



REVIEW

Status and consolidated list of threatened medicinal plants of India

R. Gowthami · Neelam Sharma · Ruchira Pandey · Anuradha Agrawal

Received: 7 September 2020 / Accepted: 29 April 2021 / Published online: 25 May 2021
© The Author(s), under exclusive licence to Springer Nature B.V. 2021

Abstract A wide array of medicinal plants in India, primarily used by locals for health care, have found wide acceptance and adoption globally (either directly or processed) due to distinct advantages of good results, low or no side-effects and ease of access to general public. Indigenous and traditional systems of medicine in practice since historical times have shown potential (direct or indirect as immune-boosters) against many dreaded ailments including the recent global pandemic of COVID-19. With prediction of sixth mass extinction, there is worldwide concern as majority of these plants, collected from natural stands, are also facing threat of extinction. Since 1990s concerted efforts have been directed towards assessment of threat status, the basic requirement for prioritizing conservation activity to various species of plants and animals. In literature there is staggered information regarding list of threatened plants,

including medicinal plants of India, compiled at either state level or national or international level. Analysis of these publications led to collation of a consolidated list of 84 species and the same is presented here. A brief account of conservation efforts in India at national level and supportive policy framework is also included. This compilation is aimed to serve as a comprehensive reference especially for beginners, researchers, conservationists, foresters, pharmaceutical professionals as well as policy makers.

Keywords Conservation · CAMP · IUCN · Medicinal plants · Policy framework · Threat assessment

Introduction

Biodiversity conservation is a demanding task that includes scientific, social, and political challenges (Pelletier et al. 2018). Given the enormous diversity of species and limited resources available to undertake these conservation programs, prioritization of species for conservation, assessment of threat status and the most suitable strategy to be adopted become the basic pre-requisites. To serve this objective, the International Union for Conservation of Nature (IUCN), a membership union composed of both government and civil society organizations, was established. An IUCN

R. Gowthami · N. Sharma (✉) · R. Pandey · A. Agrawal
Tissue Culture and Cryopreservation Unit, ICAR-National
Bureau of Plant Genetic Resources (NBPGR), Pusa
Campus, New Delhi 110012, India
e-mail: neelam.sharma1@icar.gov.in;
sharma.neel.59@gmail.com

R. Gowthami
e-mail: gowthami.r@icar.gov.in

R. Pandey
e-mail: ruchira.pandey@icar.gov.in

A. Agrawal
e-mail: anuradha.agrawal@icar.gov.in

'Red List of Threatened Species' was developed, which provides extinction risk and species distribution (Pollock et al. 2003; Brooks et al. 2004). As per IUCN classification, species are assigned a ranked threat category, such as extinct (EX), extinct in wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC)

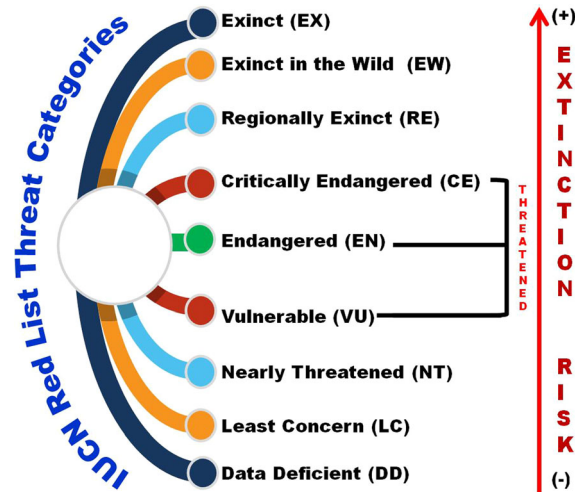


Fig. 1 IUCN Red List threat categories and their risk level

and data deficient (DD) (Fig. 1) through assessment against quantitative criteria based on indicators of extinction risk (Collen et al. 2016; Hammer and Khoshbakht 2005). As the threat categories itself are basic keys to prioritize conservation this list is the globally accepted method of assessing species extinction risk (Collar 1996). Countries around the world are adapting these criteria to prioritize species for conservation, to determine the conservation approaches and to frame regulatory and policy decisions for conservation, and multilateral agreements (Maxted et al. 1997; Rodrigues et al. 2006). Figure 2 depicts the estimated number of threatened species (till date) in Kingdom Animalia, Plantae, Chromista and Fungi, globally and in India as per the IUCN assessment (IUCN 2020). Because of ever increasing human population and anthropogenic activities, species extinction rate has increased to hundred or thousand-fold compared to background extinctions, bringing to forefront the 'sixth mass extinction' crisis (Shivanna 2020).

India has 2.4% of world's area with 8% of global biodiversity and is one of the 12 mega diversity countries of the world (Myers et al. 2000; Bapat et al. 2008). Among the world's 35 global biodiversity

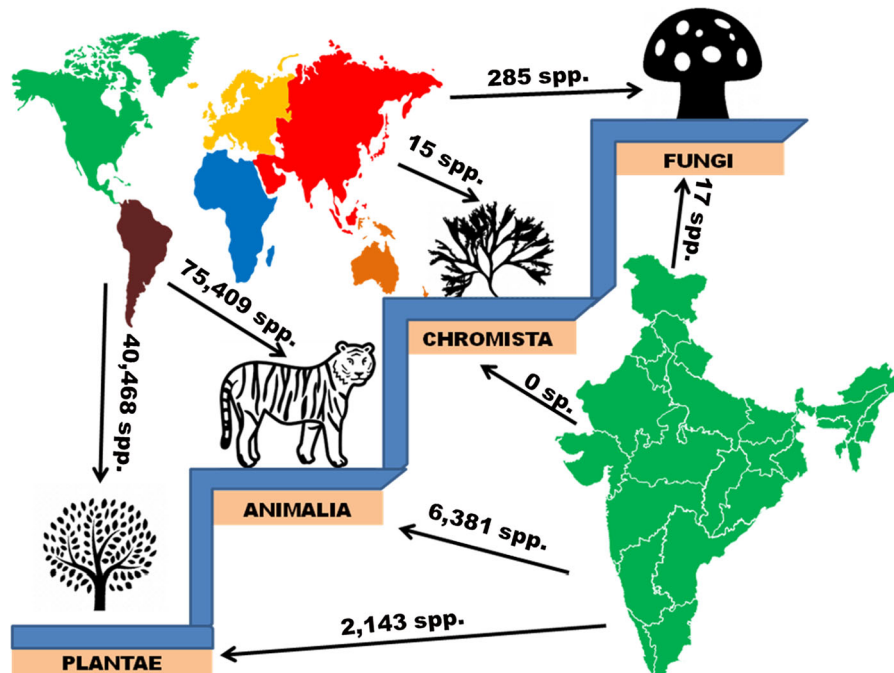


Fig. 2 Total number of threatened species of Kingdom Plantae, Animalia, Chromista and Fungi at global and national level as per IUCN estimation. Numerical values mentioned on the arrows indicate the number of threatened species (Source: IUCN 2020)

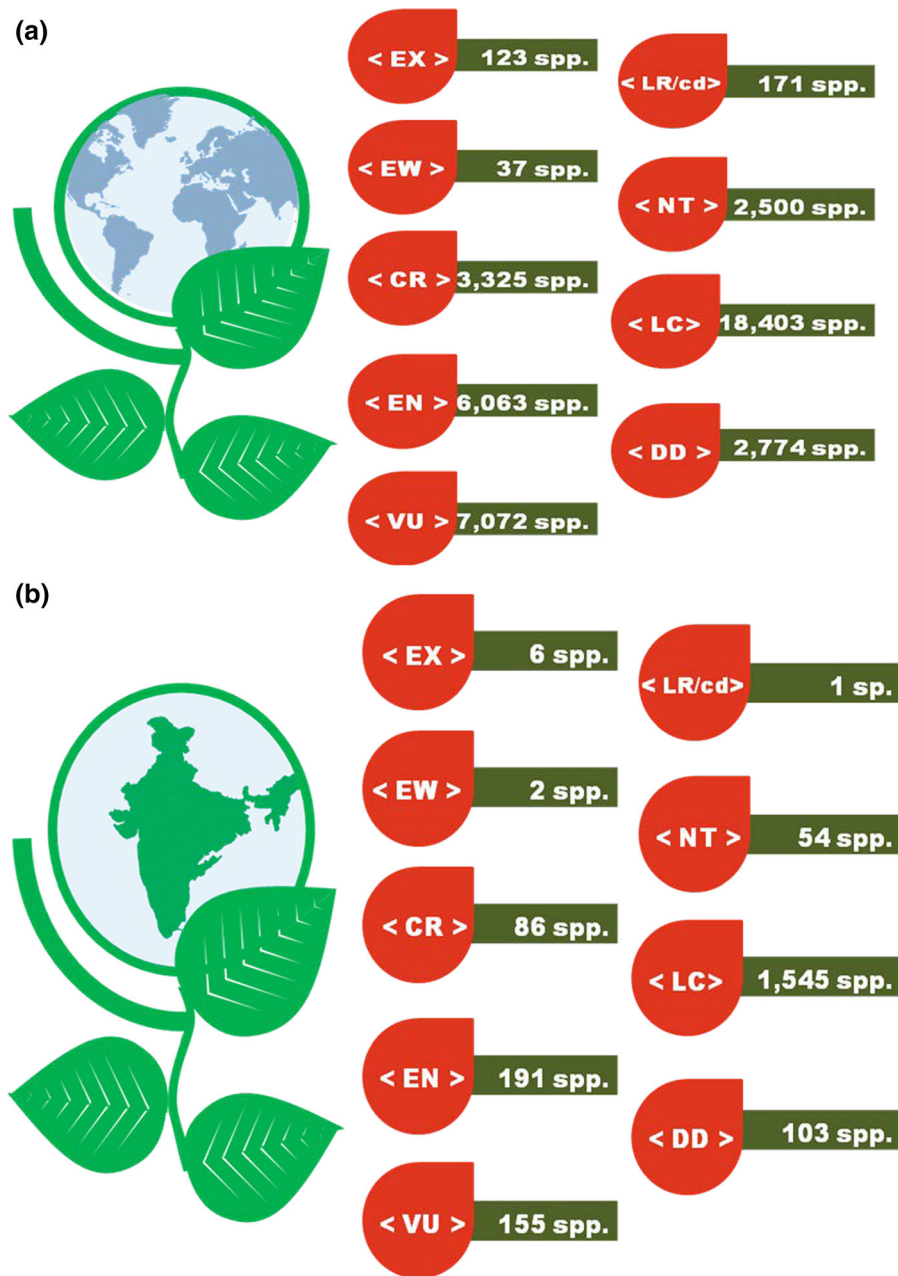


Fig. 3 Number of plant species threatened at (a) global (b) national level as per IUCN estimation (EX: Extinct; EW-Extinct in the Wild; CR-Critically Endangered; EN:

Endangered; VU: Vulnerable; LR/cd: Lower Risk-Conservation Dependent; NT: Near threatened; LC: Least concern; DD; Data deficient (Source: IUCN 2020)

hotspots (GBH), four (Himalayas, Indo-Burma, Sundaland and Western Ghats) fall in the Indian geopolitical territory (Jaisankar et al. 2018). This richness of phyto-diversity in India is owing to existence of 15 agro-climatic zones with varied ecological habitats. India has ~ 10.45% of global floral diversity. More

than 50% of the world's plant species are endemic to 35 GBH, which once covered 15.9% of the earth's land surface and are now reduced to 2.3% (Mittermeier et al. 2011). These hotspots harbor a large number of endemic species, which are facing an increasing threat of extinction (Hazarika et al. 2016).

Table 1 Updated list of medicinal plants under the category (medicine: plants and animals) in different threat categories as per IUCN (Source: IUCN 2020)**Critically Endangered (CR)**

Aconitum chasmanthum Stapf ex Holmes, *Aquilaria malaccensis* Lam. = *A. agalocha* Roxb. ex DC., *Ceropegia odorata* Nimmo ex J. Graham, *Chlorophytum borivilianum* Sant., *Commiphora wightii* (Arn.) Bhandari, *Gentiana kurroo* Royle., *Gymnocladus assamicus* Kanjilal, *Lilium polyphyllum* Don., *Nardostachys jatamansi* DC., *Paphiopedilum druryi* (Bedd.) Stein., *Saussurea costus* (Falc.) Lipsch., *Tribulus rajasthanensis* Bhandari & Sharma, *Uleria salicifolia* Bedd., *Valeriana leschenaultia* DC.

Endangered (EN)

Aconitum heterophyllum Wall., *Angelica glauca* Edgew., *Cinnamomum wightii* C.F.W.Meissn, *Coffea arabica* L., *Commiphora stocksiana* Engl., *Coptis teeta* Wall., *Curcuma caulina* J. Graham, *Cycas beddomei* Dyer., *Cycas circinalis* L., *Decalepis hamiltonii* Wight & Arn., *Dysoxylum malabaricum* Bedd., *Gymnema khandalense* Santapau, *Humboldtia vahliana* Wight, *Illicium griffithii* Hook. F. & Th., *Iphigenia stellata* Blatter, *Lamprachaenium microcephalum* Benth., *Nepenthes khasiana* Hook.f., *Pimpinella tirupatiensis* Bal. & Sub., *Piper barberi* Gamble., *Pterocarpus indicus* Willd., *Shorea tumbuggaia* Roxb., *Syzygium alternifolium* (Wt.) Wall., *Taxus contorta* Griff., *Taxus wallichiana* Zucc.

Vulnerable (VU)

Aconitum violaceum Jacq. EX Stapf, *Anacyclus pyrethrum* (L.) Lag., *Boesenbergia siphonantha* (King ex Baker) M.Sabu, Prasanthk. & Škornick., *Boswellia ovalifoliolata* Bal & Henry., *Calophyllum apetalum* Willd., *Cayratia pedata* Juss. ex Gagnepain, *Cephalotaxus mannii* Hook. f., *Cinnamomum macrocarpum* Hook., *Cinnamomum sulphuratum* Nees., *Curcuma pseudomontana* J. Graham, *Cycas nathorstii* J. Schust., *Diospyros candolleana* Wight, *Diospyros paniculata* Dalz., *Dipterocarpus alatus* Roxb. & G. Don, *Dipterocarpus costatus* Gaertn. f., *Dipterocarpus gracilis* Blume, *Etilingera fenzlii* (Kurz) Škorničk. & M.Sabu, *Garcinia indica* (Dup.) Choisy, *Hopea odorata* Roxb., *Hydnocarpus pentandrus* (Buch.-Ham.) Oken, *Ilex embelioides* Hook. f., *Jatropha nana* Dalzell & A. Gibson, *Magnolia nilagirica* (Zenker) Figlar, *Malaxis muscifera* (Lindley) Kuntze, *Myristica dactyloides* Gaertn., *Nilgiranthus ciliates* (Nees) Bremek., *Ochreinauclea missionis* (Wall. ex G. Don) Ridsdale, *Phyllanthus indofischeri* Bennet., *Piper pedicellatum* C. DC., *Rhynchosia heynei* Wight & Arn. = *Rhynchosia coodoorensis* Bedd., *Salacia oblonga* Wall., *Santalum album* L., *Terminalia pallida* Brandis, *Vanda spatulata* (L.) Spreng.

Near Threatened (NT)

Albizia thompsonii Brandis, *Allium roylei* Stearn, *Cupressus cashmeriana* Royle ex Carriere, *Dioscorea hamiltonii* Hook. f., *Dipterocarpus tuberculatus* Gaertn. f., *Mangifera andamanica* King, *Pterocarpus marsupium* Roxb., *Pterocarpus santalinus* L.f.

