Chapter 2
Biodiversity Conservation with Special Reference to Medicinal Climbers: Present Scenario, Challenges, Strategies, and Policies

Shiwali Sharma and Rekha Arya

Abstract Climbing plants typically contribute 2–15 % of the leaf biomass and about 5 % of the wood biomass to forests. In India, they are widely distributed from Nilgiris to Himalayas to Andaman Nicobar Islands. Phylogenetically, climbers are found in over 125 families of flowering plants as well as among several fern groups and even in one significant gymnosperm genus, *Gnetum*. They are largely used by all divisions of the population either directly as folk medications or indirectly in the preparation of recent pharmaceuticals. Climbers also play a vital role in horticulture and agriculture. Thus, people depend on climbers for several purposes like for medications, non-timber forest products, food, etc. Nowadays, plant-based pharmaceutical industries have been increased due to various advantages of plant-based medicine over the synthetic ones. Wild plants are the good source to provide the raw materials for such industries. Unfortunately, a huge number of medicinal climbers have been listed in Red Data Book and are on the verge of extinction due to unsustainable collection of plants, habitat loss, climate change, and industrialization coupled with urbanization. Thus, biodiversity conservation is an utmost concern globally. Various strategies are in use for biodiversity conservation such as in situ strategy, ex situ strategy, reduction of anthropogenic pressures, and rehabilitation of threatened species. Protection and preservation of germplasm within national parks, biosphere reserves, and sanctuaries are the examples of in situ conservation. However, it is not an effective means of conservation. In this regard, biotechnological approach like plant tissue culture technique proved to be fruitful. Plant tissue culture can be applied to the rapid propagation and ex situ conservation of rare, endemic, and endangered medicinal plants as explained by several authorities. Other modern biotechnological tools, including cryopreservation techniques, DNA fingerprinting, and bioreactor-mediated bio-production of phytochemicals, are

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mostly relevant in this context. The Convention on Biological Diversity (CBD), in force since 1992, is the major international conservation convention. The global strategy for conservation of plants was adopted with the intention to harmonize with existing international initiatives addressing various aspects of plant conservation.

Keywords Cryopreservation • In situ • IUCN • In vitro • Ex situ • Micropropagation

2.1 Biodiversity: Natural Capital of the Earth

Variation is the law of nature. It occurs everywhere and every moment. The variations take place at micro levels. The variations may be linear or cyclic. The variety and variability of organisms and ecosystems is referred to as biological diversity. The World Commission on Environment and Development (WCED) constituted by the UN General Assembly published a report in 1987 which provided a boost and endorsement to the need for conserving the world's rich biodiversity. Despite conflicting views among nations, a broad consensus was reached after bitter negotiations, and 170 countries signed the Biodiversity Convention, which is now ratified by 104 countries.

A variety of living organisms (flora and fauna) on the earth constitutes biodiversity. Biodiversity means variability among all the living organisms and interaction within species, between species, and with the surroundings. According to Convention on Biological Diversity (CBD), biodiversity means variability among living organism from all sources. As defined by the International Council for Bird Preservation (1992), "Biodiversity is the total variety of life on earth. It includes all genes, species and ecosystem and the ecological process of which that are part." Biodiversity is the totality of genes, species, and ecosystem in a region. The wealth of life on earth today is the product of hundreds of millions of years of evolutionary history.

It is estimated that about 1.75 million species (plant + animal) have been discovered, 20 % of which is less than those to be estimated yet. Among these identified species, only a few have been studied for their medicinal value. Moreover, most of the biodiversity is disappearing very rapidly (as many as 27,000 species are becoming extinct per year). This indicates that 3 species are disappearing every hour while 150 species are disappearing every day. Of the more than 3,000,000 known species of plants, the IUCN has evaluated only 12.914 species, finding that about 68 % of evaluated plant species are threatened with extinction.

2.2 Types of Biodiversity (Diversity Indices)

2.2.1 Alpha (α) Diversity

Species diversity within a community or habitat comprises two components, i.e., species richness and evenness. Sometimes the dominance of one vegetation stratum may affect the α diversity of the other strata.

2.2.2 Beta (β) Diversity

β Diversity is the intercommunity diversity expressing the rate of species turnover per unit change in habitat.

2.2.3 Gamma (γ) Diversity

Gamma diversity is the overall diversity at landscape level that includes both α and β diversities. The relationship is as follows:

$$\gamma = \alpha + \beta + Q$$

where Q = Total number of habitats or communities
α = Average value of α diversities
β = Average value of β diversities

2.3 Levels of Biodiversity

Theoretically there are three levels of biodiversity.

