kerala, 43% grew in forests, 16% in non-forested areas, 18% came from both ecosystems, and 14% from outside Kerala, mostly North India while only 9% were cultivated.

Dynamics of Medicinal Plants Trade- Kerala

In Kerala, the marketing of medicinal plants from the wild is undertaken by the Kerala State Federation of SC ST Development Co-operatives Ltd. The Federation is entrusted with the right of monopoly procurement and marketing of medicinal plants from the forests and marketing of Minor Forest Produces (MFPs), while many of the MFPs are collected and traded in an unauthorised manner by the non-tribes. There are weekly markets for the sale of raw drugs in four districts in Kerala, at Vadakara in Kozhikode, Velanthavalam in Palakkad, Perumbavoor in Ernakulam and Chala market in Thiruvananthapuram. The medicinal plants collected from outside the forests, private gardens, homesteads, wastelands and common properties are sold directly or through agents to the dealers and medicine manufacturing firms.

The medicinal plants collected by the tribes are officially marketed through MFP Societies of the Federation [14]. Medicinal plant trade raises issues of equity, and the way benefits are distributed along the supply chain. Often the supply chain extends to 3-4 tiers without much value addition but with the increase in sale price at each level. On an average, 70 to 100 per cent increase in the sale price of crude drugs from primary collector's level to pharmacy level happens, and many times the same crude drug is available in various grades among major traders with a considerable price difference. The final prices of most of the raw drugs are significantly higher than the collection charges, which leads to overexploitation of the natural resources much beyond the natural regeneration capacity of the species. The trade of medicinal plants in the three major cities of Kerala is handled by few traders (i.e. Kochi - 26 traders, 30 exporters, 3 importers and 16 extractors, Palakkad - 4 traders and 2 exporters, Thrissur - 4 traders and 6 exporters) [26].

The data on the resources required, catered or utilised by the traditional medicine industry and the whole herbal market including pharmaceuticals, food and nutraceutical and cosmetics is minimal, and the supply chain extends over 2-3 tiers, most of which are in the unorganised sector making the system more complex and complicated for the implementation of ABS provisions. This paper attempts to analyse the raw drug requirements by large industries in Kerala, incorporating the conservation view and a leap towards the implementation of ABS.

Materials and Methods

Annual consumption details of plant based raw materials (during the year 2016-17) in use by pharmaceutical companies from 14 districts of Kerala with turnover above one crore rupees (large industries) were collected as the baseline data. From the list of licenced herbal manufacturing units, 25 units with a turnover of more than one crore rupees were shortlisted, and data on their annual raw drug consumption were collected. The raw data were sorted, tabulated and compiled district wise. The common name and scientific name were validated with the help of authentic websites- India Biodiversity Portal, Peoples Biodiversity Register and Flowering Plants of Kerala [31, 32]. The validated data were sorted setting criteria viz: part used, quantity and IUCN status, local/regional (Western Ghats) conservation status (ENVIS-FRLHT, RET-KFRI) and graphs of the same were prepared for analysis [33-35]. The status of plants which were not found on the list was counted under the category NE or Not Evaluated.

A different method has been adopted to distinguish the exclusive and inclusive use of plant parts while developing the data based on the plant part as raw material to avoid any error of repetition. Plants with unknown common names, or whose scientific name cannot be validated were avoided to reduce the loss of quality while curing the data. About ten plants were not considered for analysis due to multiple and unlisted usages of various common names for the same species. Different vernacular names were validated, and the most frequently used one was accepted.

Results and Discussions

In order to cater to the growing industrial needs, plant and animal based bioresources (raw/processed) are extracted in varying quantities, from few grams to tonnes, annually irrespective of the size of the industry. While investigating the trend in uptake and utilisation of plant based bioresources, about 562 species of plants are currently in trade for the use of herbal preparations by herbal-cosmetic and nutraceutical industries. The analysis (Fig. 1) on the total annual purchase/consumption by large industries observes that 40% of the plant species are consumed below 100 kilograms (224 species). Few plants (57/565) are used in huge quantities above 10 tonnes annually, accounting roughly 10% of total species in trade implying that more than 90% of plants in use are annually consumed below 10 tonnes.