Least Concern (LC)

Abelmoschus crinitus Wall., *Abelmoschus ficulneus* (L.) Wight & Arn. ex Wight, *Acacia aneura* F. Muell ex Benth., *Acacia auriculiformis* A. Cunn. ex Benth., *Acacia nilotica* (L.) Willd. ex Delile, *Acanthus ebracteatus* Vahl, *Acanthus ilicifolius* L., *Acanthus volubilis* Wall., *Acer caesium* (Reinw. Ex Blume) Kosterm, *Acer laevigatum* Wall., *Acer pseudoplatanus* L., *Acmella paniculata* (Wall. ex DC.) R.K.Jansen, *Acorus calamus* L., *Acorus gramineus* Aiton, *Adenosma indianum* (Lour.) Merr., *Adenostemma viscosum* J.R.Forst. & G. Forst., *Adiantum capillus-veneris* L., *Aegiceras corniculatum* (L.) Blanco, *Aeschynomene indica* L., *Alangium salviifolium* (L. f.) Wangerin, *Alchornea rugosa* (Lour.) Müll.Arg., *Alisma plantago-aquatica* L., *Alnus nepalensis* D. Don, *Alnus nitida* (Spach) Endl., *Alocasia fornicata* (Roxb.) Schott, *Alocasia odora* (Lindl.) K.Koch, *Alpinia nigra* (Gaertn.) Burt, *Alternanthera sessilis* (L.) R.Br. ex DC., *Alysicarpus bupleurifolius* (L.) DC., *Ammannia auriculata* Willd., *Ammannia baccifera* L., *Amorphophallus paeoniifolius* (Dennst.) Nicolson, *Andira fraxinifolia* Benth., *Aphanamixis polystachya* (Wall.) R.Parker, *Archidendron ellipticum* (Blanco) I.C.Nielsen, *Artocarpus hirsutus* Lam., *Arundo donax* L., *Astragalus tribuloides* Delile, *Avicennia marina* (Forssk.) Vierh., *Azadirachta indica* A.Juss., *Azolla pinnata* R. Br., *Bacopa monnieri* (L.) Wettst., *Baphia nitida* Lodd., *Barringtonia acutangula* L. Gaertn., *Barringtonia racemosa* (L.) Spreng., *Bauhinia acuminata* L., *Bauhinia purpurea* L., *Beilschmiedia roxburghiana* Nees., *Berberis aristata* DC., *Betula alnoides* Buch.-Ham. ex D. Don, *Betula utilis* D. Don, *Biancaea decapetala* (Roth) Alston = *Caesalpinia decapetala* (Roth) Alston, *Bidens cernua* L., *Bidens tripartita* L., *Bischofia javanica* Blume = *Bischofia javanica* var. *toui* (Decne.) Müll.Arg., *Boesenbergia rotunda* (L.) Mansf. = *Boesenbergia pandurata* (Roxb.) Schltr., *Bolboschoenus maritimus* (L.) Palla, *Brachiaria mutica* (Forssk.) Stapf, *Brachiaria reptans* (L.) C.A.Gardner & C.E.Hubb, *Bridelia stipularis* (L.) Blume = *Bridelia scandens* (Roxb.) Willd., *Caesulia axillaris* Roxb., *Cajanus scarabaeoides* (L.) Benth. = *Atylosia scarabaeoides* (L.) Benth., *Calophyllum inophyllum* L., *Camellia kissii* Wall., *Cananga odorata* (Lam.) Hook.f. & Thomson, *Capparis spinosa* L., *Carex filicina* Nees., *Carex phacota* Spreng., *Caryota urens* L., *Cassia javanica* L., *Casuarina equisetifolia* L., *Catambrosa aquatica* (L.) P.Beauv., *Celtis australis* L., *Cenchrus hordeoides* (Lam.) Morrone, *Centella asiatica* (L.) Urb. = *Hydrocotyle asiatica* L., *Centipeda minima* (L.) A. Braun & Asch., *Centrostachys aquatic* (R.Br.) Moq., *Cerasus cerasoides* (Buch.-Ham. ex D. Don) S. Ya. Sokolov = *Prunus cerasoides* Buch.-Ham. ex D. Don., *Ceratopteris thalictroides* (L.) Brongn., *Chamaecrista absus* (L.) H.S. Irwin & Barneby = *Cassia absus* L., *Chlorophytum tuberosum* (Roxb.) Baker, *Christia vespertilionis* (L.f.) Bakh.f., *Chukrasia tabularis* A.Juss., *Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm, *Colocasia esculenta* (L.) Schott, *Colvillea racemosa* Bojer, *Commelina benghalensis* L., *Commelina clavata* C.B. Clarke, *Commelina diffusa* Burm.f., *Commelina erecta* L., *Commelina imberbis* Ehrenb. ex Hassk., *Cordia dichotoma* (Ruiz & Pav.) Gürke = *Cordia bifurcata* Roem. & Schult., *Cotinus coggygria* Scop., *Cressa cretica* L., *Crinum viviparum* (Lam.) R. Ansari & V.J. Nair, *Crotalaria albida* Roth, *Crotalaria*

Table 1 continued

Critically Endangered (CR)

Aconitum chasmanthum Stapf ex Holmes, *Aquilaria malaccensis* Lam. = *A. agalocha* Roxb. ex DC., *Ceropegia odorata* Nimmo ex J. Graham, *Chlorophytum borivilianum* Sant., *Commiphora wightii* (Arn.) Bhandari, *Gentiana kurroo* Royle., *Gymnocladus assamicus* Kanjilal, *Lilium polyphyllum* Don., *Nardostachys jatamansi* DC., *Paphiopedilum druryi* (Bedd.) Stein., *Saussurea costus* (Falc.) Lipsch., *Tribulus rajasthanensis* Bhandari & Sharma, *Uleria salicifolia* Bedd., *Valeriana leschenaultia* DC. *assamica* Benth. = *Crotalaria burmannii* DC., *Crotalaria micans* Link = *Crotalaria dombeyana* DC., *Crotalaria paniculata* Willd., *Crotalaria quinquefolia* L., *Croton argyratus* Blume, *Cryptocoryne ciliate* (Roxb.) Fisch. ex Wydler, *Cryptocoryne retrospiralis* (Roxb.) Kunth, *Curanga amara* Juss. = *Picria fel-terrae* Lour., *Curcuma haritha* Mangaly & M.Sabu, *Curcuma inodora* Blatt., *Cyanotis arcotensis* R.S.Rao, *Cyanotis axillaris* (L.) Schult. F. = *Cyanotis axillaris* (L.) D. Don ex Sweet., *Cyathocline purpurea* (Buch.-Ham. ex D. Don) Kuntze., *Cynometra ramiflora* L., *Cyperus alopecuroides* Rottb., *Cyperus articulatus* L., *Cyperus cephalotes* Vahl., *Cyperus compressus* L., *Cyperus cyperoides* (L.) Kuntze, *Cyperus difformis* L., *Cyperus diffusus* Vahl, *Cyperus distans* L.f., *Cyperus dives* Delile, *Cyperus esculentus* L., *Cyperus exaltatus* Retz., *Cyperus haspan* L., *Cyperus iria* L., *Cyperus laevigatus* L., *Cyperus platyphyllus* Roem. & Schult., *Cyperus pumilus* L. = *Pycreus pumilus* (L.) Nees., *Cyperus stoloniferus* Retz., *Cyperus tuberosus* Rottb. = *C. rotundus* L., *Delonix elata* (L.) Gamble = *Poinciana elata* L., *Desmodium adscendens* (Sw.) DC., *Desmodium barbatum* (L.) Benth., *Desmodium elegans* DC., *Desmodium microphyllum* (Thunb.) DC. = *Leptodesmia microphylla* (Thunb.) H. Ohashi & K. Ohashi (IPNI), *Dichrostachys cinerea* (L.) Wight & Arn, *Dicranopteris linearis* (Burm. f.) Underw., *Drosera burmanni* Vahl., *Drosera indica* L., *Drosera peltata* Thunb., *Echinochloa colona* (L.) Link, *Echinochloa picta* (K.D.Koenig) P.W.Michael, *Eclipta prostrata* Kehraj., *Eclipta alba* (L.) Hassk., *Elaeagnus rhamnooides* (L.) A.Nelson. = *Rhamnoides hippophae* Moench., *Eleocharis acicularis* (L.) Roem. & Schult., *Eleocharis geniculata* (L.) Roem. & Schult., *Eleusine indica* (L.) Gaertn, *Engelhardtia roxburghiana* Lindl., *Enhalus acoroides* (L.f.) Royle, *Enydra fluctuans* DC., *Epaltes divaricata* (L.) Cass., *Ephedra foliata* Boiss. ex C.A.Mey., *Ephedra intermedia* Schrenk & C.A.Mey., *Ephedra kardangensis* P.Sharma & P.L.Uniyal, *Ephedra major* Host, *Epilobium hirsutum* L., *Epilobium latifolium* L., *Erythrina variegata* L., *Ethulia conyzoides* L.f., *Euryale ferox* Salisb., *Excoecaria agallocha* L., *Fimbristylis dichotoma* (L.) Vahl, *Floscopa scandens* Lour., *Fraxinus floribunda* Wall., *Fuirena umbellata* Rottb., *Gloriosa superba* L., *Gmelina arborea* Roxb., *Gmelina asiatica* L., *Gmelina elliptica* Sm. = *G. villosa* Roxb., *Gnetum gnemon* L., *Gnetum montanum* Markgr., *Gnetum ula* Brongn. = *G. pyriforme* Miq. Ex Parl., *Gordonia obtusa* Wall. ex Wight, *Grangea maderaspatana* (L.) Poir., *Grewia asiatica* L., *Grewia villosa* Willd., *Harpullia arborea* (Blanco) Radlk., *Helicia nilagirica* Bedd., *Heliciopsis terminalis* (Kurz) Sleumer = *Helicia terminalis* Kurz, *Heliotropium ovalifolium* Forssk. = *Euploca ovalifolia* (Forssk.) Diane & Hilger, *Hemarthria compressa* (L.f.) R.Br., *Hemisteptia lyrata* Fisch. & C.A.Mey., *Heritiera littoralis* Aiton, *Hibiscus tiliaceus* L., *Homonoia retusa* (Graham ex Wight) Müll.Arg., *Homonoia riparia* Lour., *Hoppea dichotoma* Willd., *Hydrilla verticillata* (L.f.) Royle, *Hydrocotyle sibthorpioides* Lam., *Hydrolea zeylanica* (L.) Vahl, *Hygrophila auriculata* (Schumach.) Heine., *Hygrophila pinnatifida* (Dalzell) Sreem., *Hygrophila polysperma* (Roxb.) T.Anderson, *Hygrophila salicifolia* (Vahl) Nees., *Hygrophila schulli* M.R.Almeida & S.M.Almeida = *H. auriculata* (Schumach.) Heine., *Indigofera linifolia* (L. f.) Retz., *Indigofera oblongifolia* Forssk., *Indigofera trita* L. f., *Ipomoea aquatica* Forssk., *Ipomoea cairica* (L.) Sweet, *Ipomoea coptica* (L.) Roth ex Roem. & Schult., *Iris pseudacorus* L. = *Linnirion pseudacorus* (L.) Opiz, *Ixora grandifolia* Zoll. & Moritz, *Juglans regia* L., *Juncus decipiens* (Buchenau) Nakai, *Juncus effuses* L., *Juniperus communis* L., *Knema globularia* (Lam.) Warb., *Kyllinga brevifolia* Rottb., *Kyllinga bulbosa* P.Beauv., *Kyllinga nemoralis* (J.R.Forst. & G.Forst.) Dandy ex Hutch. & Dalziel., *Lagenandra ovate* (L.) Thwaites, *Lagenandra toxicaria* Dalzell, *Lasia spinosa* (L.) Thwaites, *Lennea minor* L., *Leptochilus decurrens* Blume, *Lespedeza cuneata* (Dum.Cours.) G.Don, *Linnophila aromatica* (Lam.) Merr., *Linnophila indica* (L.) Druce, *Linnophila polystachya* Benth., *Linnophila repens* (Benth.) Benth., *Linnophila rugosa* (Roth) Merr., *Linnophyton obtusifolium* (L.) Miq., *Lindernia anagallis* (Burm.f.) Pennell, *Lindernia antipoda* (L.) Alston, *Lindernia ciliate* (Colsm.) Pennell, *Lindernia crustacea* (L.) F.Muell. = *Torenia crustacean* (L.) Cham. & Schltdl., *Lindernia oppositifolia* (L.) Mukerjee, *Lindernia procumbent* (Krock.) Philcox, *Lindernia pusilla* (Willd.) Bold., *Lindernia ruellioides* (Colsm.) Pennell, *Liquidambar excelsa* (Noronha) Oken = *Altingia excelsa* Noronha, *Lobelia heyneana* Schult., *Ludwigia hyssopifolia* (G.Don) Exell, *Ludwigia octovalvis* (Jacq.) P.H.Raven., *Ludwigia perennis* L., *Lygodium microphyllum* Link. = *L. japonicum* (Thunb.) Sw., *Magnolia baillonii* Pierre, *Magnolia champaca* (L.) Baill. ex Pierre = *Michelia champaca* L., *Magnolia oblonga* (Wall. ex Hook.f. & Thomson) Figlar, *Malus baccata* (L.) Borkh., *Marsilea minuta* L., *Marsilea quadrifolia* L., *Mecopus nidulans* Benn., *Medicago sativa* L., *Meistera masticatorum* (Thwaites) Skornick & M. F. Newman, *Melia azedarach* L., *Melicope lunu-ankenda* (Gaertn.) T.G. Hartley, *Mentha arvensis* L., *Menyanthes trifoliata* L., *Merremia gangetica* Cufod., *Mimosa elengi* L., *Monochoria hastate* (L.) Solms, *Monochoria korsakowii* Regel & Maack, *Monochoria vaginalis* (Burm. f.) C. Presl, *Mucuna bracteata* DC., *Musa acuminata* Colla, *Musa balbisiana* Colla, *Myriophyllum indicum* Willd., *Myriophyllum oliganthum* (Wight & Arn.) F. Muell., *Myriophyllum tuberculatum* Roxb., *Myriophyllum verticillatum* L., *Nageia wallichiana* (C.Presl) Kuntze, *Nasturtium officinale* R.Br., *Neottia acuminata* Schltr., *Nephrolepis undulate* (Afzel. ex Sw.) J. Sm., *Nerium oleander* L., *Nymphaea alba* L., *Nymphaea nouchali* Burm.f., *Nymphaea pubescens* Willd., *Nymphaea tetragona* Georgi, *Nymphoides hydrophylla* (Lour.) Kuntze, *Oenanthe javanica* (Blume) DC., *Oldenlandia diffusa* (Willd.) Roxb., *Osmunda hugeliana* C.Presl, *Osmunda regalis* L., *Otelia alismoides* (L.) Pers., *Oxystelma esculentum* (L. f.) Sm., *Palaquium obovatum* (Griff.) Engl., *Parkia timoriana* (DC.) Merr., *Paspalidium flavidum* (Retz.) A.Camus, *Paspalum conjugatum* P.J.Bergius., *Paspalum distichum* L., *Paspalum scrobiculatum* L., *Peltophorum africanum* Sond., *Persicaria amphibian* (L.) Delarbre, *Persicaria barbata* (L.) H. Hara, *Persicaria glabrum* (Willd.) M.Gómez, *Persicaria lapathifolia* (L.)

Table 1 continued

Critically Endangered (CR)

Aconitum chasmanthum Stapf ex Holmes, *Aquilaria malaccensis* Lam. = *A. agalocha* Roxb. ex DC., *Ceropegia odorata* Nimmo ex J. Graham, *Chlorophytum borivilianum* Sant., *Commiphora wightii* (Arn.) Bhandari, *Gentiana kurroo* Royle., *Gymnocladus assamicus* Kanjilal, *Lilium polyphyllum* Don., *Nardostachys jatamansi* DC., *Paphiopedilum druryi* (Bedd.) Stein., *Saussurea costus* (Falc.) Lipsch., *Tribulus rajasthanensis* Bhandari & Sharma, *Uleria salicifolia* Bedd., *Valeriana leschenaultia* DC. Delarbre, *Persicaria strigosa* (R.Br.) Nakai, *Phragmites australis* (Cav.) Trin. ex Steud., *Phyla nodiflora* (L.) Greene, *Phyllodium pulchellum* (L.) Desv., *Pistacia khinjuk* Stocks, *Pistia stratiotes* L., *Plantago major* L., *Polygonum punctatum* Elliott, *Pometia pinnata* J.R.Forst. & G.Forst., *Pongamia pinnata* (L.) Pierre, *Potamogeton crispus* L., *Potamogeton nodosus* Poir., *Potamogeton perfoliatus* L., *Potamogeton pusillus* L., *Potentilla supine* L., *Prunella vulgaris* L., *Psidium guajava* L., *Psidium guineense* Sw., *Pterospermum diversifolium* Blume, *Quercus acutissima* Carruth., *Quercus glauca* Thunb., *Ranunculus scleratus* L., *Rhynchosia minima* (L.) DC., *Sagittaria guayanensis* Kunth, *Sagittaria trifolia* L., *Schima khasiana* Dyer, *Schima wallichii* Choisy, *Scleria lithosperma* (L.) Sw., *Scyphiphora hydrophylacea* C.F.Gaertn., *Sesbania bispinosa* (Jacq.) W.Wight, *Silene vulgaris* (Moench) Garcke, *Sirhookera lanceolata* (Wight) Kuntze, *Smithia sensitive* Aiton, *Sonneratia alba* Sm., *Sonneratia apetala* Buch.-Ham., *Spathodea campanulata* P.Beauv., *Spatholobus parviflorus* (DC.) Kuntze, *Sphaeranthus africanus* L., *Sphaeranthus amaranthoides* Burm.f., *Sphaeranthus indicus* L., *Sphaeranthus senegalensis* DC., *Spirodela polyrhiza* (L.) Schleid., *Tacca leontopetaloides* (L.) Kuntze, *Tephrosia tinctoria* Pers., *Tephrosia villosa* (L.) Pers., *Terminalia calamansanai* (Blanco) Rolfe., *Terminalia catappa* L., *Thespesia populnea* (L.) Sol. ex Corrêa, *Toona ciliata* M.Roem., *Toona sinensis* (Juss.) M.Roem., *Toona sureni* (Blume) Merr., *Trapa natans* L., *Trema orientale* (L.) Blume, *Triadica cochinchinensis* Lour., *Trifolium pretense* L., *Typha angustifolia* L., *Typha domingensis* Pers., *Typha elephantina* Roxb., *Typha orientalis* C.Presl, *Typhonium flagelliforme* (Lodd.) Blume, *Ulex europaeus* (Lodd.) Blume, *Uraria picta* (Jacq.) DC., *Utricularia aurea* Lour., *Utricularia bifida* L., *Vallisneria natans* (Lour.) H.Hara, *Vallisneria spiralis* L., *Vanda tessellate* (Roxb.) Hook. ex G.Don, *Veronica anagallis-aquatica* L., *Vigna angularis* (Willd.) Ohwi & H. Ohashi, *Vitex glabrata* R.Br., *Vitex quinata* (Lour.) F.N.Williams, *Wedelia chinensis* (Osbeck) Merr., *Wurfbainia villosa* (Lour.) Skornick. & A.D.Poulsen, *Xylia xylocarpa* (Roxb.) Taub., *Xyris complanata* R.Br., *Xyris indica* L., *Zanthoxylum armatum* DC., *Zeuxine strateumatica* (L.) Schltr.