2.3.1 Genetic Diversity

Variation of genes within the species is referred as genetic diversity. This constitutes distinct population of the same species or genetic variation within population or varieties within a species.

2.3.2 Species Diversity

The number of species in a region is known as species diversity.

2.3.3 Ecological Diversity

Different species present in local ecosystem and the dynamic interplay between them are known as ecological diversity. An ecosystem consists of organisms from many different species living together in a region that are connected by the flow of energy, nutrients, and matter that occurs as the organisms of different species interact with one another.

2.4 The Mega-Diversity Regions

Seventeen megadiverse countries have been recognized by the World Conservation Monitoring Centre including Australia, Brazil, China, Colombia, Democratic Republic of the Congo (DRC) (formerly Zaire), Ecuador, India, Indonesia, Madagascar, Malaysia, Mexico, Papua New Guinea, Peru, the Philippines, South Africa, the United States of America (USA), and Venezuela that harbor more than 70 % of the earth's species. Some of the very valuable "gene pool" from these countries have been identified, and they have been utilized for the buildup of modern agriculture and allied business.

2.5 Hotspots of Biodiversity

Thousands of "ecoregions" located in diverse ecological regions comprise the earth's biodiversity. About 200 ecoregions are recognized as richest, rarest, and most distinctive in terms of biodiversity and now referred as "global 200." As much as 20 % of global plant diversity richness comprising about 50,000 endemic plant species is restricted to 18 ecoregions, known as "hotspot"; henceforth the countries having more hotspots are collectively known as "mega-diversity nations."

2.6 Threats to Biodiversity: Causes

These days, biodiversity loss is a global problem. Population explosion and unsustainable utilization of natural resources result in drastic change in environment and habitat loss that ultimately lead to biodiversity loss. The following are some natural and man-made factors of biodiversity loss:

2.6.1 Development Pressure

- Construction
- Forest-based industries
- Hydel/irrigation projects
- Mining
- Oil drilling
- Pollution
- Resource extraction
- Road and transport

2.6.2 Encroachment

- Agriculture
- Expansion of forest villages
- Fishery
- Grazing/increased domestic animals
- Habitat depletion/change
- New settlements
- Shifting cultivation

2.6.3 Exploitation

- Collection made by scientific/educational institutions
- Exploitation by local authorities as revenue resources
- Firewood collection
- Food gathering and hunting
- Poaching

2.6.4 Human-Induced Disasters

- Floods
- Major oil spills/leakage
- Epidemics
- Forest fires

2.6.5 Management of Natural Resources

- Genetic uniformity
- Inadequate water/food for wildlife
- Increased competition
- Introduction of exotic species
- Predation

2.6.6 Management of Human Resource

- Change in people's lifestyle
- Increasing demands
- Dilution of traditional value
- Human harassment
- Inadequate trained human resources
- Lack of effective management
- Inappropriate land use

2.6.7 Political and Policy Issues

- Change in use/legal status
- Civil unrest
- Intercommunity conflict
- Military activities

2.7 IUCN Threat Categories

Latest IUCN red listing recognizes three threatened categories which are as follows.

2.7.1 Critically Endangered (CR)

Such species face a very high risk of extinction in the wild. It is the highest risk category assigned by the IUCN Red List for wild species, for example, *Coscinium fenestratum* and *Piper barberi*.

2.7.2 Endangered (EN)

The taxa whose number has been reduced to a critical level or whose habitats have been so drastically reduced that they seemed to be in immediate danger of extinction, for example, *Nepenthes* species.

2.7.3 Vulnerable (VU)

Species can be moved into endangered category in the near future if deliberate conservation measures are not given, for example, *Dioscorea deltoidea*.

- *Threatened*: Species that come under any one of the above categories is known as "threatened."
- *Rare*: Species with small population, not endangered or vulnerable at present but are at risk. They are confined to a very restricted area, for example, *Stemona tuberosa*.

2.8 Market Scenario for Medicinal Plants

Today, the global market for traditional therapies stands at US$60 billion a year and is steadily growing. The global demand for herbal medicine has increased at an annual rate of 8 % during the period of 1994–2001, and according to WHO forecast, the global herbal market would be worth $5 trillion by the year 2050 (http://www.expresspharmapulse.com /20021226/ cover3.htm). This clearly indicates that there is vast scope for the traditional medicine practitioners; there is a worry on resource conservation front. Even if only 25 % of the modern medicines descend from plants, it would mean substantial pressure on plants as there is an ever-increasing demand for the modern medicines.