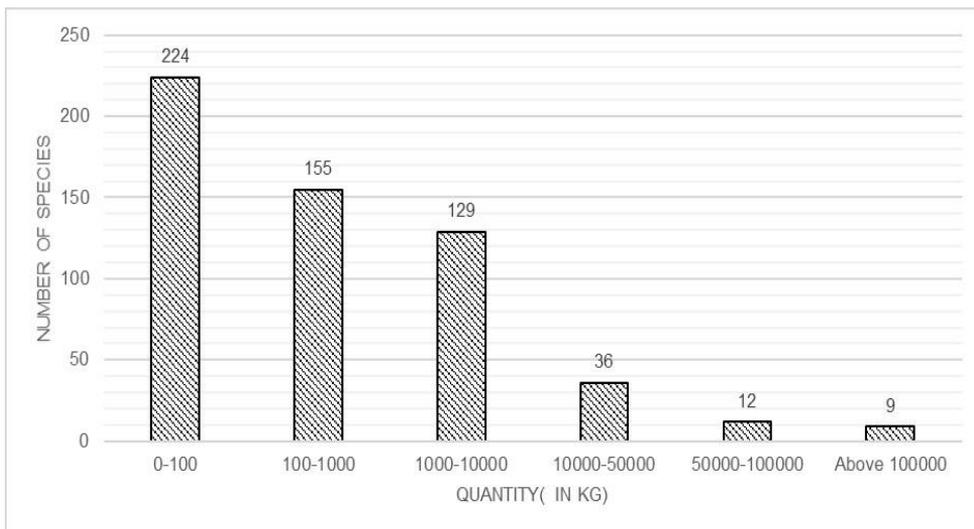


Fig. 1. Annual consumption of plant based raw materials by large scale industries- Kerala (2016-17)

Irrespective of root or shoot, the plant parts as raw material in trade covers leaf and leaf bud, flower, seed, stem, bark, root, rhizome, tuber, heartwood, grain, gall, exudate, extracts and as a whole for certain preparations. Among the plant parts, the root is considered to be the most important one (Fig. 2) for herbal preparations followed by the whole plant as such. To meet the demand for the root part, 142 species are harvested destructively apart from rhizomes (34), bulbs (2) and tubers (18). The large pharma-based industries in Kerala procure 116 species wholly for special herbal preparations and seeds of about 87 species of plants for formulations. The industries also use heartwood and metabolites like exudate, oil, galls and extract of few species for meeting their needs.

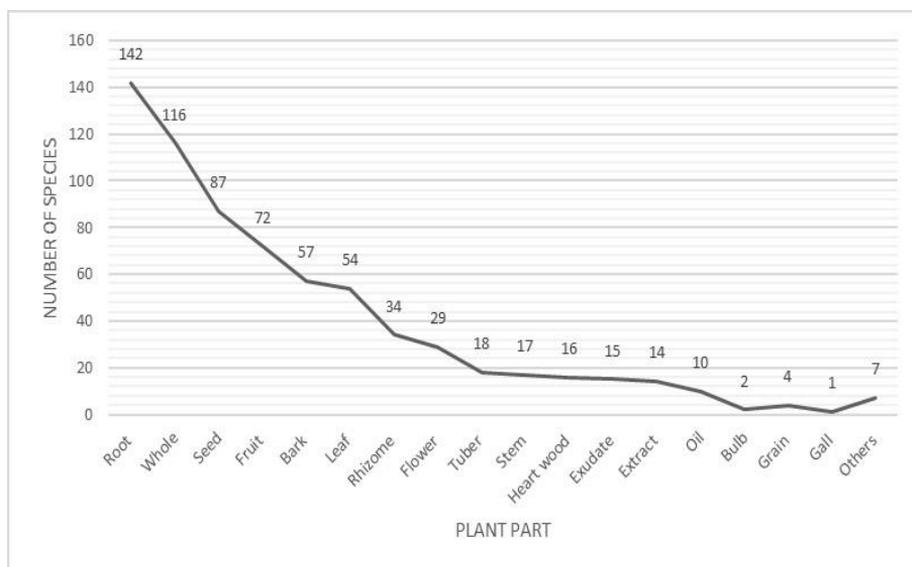


Fig. 2. Distribution of plant based bioresources in terms their part in trade - Kerala

Conservation status of the plant based bioresources in trade reveals that the most used plant species fall either in the Least Concerned (LC) or Not Evaluated (NE) or Data Deficient (DD) category of conservation status and these species of lesser significance account for roughly 90% of whole plants of our consideration (Fig. 3).