Data Deficient (DD)

Abrus fruticulosus Wight & Arn., *Amomum sericeum* Roxb., *Asparagus filicinus* Buch.-Ham. ex D.Don., *Coscinium fenestratum* (Goetgh.) Colebr., *Dioscorea wightii* Hook.f., *Ephedra khurikensis* P.Sharma & P.L.Uniyal, *Fraxinus micrantha* Lingelsh., *Limnophila pulcherrima* Hook.f., *Milletia fruticosa* (DC.) Baker, *Platanus orientalis* L., *Zingiber zerumbet* (L.) Roscoe ex Sm.

Authority and appropriate synonyms as per The Plant List (www.theplantlist.org), International Plant Names Index (IPNI; www.ipni.org) and India Biodiversity Portal (indiabiodiversity.org)

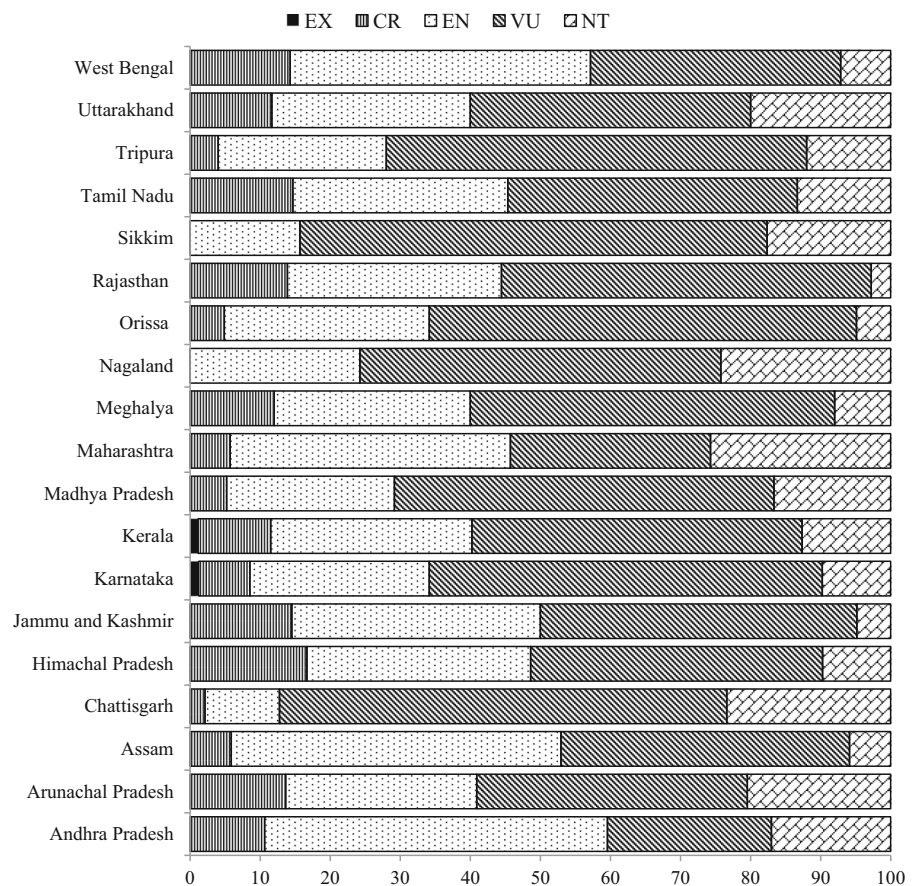
The IUCN Red List of Threatened Plants, first published in 1998, lists more than 8,000 species under threat (Walter and Gillett 1998).

On a global basis, IUCN has estimated that about 13.49% of the world's vascular plants (3,00,000 species), totaling about 40,468 species are under varying degrees of threat. Many plant species are becoming extinct (123 are extinct and 37 are extinct in wild) and under threatened categories CR (3,325), EN (6,063), VU (7,072) (Fig. 3) or vulnerable to extinction due to various reasons like population loss, loss of pollinators, loss of reproduction and/or seed germination capacity, habitat destruction (both natural and human-induced), over exploitation and loss of genetic variability (IUCN, 2020; Kala 2000, 2005). In India about 11.53% of vascular plants (18,532), totaling about 2,142 species are red listed. Out of these 8 are extinct, 432 species are threatened (CR, EN and VU)

and nearly 54 species are grouped under near threatened (Fig. 3) (IUCN 2020).

Nature has bestowed India with an enormous wealth of medicinal plants, due to which the country is often referred as 'Medicinal Garden' or 'Botanical Garden' of the world (Ahmadullah and Nayar 1999). Of 48,655 plant species documented (including virus, bacteria, algae, fungi and lichens) 9,500 species have ethno-botanical importance and 7,500 species are in medicinal use for indigenous health practices as well as modern system of medicines (Kumar et al. 2013; Sharma and Pandey 2013). From ancient period medicinal plants have been used in all cultures as a source of medicine and its use as herbal medicine is described in numerous ancient texts. Besides being a major source of raw material for the traditional healthcare practices (Ayurveda, Siddha, Unani, Homeopathy, Naturopathy, Sowa-Rigpa and diverse

Fig. 4 State-wise proportion of medicinal plants of India in different threat categories (except LC and DD) based on CAMP exercise (EX: Extinct; CR: Critically endangered; EN: Endangered; VU: Vulnerable; NT: Near threatened) (Source: Ved and Tandon 1998; Jadhav et al. 2001; Ved et al. 2003a, b; Ved et al. 2005; Goraya et al. 2013; Ved et al. 2016a, b)



area- and community-specific folk medicine) and pharmaceutical industry, also provide livelihood to a large Indian population (Kumar et al. 2015). Indigenous and traditional systems of medicine using plants have shown potential (direct or indirect as immune-boosters) against many dreaded ailments including the recent global pandemic of COVID-19. For example Ayurveda preparations ('rasayana') with 'Ashwagandha' (*Withania somnifera* Dunal) can be a potential candidate for management of COVID-19, as also 'Shatavari' (*Asparagus racemosus* Willd.), 'Amala' (*Phyllanthus emblica* L. syn *Embelica officinalis*), 'Guduchi' [*Tinospora cordifolia* (Willd.) Miers], as these have immunomodulatory properties, and may have the potential to boost health and immunity to fight against SARS-CoV-2 infection (Patwardhan et al. 2020).

In India more than 90% of medicinal plants are facing threat due to excessive and unsustainable collection, utilization, overexploitation or un-skilled

harvesting (Kumari et al. 2011). Based on global rates of plant species threatened with extinction, it is estimated that around 1,000 medicinal plant species may be under threat in different eco-systems across India (FRLHTENVIS 2016a). As per the IUCN Red List, a total of 457 species out of 2,143 species are listed under medicine for human and veterinary group (Table 1). Of these, 73 are threatened (CR, EN, VU), 8 (NT), 1 (DD) and 366 (LC). Although there are publications enlisting threatened plants of medicinal value at state, region, national and global levels prepared by Conservation Assessment and Management Prioritization (CAMP), Botanical Survey of India (BSI) and IUCN, etc., there is no consolidated compilation at one place, to get an accurate assessment. Therefore, in this paper an attempt has been made to review the existing information and compile an exhaustive list of threatened medicinal plants of India. This easy, one-stop-shop ready reckoner for information related to Indian threatened medicinal

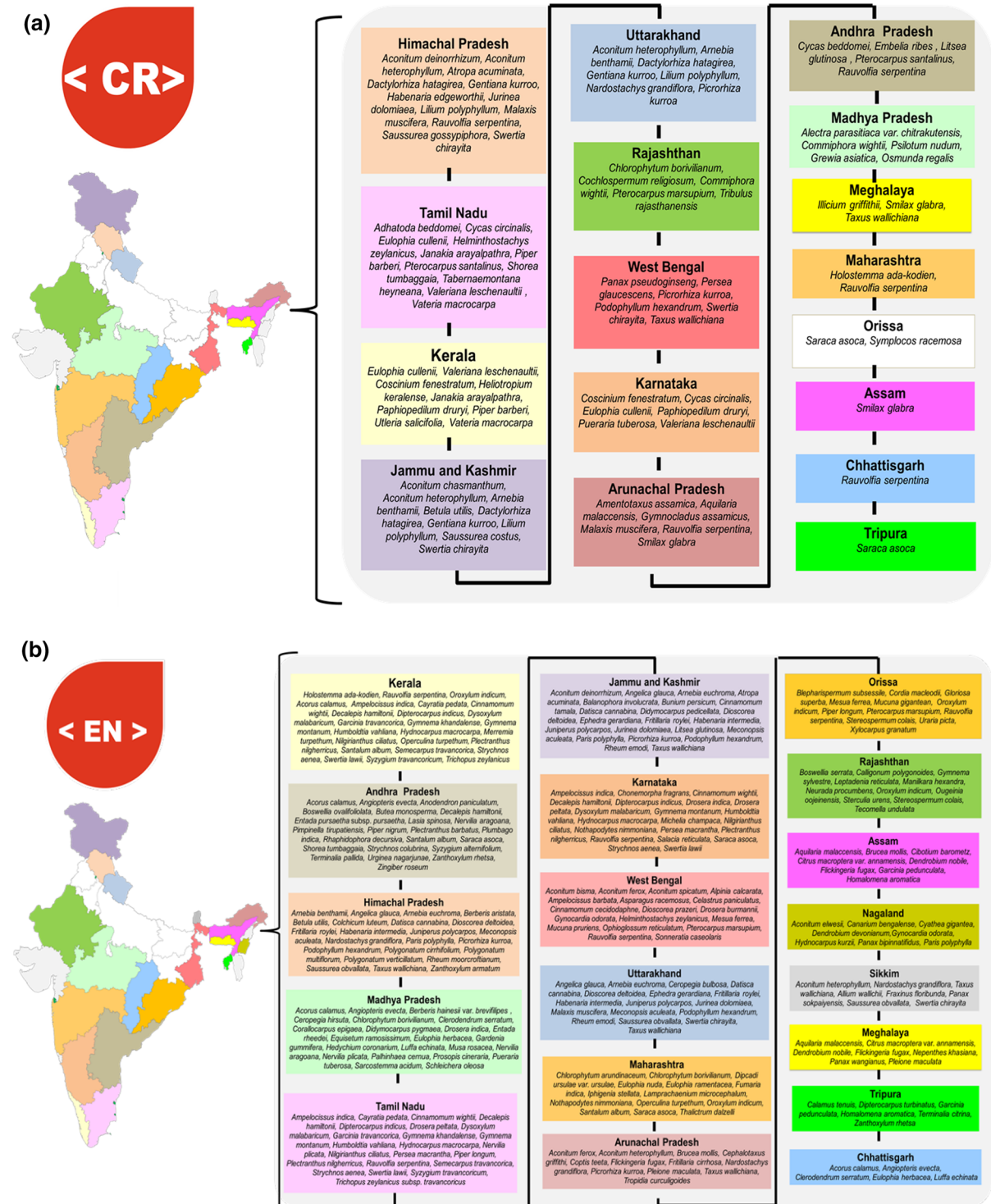


Fig. 5 State-wise list of threatened medicinal plants of India based on CAMP exercise represented from state with highest number of species to state with lowest number of species under different threat categories (a) Critically endangered

(b) Endangered (c) Vulnerable. Same colour represents the state on the map. (Source: Ved and Tandon 1998; Jadhav et al. 2001; Ved et al. 2003a, b; Ved et al. 2005; Goraya et al. 2013; Ved et al. 2016a, b)

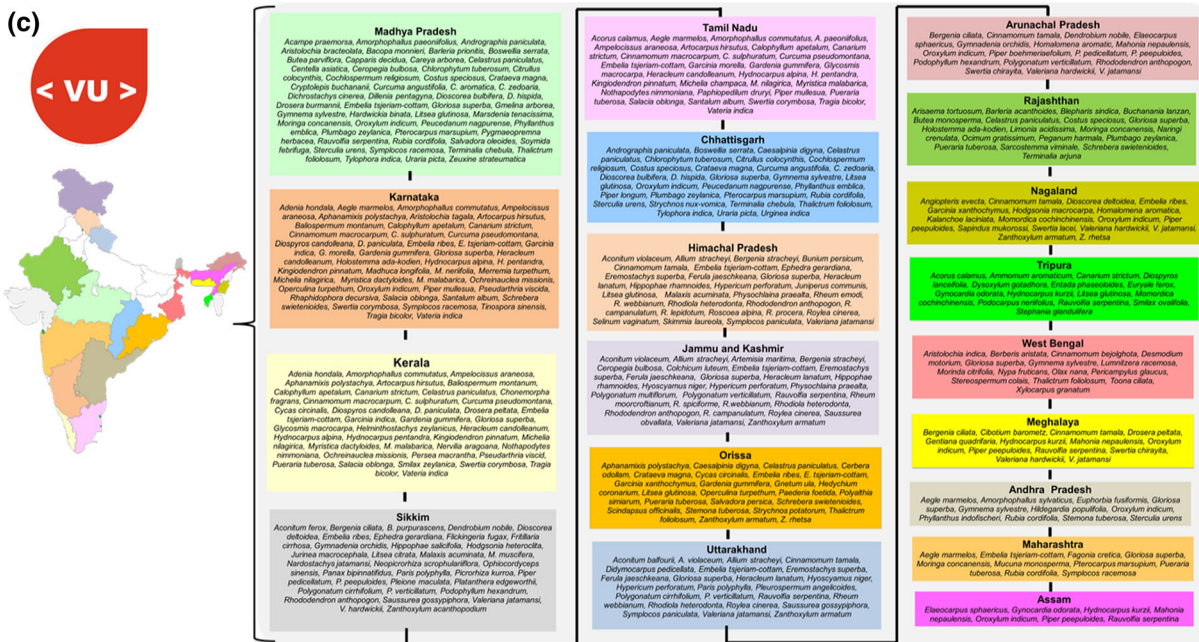


Fig. 5 continued

plant species will be beneficial especially for young researchers to strategize conservation, repatriation and use of such species. It will help not only the researchers but also policy makers in developing strategies for efficient conservation/cultivation to ensure availability of these precious resources for utilization by future generations.

Threat assessment

At national level several institutes have assessed the threat status of medicinal plants in India (Jain and Rao 1983; Nayar and Shastry 1987–1990). During 1987–1990, a total of 602 vascular plants were listed as threatened in Red Data Book of Indian Plants, which increased to 1,255 in 2003 (Rao et al. 2003), and 2,152 in 2020 (IUCN 2020). Over the past two decades, 14 CAMP workshops covering 17 states of India were conducted for rapid assessment of prioritized medicinal plant species of conservation concern in different states/regions of India by the Conservation Breeding Specialist Group (CBSG), India, in collaboration with Foundation for Revitalization of Local Health Traditions (FRLHT) (Fig. 4). CAMP workshop also uses IUCN threat categories of the respective

period for assigning threat status. State-wise CAMP list of threatened medicinal plants is presented in Fig. 5a-c. We compared IUCN and CAMP list of medicinal plants and observed inconsistencies in threat status reported, and also few species missing (Table 2).