2.9 Impact of Biodiversity Loss and Challenges

Regional and global climate changes adversely affect biodiversity (Penner et al. 1994; Houghton et al. 1999; Chapin et al. 2000; Sala et al. 2000; Franco et al. 2006). Loss of biodiversity hampered the biological systems (Vitousek et al. 1997). Various protected areas have been established in the Eastern Himalayas. The first protected area, established in 1918, was the Pidaung Wildlife Sanctuary in Myanmar. A total of 99 protected areas of varied sizes measuring more than 79,000 km^2 (15 % of the total area) coverage across the region is the most significant contribution to protect biodiversity as compared to the global percentage of 11.5 % for mountain protected areas (Kollmair et al. 2005). Protected areas have been increased from 23,379 km^2 (1977–1987) to 71,972 km^2 (1997–2007), while their number increased from 46 to 99.

2.10 Climbing Phytodiversity in India

India is one of the 18 megadiverse countries and has all the 13 biomes found in the world, with 2 major hotspots (Eastern Himalayas and Western Ghats) out of a total of 34. It has only 8 % of the global biodiversity in 2.4 % land (Bapat et al. 2008). India has been reputed as the treasure house of a wide range of valuable medicinal and aromatic plants inhabiting in diverse climatic condition. The entire Western Ghats is known for its biodiversity, richness, and endemism (about 4500 known plant species; 2000 species of higher plants), with nearly 1500 endemic. This bioregion is under constant threat due to human pressure. The tropical climate conditions, heavy rainfall, and favorable edaphic factors support the luxuriant growth of plant species (Daniel 1997).

Another hotspot in India is the Eastern Himalayas which is also listed in the "crisis ecoregions" (Hoekstra et al. 2005), "biodiversity hotspots" (Myers et al. 2000), "endemic bird areas" (Stattersfield et al. 1998), "megadiverse countries" (Mittermeier et al. 1997), and "global 200 ecoregions" (Olson and Dinerstein 2002). Diverse ecological and altitudinal gradients result in diversity of flora and fauna. Palaearctic, Indo-Malayan, and Sino-Japanese realms are joined in the Eastern Himalayas (CEPF 2005). According to Dhar (2002), the world's richest alpine flora is found in this hotspot, and about one-third of them are endemic to the region, comprising 7500 flowering plants, 728 lichens, 700 orchids, 700 ferns, 500 mosses, 64 *Citrus* species, 58 bamboo species, and 28 conifers.

Climbers occur in many plant families with only a few families such as Dioscoreaceae, Cucurbitaceae, and Convolvulaceae consisting completely of climbing plants. Nearly 60 % of all dicotyledonous plant order has at least one representative climber (Heywood 1993). Table 2.1 shows different medicinal climbers and their medicinal properties.

Table 2.1 List of different medicinal climbers and their medicinal properties (alphabetically)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
1	*Abrus precatorius*	Ratti, Gunja	Fabaceae	Seeds	Glycyrrhizin, precol, abrol, abrasine, hyaphorine	Nervous disorders
2	*Acacia torta*	Incha	Mimosaceae	Stem bark	Saponins, acacinins	Decoction is taken for cough and dysentery
3	*Acalypha fruticosa*		Euphorbiaceae	Leaves	Kaempferol, sitosterol, triacetonamine	Stomachic, alterative, digestive, dyspepsia, diarrhea
4	*Aganosma cymosa*	Seellakkodi	Apocynaceae	Whole plant	Saponins, terpenoids, alkaloids	Anthelmintic, emetic, and used in the treatment of bronchitis. Flowers are useful in ophthalmia
5	*Anamirta cocculus*	Kakamari	Menispermaceae	Leaves, fruits, and seeds	Magnoflorine, berberine, picrotoxin, sitosterols	Expectorant, antifungal, anthelmintic, and depurative
6	*Anodendron paniculatum*		Apocynaceae	Roots	Anodendrosides A-G	Emetic, expectorant, and alterative
7	*Antigonon leptopus*	Anantlata	Polygonaceae	Root tuber	Kaempferol, quercetins	Tonic, anti-inflammatory
8	*Argyreia elliptica*	Kedari	Convolvulaceae	Leaves	The seed oil revealed the presence of myristoleic, myristic, palmitic, linoleic, linolenic, oleic, stearic, nonadecanoic, eicosenoic, heneicosanoic, and behenic acids	Plant extracts and its metal salt combination used as antibacterial, anthelmintic, and antioxidant agents