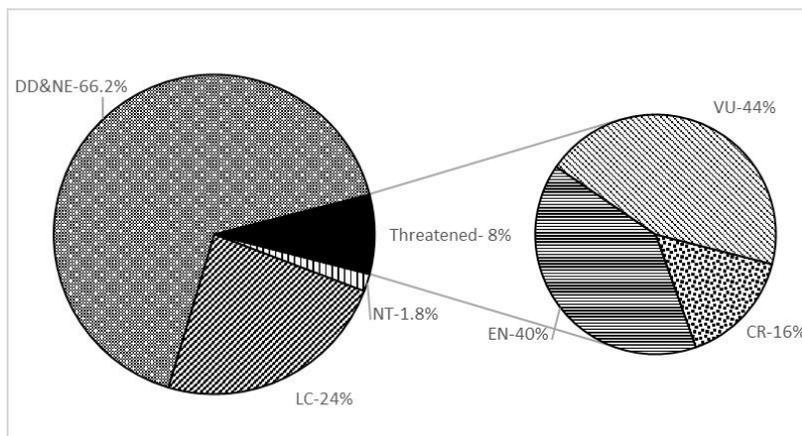


Fig. 3. Conservation of plant bioresources utilised by herbal industries - Kerala

Of the remaining 10% of the species, which needs attention from the conservation view, 8% (45) are in the threatened list at global (IUCN) or regional level (Western Ghats). Among the threatened species, 7 are Critically Endangered (CR), 18 are Endangered (EN) and 20 are Vulnerable (VU) either at the global or regional level. Ten species in trade are with Near Threatened (NT) status whose overexploitation may result in up-gradation of conservation status towards extinction (Fig. 3).

India, the second-largest populated country in the world, with the diverse indigenous population and varied culture is the home for traditional knowledge and folk practices. The livelihood of its population is directly or indirectly linked with biological resources. The increasing human population, the pressure it exerts have made adverse impacts on nature, leading to the depletion of many naturally occurring precious resources. The depletion of this treasure is a loss for future pharmacopoeia. Certain plant species and their byproducts play a pivotal role in the traditional and modern medicines, where some are used as raw drugs while others in processed form. Commonly the dried parts of medicinal plants (roots, stem, wood, bark, leaves, flowers, seeds, fruits, and whole plants) are used as raw materials for the production of traditional formulations, and the price that they fetch in the market depends on their availability and the commercial importance [36].

The medicinal properties of plant species may be localised to a specific part or can be spread from root to shoot tip. The harvest for root parts or plant as a whole result in the destruction of that certain individual raising an ecological concern particularly to those collected from the wild as part of MFP. 45% of the plants in trade are collected in this manner to meet the need for parts like root, rhizome, tuber, bulb, heartwood and the whole plant in case of herbs. Root parts specifically account for 27% of trade, and thus the threat of overexploitation of the species depends specifically on the plant part of medicinal value [37]. 20% of the plant species catering the need for the large-scale herbal market of Kerala is specifically exploited for their root, taking not in account the species traded for rhizomes, tubers and bulbs.

Though the species under study ranges about 565, only a few are consumed above 10 tonnes. The most consumed MAP includes nutraceuticals like *Moringa oleifera*, medicinal plants like *Curcuma longa*, *Eclipta prostrata*, *Sida rhombifolia*, *Aegle marmelos*, and *Justicia*

adhatoda (Table.1). Regionally threatened species, *Aegle marmelos*, *Strobilanthes ciliatus* and *Oroxylum indicum* are traded in quantities above 10 tonnes where the harvest of bark and root of species like bael may result in regional extinction of species if harvested unsustainably.