It is estimated that about 7,500 plants are used in local health traditions in most rural and tribal villages in India (Shakya 2016). Herbal treatments are the most popular form of traditional medical system (Sarker and Nahar 2007). The various codified Indian systems of medicine are complemented by a strong inheritance of non-codified and non-commercial living folk healthcare traditions. These folk healthcare traditions, carried from generation to generation and practiced by around one million folk practitioners are spread across 29 states, 7 union territories, 497 cities, 7,935 towns and 6,49,481 villages and nearly 140 million rural households in the country. The first effort to assess the demand and supply of medicinal plants of selected 162 species in the country was made by the National Medicinal Plant Board (NMPB) during 2001–02, through Centre for Research, Planning and Action (CERPA) (Goraya and Ved 2017). In 2003, export potential of medicinal plants was assessed by the FRLHT through Export Import (EXIM) Bank (Goraya

Table 2 Consolidated list of threatened medicinal plants represented in both IUCN (India region) and CAMP exercise (India region)

Species	Threat Status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Aconitum chasmanthum</i> Stapf ex Holmes	CR	Jammu and Kashmir (CR 2003)
<i>Aconitum heterophyllum</i> Wall.	EN	Arunachal Pradesh (EN 2003), Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (CR 2003), Sikkim (EN 2003), Uttarakhand (CR 2003)
<i>Aconitum violaceum</i> Jacq. ex Stapf.	VU	Himachal Pradesh (VU 2003, VU 2010), Jammu and Kashmir (VU 2003), Uttarakhand (VU 2003)
<i>Acorus calamus</i> L.	LC	Andhra Pradesh (EN 2001), Chhattisgarh (EN 2003), Kerala (EN 1999), Madhya Pradesh (EN 2003), Tamil Nadu (VU 1998), Tripura (VU 2016)
<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicolson	LC	Kerala (NT 1999), Madhya Pradesh (VU 2006), Tamil Nadu (VU 1998)
<i>Angelica glauca</i> Edgew.	EN	Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (EN 2003), Uttarakhand (EN 2003)
<i>Aphanamixis polystachya</i> (Wall.) R.Parker	LC	Karnataka (VU 1997), Kerala (VU 1997), Orissa (VU 2007)
<i>Aquilaria malaccensis</i> Lam. = <i>A. agalocha</i> Roxb.ex DC	CR	Arunachal Pradesh (CR 2003), Assam (EN 2003), Meghalaya (EN 2003), Tripura (DD 2016)
<i>Artocarpus hirsutus</i> Lam.	LC	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (VU 1998)
<i>Bacopa monnieri</i> (L.) Wettst.	LC	Madhya Pradesh (VU 2006)
<i>Berberis aristata</i> DC.	LC	Himachal Pradesh (EN 2010), Sikkim (DD 2014), West Bengal (VU 2007)
<i>Betula utilis</i> D. Don	LC	Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (CR 2003), Sikkim (NT 2014), Uttarakhand (NT 2003)
<i>Boswellia ovalifoliolata</i> Bal & Henry	VU	Andhra Pradesh (EN 2001)
<i>Calophyllum apetalum</i> Willd.	VU	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (VU 1998)
<i>Cayratia pedata</i> Juss. ex Gagnepain	VU	Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Centella asiatica</i> (L.) Urb. = <i>Hydrocotyle asiatica</i> L.	LC	Madhya Pradesh (VU 2006)
<i>Chlorophytum borivillianum</i> Santapau & R.R.Fern.	CR	Madhya Pradesh (EN 2006), Maharashtra (EN 2001), Rajasthan (CR 2007)
<i>Chlorophytum tuberosum</i> (Roxb.) Baker	LC	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Cinnamomum macrocarpum</i> Hook.	VU	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (VU 1998)
<i>Cinnamomum sulphuratum</i> Nees	VU	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (VU 1998)
<i>Cinnamomum tamala</i> (Buch.-Ham.) T.Nees & Eberm	LC	Arunachal Pradesh (VU 2003), Himachal Pradesh (VU 2003, VU 2010), Jammu and Kashmir (EN 2003), Meghalaya (VU 2003), Nagaland (VU 2015), Uttarakhand (VU 2003)
<i>Cinnamomum wightii</i> C.F.W.Meissn	EN	Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Commiphora wightii</i> (Arn.) Bhandari	CR	Madhya Pradesh (CR 2003), Rajasthan (CR 2007)
<i>Coptis teeta</i> Wall.	EN	Arunachal Pradesh (EN 2003)
<i>Coscinium fenestratum</i> (Goetgh.) Colebr.	DD	Karnataka (CR 1999), Kerala (CR 1999)
<i>Curcuma pseudomontana</i> Graham	VU	Karnataka (VU 1999), Kerala (EN1999), Tamil Nadu (EN 1998)
<i>Cycas beddomei</i> Dyer	EN	Andhra Pradesh (CR 2001)

Table 2 continued

Species	Threat Status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Cycas circinalis</i> L.	EN	Karnataka (CR 1999), Kerala (VU 1999), Orissa (VU 2007), Tamil Nadu (CR 1998)
<i>Decalepis hamiltonii</i> Wight & Arn.	EN	Andhra Pradesh (EN 2001), Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Dendrobium devosianum</i> J.J.Sm.	DD	Nagaland (EN 2015)
<i>Dichrostachys cinerea</i> Wight & Arn.	LC	Madhya Pradesh (VU 2006)
<i>Diospyros candolleana</i> Wight	VU	Karnataka (VU 1999), Kerala (VU 1999)
<i>Diospyros paniculata</i> Dalz.	VU	Karnataka (VU 1999), Kerala (VU 1999)
<i>Drosera burmanni</i> Vahl	LC	Madhya Pradesh (VU 2006), West Bengal (EN 2007)
<i>Drosera indica</i> L.	LC	Karnataka (EN 1999), Madhya Pradesh (EN 2006)
<i>Drosera peltata</i> Thunb.	LC	Arunachal Pradesh (NT 2003), Karnataka (EN 1999), Kerala (VU 1999), Meghalaya (VU 2003), Tamil Nadu (EN 1998)
<i>Dysoxylum malabaricum</i> Bedd.	EN	Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Euryale ferox</i> Salisb.	LC	Tripura (VU 2016)
<i>Fraxinus floribunda</i> Wall.	LC	Sikkim (EN 2014)
<i>Garcinia indica</i> (Thouars) Choisy	VU	Karnataka (VU 1999), Kerala (VU 1999), Maharashtra (NT 2001)
<i>Gentiana kurroo</i> Royle	CR	Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (CR 2003), Uttarakhand (CR 2003)
<i>Gloriosa superb</i> L.	LC	Andhra Pradesh (VU 2001), Chhattisgarh (VU 2003), Himachal Pradesh (VU 2003), Jammu and Kashmir (VU 2003), Karnataka (VU 1999), Kerala (VU 1999), Madhya Pradesh (VU 2003), Maharashtra (VU 2001), Orissa (EN 2007), Rajasthan (VU 2007), Uttarakhand (VU 2003), West Bengal (VU 2007)
<i>Gmelina arborea</i> Roxb.	LC	Madhya Pradesh (VU 2006)
<i>Gnetum montanum</i> Markgr.	LC	Tripura (DD 2016)
<i>Gnetum ula</i> Brongn. = <i>G. pyriforme</i> Miq. Ex Parl.	LC	Orissa (VU 2007)
<i>Grewia asiatica</i> L.	LC	Madhya Pradesh (CR 2006)
<i>Gymnema khandalense</i> Santapau	EN	Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Gymnocladus assamicus</i> Kanjilal	CR	Arunachal Pradesh (CR 2003)
<i>Humboldtia vahliana</i> Wight	EN	Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Illicium griffithii</i> Hook. F. & Th.	EN	Arunachal Pradesh (NT 2003), Meghalaya (CR 2003)
<i>Iphigenia stellata</i> Blatter	EN	Maharashtra (EN 2001)
<i>Juniperus communis</i> L.	LC	Himachal Pradesh (VU 2010)
<i>Lamprachaenium microcephalum</i> Benth.	EN	Maharashtra (EN 2001)
<i>Lasia spinosa</i> (L.) Thwaites	LC	Andhra Pradesh (EN 2001)
<i>Lilium polyphyllum</i> Don	CR	Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (CR 2003), Uttarakhand (CR 2003)
<i>Malaxis muscifera</i> (Lind.) Kuntze	VU	Arunachal Pradesh (CR 2003), Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (NT 2003), Sikkim (EN 2003, VU 2014), Uttarakhand (EN 2003)
<i>Myristica dactyloides</i> Gaertn.	VU	Karnataka (VU 1999), Kerala (VU 1999)
<i>Nardostachys jatamansi</i> DC.	CR	Sikkim (VU 2014)
<i>Nepenthes khasiana</i> Hook.f.	EN	Meghalaya (EN 2003)

Table 2 continued

Species	Threat Status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Nilgirianthus ciliates</i> (Nees) Bremek	VU	Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Ochreinauclea missionis</i> (Wall.ex G.Don) Ridsdale	VU	Karnataka (VU 1999), Kerala (VU 1999)
<i>Osmunda regalis</i> L.	LC	Madhya Pradesh (CR 2006)
<i>Paphiopedilum druryi</i> (Bedd.) Stein	CR	Karnataka (CR 1999), Kerala (CR 1999), Tamil Nadu (VU 1998)
<i>Phyllanthus indofischeri</i> Bennet	VU	Andhra Pradesh (VU 2001)
<i>Pimpinella tirupatiensis</i> Bal. & Sub.	EN	Andhra Pradesh (EN 2001)
<i>Piper barberi</i> Gamble	EN	Kerala (CR 1999), Tamil Nadu (CR 1998)
<i>Piper pedicellatum</i> C. DC.	VU	Arunachal Pradesh (VU 2003), Sikkim (VU 2003)
<i>Pterocarpus marsupium</i> Roxb.	NT	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Maharashtra (VU 2001), Orissa (EN 2007), Rajasthan (CR 2007), West Bengal (EN 2007)
<i>Pterocarpus santalinus</i> L.f.	NT	Andhra Pradesh (CR 2001), Tamil Nadu (CR 1998)
<i>Salacia oblonga</i> Wall.	VU	Karnataka (VU 1999), Kerala (VU 1999) Tamil Nadu (VU 1998)
<i>Santalum album</i> L.	VU	Andhra Pradesh (EN 2001), Karnataka (VU 1999), Kerala (EN 1999), Maharashtra (EN 2001), Tamil Nadu (VU 1998)
<i>Saussurea costus</i> (Falc.) Lipsch.	CR	Jammu and Kashmir (CR 2003)
<i>Spatholobus parviflorus</i> (L.) Engl.	LC	Tripura (DD 2016)
<i>Syzygium alternifolium</i> (Wt.) Wall.	EN	Andhra Pradesh (EN 2001)
<i>Tacca leontopetaloides</i> (L.) Kuntze	LC	Andhra Pradesh (NT 2001), Madhya Pradesh (NT 2006)
<i>Taxus wallichiana</i> Zucc.	EN	Arunachal Pradesh (EN 2003), Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (EN 2003), Meghalaya (CR 2003), Sikkim (EN 2003), Uttarakhand (EN 2003), West Bengal (CR 2007)
<i>Terminalia pallida</i> Brandis	VU	Andhra Pradesh (EN 2001)
<i>Toona ciliate</i> M. Roem = <i>Cedrela toona</i> Roxb. ex Rottler	LC	West Bengal (VU 2007)
<i>Tribulus rajasthanensis</i> Bhandari & Sharma	CR	Rajasthan (CR 2007)
<i>Uraria picta</i> (Jacq.) DC.	LC	Chhattisgarh (VU 2003), Himachal Pradesh (NE 2010), Madhya Pradesh (VU 2003), Orissa (EN 2007)
<i>Utleria salicifolia</i> Bedd.	CR	Kerala (CR 1999)
<i>Valeriana leschenaultia</i> DC.	CR	Karnataka (CR1997), Kerala (CR1997), Tamil Nadu (CR1997)
<i>Zanthoxylum armatum</i> DC.	LC	Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (VU 2003), Nagaland (VU 2015), Orissa (VU 2007), Uttarakhand (VU 2003)
<i>Zeuxine strateumatica</i> (L.) Schltr.	LC	Madhya Pradesh (VU 2006)

EX: Extinct; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; LR: Lower Risk; LR: Lower Risk; NT: Near threatened; LC: Least concern; DD: Data deficient

IUCN Red list under medicine for human and veterinary group is used

(Source: Ved and Tandon 1998; Jadhav et al. 2001; Ved et al. 2003a, b, 2016a; Ved et al. 2005; Goraya et al. 2013 IUCN 2020) Authority and appropriate synonyms as per The Plant List (www.theplantlist.org), International Plant Names Index (IPNI; www.ipni.org) and India Biodiversity Portal (indiabiodiversity.org)

and Ved 2017). Under this study, a total of 880 medicinal plant species were found traded. NMPB also assigned to the Indian Council of Forestry

Research and Education (ICFRE) with FRLHT to re-assess the demand and supply of medicinal plants in the country and developed a comprehensive database

Table 3 Threat status of 242 plant species with high commercial demand (> 100 MT/year) in India

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Abelmoschus moschatus</i> Medik. *	–	–
<i>Abies spectabilis</i> (D.Don) Mirb.	–	–
<i>Abrus precatorius</i> L.	–	Chhattisgarh (NT 2003), Madhya Pradesh (NT 2003)
<i>Abutilon indicum</i> (L.) Sweet	–	–
<i>Acacia catechu</i> (L.f.) Willd.	–	–
<i>Acacia nilotica</i> subsp. <i>indica</i> (Benth.) Brenan	–	–
<i>Acacia senegal</i> (L.) Willd.	–	–
<i>Acacia seyal</i> Delile	–	–
<i>Acacia sinuata</i> (Lour.) Merr.	–	–
<i>Acalypha indica</i> L.	–	–
<i>Achillea millefolium</i> L.	–	–
<i>Achyranthes aspera</i> L.	–	–
<i>Aconitum heterophyllum</i> Wall. ex Royle	EN	Arunachal Pradesh (EN 2003), Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (CR 2003), Sikkim (EN 2003), Uttarakhand (CR 2003)
<i>Acorus calamus</i> L.*	LC	Andhra Pradesh (EN 2001), Chhattisgarh (EN 2003), Kerala (EN 1999), Madhya Pradesh (EN 2003), Tamil Nadu (VU 1998), Tripura (VU 2016)
<i>Aegle marmelos</i> (L.) Correa	–	Andhra Pradesh (VU 2001), Karnataka (VU 1999), Maharashtra (VU2001), Tamil Nadu (VU 1998)
<i>Aerva lanata</i> (L.) Juss.	–	–
<i>Albizia amara</i> (Roxb.)B. Boivin	–	–
<i>Alhagi pseudalhagi</i> (M.Bieb.) Desv. Ex B.Keller & Shap. = <i>Alhagi maurorum</i> Medik	–	–
<i>Aloe vera</i> (L.) Burm.f.*	–	–
<i>Alpinia calcarata</i> (Haw.) Roscoe*	–	West Bengal (EN 2007)
<i>Alpinia galanga</i> (L.) Willd.*	–	–
<i>Amorphophallus paeoniifolius</i> (Dennst.) Nicolson	LC	Kerala (NT 1999), Madhya Pradesh (VU 2006), Tamil Nadu (VU 1998)
<i>Anacyclus pyrethrum</i> (L.) Lag.	VU	–
<i>Andrographis paniculata</i> (Burm.f.) Nees	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Argyreia elliptica</i> Arn. ex Choisy	–	–
<i>Arnebia benthamii</i> (Wall. Ex G.Don) Johnston	–	Himachal Pradesh (CR 2003, EN 2010), Jammu and Kashmir (CR 2003), Uttarakhand (CR 2003)
<i>Artemisia annua</i> L.*	–	–
<i>Asparagus adscendens</i> Roxb.	–	–
<i>Asparagus racemosus</i> Willd.	–	Chhattisgarh (NT 2003), Madhya Pradesh (NT 2003), West Bengal (EN 2007)
<i>Atropa belladonna</i> L.	–	–
<i>Azadirachta indica</i> A.Juss.*	LC	–
<i>Baccharoides anthelmintica</i> (L.) Moench	–	–
<i>Bacopa monnieri</i> (L.) Wettst.	LC	Madhya Pradesh (VU 2006)
<i>Baliospermum montanum</i> (Willd.) Müll.Arg = <i>B. solanifolium</i> (Burm.) Suresh	–	Chhattisgarh (NT 2003), Karnataka (VU 1999), Kerala (VU 1999), Madhya Pradesh (NT 2003)