(continued)

Table 2.1 (continued)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
9	*Argyreia speciosa*	Samandar-ka-pat	Convolvulaceae	Roots and seeds	Triacontanol, sitosterols, coumarins, epifriedinol	Bitter, aphrodisiac, alterative, diuretic, carminative, anti-inflammatory, nervine
10	*Aristolochia bracteolata*	Bhringi	Aristolochiaceae	Whole plant	β-Sitosterols, aristolochic acid, aristo red	Antioxidant and insecticidal properties
11	*Aristolochia indica*	Sunanda	Aristolochiaceae	Leaves	Isoaristolochic acid, allantoin	Antidote to snakebite, appetizer, anthelmintic, used for treatment of leprosy
12	*Aristolochia tagala*	Nakuli	Oxalidaceae	Roots	Ceryl alcohol, β-sitosterols, aristolochic acid	Tonic, carminative, and emmenagogue
13	*Artabotrys hexapetalus*	Manoranjini	Annonaceae	Roots, flower, and fruits	Artabotrine, yingzhaosu A and B, quercetin	Antifungal, antimalarial
14	*Asparagus asiaticus*		Liliaceae	Leaves		Applied topically on swellings
15	*Averrhoa carambola*	Karukah	Oxalidaceae	Roots, leaf, and shoot	Quercetin, epicatechin, sitosterol, lupeol	Antidote in poisoning, antipyretic, anthelmintic, anti-inflammatory
16	*Basella alba*	Pui	Basellaceae	Stem, leaves	Kaempferols, basellasaponins	Emollient, laxative, hemostatic, sedative, demulcent, diuretic
17	*Bauhinia vahlii*	Malu	Caesalpiniaceae	Leaves	Kaempferol 3-glucoside, lupeols	Against dysentery and stomachache
18	*Benincasa hispida*	Petha	Cucurbitaceae	Fruit	Triterpenes, alunsenol, mutiflorenol	Antidiabetic, coolant, digestive, tonic

19	*Bridelia scandens*	Ghonta	Euphorbiaceae	Leaves, stem bark	Ovatolide, bridelyl alcohol, phlobatamine, taraxerone	Antipyretic, antibacterial, antiasthmatic, antinociceptive
20	*Butea parviflora*	Maula	Fabaceae	Stem bark		To treat hair loss
21	*Caesalpinia crista*	Latakaranja	Caesalpiniaceae	Whole plant	Cassane- and norcassane-type diterpenes	Anthelmintic, febrifuge, periodic, vesicant, rubefacient
22	*Calycopteris floribunda*	Shvetadhataki	Combretaceae	Leaf, fruits, and seeds	Calycopterin, helleborine, veratine, quercetin	Antidysenteric, laxative, anthelmintic, depurative, diaphoretic, and febrifuge
23	*Capparis sepiaria*	Kanthari	Capparidaceae	Leaves and roots		Antiseptic, antipyretic used for eczema and scabies
24	*Capparis zeylanica*	Aradanda	Capparidaceae	Leaves and root bark	Betulin 28-acetate, capparispine	Antirheumatic, anti-inflammatory, anti-blood coagulant, appetizer, emetic
25	*Cardiospermum canescens*		Sapindaceae	Leaves	Methanamine, hexadecanoic acid	Antidiarrheal, antirheumatic
26	*Cardiospermum halicacabum*	Indravalli	Sapindaceae	Roots	1-Triacontanol, pentacosane, pelargonidin	Analgesic, diuretic, laxative, stomachic, anti-inflammatory
27	*Ceropegia juncea*	Somlata	Asclepiadaceae	Stem	Cerepegin	The extract is used for stomach and gastric disorders
28	*Cissampelos pareira*	Bhatvel	Menispermaceae	Stem and leaves	Furo pyridine, phytosterols, terpenes	For gastrointestinal disorder, urogenital problems
29	*Cissus quadrangularis*	Asthisamharaka	Vitaceae	Stem	Tetracyclic triterpenoids	To heal broken bones and injured ligaments, analgesic and tonic

(continued)