Table 1. Top traded plant bioresources

Species	Part Used	Annual Consumption (in kg)
<i>Moringa oleifera</i>	Leaf, Seed, Bark, Root	292047.6
<i>Curcuma longa</i>	Rhizome	189049
<i>Saccharum officinarum</i>	Stem	156687
<i>Eclipta prostrata</i>	Whole plant	123823
<i>Tamarindus indica</i>	Leaf, Fruit, Root, Bark	111073
<i>Sida rhombifolia</i>	Root	102841
<i>Aegle marmelos</i>	Whole plant	101048
<i>Phyllanthus emblica</i>	Fruits, Seed	94566
<i>Zingiber officinale</i>	Rhizome	86203
<i>Justicia adhatoda</i>	Whole plant	80040
<i>Aloe vera</i>	Whole plant	77906
<i>Cinnamomum verum</i>	Bark, Root, Extract	77579
<i>Bacopa monnieri</i>	Whole plant	74093
<i>Cardiospermum halicacabum</i>	Whole plant	69860
<i>Terminalia chebula</i>	Fruit, Seed	68058
<i>Aloe barbadensis</i>	Whole plant	57612
<i>Asparagus racemosus</i>	Rhizome	54213
<i>Momordica charantia</i>	Whole plant	52024

Critically Endangered (CR) species of *Commiphora wightii*, *Saussurea costus*, *Nardostachys jatamansi*, *Coscinium fenestratum* and *Justicia beddomei*, and *Lilium polyphyllum* are exploited for their root, stem or rhizome in quantities above 1000 kilograms annually to meet the current annual demand of industries. The annual demand for *C. wightii*, *S. costus*, *N. jatamansi*, *C. fenestratum* and *J. beddomei* are 4,059, 3,867, 3,825, 3,606 and 1,718 kilograms respectively. The increasing population and rising need for these resources marks a shadow on their survivability and sustenance. Most of the endangered species are also used for their under-soil parts in high quantities, and the concern for their survivability is in question when considering their conservation status (Table 2).

The raw materials for the industries also include species of high conservation priority viz Endangered (18), Vulnerable (20) and Near Threatened (10) species, either at the global or regional level. *Strobilanthes ciliatus* (EN), *Oroxylum indicum* (EN) and *Aegle marmelos* (VU) in these threatened categories are consumed above 10 tonnes annually, and thus requires much attention. Seven plants which are used in highest quantities above 100 tonnes annually are either LC, DD or NE (Table 1). The DD and NE species may or may not be conservationally important, and its status has to be identified, giving due concern. The high and un-audited usage due to unavailability of conservation status may lead to its extinction. Destructive harvesting methods are required when in need of underground parts or when plants are used as a whole. Five of the above mentioned highly traded species (Table 1) are used for their root or rhizome or as whole plant which leads to destructive harvesting. An understanding on the annual demand along with part used and conservation status is inevitable for formulating the threats for non-evaluated species.

Table 2. Destructively harvested threatened species in trade

Species	Conservation Status	Part Used
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<i>Saussurea costus</i>	Critically Endangered	Seed, Root
<i>Nardostachys jatamansi</i>	Critically Endangered	Rhizome
<i>Lilium polyphyllum</i>	Critically Endangered	Fruit, Root
<i>Coscinium fenestratum</i>	Critically Endangered	Stem, Root
<i>Justicia beddomei</i>	Critically Endangered	Root
<i>Coptis teeta</i>	Endangered	Whole plant
<i>Orchis latifolia</i>	Endangered	Whole plant
<i>Chonemorpha fragrans</i>	Endangered	Fruit, Stem, Root
<i>Saraca asoca</i>	Endangered	Leaf, Flower, Seed, Root
<i>Strobilanthes ciliatus</i>	Endangered	Whole plant
<i>Oroxylum indicum</i>	Endangered	Whole plant
<i>Holostemma ada-kodien</i>	Endangered	Tuber
<i>Salacia reticulata</i>	Endangered	Bark, Root, Extract
<i>Operculina turpethum</i>	Endangered	Stem, Root
<i>Rauvolfia serpentina</i>	Endangered	Root
<i>Malaxis muscifera</i>	Vulnerable	Seed, Tuber
<i>Anacyclus pyrethrum</i>	Vulnerable	Whole plant
<i>Celastrus paniculatus</i>	Vulnerable	Flower, Seed, Root
<i>Nervilia aragoana</i>	Vulnerable	Tuber
<i>Smilax zeylanica</i>	Vulnerable	Root
<i>Acorus calamus</i>	Vulnerable	Rhizomes
<i>Aegle marmelos</i>	Vulnerable	Whole plant
<i>Pseudarthria viscida</i>	Vulnerable	Whole plant
<i>Baliospermum montanum</i>	Vulnerable	Root