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Barleria prionitis</i> L.	–	Madhya Pradesh (VU 2006)
<i>Bauhinia variegata</i> L.	–	–
<i>Berberis aristata</i> DC.	LC	Himachal Pradesh (EN 2010), Sikkim (DD 2014), West Bengal (VU 2007)
<i>Berberis lycium</i> Royle	–	–
<i>Bergenia ciliata</i> (How.) Sternb.	–	Arunachal Pradesh (VU 2003), Meghalaya (VU 2003), Nagaland (NT 2015), Sikkim (VU 2003)
<i>Betula utilis</i> D. Don	LC	Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (CR 2003), Sikkim (NT 2014), Uttarakhand (NT 2003)
<i>Boerhavia diffusa</i> L.	–	–
<i>Bombax ceiba</i> L.	–	–
<i>Boswellia serrata</i> Roxb. ex Colebr.	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Rajasthan (EN 2007)
<i>Buchanania cochinchinensis</i> (Lour.) M.R.Almeida	–	–
<i>Butea monosperma</i> (Lam.) Taub.	–	Andhra Pradesh (EN 2001), Rajasthan (VU 2007)
<i>Caesalpinia bonduc</i> (L.) Roxb.	–	–
<i>Calendula officinalis</i> L.*	–	–
<i>Capparis spinosa</i> L.	LC	–
<i>Cardiospermum halicacabum</i> L.	–	–
<i>Cassia fistula</i> L.	–	–
<i>Catharanthus roseus</i> (L.) G.Don*	–	–
<i>Cedrus deodara</i> (Roxb. Ex D.Don) G.Don	–	–
<i>Celastrus paniculatus</i> Willd.	–	Andhra Pradesh (NT 2001), Chhattisgarh (VU 2003), Karnataka (NT 1999), Kerala (VU 1999), Madhya Pradesh (VU 2003), Orissa (VU 2007), Rajasthan (VU 2007), Tamil Nadu (NT 1998), West Bengal (EN 2007)
<i>Centella asiatica</i> (L.) Urb. = <i>Hydrocotyle asiatica</i> L.	LC	Madhya Pradesh (VU 2006)
<i>Chamaecrista absus</i> (L.) H.S Irwin & Barneby	LC	–
<i>Chlorophytum borivilianum</i> Sant.*	CR	Madhya Pradesh (EN 2006), Maharashtra (EN 2001), Rajasthan (CR 2007)
<i>Chlorophytum tuberosum</i> (Roxb.) Baker	LC	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Chrysopogon zizanioides</i> (L.) Roberty*	–	–
<i>Cichorium intybus</i> L.*	–	–
<i>Cinnamomum cassia</i> (L.) J.Presl	–	–
<i>Cinnamomum sulphuratum</i> Nees	VU	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (VU 1998)
<i>Cinnamomum tamala</i> (Buch.-Ham.) T.Nees & Eberm	LC	Arunachal Pradesh (VU 2003), Himachal Pradesh (VU 2003, VU 2010), Jammu and Kashmir (EN 2003), Meghalaya (VU 2003), Nagaland (VU 2015), Uttarakhand (VU 2003)
<i>Cinnamomum verum</i> J.Presl *	–	–
<i>Cissus quadrangularis</i> L.	–	–
<i>Citrullus colocynthis</i> (L.) Schrad.	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Clerodendrum phlomidis</i> L.f.	–	–

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Clerodendrum serratum</i> (L.) Moon = <i>Rothea serrata</i> (L.) Steane & Mabb	–	Chhattisgarh (EN 2003), Madhya Pradesh (EN 2003)
<i>Coleus forskohlii</i> (Willd.) Briq.*	–	–
<i>Commiphora wightii</i> (Arn.) Bhandari	CR	Madhya Pradesh (CR 2003), Rajasthan (CR 2007)
<i>Convolvulus prostratus</i> Forsk.	–	–
<i>Coptis teeta</i> Wall.	EN	Arunachal Pradesh (EN 2003)
<i>Crateva religiosa</i> G.Forst.	–	–
<i>Cullen corylifolium</i> (L.) Medik.	–	–
<i>Curculigo orchioides</i> Gaertn.	–	–
<i>Curcuma zerumbet</i> Roxb = <i>Curcuma euchroma</i> Valetan*	–	–
<i>Cymbopogon citratus</i> (DC.) Stapf. *	–	–
<i>Cymbopogon flexuosus</i> (Nees ex Steud.)W.Watson*	–	–
<i>Cynodon dactylon</i> (L.) Pers.	–	–
<i>Cyperus rotundus</i> L.	–	–
<i>Cyperus scariosus</i> R.Br.	–	–
<i>Datura metel</i> L.	–	–
<i>Decalepis hamiltonii</i> Wight & Arn.	EN	Andhra Pradesh (EN 2001), Karnataka (EN 1999), Kerala (EN 1999), Tamil Nadu (EN 1998)
<i>Desmodium gangeticum</i> (L.) DC.	–	Himachal Pradesh (NE 2010)
<i>Didymocarpus pedicellatus</i> R.Br.	–	Himachal Pradesh (VU 2003, NT 2010), Jammu and Kashmir (EN 2003), Uttarakhand (VU 2003)
<i>Dioscorea bulbifera</i> L.	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Eclipta prostrata</i> (L.) L.	LC	–
<i>Embelia ribes</i> Burm.f.	–	Andhra Pradesh (CR 2001), Arunachal Pradesh (NT 2003), Karnataka (VU 1999), Kerala (NT 1999), Nagaland (VU 2015), Orissa (VU 2007), Sikkim (VU 2003)
<i>Embelia tsjeriam-cottam</i> (Roem. & Schult.) A. DC.	–	Chhattisgarh (NT 2003), Himachal Pradesh (VU 2003), Jammu and Kashmir (VU 2003), Karnataka (VU 1999), Kerala (NT 1999), Madhya Pradesh (VU 2003), Maharashtra (VU 2001), Orissa (VU 2007), Tamil Nadu (VU 1997), Uttarakhand (VU 2003)
<i>Ephedra gerardiana</i> Wall. Ex Stapf	–	Himachal Pradesh (VU 2003, VU 2010), Jammu and Kashmir (EN 2003), Sikkim (VU 2014), Uttarakhand (EN 2003)
<i>Erythrina variegata</i> L.	LC	–
<i>Eucalyptus globulus</i> Labill. *	–	–
<i>Ferula assa-foetida</i> L.	–	–
<i>Ficus benghalensis</i> L.	–	–
<i>Ficus religiosa</i> L.*	–	–
<i>Flickingeria macraei</i> (Lindl.) Seidenf. = <i>Dendrobium macraei</i> Lindl.	–	–
<i>Fumaria indica</i> (Hausskn.) Pugsley	–	Maharashtra (EN 2001)
<i>Garcinia gummi-gutta</i> (L.) Roxb.	–	Karnataka (NT 1999), Kerala (NT 1999), Tamil Nadu (NT 1998)

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Garcinia indica</i> (Thouars) Choisy	VU	Karnataka (VU 1999), Kerala (VU 1999), Maharashtra (NT 2001)
<i>Gloriosa superb</i> L.*	LC	Andhra Pradesh (VU 2001), Chhattisgarh (VU 2003), Himachal Pradesh (VU 2003), Jammu and Kashmir (VU 2003), Karnataka (VU 1999), Kerala (VU 1999), Madhya Pradesh (VU 2003), Maharashtra (VU 2001), Orissa (EN 2007), Rajasthan (VU 2007), Uttarakhand (VU 2003), West Bengal (VU 2007)
<i>Glycyrrhiza glabra</i> L.	–	–
<i>Gmelina arborea</i> Roxb.	LC	Madhya Pradesh (VU 2006)
<i>Gymnema sylvestre</i> (Retz.) R.Br. ex Sm.	–	Andhra Pradesh (VU 2001), Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Maharashtra (NT 2001), Rajasthan (EN 2007), West Bengal (VU 2007)
<i>Hedychium spicatum</i> Sm.	–	Nagaland (LC 2015), Sikkim (LC 2014)
<i>Helicteres isora</i> L.	–	–
<i>Hemidesmus indicus</i> (L.) R.Br. ex Schult.	–	–
<i>Hibiscus rosa-sinensis</i> L.	–	–
<i>Holarrhena pubescens</i> Wall. ex G.Don	–	–
<i>Holoptelea integrifolia</i> Planch.	–	–
<i>Homalomena aromatica</i> (Spreng.) Schott*	–	Arunachal Pradesh (VU 2003), Assam (EN 2003), Nagaland (VU 2015), Tripura (EN 2016)
<i>Hygrophila schulli</i> M. R. Almeida & S.M. Almeida = <i>Hygrophila auriculata</i> (Schumach.) Heine	LC	–
<i>Hyoscyamus niger</i> L.	–	Himachal Pradesh (EN 2003, NT 2010), Jammu and Kashmir (VU 2003), Uttarakhand (VU 2003)
<i>Indigofera tinctoria</i> L.*	–	–
<i>Inula racemosa</i> Hook.f.*	–	–
<i>Ipomoea mauritiana</i> Jacq.	–	West Bengal (NT 2007)
<i>Ipomoea nil</i> (L.) Roth	–	–
<i>Jasminum officinale</i> L.*	–	–
<i>Jasminum sambac</i> (L.) Aiton*	–	–
<i>Juniperus communis</i> L.	LC	Himachal Pradesh (VU 2010)
<i>Justicia adhatoda</i> L.*	–	–
<i>Justicia beddomei</i> (C.B.Clarke) Bennet *	–	–
<i>Kaempferia galanga</i> L.*	–	Tripura (DD 2016)
<i>Lactuca sativa</i> L.	–	–
<i>Lawsonia inermis</i> L.*	–	–
<i>Lepidium sativum</i> L.*	–	–
<i>Leptadenia reticulata</i> (Retz.) Wight & Arn.	–	Rajasthan (EN 2007)
<i>Litsea glutinosa</i> (Lour.) C.B.Rob.	–	Andhra Pradesh (CR 2001), Chhattisgarh (VU 2003), Himachal Pradesh (VU 2003, VU2010), Jammu and Kashmir (EN 2003), Madhya Pradesh (VU 2003), Orissa (VU 2007), Tripura (VU 2016), Uttarakhand (NT 2003)
<i>Madhuca indica</i> J.F.Gmel. = <i>Madhuca longifolia</i> var. <i>latifolia</i> (Roxb.) A.Chev	–	–

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Madhuca longifolia</i> (J.Koenig ex L.) J.F.Macbr.	–	Karnataka (VU 1999)
<i>Martynia annua</i> L.	–	–
<i>Melaleuca leucadendra</i> (L.) L.	–	–
<i>Melia azedarach</i> L.*	LC	–
<i>Mentha longifolia</i> (L.) L.	–	–
<i>Mesua ferrea</i> L.	–	Orissa (EN 2007), Tripura (NT 2016), West Bengal (EN 2007)
<i>Mimusops elengi</i> L.	LC	–
<i>Morinda citrifolia</i> L.*	–	West Bengal (VU 2007)
<i>Morinda coreia</i> Buch.-Ham.	–	–
<i>Moringa oleifera</i> Lam.*	–	–
<i>Mucuna pruriens</i> var. <i>utilis</i> (Wall. ex Wight) L.H.Bailey	–	Chhattisgarh (NT 2003), Madhya Pradesh (NT 2003), West Bengal (EN 2007)
<i>Murraya koenigii</i> (L.) Spreng.*	–	–
<i>Myristica fragrans</i> Houtt.*	–	–
<i>Nardostachys jatamansi</i> (D.Don) DC.	CR	Sikkim (VU 2014)
<i>Nelumbo nucifera</i> Gaertn.*	–	–
<i>Neopicrorhiza scrophulariiflora</i> (Pennell) D. Y. Hong	–	Sikkim (VU 2014)
<i>Ocimum americanum</i> L.	–	–
<i>Ocimum basilicum</i> L.*	–	–
<i>Ocimum gratissimum</i> L.*	–	Rajasthan (VU 2007)
<i>Ocimum tenuiflorum</i> L.*	–	–
<i>Onosma bracteata</i> Wall.	–	–
<i>Onosma hispida</i> Wall. ex G.Don	–	–
<i>Operculina turpethum</i> (L.) Silva Manso	–	Chhattisgarh (NT 2003), Karnataka (VU 1999), Kerala (EN 1999), Madhya Pradesh (NT 2003), Maharashtra (EN 2001), Orissa (VU 2007), Tamil Nadu (NT 1998)
<i>Oroxylum indicum</i> (L.) Kurz	–	Andhra Pradesh (VU 2001), Arunachal Pradesh (VU 2003), Assam (VU 2003), Chhattisgarh (VU 2003), Himachal Pradesh (NE 2010), Karnataka (VU 1996), Kerala (EN 1996), Madhya Pradesh (VU 2003), Maharashtra (EN 2001), Meghalaya (VU 2003), Nagaland (VU 2015), Orissa (EN 2007), Rajasthan (EN 2007), Sikkim (VU 2003, NT 2014), Tripura (NT 2016)
<i>Paederia foetida</i> L.	–	Andhra Pradesh (NT 2001), Orissa (VU 2007)
<i>Parmelia perlata</i> (Huds.) Ach	–	–
<i>Pedaliium murex</i> L.	–	–
<i>Peganum harmala</i> L.	–	Rajasthan (VU 2007)
<i>Phyllanthus amarus</i> Schum. & Thonn.	–	–
<i>Phyllanthus emblica</i> L.	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Phyllanthus maderaspatensis</i> L.	–	–
<i>Picrorhiza kurroa</i> Royle ex Benth.	–	Arunachal Pradesh (EN 2003), Himachal Pradesh (EN 2003, EN2010), Jammu and Kashmir (EN 2003), Sikkim (VU 2003), Uttarakhand (VU 2003), West Bengal (CR 2007)

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Pinus roxburghii</i> Sarg.	–	–
<i>Piper chaba</i> Hunter = <i>Piper retrofractum</i> Vahl	–	–
<i>Piper longum</i> L.*	–	Chhattisgarh (VU 2003), Kerala (NT1995), Orissa (EN 2007), Tamil Nadu (EN 1995)
<i>Pistacia integerrima</i> J.L. Stewart ex Brandis = <i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J. L. Stewart ex Brandis) Rech. f.	–	–
<i>Plantago ovata</i> Forssk.*	–	–
<i>Pluchea lanceolata</i> (DC.) C.B.Clarke	–	Madhya Pradesh (NT 2003)
<i>Plumbago indica</i> L.*	–	Andhra Pradesh (EN 2001),
<i>Plumbago zeylanica</i> L.	–	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Rajasthan (VU 2007)
<i>Polygonatum cirrhifolium</i> (Wall.) Royle	–	Himachal Pradesh (EN 2003, EN 2010), Sikkim (VU 2014), Uttarakhand (VU 2003)
<i>Pongamia pinnata</i> (L.) Pierre*	LC	–
<i>Premna corymbosa</i> Rottler & Willd.	–	–
<i>Premna serratifolia</i> L.	–	–
<i>Prunus armeniaca</i> L.*	–	–
<i>Prunus cerasoides</i> Buch.-Ham. ex D.Don	–	–
<i>Pseudarthria viscida</i> (L.) Wight & Arn.	–	Karnataka (VU 1999), Kerala (VU 1999), Tamil Nadu (NT 1998)
<i>Pterocarpus marsupium</i> Roxb.	NT	Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Maharashtra (VU 2001), Orissa (EN 2007), Rajasthan (CR 2007), West Bengal (EN 2007)
<i>Pterocarpus santalinus</i> L.f	NT	Andhra Pradesh (CR 2001), Tamil Nadu (CR 1998)
<i>Pueraria tuberosa</i> (Roxb. ex Willd.) DC.	–	Andhra Pradesh (NT 2001), Karnataka (CR 1999), Kerala (VU 1999), Madhya Pradesh (EN 2006), Maharashtra (VU 2001), Orissa (VU 2007), Rajasthan (VU 2007), Tamil Nadu (VU 1998)
<i>Punica granatum</i> L.	–	–
<i>Quercus infectoria</i> G. Olivier	–	–
<i>Rauwolfia serpentina</i> (L.) Benth. ex Kurz	–	Andhra Pradesh (CR 2001), Arunachal Pradesh (CR 2003), Assam (VU 2003), Chhattisgarh (CR 2003), Himachal Pradesh (CR 2003), Jammu and Kashmir (VU 2003), Karnataka (EN 1995), Kerala (EN 1995), Madhya Pradesh (VU 2003), Maharashtra (CR 2001), Meghalaya (VU 2003), Nagaland (DD 2015), Orissa (EN 2007), Tamil Nadu (VU 1995), Tripura (VU 2016), Uttarakhand (VU 2003), West Bengal (EN 2007)
<i>Rheum australe</i> D.Don	–	–
<i>Rhododendron arboretum</i> Sm.	–	–
<i>Rubia cordifolia</i> L.	–	Andhra Pradesh (VU 2001), Chhattisgarh (VU 2003), Madhya Pradesh (VU 2003), Maharashtra (VU 2001)
<i>Salacia reticulata</i> Wight	–	Karnataka (EN 1999)
<i>Salix caprea</i> L.	–	–

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Santalum album</i> L.	VU	Andhra Pradesh (EN 2001), Karnataka (VU 1999), Kerala (EN 1999), Maharashtra (EN 2001), Tamil Nadu (VU 1998)
<i>Sapindus mukorossi</i> Gaertn.*	–	Nagaland (VU 2015)
<i>Saraca asoca</i> (Roxb.) Willd.	–	Andhra Pradesh (EN 2001), Karnataka (EN 1995), Maharashtra (EN 2001), Orissa (CR 2007), Tripura (CR 2016)
<i>Saussurea costus</i> (Falc.) Lipsch.*	CR	Jammu and Kashmir (CR 2003)
<i>Scindapsus officinalis</i> (Roxb.) Schott	–	Orissa (VU 2007)
<i>Semecarpus anacardium</i> L.f.	–	–
<i>Senna alexandrina</i> Mill.*	–	–
<i>Senna auriculata</i> (L.) Roxb.	–	–
<i>Senna occidentalis</i> (L.) Link	–	–
<i>Senna tora</i> (L.) Roxb.	–	–
<i>Shorea robusta</i> Gaertn.	LR/lc	Andhra Pradesh (NT 2001)
<i>Sida acuta</i> Burm.f.	–	–
<i>Sida cordifolia</i> L.	–	–
<i>Sida rhombifolia</i> L.	–	–
<i>Smilax china</i> L.	–	–
<i>Solanum anguivi</i> Lam.	–	–
<i>Solanum nigrum</i> L. = <i>Solanum americanum</i> Mill.	–	–
<i>Solanum virginianum</i> L.	–	–
<i>Spermacoce hispida</i> L.	–	–
<i>Sphaeranthus indicus</i> L.	LC	–
<i>Stereospermum chelonoides</i> (L.f.) DC.	–	Chhatisgarh (NT 2003), Madhya Pradesh (NT 2003)
<i>Stereospermum tetragonum</i> DC.	–	–
<i>Strobilanthes ciliata</i> Nees	–	–
<i>Strychnos nux-vomica</i> A.W.Hill	–	Chhatisgarh (VU 2003)
<i>Strychnos potatorum</i> L.f.	–	Orissa (VU 2007)
<i>Swertia chirayita</i> (Roxb.) Buch.-Ham. ex C.B.Clarke	–	Arunachal Pradesh (VU 2003), Himachal Pradesh (CR 2003, CR 2010), Jammu and Kashmir (CR 2003), Meghalaya (VU 2003), Sikkim (VU 2003, EN 2014), Uttarakhand (EN 2003), West Bengal (CR 2007)
<i>Symplocos cochinchinensis</i> (Lour.) S. Moore	–	–
<i>Symplocos racemosa</i> Roxb.	–	Karnataka (VU 1996), Madhya Pradesh (VU 2006), Maharashtra (VU 2001), Nagaland (NT 2015), Orissa (CR 2007), Tamil Nadu (NT 1996)
<i>Syzygium cumini</i> (L.) Skeels*	–	–
<i>Tamarix gallica</i> L.	–	–
<i>Tamarix indica</i> Willd	–	–
<i>Tanacetum cinerariifolium</i> (Trevir.) Sch. Bip.*	–	–
<i>Taxus wallichiana</i> Zucc.	EN	Arunachal Pradesh (EN 2003), Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (EN 2003), Meghalaya (CR 2003), Sikkim (EN 2003), Uttarakhand (EN 2003), West Bengal (CR 2007)

Table 3 continued

Species	Threat status	
	IUCN threat category	CAMP exercise threat category [State (threat category and year of CAMP exercise)]
<i>Tecomella undulata</i> (Sm.) Seem.	–	Rajasthan (EN 2007)
<i>Tephrosia purpurea</i> (L.) Pers.	–	–
<i>Teramnus labialis</i> (L.f.) Spreng.	–	–
<i>Terminalia arjuna</i> (Roxb. Ex DC.) Wight & Arn.	–	Chhatisgarh (NT 2003), Karnataka (NT 1997), Kerala (NT 1997), Madhya Pradesh (NT 2003), Maharashtra (NT 2001), Rajasthan (VU 2007)
<i>Terminalia bellirica</i> (Gaertn.) Roxb.	–	–
<i>Terminalia chebula</i> Retz.	–	Chhatisgarh (VU 2003), Madhya Pradesh (VU 2003)
<i>Tinospora cordifolia</i> (Willd.) Miers	–	–
<i>Tinospora sinensis</i> (Lour.) Merr.	–	Karnataka (VU 1999), Kerala (NT 1999), Maharashtra (NT 2001)
<i>Tragia involucrata</i> L.	–	–
<i>Trianthema decandra</i> L.	–	–
<i>Tribulus lanuginosus</i> L.	–	–
<i>Tribulus terrestris</i> L.	–	–
<i>Trichosanthes cucumerina</i> L.	–	Andhra Pradesh (NT 2001), Madhya Pradesh (NT 2006)
<i>Trillidium govanianum</i> Wall. ex D.Don	–	Sikkim (DD 2015)
<i>Uraria picta</i> (Jacq.) DC.	LC	Chhatisgarh (VU 2003), Himachal Pradesh (NE 2010), Madhya Pradesh (VU 2003), Orissa (EN 2007)
<i>Valeriana jatamansi</i> Jones	–	Arunachal Pradesh (VU 2003), Himachal Pradesh (VU 2003), Jammu and Kashmir (VU 2003), Meghalaya (VU 2003), Nagaland (VU 2015), Sikkim (VU 2003, VU 2014), Uttarakhand (VU 2003)
<i>Viola pilosa</i> Blume	–	–
<i>Vitex negundo</i> L.*	–	–
<i>Withania somnifera</i> Dunal *	–	–
<i>Woodfordia fruticosa</i> (L.) Kurz	–	–
<i>Wrightia tinctoria</i> R.Br.	–	–
<i>Zanthoxylum armatum</i> DC.	LC	Himachal Pradesh (EN 2003, EN 2010), Jammu and Kashmir (VU 2003), Nagaland (VU 2015), Orissa (VU 2007), Uttarakhand (VU 2003)
<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm.	DD	–
<i>Ziziphus mauritiana</i> Lam.	–	–

EX: Extinct; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; LR: Lower Risk; LR: Lower Risk; NT: Near threatened; LC: Least concern; DD: Data deficient

IUCN Red list under medicine for human and veterinary group is used

(Source: Goraya and Ved 2017)

*species which are in cultivation

pertaining to the medicinal plants (NMPB 2020a). Thereafter in 2006–07 and 2015, NMPB commissioned the nation-wide study through the ICFRE in strategic partnership with FRLHT with the major

objective to assess the status of demand and supply of medicinal plants in India for the said period (Goraya and Ved 2017).

In a span of ten years (2005–14) tremendous increase in demand and supply of the medicinal plants is recorded (Goraya and Ved 2017). A 62% increase in annual demand of herbal raw drugs was observed for the year 2014–15 over the demand estimated for the year 2005–06 (Ved and Goraya 2008). The volume of botanical drugs exported increased from 56,500 Metric Tonne (MT) in 2005–06 to 1,34,500 MT in 2014–15. About seven times higher (10,680 million in 2005–06 to 70,000 million in 2014–15) estimated trade value of herbal drugs was registered in 10 years. The trade value of herbal raw drugs consumed by the domestic herbal industry has also registered more than two fold increase as per the latest estimates during 2014–15. A total of 242 species are enlisted as high commercial demand (> 100 MT/year) during 2014–15 (Table 3) in contrast to 178 species in 2005–06 (Ved and Goraya 2008). Out of 242 species 114 (47%) are collected from forests, 59 species (25%) are wild and collected from landscapes outside forests, 54 species (22%) are obtained from cultivation and 15 species (6%) are imported. A total of 1,389 botanical entities corresponding to 960 plant species were enlisted under trade in the study conducted by NMPB (Goraya and Ved 2017). India's domestic herbal industry is represented by 8,610 licensed herbal units (Ayurveda-7,494, Unani-421, Siddha-328 and Homeopathy-367) spread across different states in the country. Uttar Pradesh has the highest units of 2,247 followed by Kerala (905), Maharashtra (705), Tamil Nadu (662), Madhya Pradesh (633), Andhra Pradesh (610), Gujarat (495), Haryana (300), Punjab (284), Bihar (281), West Bengal (277), Rajasthan (268), Uttarakhand (240), Karnataka (177), Orissa (160), Himachal Pradesh (138), Delhi (63), Assam (53), Pondicherry (41), Nagaland (34), Chhattisgarh (31), Jammu and Kashmir (15), Daman and Diu (10), Goa (7), Dadra and Nagar Haveli (5), Chandigarh (1), Meghalaya (1) and Sikkim (1) (Goraya and Ved 2017).

National efforts towards conservation of medicinal plants

The Government of India (GoI) took due cognizance for medicinal plants since early 1990s and several activities have been undertaken to protect and conserve these species both in situ (biosphere reserves, national parks, wild life sanctuaries, sacred groves

etc.) and ex situ (botanical gardens, field gene banks, seed gene banks, in vitro gene banks and cryo-genebanks). For in situ conservation, of the total geographical area of India about 16.5 million ha (5.02%) is under protected areas and 70.8 million ha (21.54%) is under forests. In India, a total of 870 protected areas are earmarked which include 104 national parks, 551 wildlife sanctuaries, 127 community reserves, 88 conservation reserves (WIENVIS 2019). Further, an estimated 100,000 – 150,000 sacred groves are present in India (Kandari et al. 2014). For ex situ conservation several institutes/organizations have been established by GoI, especially to undertake research on medicinal plants viz., Central Council for Research in Ayurvedic Sciences (CCRAS), Central Council for Research in Homoeopathy (CCRH), Central Council for Research in Siddha (CCRS) and Central Council for Research in Unani Medicine (CCRUM) under Ministry of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Botanical Survey of India (BSI) and its regional circles and experimental gardens at different geographic regions of India, Kerala State Council for Science, Technology and Environment (KSCSTE)-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE – JNTBGRI, formerly TBGRI), Indian Council of Forestry Research and Education (ICFRE), Council of Scientific and Industrial Research (CSIR) institutes *i.e.*, Central Drug Research Institute (CDRI), Central Institute of Medicinal and Aromatic Plants (CIMAP), National Botanical Research Institute (NBRI) and the Regional Research Laboratories (RRLs), Institute of Himalayan Bioresource Technology; Institutes under the Indian Council of Agricultural Research (ICAR) namely ICAR-National Bureau of Plant Genetic Research (ICAR-NBPGR), ICAR-Directorate of Medicinal and Aromatic Plants (ICAR-DMAPR) and ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), ICAR-All India Network Research Project on Medicinal and Aromatic Plants (AINRP MAPs). In addition, several other government and non-government organizations, industries, ayurvedic practitioners are also involved in conservation and cultivation of these medicinal plants (Bhattacharyya et al. 2006).

A network of four National Gene Banks for Medicinal and Aromatic Plants (GEBMAP) were set up in 1993 at (1) ICAR-NBPGR (2) KSCSTE – JNTBGRI, (3) CSIR-CIMAP, and (4) Regional

Research Laboratory (RRL) Jammu (added later) under the G-15 GEBMAP program with Department of Biotechnology (DBT), Ministry of Science and Technology, GoI, as nodal agency. This has not only given better focus and thrust especially on collection and conservation of medicinally important threatened species but also helped in consolidating the ongoing efforts in the country (Sharma and Pandey 2013; Sharma et al. 2019, 2020). JNTBGRI herbal garden has a collection of 1,200 taxa herbals in an area of 10 acres (KSCSTE-JNTBGRI 2019). At CSIR-CIMAP, a total of 3,334 accessions in seed bank (2,476 accessions) and field genebank (868 accessions) are being maintained (Rajpurohit and Jhang 2015).

ICAR-NBPGR is the nodal agency for all the activities introduction, collection, conservation, documentation, evaluation and distribution of plant genetic resources (PGR) in the country. It has 10 regional stations located in different agro-climatic zones of the country and the 59 National Active Germplasm Sites (NAGS) which are based at ICAR institutes (specific crops groups) and are assigned with multiplication, evaluation, conservation of active collections of germplasm and their distribution to users both at the national and international levels. In addition, several ICAR institutes, State Agricultural Universities and other stakeholders are also linked to the network (Singh et al. 2016). The National Gene Bank of ICAR-NBPGR has four types of conservation facilities i.e., seed gene bank, cryogenebank, in vitro gene bank and field genebank. At ICAR-NBPGR, 8,071 accessions of MAPs in seed genebank, 178 accessions in in vitro genebank and 1,041 accessions in cryogenebank are being conserved (Singh and Pandey 2019; Sharma et al. 2020).

The GoI has also established NMPB in 2000 under Ministry of AYUSH, and provided funds for research on medicinal plants. In addition to NMPB, DBT and Department of Science and Technology (DST) have also supported researchers to undertake research on medicinal plants. Recently (2019) NMPB prioritized 32 medicinal plants for conservation (*Aconitum ferox* Wall ex Ser., *Aconitum heterophyllum* Wall., *Aegle marmelos* (L.) Corr., *Andrographis paniculata*, *Asparagus racemosus* (Burm.) Nees, *Bacopa monnieri* (L.) Wettst., *Berberis aristata* DC., *Cassia angustifolia* M Vahl. = *Senna alexandrina* Mill., *Chlorophytum borivillianum* Sant., *Coleus barbatus* Benth., *Commiphora wightii* (Arn.) Bhandari, *Crocus sativus* L.,

Embelia ribes Burm.f., *Embliba officinalis* Gaertn. = *Phyllanthus emblica* L, *Garcinia indica* Choisy, *Gloriosa superb* L., *Glycyrrhiza glabra* L., *Gymnema sylvestre* (Retz.) R. Br., *Nardostachys jatamansi* (Retz.) R. Br., *Ocimum sanctum* L., *Phyllanthus amarus* Schum. & Thonn., *Picrorhiza kurroa* Royle ex Benth., *Piper longum* L, *Plantago ovate* Forsk., *Rauvolfia serpentina* Benth. ex Kurz., *Santalum album* L., *Saraca asoca* (Roxb.) De Wilde, *Saussurea costus* (Falc.) Lipsch, *Solanum nigrum* L., *Swertia chirata* Roxb. ex Flem., *Tinospora cordifolia* Miers., *Withania somnifera* Dunal (NMPB 2020b). NMPB has also taken initiatives for in situ conservation of medicinal plants through establishment of 72 Medicinal Plants Conservation and Development Areas (MPCDAs) across 13 states of the country, covering an area of 10,935 ha in forest areas (Biswas et al. 2017) and 36 State Medicinal Plant Boards in State/UT. FRLHT in collaboration with the State Forest Departments and with financial support of Danish International Development Aid (DANIDA), Netherlands, and United Nations Development Programme (UNDP) has established 108 Medicinal Plant Conservation Areas (MPCAs) across 13 states and 18 Medicinal Plants Conservation Parks (MPCPs) in southern India for focusing on conservation of prioritized wild medicinal plants occurring in different regions of the country (FRLHTENVIS 2016b). In 2012, DBT initiated a mega-network programme on 'Preventing extinction and improving the conservation status of threatened plants through application of biotechnological tools and conserved 100 threatened species of India (Barik et al. 2018). Under this project 115 species were reintroduced, macropropagation protocols were standardized for 106 species and micropropagation protocols were standardized for 76 species (Barik et al. 2018).