Harvest of leaves, flowers, seeds or fruits has comparatively lesser impact than heartwood, root, tuber, bulb or rhizome. On average, about 54% (312/578) of the plants in trade are taken for their underground parts, where destructive harvesting is done by picking off the whole plant. Other threatened species' whose root parts are in use include *Smilax zeylanica* (VU), *Saraca asoca* (EN), *Oroxylum indicum* (EN), *Anacyclus pyrethrum* (VU) (Table 2). Seeds of *Cycas circinalis*, *Myristica sps* form the integral composition of some formulations, whereas plant-based metabolites from *Boswellia serrata* and *Achatina fulica* are also in trade. The overconsumption of reproductive parts like flowers, seeds, and fruits also challenges the existence of threatened plants in the future unless cultivated.

Unsustainable harvesting methods, interference of middlemen and lack of monitoring in this sector, challenges the threatened category species, consumed in large quantities like *Dysoxylum malabaricum* (1.5 tonnes), *Salacia oblonga* (7 tonnes), *Oroxylum indicum* (15 tonnes), *Strobilanthes ciliates* (25 tonnes), *Aegle marmelos* (101 tonnes). Species that are most susceptible to over-harvesting are habitat specific, slow-growing and the one destructively harvested for their heartwood, roots or the whole plant, which limits the natural regeneration capacity leading to a dwindling in the genetic stock. The DD and NE status of many species may raise the question of the existence in future at the regional level at least when consumed in higher quantities. Sustainable harvesting is more important for species which are slow growing with narrow distribution and specific habitat requirement. Medicinal plants are collected without much awareness of the optimum stage of maturity, degree of permissible moisture content or the proper storage condition for maintaining the shelf life of the active ingredients.

To meet the rising demands, domestication of some MAPs is in practice, but still, most of them are limited to the wild due to habitat specificity and need of specialised ecological niches or restricted distribution. The data regarding the raw drug requirement of the herbal market is very limited and works in an unorganised manner, complicating proper value and supply chain analysis inhibiting the ABS and thereby conservation at the regional level. The middlemen marketing and lack of value and supply chain analysis bring low income to the

tribes or gatherers, and the drop in income and rising livelihood demands stress them to collect more, without considering the future regeneration [14]. The Biodiversity Management Committees (BMC) are statutory bodies at the local level with power and the right to interfere in the matters of bioresources at the regional level to ensure conservation and equitable sharing. Hence the integration of BMC with other local committees and tribal societies will ensure protection, conservation, and sustainable harvesting of medicinal plants from both forest and non-forest areas. BMC is also entrusted in regulating ABS of the bioresources as per section 41 (3) of Biological Diversity Act (2002), and BMC is authorised to levy charges for collection of bioresources in the area. Hence, they can play a crucial role in developing marketing linkages, value addition and development of micro enterprises in future also.

Conclusions

With its rich biodiversity and traditional healthcare practices, Kerala has immense opportunity to be a part of global trade of herbal products ranging in cosmetics, nutraceutical and pharmaceuticals. An understanding on balancing resource availability, renewability, usage, and conservation of medicinal plants and products thereof can bring out sustainability. The cost-effectiveness and the availability of materials in plenty from the wild have set back the people from cultivation leading to unsustainable extraction and thereby to the depletion of the resource base. The raw material consumption pattern of representative herbal industries, bring out the importance that the plant part in trade imparts, the conservation status of species and the importance for developing conservation strategies for ensuring the survival of certain species.

The conservation status of the majority of the species used in the pharma industries are to be evaluated, leaving a critical gap in understanding the need for conservation and attention. Though the conservation advocates for sustainable use, study on of the level of produce to be extracted or harvested for each species are yet to be evaluated and standardized according to the region. A joint initiative of BMC and the gatherers along with the marketing federation may result in better understanding of the difference in demand and supply of resources at their locality. If communities realise the economic potential of bioresources and receive an adequate income or secure livelihood, initiatives for conservation and sustainable utilisation of bioresources will be taken up by the community itself with a sense of ownership and will aid in long term conservation of MAP.