Regulatory and policy framework in India

The medicinal plant species in trade (both domestic and international) are sourced from many different agro-climatic zones in the country from the wild, and only a very small number of species are cultivated (Pareek et al. 2005; Sharma and Pandey 2013). Besides these, there is no data documented regarding the consumption levels of botanicals by the non-codified and non-commercial folk healthcare

Table 4 List of plants notified by the Central Government, in consultation with the State Government under Sect. 38 of India's Biological Diversity Act, 2002 (Source: The Gazette of India: Extraordinary, Ministry of Environment and Forests of each state)

State/Union Territory	Listed species	Notification date in Gazette of India
Assam	<i>Cycas pectinata</i> Buch.-Ham., <i>Magnolia cathcartii</i> (Hook.f. & Thomson) Noot., <i>Magnolia manni</i> (King) Figlar, <i>Mesua assamica</i> (King & Prain) Kosterm., <i>Paphiopedilum spicerianum</i> (Rchb.f.) Pfitzer, <i>Vatica lanceaefolia</i> (Roxburgh) Blume	August 3, 2018
Andaman and Nicobar Islands	<i>Artabotrys nicobarianus</i> D.Das, <i>Calamus nicobaricus</i> Becc., <i>Korthalsia rogersii</i> Becc., <i>Mangifera andamanica</i> King, <i>Ophioglossum pendulum</i> L.	October 26, 2012
Bihar	<i>Chrysopogon hamiltonii</i> (Hook.f.) Haines	February 8, 2011
Goa	<i>Ceropegia fantastica</i> Sedgw., <i>Phyllanthus talbotii</i> Sedgw.	March 31, 2010
Himachal Pradesh	<i>Aconitum deinorrhizum</i> Stapf., <i>Aconitum heterophyllum</i> Wall. ex Royle., <i>Aconitum violaceum</i> Jacquem. ex Stapf, <i>Dactylorhiza hatagirea</i> (D.Don) Soó, <i>Eremostachys superba</i> Royle ex Benth., <i>Jasminum parkeri</i> Dunn., <i>Nardostachys grandiflora</i> DC., <i>Taxus wallichiana</i> Zucc.	March 19, 2009
Jammu & Kashmir	<i>Aconitum chasmanthum</i> Stapf. ex Holmes, <i>Aconitum deinorrhizum</i> Stapf., <i>Aconitum heterophyllum</i> Wall. ex Royle., <i>Aconitum kasmiricum</i> Stapf Ex. Coventry., <i>Aconitum violaceum</i> Jacquem. ex Stapf., <i>Betula utilis</i> D. Don, <i>Dactylorhiza hatagirea</i> (D.Don) Soó., <i>Eremostachys superba</i> Royle ex Benth., <i>Gentiana ornata</i> Wall. Ex. Griseb., <i>Gentiana kurroo</i> Royle, <i>Lagotis cashmeriana</i> (Royle) Rupr., <i>Meconopsis latifolia</i> (Prain) Prain., <i>Meconopsis aculeata</i> Royle, <i>Podophyllum hexandrum</i> Royle, <i>Picrorrhiza kurroa</i> Royle Ex. Benth., <i>Taxus wallichiana</i> Zucc., <i>Saussurea costus</i> (Falc.) Lipsch., <i>Saussurea medusa</i> Maxim., <i>Saussurea simpsoniana</i> (Fielding & Gardner) Lipsch., <i>Sophora moorcroftiana</i> Benth. Ex. Baker	August 3, 2018
Kerala	<i>Adenosma malabaricum</i> Hook.f., <i>Agasthiyamalaia pauciflora</i> (Bedd.) S.Rajkumar & Janarth. (= <i>Poeciloneuron pauciflorum</i> Bedd.), <i>Aglaiia malabarica</i> Sasidh., <i>Anacolosia densiflora</i> Bedd., <i>Atuna indica</i> (Bedd.) Kosterm., <i>Calliandra cynometroides</i> Bedd., <i>Cinnamomum travancoricum</i> Gamble, <i>Dialium travancoricum</i> Bourd., <i>Dimorphocalyx beddomei</i> (Benth.) Airy Shaw, <i>Dipterocarpus bourdillonii</i> Brandis, <i>Elaeocarpus venustus</i> Bedd., <i>Garcinia imbertii</i> Bourd., <i>Haplothismia exannulata</i> Airy Shaw, <i>Humboldtia bourdillonii</i> Prain, <i>Humboldtia trijuga</i> (Bedd.) M. Mohanan, <i>Janakia arayalpathra</i> J. Joseph & Chandras., <i>Madhuca bourdillonii</i> (Gamble) H.J.Lam, <i>Memecylon sisparens</i> Gamble, <i>Paphiopedilum druryi</i> (Bedd.) Stein, <i>Salacia malabarica</i> Gamble, <i>Syzygium palghatense</i> Gamble, <i>Syzygium periyarensis</i> Augustine & Sasidh., <i>Toxocarpus beddomei</i> Gamble, <i>Toxocarpus palghatensis</i> Gamble, <i>Vanda thwaitesii</i> Hook.f., <i>Vanda wightii</i> Rchb.f	April 23, 2009
Karnataka	<i>Barleria grandiflora</i> Dalzell., <i>Beaumontia jerdoniana</i> Wight, <i>Ceropegia decaisneana</i> Wight, <i>Cinnamomum goense</i> Kosterm., <i>Holigarna beddomei</i> Hook.f., <i>Hopea canarensis</i> Hole, <i>Impatiens mysorensis</i> Roth, <i>Impatiens raziana</i> Bhaskar & Razi, <i>Justicia nilgherrensis</i> (Nees) Wall. ex C.B.Clarke, <i>Madhuca insignis</i> (Radlk.) H.J.Lam, <i>Phyllanthus talbotii</i> Sedgw., <i>Salacia malabarica</i> Gamble, <i>Toxocarpus concanensis</i> Hook.f., <i>Toxocarpus palghatensis</i> Gamble, <i>Vanda thwaitesii</i> Hook.f., <i>Vanda wightii</i> Rchb.f	November 4, 2020
Manipur	<i>Kalanchoe rosea</i> Clarke, <i>Lilium davidii</i> Duch. ex Elwes, <i>Malus baccata</i> (L.) Borkh., <i>Rhododendron macabeanum</i> Watt ex Balf.f., <i>Rhododendron wattii</i> Cowan	October 29, 2012
Madhya Pradesh	<i>Alsophila balakrishnani</i> (Dixit & Tripathi) Dixit = <i>Cyathea gigantea</i> (Wall.ex Hook.) Holtt., <i>Ficus cupulata</i> Haines, <i>Jasminum brevipetiolatum</i> Duthie	June 7, 2010
Meghalaya	<i>Aquilaria khasiana</i> Hallier f., <i>Gymnocladus assamicus</i> P.C.Kanjilal, <i>Ilex khasiana</i> Purkay., <i>Jasminum adenophyllum</i> Wall. ex C.B.Clarke, <i>Nepenthes khasiana</i> Hook.f., <i>Nymphaea tetragona</i> Georgi	September 30, 2009

Table 4 continued

State/Union Territory	Listed species	Notification date in Gazette of India
Mizoram	<i>Aquilaria malaccensis</i> Lam., <i>Cinnamomum aromaticum</i> Nees = <i>C. cassia</i> (L.) J.Presl., <i>Dalbergia pinnata</i> var. <i>acaciifolia</i> (Dalzell) Thoth., <i>Hydnocarpus kurzii</i> (King) Warb., <i>Jasminum wengeri</i> C.E.C.Fisch., <i>Mantisia wengeri</i> C.E.C.Fisch., <i>Paphiopedilum spicerianum</i> (Rchb.f.) Pfitzer, <i>Paphiopedilum villosum</i> (Lindl.) Stein	October 5, 2009
Orissa	<i>Lasiococca comberi</i> Haines	September 30, 2009
Punjab	<i>Alysicarpus bupleurifolius</i> var. <i>hybridus</i> DC., <i>Ceropegia bulbosa</i> var. <i>lushii</i> (Graham) Hook.f. = <i>Ceropegia lushii</i> Graham, <i>Hibiscus hoshiarpurensis</i> T.K.Paul & M.P.Nayar, <i>Ophioglossum gramineum</i> Willd., <i>Ophioglossum polyphyllum</i> A. Braun ex Schub., <i>Tecomella undulata</i> (Sm.) Seem., <i>Withania coagulans</i> (Stocks) Dunal, <i>Anogeissus sericea</i> var. <i>nummularia</i> King ex Duthie	February 4, 2014
Tamil Nadu	<i>Belosynapsis kewensis</i> Hassk., <i>Byrosphyllum tetrandrum</i> (Bedd.) J.Hk. ex Bedd., <i>Cinnamomum walaiwarensense</i> Kosterm., <i>Didymocarpus missionis</i> Wall. ex R.Br., <i>Dimorphocalyx beddomei</i> (Benth.) Airy Shaw, <i>Diospyros barberi</i> Ramaswami, <i>Diospyros humilis</i> (R.Br.) F.Muell., <i>Drypetes porteri</i> (Gamble) Pax & K.Hoffm., <i>Elaeocarpus blascoi</i> Weibel, <i>Elaeocarpus venustus</i> Bedd., <i>Hoya kanyakumariana</i> A.N.Henry & Swamin., <i>Impatiens auriculata</i> Wight, <i>Janakia arayalpathra</i> J. Joseph & Chandras., <i>Memecylon sisparensense</i> Gamble, <i>Paphiopedilum druryi</i> (Bedd.) Stein, <i>Phyllanthus anamalayanus</i> (Gamble) G.L.Webster (= <i>Pseudoglochidion anamalayapum</i> Gamble), <i>Popowia beddomeana</i> Hook.f. & Thomson, <i>Sonerila pulneyensis</i> Gamble, <i>Symplocos oligandra</i> Bedd., <i>Syzygium beddomei</i> (Duthie) Chithra, <i>Syzygium courtallense</i> (Gamble) Alston, <i>Syzygium gambleanum</i> Rathakr. & V. Chithra, <i>Toxocarpus beddomei</i> Gamble	March 3, 2011
Tripura	<i>Stichoneuron membranaceum</i> Hook.f	February 3, 2011
Uttarakhand	<i>Aconitum balfourii</i> Stapf, <i>Aconitum heterophyllum</i> Wall. ex Royle, <i>Aconitum violaceum</i> Jacquem. ex Stapf, <i>Butea pellita</i> Prain, <i>Cyathea spinulosa</i> Wall. ex Hook., <i>Diplomeris hirsuta</i> (Lindl.) Lindl., <i>Eremostachys superba</i> Royle ex Benth., <i>Gentiana kurroo</i> Royle, <i>Indoptadenia oudhensis</i> (Brandis) Brenan, <i>Nardostachys grandiflora</i> DC., <i>Pinguicula alpina</i> L., <i>Schrebera swietenoides</i> Roxb., <i>Trachycarpus takil</i> Becc., <i>Turpinia nepalensis</i> Wall	April 15., 2019
West Bengal	<i>Hibiscus fragrans</i> Roxburgh, <i>Streptocaulon sylvestre</i> Wight	April 7, 2010

Authority and appropriate synonyms as per The Plant List (www.theplantlist.org), International Plant Names Index (IPNI; www.ipni.org) and India Biodiversity Portal (indiabiodiversity.org)

traditions, based primarily on ecosystem and region-specific plant material practiced by around one million folk practitioners and ~ 140 millions of rural households in the country. It is important to note that of 242 species in high commercial demand (> 100 MT per year), 72% of these species is sourced largely from wild plants as roots, bark, wood stem or the whole plant. This poses a major concern as it affects the survival of these species. Unsustainable collecting activities coupled with limited or no efforts of replenishment/cultivation, long duration life cycle of plants, climate change and developmental activities have led to rapid decline in the availability of many medicinal plant species in the country during the last three decades. This has culminated into a large number

of species falling in to threatened group at country as well as global level. In order to minimize this, the GoI has developed few regulatory frameworks and policies viz.,

- Indian Forest Act, 1927;
- Panchayat Raj Act, 1933;
- The West Bengal Forest Produce Transit Rules, 1955;
- Andaman and Nicobar Island Forest Produce Transit Rules, 1966;
- Wildlife (Protection) Act, 1972 (Amended 2003) Also 2006;
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1975;
- Kerala Forest Produce Transit Rules, 1975;

- The Forest (Conservation) Act (Amended), 1980;
- Environment Protection Act, 1986;
- National Forest Policy, 1988;
- Negative list of Plants for Exports and Imports (Revised), 1994;
- Panchayat (Extension to Scheduled Areas)(PESA) Act, 1996;
- National Biodiversity Strategy and Action Plan, 2002;
- The Biological Diversity Act, 2002;
- Biological Diversity Rules, 2004;
- Negative list of MAP Collection from Wild, 2004;
- Scheduled Tribes and Other Traditional Forest Dwellers Act (FRA), 2006;
- Maharashtra Forests Rules, 2014, The HP Forest Produce Transit (Land Route) Rules, 2013;
- Export Import Policy, 2015–20;
- National Wildlife Action Plan 2017–31;

As per Sect. 38 of the Biological Diversity Act, 2002, the Central Government, in consultation with the Government of states, notifies the plants which are on the verge of extinction (Table 4). The NMPB has developed several policies, strategies and programs for conservation, proper harvesting, cost-effective cultivation, research and development, processing, marketing of raw material to promote and develop medicinal plants sector. Recently a Memorandum of Understanding (MoU) has been signed between ICAR-NBPGR and NMPB on July 6, 2020 for safe conservation of Medicinal and Aromatic Plants Genetic Resources for long-term storage at the National Gene Bank of ICAR-NBPGR (ICAR-NBPGR 2020).

In addition to national policy framework, India has also signed few international agreements:

(i) Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), an international agreement between governments which aims to ensure that international trade of wild animals and plants does not lead to any threat on their survival. There are about 5,000 species of animals and 28,000 species of plants that are protected by CITES against over-exploitation through international trade. The Ministry of Environment, Forest and Climate Change, GoI, has notified a list of 113 species (CITES 2017), the export of which requires 'Certificate of Cultivation' or 'Legal Procurement Certificate' from the designated authorities of the Forest Departments. At

present twelve of the Indian medicinal plants are included in the appendices of CITES viz., Appendix I (*Saussurea costus*), Appendix II (*Aquilaria malaccensis* Lam. = *A. agalocha* Roxb.ex DC., *Cycas bedonii* Dyer., *Dioscorea deltoidea* Wall. Ex Kunth, *Rauvolfia serpentina*, *Cibotium barometz* Link., *Podophyllum hexandrum* Royle, *Pterocarpus santalinus* L.F., *Nardostachys grandiflora* DC., *Nepenthes khasiana* Hook. f., *Picrorhiza kurrooa*, *Taxus wallichiana* Zucc.).

(ii) The EXIM Policy—Plants Prohibited for Exports. Under this export of 29 plants (*Aconitum* species, *Aquilaria malaccensis*, *Coscinium fenestratum* (Gaertn.) Coleb., *Coptis teeta* Wall., Cyatheaceae species, *Cycas beddomei*, Cycadaceae species, *Dioscorea deltoidea*, *Dactylorhiza hatagirea* (DON.) SOO, *Euphorbia* species, *Frerea indica* Dalz, *Gentiana kurroo* Royle., *Gnetum* species, *Podophyllum hexandrum*, *Kaempferia galanga* L., *Nardostachys grandiflora*, *Nepenthes khasiana*, Orchidaceae species, *Panax pseudoginseng* Wall., *Paphiopedilum* species, *Picrorhiza kurrooa*, *Pterocarpus santalinus*, *Rauvolfia serpentina*, *Renanthera imschootiana* Rolfe., *Saussurea costus*, *Swertia chirata*, *Taxus wallichiana*, *Vanda coerulea* Griff. Ex Lindl.), plant portions and their derivatives and extracts as such obtained from the wild except the formulations made there from, is prohibited.

(iii) Foreign Trade under ITC (HS) Codes and its Limitations.

Reintroduction of threatened plants in natural habitat

Reintroduction of threatened plants is the approach of re-establishment into an area suitable for its growth or from where it has become threatened. Through micro- or macropropagation, such plants have to be produced in large numbers to reintroduce in nature especially. The basic idea of this approach is to establish a self-sustaining population for conservation purposes. A species is said to be 'recovered', once the factors that initially led to its listing in threatened species are remedied and protection is no longer required. This approach has been successfully applied in India as a part of conservation efforts of threatened plants *i.e.*, *Vanda coerulea* Griff ex. Lindl. (Seeni and Latha 2000), *Syzygium travancorium* Gamble (Anand 2003),

Decalpis arayalpathra J. Joseph & V. Chandrasekaran, *Mahonia leschenaultia* (Wallich ex Wight & Arnott) Takeda = *Berberis napaulensis*, *Heracleum candolleanum* (WT. & ARN.) GAMBLE, *Calophyllum apetalum* Willd. and *Blepharistemma serratum* (Densst.) Suresh = *Blepharistemma membranifolia* (Krishnan et al. 2011), *Ceropegia fantastica* Sedgwick (Ravikanth et al. 2018). In recent years, the DBT has initiated a several species-specific recovery programmes targeting 156 highly threatened species of the country during the past three decades. These species belong to 101 genera and 64 families, and comprise herbs (50), trees (42), orchids (24), shrubs (14), climbers (14), bamboos (3), palms (3), rattans (3), cycads (2), and tree fern (1) (DBT 2019).

Way Forward

- Every plant on this planet is known to possess one or the medicinal properties, but all these plants can't be classified as medicinal plants. For example, *Abelmoschus esculentus* (L.) Moench., *Allium cepa* L., *A. sativum* L., *Amaranthus spinosus* L., *A. tricolor* L., *Brassica juncea* (L.) Czern., *Carica papaya* L., *Citrus acida* Roxb., *C. limon* (L.) Burm. etc. are listed in Indian traded medicinal plants list, *Abelmoschus moschatus* Medik. in CAMP, *Psidium guajava* L. and *Vigna angularis* (Willd.) Ohwi & H. Ohashi in IUCN. Hence, it is urgently required to regroup and clearly demarcate the medicinal plants.
- As many projects have been completed in the past two decades, a database should be prepared at national level, with significant outcomes of the projects. Duplication of work may be avoided and it would help to identify research gap.
- Instead of several projects in parts, a mega-network project needs to be carried out for ex situ conservation of medicinal plants. As many botanical gardens are being established, but maintaining in botanical gardens/field gene banks is a risky approach, costly affair and more chances of loss of crops due to climate change, pests, diseases and natural calamities. Hence, seed conservation/ in vitro conservation/ cryopreservation may be used for long-term safe conservation.
- Large diversity of any crop is essential for crop improvement, so emphasis may be given that entire genetic diversity of priority medicinal plants are conserved.
- Though India has taken extensive activities to conserve medicinal plants, the collections remain fragmented. There is need for establishment of long-term conservation strategies which are both sustainable and accessible. The ICAR- NBPGR has been conserving all diversity in agri-horticultural crops, where it is mandatory to obtain a national identity- indigenous collection (IC) number before release of any varieties. Similarly for medicinal plants, there is need to follow similar system by all Institutes across India. Recent MOU between ICAR-NBPGR is one such step to enhance focus on conservation of this important group of plants.
- All germplasm with relevant passport information must be conserved in National Gene Bank (seed genebank/in vitro/field genebanks) with a back up duplicate set at regional/Institute level, to not only ensure sustainable availability of diversity for use but also safeguarding threatened medicinal plants for future generations and future unforeseeable diseases/pandemics.