Abbreviations

MAP - Medicinal and Aromatic Plant; GMP - Good Manufacturing Practices; UN - United Nations; CBD - Convention on Biological Diversity; ABS - Access and Benefit Sharing; SBB - State Biodiversity Board; NBA - National Biodiversity Authority; MoEFCC - Ministry of Environment, Forest & Climate Change; AYUSH - Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy; CII - Confederation of Indian Industry; USD - US Dollar; ADMA - Ayurvedic Drug Manufacturers Association; OTC - Over the Counter; CAGR - Calculated Compound Annual Growth Rate; SC ST - Scheduled Caste & Scheduled Tribe; MFP - Minor Forest Produce; IUCN - International Union for Conservation of Nature; ENVIS - Environmental Information System; FRLHT - Foundation for Revitalisation of Local Health Traditions; KFRI - Kerala Forest Research Institute; RET - Rare, Endangered and Threatened.

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References

- [1] * * *, **Fact sheet no. 134: Traditional Medicine**, World Health Organization, 2008.
- [2] X. Zhang, **Traditional Medicine Strategy 2002-2005**, World Health Organization, 2002.
- [3] D.K. Ved, G.S. Goraya, *Demand and supply of medicinal plants*, **Medplant-ENVIS Newsletter on Medicinal Plants**, **1**(1), 2008, pp. 2-4.
- [4] D.B. Shelar P.J. Shirote, *Natural product in drug discovery: Back to future*, **Biomedical and Pharmacology Journal**, **4**(1), 2011, pp. 141-146.
- [5] G. Dumitru, S. Abidar, M. Nhiri, L. Hritcu, R.S. Boianuiu, I. Sandu, E. Todirascu-Ciornea, *Effect of Ceratonia siliqua methanolic extract and 6-hydroxydopamine on memory impairment and oxidative stress in zebrafish (Danio rerio) model*, **Revista de Chimie**, **69**(12), 2018, pp. 3545-3548.
- [6] L. Hritcu, S. Abidar, G. Dumitru, R.S. Boianuiu, M. Nhiri, I. Sandu, E. Todirascu-Ciornea, *Ceratonia siliqua methanolic extract on 6-OHDA zebrafish model: antiacetylcholinesterase and anxiolytic profile*, **Revista de Chimie**, **70**(4), 2019, pp. 1364-1367.
- [7] D.N. Tewari, *Report of the task force on conservation and sustainable use of medicinal plants*, **Bulletin of Planning Commission**, Government of India, New Delhi, India, 2000.
- [8] S. Maiti, K.A. Geetha, *Characterization, genetic improvement and cultivation of Chlorophytum borivilianum--an important medicinal plant of India*, **Plant Genetic Resources**, **3**(2), 2005, pp. 264-272.
- [9] K.P. Laladhas, V.O. Oommen, P.R. Sudhakaran (Editors), **Biodiversity Conservation - Challenges for Future**, 2005. DOI: 10.2174/97816810802151150101.
- [10] * * *, **The Drugs and Cosmetics Act and Rules**, The Drugs and Cosmetics Act, 1940 (23 of 1940) (As amended up to the 30th June, 2005) and The Drugs and Cosmetics Rules, 1945 (As amended up to the 30th June, 2005), Ministry of Health and Family Welfare, Government of India.
https://nmpb.nic.in/sites/default/files/Drugs%20and%20Cosmetic%20Act%2C%201940_0.pdf (accessed: 22/02/2022)
- [11] N. Wilson, *Guidelines for access and benefit sharing for utilization of biological resources based on nagoya protocol effective*, **Journal of Intellectual Property Rights**, **20**(1), 2015, pp. 67-70.
- [12] N. Prakash, B. Meenakumari, **Compliance of Access and Benefit Sharing (ABS): A Sector Specific Review**, Centre for Biodiversity Policy and Law, National Biodiversity Authority, 2018.
- [13] N. Gayathri Shanbhag, R.S. Rana, **Regulation of Access to biological Resources and Benefit Sharing in India: An Analytical Study**, National Biodiversity Authority, Chennai, 2018.
- [14] N. Sasidharan, P.K. Muraleedharan, **The Raw Drug Requirement of Ayurvedic Medicine Manufacturing Industry in Kerala**, Kerala Forest Research Institute, 2009.
- [15] L.C. De, *Medicinal and aromatic plants of North-East India*, **International Journal of Development Research**, **6**(11), 2016, pp. 10104-10114.
- [16] * * *, **Proceedings of International Conference on Traditional Medicine for SouthEast Asian Countries**, 2013.
- [17] K. Venkataraman, *India's Biodiversity Act 2002 and its role in conservation*, **Tropical Ecology**, **50**(1), 2009, pp. 23-30.
- [18] V. Mudgal, *Floristic diversity and conservation strategies in India*, **Botanical Survey of India, Ministry of Environment and Forests, vol. 1** (Edited by P.K. Hajra), 1997.
- [19] N. Sivaraj, S.R. Kamala Venkateswaran, S.R. Pandravada, M. Thirupathi Reddy, P.E. Rajasekharan, *Threatened Medicinal Plants of Eastern Ghats and Their Conservation*,

- Conservation and Utilization of Threatened Medicinal Plants**, Springer, Cham, 2020, pp. 31-62.
- [20] S. Paroda Raj, ed B.M. Dasgupta, S.P. Ghosh, S.K. Pareek, *Expert Consultation on Promotion of Medicinal and Aromatic Plants in the Asia-Pacific Region*, **Proceedings, APAARI**, 2013.
- [21] S. Natarajan, K. Venkateswaran, P. Rao, M. Reddy, P.E. Rajasekharan, **Threatened Medicinal Plants of Eastern Ghats and Their Conservation**, 10.1007/978-3-030-39793, 2020, pp. 7-2.
- [22] * * *, **Searching Medicinal Plants Information? Click to Know About Botanical and Vernacular (Local) Names of Plants?** (Overview), <http://envis.frlht.org/overview.php>
- [23] * * *, **Medicinal plants scenario in India, Report of the foundation for Revitalization of Local Health Traditions**, FRLHT, Bangalore, India, 2002.
- [24] K. Babu, Lenin, *Health and livelihoods of community and traditional medicinal plants: SWOT of two agro climatic zones of India*, **Report of South Asia Network of Economic Research Institutes (SANEI)**, 2010, pp. 1-78.
- [25] D.K. Gopi, R. Mattummal, S.K.K. Narayana, S. Parameswaran, *IUCN Red Listed Medicinal Plants of Siddha*, **IUCN Red List**, 1(1), 2018, pp. 15–22.
- [26] * * *, **COVID-19 Related Information**, <https://www.ayush.gov.in/>
- [27] * * *, **Ayurveda Industry Market Size, Strength and Way Forward**, Confederation of Indian Industry (CII), November 2018.
- [28] Chaturvedi, Sachin (ed), **The living tree: Traditional medicine and public health in China and India**, Academic Foundation, New Delhi, 2014.
- [29] L. Dejouhanet, *Supply of Medicinal Raw Materials: The Achilles Heel of Today's Manufacturing Sector for Ayurvedic Drugs in Kerala*, **Asian Medicine** 9(1-2), 2014, pp. 206-235.
- [30] K. Nishteswar, *Depleting medicinal plant resources: A threat for survival of Ayurveda*, **Ayu**, 35(4), 2014, 349.
- [31] * * *, **India Biodiversity Portal**, <https://indiabiodiversity.org/>
- [32] N. Sasidharan. **Flowering Plants of Kerala**, CD Rom, KFRI, 2011.
- [33] * * *, **IUCN Red List**, <https://www.iucnredlist.org/>
- [34] * * *, **ENVIS-FRLHT**, <http://envis.frlht.org/medicinal-plants-conservation-concern-species.php>
- [35] * * *, **RET-KFRI**, <http://retplants.kfri.res.in/>
- [36] N. Subrat, M. Iyer, R. Prasad, **The Ayurvedic Medicine Industry: Current Status and Sustainability**, Ecotech Services, London, and International Institute for Environment and Development, New Delhi, 2002.
- [37] D.K. Ved, G.A. Kinhal, K. Ravikumar, R. Vijaya Sankar, K. Haridasan, *Conservation Assessment and Management Prioritisation (CAMP) for wild medicinal plants of North-East India*, **Medicinal Plant Conservation**, 11, 2005, pp. 40-44.

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