Conclusion

This paper provides, an easy, updated, ready-to-use guide for information for Indian threatened medicinal plant species, as designated by Indian and global agencies and conservation efforts. Further, online access to data is subject to availability of internet access. Consolidated offline information, as provided in this paper, is often required by students, teachers, policy makers etc., as a ready reckoner. This will help not only the researchers but also policy makers in developing strategies for efficient conservation/cultivation to ensure availability of these precious resources for utilization by future generations.

Acknowledgements Authors are thankful to Director, ICAR-NBPGR, New Delhi, for encouragement.

Author contributions Gowthami R and Neelam Sharma conceived the idea, gathered information and wrote the draft. Ruchira Pandey and Anuradha Agrawal provided constructive

feedback and editorial inputs. All authors have reviewed, edited and approved the manuscript.

Funding No funding.

Declaration

Conflict of interest The authors declare no conflicts of interest.

References

- Ahmadullah M, Nayar MP (1999) Red data book of Indian Plants (Peninsular India): Botanical Survey of India. Calcutta
- Anand A (2003) Studies on genetic stability of micropropagated plants and reintroduction in an endemic and endangered taxon: *Syzygium travancorium* Gamble. J Plant Biotechnol 5:201–207
- Bapat VA, Yadav SR, Dixit GB (2008) Rescue of endangered plants through biotechnological applications. Nat Acad Sci Lett 31:201–210
- Barik SK, Tiwari ON, Adhikari D, Singh PP, Tiwary R, Barua S (2018) Geographic distribution pattern of threatened plants of India and steps taken for their conservation. Curr Sci 114:470–503
- Bhattacharyya R, Bhattacharya S, Chaudhuri S (2006) Conservation and documentation of the medicinal plant resources of India. In: Hawksworth DL, Bull AT (eds) Human Exploitation and Biodiversity Conservation, Springer, Dordrecht, pp 365–377. <https://doi.org/10.1007/978-1-4020-5283-5>.
- Biswas S, Rawat MS, Tantray FA, Sharma S (2017) Medicinal plants conservation and development areas (MPCDAs) - An initiative towards conservation of medicinal plants. Medicinal Plants. Int J Phytomedicines Related Industries 9:143–149. <https://doi.org/10.5958/0975-6892.2017.00022.3>
- Brooks TM, Bakarr MI, Boucher T, Da Fonseca GA, Hilton-Taylor C, Hoekstra JM, Moritz T, Olivieri S, Parrish J, Pressey RL, Rodrigues AS (2004) Coverage provided by the global protected-area system: is it enough? Bioscience 54:1081–1091. [https://doi.org/10.1641/0006-3568\(2004\)054\[1081:CPBTGP\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2004)054[1081:CPBTGP]2.0.CO;2)
- CITES (2017) CITES listed species. <https://www.cites.org/eng/disc/species.php>. Accessed on 3.1.2020.
- Collar NJ (1996) The reasons for Red Data Books. Oryx 30:121–130. <https://doi.org/10.1017/S0030605300021505>
- Collen B, Dulvy NK, Gaston KJ, Gärdenfors U, Keith DA, Punt AE, Regan HM, Böhm M, Hedges S, Seddon M, Butchart SH (2016) Clarifying misconceptions of extinction risk assessment with the IUCN Red List. Biol Lett 12:20150843. <https://doi.org/10.1098/rsbl.2015.0843>
- DBT (2019) Department of Biotechnology. Conservation of Threatened Plants of India. <http://www.dbtindia.gov.in/conservation-threatened-plants-india>. Accessed on 4.5.2020.
- FRLHTENVIS (2016a) Centre on Medicinal Plants. Medicinal plants under threat. <http://envis.frlht.org/overview.html>. Accessed on 6.4.2020.
- FRLHTENVIS (2016b) Centre on Medicinal Plants. Medicinal Plant Conservation Areas <http://envis.frlht.org/mpca.php>. Accessed on 6.4.2020.
- Goraya GS, Jishtu V, Rawat GS, Ved DK (2013) Wild medicinal plants of Himachal Pradesh: An assessment of their conservation status and management prioritization. Himachal Pradesh Forest Department, Shimla
- Goraya GS, Ved DK (2017) Medicinal plants in India: an assessment of their demand and supply. National Medicinal Plants Board, Ministry of AYUSH, Government of India, New Delhi and Indian Council of Forestry Research and Education, Dehradun
- Hammer K, Khoshbakht K (2005) Towards a 'red list' for crop plant species. Genet Resour Crop Evol 52:249–265. <https://doi.org/10.1007/s10722-004-7550-6>
- Hazarika TK, Marak S, Mandal D, Shukla AC (2016) Underutilized and unexploited fruits of Indo-Burma hot spot, Meghalaya, north-east India: ethno-medicinal evaluation, socio-economic importance and conservation strategies. Genet Resour Crop Evol 63:289–304. <https://doi.org/10.1007/s10722-015-0248-0>
- ICAR-NBPGR (2020) Memorandum of Undertaking signed between National Medicinal Plants Board and ICAR-National Bureau of Plant Genetic Resources on 06–07–2020. http://www.nbpgr.ernet.in/News_Details/aid/249.aspx. Accessed on 23.07.2020.
- IUCN (2020) The IUCN red list of threatened species. Version 2020–1. <https://www.iucnredlist.org>. Accessed on 4.04.2020.
- Jadhav SN, Ved DK, Ghate U, Reddy KN, Reddy CS (2001) Proceedings of the workshop on Conservation Assessment and Management Planning for Medicinal Plants of Andhra Pradesh. FRLHT, Bangalore
- Jain SK, Rao RR (1983) An assessment of threatened plants of India, Botanical Survey of India, Howrah
- Jaisankar I, Velmurugan A, Swarnam TP, Singh AK (2018) Hotspots: an introduction and role in conservation. In: Sivaperuman C, Venkataraman K (eds) Indian Hotspots. Springer, Singapore, pp 1–21. https://doi.org/10.1007/978-981-10-6983-3_1.
- Kala CP (2000) Status and conservation of rare and endangered medicinal plants of Indian trans-Himalaya. Biol Conserv 93:371–379
- Kala CP (2005) Indigenous uses, population density, and conservation of threatened medicinal plants in protected areas of the Indian Himalayas. Conserv Biol 19:368–378. <https://doi.org/10.1111/j.1523-1739.2005.00602.x>
- Kandari LS, Bisht VK, Bhardwaj M, Thakur AK (2014) Conservation and management of sacred groves, myths and beliefs of tribal communities: a case study from north-India. Environmental Systems Research 3:16. <https://doi.org/10.1186/s40068-014-0016-8>
- Krishnan PN, Decruse SW, Radha RK (2011) Conservation of medicinal plants of Western Ghats, India and its sustainable utilization through *in vitro* technology. Vitro Cell Dev Biol Plant 47:110–122. <https://doi.org/10.1007/s11627-011-9344-9>

- Kumar A, Pandey VC, Singh AG, Tewari DD (2013) Traditional uses of medicinal plants for dermatological healthcare management practices by the Tharu tribal community of Uttar Pradesh, India. *Genet Resour Crop Evol* 60:203–224. <https://doi.org/10.1007/s10722-012-9826-6>
- KSCSTE-JNTBGRI (2019) Jawaharlal Nehru Tropical Botanic Garden and Research Institute. Herbal garden. <https://jntbgri.res.in/index.php/research/plant-genetic-resources/medicinal-aromatic-and-spice-plants-unit>. Accessed on 15.4.2020.
- Kumar G, Srivastava A, Sharma SK, Rao TD, Gupta YK (2015) Efficacy and safety evaluation of Ayurvedic treatment (Ashwagandha powder and Sidh Makardhwaj) in rheumatoid arthritis patients: a pilot prospective study. *Indian J Med Res* 141:100–106. <https://doi.org/10.4103/0971-5916.154510>
- Kumari GP, Joshi C, Tewari LM (2011) Diversity and status of ethno-medicinal plants of Almora district in Uttarakhand India. *Int J Biodivers Conserv* 3:298–326
- Maxted N, Hawkes JG, Guarino L, Sawkins M (1997) Towards the selection of taxa for plant genetic conservation. *Genet Resour Crop Evol* 44:337–348. <https://doi.org/10.1023/A:1008643206054>
- Mittermeier RA, Turner WR, Larsen FW, Brooks TM and Gascon C (2011) Global biodiversity conservation: the critical role of hotspots. In Zachos F, Habel J (eds) *Biodiversity hotspots*. Springer, Berlin, Heidelberg, pp. 3–22. https://doi.org/10.1007/978-3-642-20992-5_1.
- Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GA, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403:853–858. <https://doi.org/10.1038/35002501>
- Nayar MP and Sastry ARK (1987–1990) *Red Data Book of Indian Plants*, Botanical Survey of India, Calcutta, vols 3:15.
- NBA (2020) National Biodiversity Authority. Species of Plants and animals which are on the verge of extinction in different states of India. <http://nbaindia.org/content/500/55/1/biodiversityrelatedi.html>. Accessed on 25.01.2020.
- NMPB (2020a) Demand and supply of medicinal plants. National Medicinal Plants Board (NMPB). https://nmpb.nic.in/medicinal_list. Accessed on 27.07.2020.
- NMPB (2020b) National Medicinal Plants Board (NMPB). <https://www.nmpb.nic.in/> (accessed on 31.1.2020).
- Pareek SK, Gupta V, Bhatt KC, Negi KS, Sharma N (2005) Medicinal and aromatic plants. In: Dhillon BS, Tyagi RK, Saxena S, Randhawa GJ (eds) *Plant genetic resources: horticultural crops*. Narosa Publishing House, New Delhi, pp 279–308
- Patwardhan B, Chavan-Gautam P, Gautam M, Tillu G, Chopra A, Gairola S, Jadhav S (2020) Ayurveda rasayana in prophylaxis of covid-19. *Curr Sci* 118:1158–1160
- Pelletier TA, Carstens BC, Tank DC, Sullivan J, Espíndola A (2018) Predicting plant conservation priorities on a global scale. *Proc Natl Acad Sci USA* 115:13027–13032. <https://doi.org/10.1073/pnas.1804098115>
- Pollock C, Mace GM, Hilton-Taylor C (2003) The revised IUCN Red List Categories and Criteria, Version 3.1. In: de Iongh HH, Bánki OS, Bergmans W, van der Werff ten Bosch, MJ (eds) *The Harmonization of Red Lists for Threatened Species in Europe*. Leiden (The Netherlands): The Netherlands Commission for International Nature Protection, pp 33–48.
- Rajpurohit D, Jhang T (2015) In situ and ex situ conservation of plant genetic resources and traditional knowledge. In: Salgotra RK, Gupta BB (eds) *Plant Genetic Resources and Traditional Knowledge for Food Security*. Springer, Berlin, pp 137–162
- Rao CK, Geetha BL, Suresh G (2003) Red List of Threatened Vascular Plant Species in India, Botanical Survey of India, Howrah, pp ix–144.
- Ravikanth G, Jagadish MR, Vasudeva R, Shaanker RU, Aravind NA (2018) Recovery of critically endangered plant species in India: need for a comprehensive approach. *Curr Sci* 114:504
- Rodrigues AS, Pilgrim JD, Lamoreux JF, Hoffmann M, Brooks TM (2006) The value of the IUCN Red List for conservation. *Trends Ecol Evol* 21:71–76. <https://doi.org/10.1016/j.tree.2005.10.010>
- Sarker SD, Nahar L (2007) *Chemistry for Pharmacy Students General, Organic and Natural Product Chemistry*. Wiley, England, pp 283–359
- Seeni S, Latha PG (2000) *In vitro* multiplication and eco-rehabilitation of the endangered Blue Vanda. *Plant Cell Tissue Organ Cult* 61:1–8. <https://doi.org/10.1023/A:1006444614657>
- Shakya AK (2016) Medicinal plants: future source of new drugs. *Int J Herb Med* 4:59–64
- Sharma N, Gowthami R, Pandey R (2019) Synthetic Seeds: A Valuable Adjunct for Conservation of Medicinal Plants. In: Faisal M, Alatar AA (eds) *Synthetic Seeds – Germplasm Regeneration, Preservation and Prospects*. Springer Nature, Switzerland, pp 181–216. doi.org/https://doi.org/10.1007/978-3-030-24631-0_7.
- Sharma N, Pandey R (2013) Conservation of medicinal plants in Tropics. In: Normah MN, Chin HF, Reed BM (eds), *Conservation of tropical plant species*. Springer, New York, pp 437–487. <https://doi.org/10.1007/978-1-4614-3776-5>.
- Sharma N, Pandey R, Gowthami R (2020) *In vitro* conservation and cryopreservation of threatened medicinal plants of India. In: Rajasekharan PE, Wani SH (eds) *Conservation and utilization of threatened medicinal plants*. Springer, India, pp 181–228. <https://doi.org/10.1007/978-3-030-39793-7>
- Shivanna KR (2020) The Sixth Mass Extinction Crisis and its Impact on Biodiversity and Human Welfare. *Resonance* 25:93–109. <https://doi.org/10.1007/s12045-019-0924-z>
- Singh JP, Kumar S, Venkatesan K, Kulloli RN (2016) Conservation status and utilization of *Caralluma edulis*: an important threatened medicinal plant species of the Thar Desert, India. *Genet Resour Crop Evol* 63:721–732. <https://doi.org/10.1007/s10722-016-0366-3>
- Singh N, Pandey S (2019) Conservation of plant genetic resources. In: Pandey CD, Koul AK, Vimala Devi S, Singh N, Radhamani J, Pandey S, Jacob SR, Aravind J, Gore PG, Gupta V (eds) *International training programme on management of plant genetic resources for officers from directorate of seed testing and certification ministry of agriculture, Baghdad. Republic of Iraq, ICAR-NBPGR, New Delhi, p 27*

- Ved DK, Tandon V (1998) CAMP report for high altitude medicinal plants of Jammu-Kashmir and Himachal Pradesh. FRLHT, Bangalore, India
- Ved DK, Goraya GS (2008) Demand and supply of medicinal plants in India. Bishen Singh, Mahendra Pal Singh, Dehradun and FRLHT, Bangalore, India
- Ved DK, Kinhal GA, Haridasan K, Ravikumar K, Ghate U, Shankar RV, Indresha J H (2003a) Conservation assessment and management prioritization for the medicinal plants of Arunachal Pradesh, Assam, Meghalaya and Sikkim- Proceedings of the workshop held at Guwahati during 27th February to 1st March 2003. FRLHT, Bangalore
- Ved DK, Kinhal GK, Ravikumar K, Prabhakaran V, Ghate U, Sankar RV, Indresha JH (2003b) Conservation assessment management prioritization for the Medicinal plants of Jammu and Kashmir, Himachal Pradesh and Uttaranchal. FRLHT, Bangalore
- Ved DK, Kinhal GA, Ravikumar K, Sankar RV, Haridasan K (2005) Conservation Assessment and Management Prioritisation (CAMP) for wild medicinal plants of North-East India. *Medicinal Plant Conservation* 11:40–44
- Ved DK, Suma TS, Barve V, Srinivas V, Sangeetha S, Ravikumar K, Kartikeyan R, Kulkarni V, Kumar AS, Venugopal SN, Somashekhar BS, Sumanth MV, Begum N, Sugandhi Rani, Surekha KV, Desale N (2016a) State wise CAMP workshop details. (envis.frlht.org/frlhtenvis.nic.in) (<http://envis.frlht.org/conservation-concern-species>). FRLHT's ENVIS Centre on Medicinal Plants, Bengaluru. Copy Right: FRLHT, Bengaluru and MoEFCC, GoI. Accessed on 6.4.2020.
- Ved DK, Suma TS, Barve V, Srinivas V, Sangeetha S, Ravikumar K, Kartikeyan R, Kulkarni V, Kumar AS, Venugopal SN, Somashekhar BS, Sumanth MV, Begum N, Sugandhi Rani, Surekha KV, Desale N (2016b) State wise list of medicinal plants of conservation concern. (envis.frlht.org/frlhtenvis.nic.in) (<http://envis.frlht.org/mpcc-species>). FRLHT's ENVIS Centre on Medicinal Plants, Bengaluru. Copy Right: FRLHT, Bengaluru and MoEFCC, GoI. Accessed on 6.4.2020.
- Walter KS, Gillett HJ (1998) 1997 IUCN Red list of threatened plants. Compiled by the World Conservation Monitoring Centre, IUCN-The World Conservation Union, Gland, Switzerland and Cambridge, UK.
- WIIENVIS (2019) ENVIS Centre on Wildlife and Protected Areas. Protected Areas of India. http://wiienvis.nic.in/Database/Protected_Area_854.aspx. Accessed on 20.2.2020.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.