Table 2.1 (continued)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
30	*Citrullus lanatus*	Tarbooz	Cucurbitaceae	Seeds		As purgative and emetic
31	*Clitoria ternatea*	Aparajita	Fabaceae	Roots, leaves, seeds	Stigmast-4-ene-3,6-diene, taraxerol, taraxerone	Hemostatic, paste of whole plant is used in piles
32	*Coccinia grandis*	Bimbika	Cucurbitaceae	Fruits	Taraxerol, sitosterol, cycloartenol acetate	Analgesic, anti-inflammatory, antidiabetic
33	*Cocculus hirsutus*	Patala garuda	Menispermaceae	Roots and leaves	Cohirsine, haiderine, jammin-N-oxide, trilobine, syringaresinol	Used for stomach and urinary problems, also a detoxifier used against snakebite
34	*Convolvulus microphyllus*	Shankhpushpi	Convolvulaceae	Whole plant	Triterpenoids, flavonol glycosides	Antiepileptic, antiulcer activity, tonic, alterative, febrifuge, psychostimulant, and tranquilizer
35	*Corallocarpus epigaeus*	Sukanasa	Cucurbitaceae	Roots		Anti-inflammatory, used in joint pain
36	*Cryptolepis buchanani*	Anantmul	Asclepiadaceae	Leaves and roots	Sarverogenin isosarverogenin, cryptosin, buchanin, cryptolepain	Antidiarrheal, anti-inflammatory, blood purifier, anti-cough, antibacterial, demulcent, diaphoretic, diuretic
37	*Cucumis trigonus*	Indravaruni	Cucurbitaceae	Leaves		Useful as helminthiasis, flatulence, leprosy, fever, jaundice, cough, bronchitis, anemia, constipation, other abdominal disorders, and amentia

38	*Cuscuta reflexa*	Amarbel	Convolvulaceae	Whole plant	Scoparone, melanettin, quercetin, hyperoside	Astringent, carminative, anthelmintic, and diuretic
39	*Cyclea arnotii*	Patha	Menispermaceae	Roots	Telradrine, phaeanthine, uronic acid	Used in small pox, bone fracture, malarial fever, jaundice, stomachache
40	*Dioscorea oppositifolia*	Khamalu	Dioscoreaceae	Tuber	Dioscorine	Prolonged diarrhea, chronic enteritis, cough, and dyspnea
41	*Diplocyclos palmatus*	Shivlingi	Cucurbitaceae	Fruits	Goniothalamin, bryonin	For female infertility, leukorrhea
42	*Entada rheedii*	Gilla	Mimosaceae	Seeds	Saponins	Alexiteric, narcotic, tonic, emetic, antipyretic, febrifuge, and hemorrhoidal
43	*Gloriosa superba*	Kalihari	Liliaceae	Leaves, rhizome roots	Colchicine, gloriocine	To treat acute gout, intestinal worms, infertility, wounds, and other skin problems; as an antidote for snakebite
44	*Gnetum ula*	Kumbal	Gnetaceae	Seeds	Glucosylflavones, stilbenes, malvalic acid, sterculic acid	Antirheumatic, antiperiodic
45	*Gymnema sylvestre*	Gudmar	Asclepiadaceae	Leaves	Gymnemic acid, Gymnema saponins	Leaf decoction mixed with milk is taken internally to cure diabetes, also in malaria and snakebite
46	*Hemidesmus indicus*	Anantmool	Asclepiadaceae	Roots	Hexatriacontane, hemide	Diuretic and blood purifier, skin infections, rheumatism, piles; one important use is to ease the mind

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Table 2.1 (continued)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
47	*Hiptage benghalensis*	Madhavi	Malpighiaceae	Seeds	Hiptagin	Aromatic, coolant, expectorant, cardiotonic, anti-inflammatory, and insecticidal
48	*Ichnocarpus frutescens*	Kalidoodhi/shyamlata	Apocynaceae	Roots	Quercetin, lupeol apigenin, friedelin, kaempferol, vanillic acid	Atrophy, bleeding gums, convulsions, cough, delirium, dysentery, inflammatory, analgesic, antidiabetic, antioxidant, and antitumor spectrum of activity
49	*Ipomoea aquatica*	Kalamisaag	Convolvulaceae	Stem and leaves		Carminative, anti-inflammatory, purgative, antipyretic, antibronchitis, hepatoprotective
50	*Ipomoea eriocarpa*	Buta	Convolvulaceae	Whole plant	Hentriacontane, stigmasterol	Ulcer, fever, and rheumatism
51	*Ipomoea mauritiana*	Vidari	Convolvulaceae	Roots, leaves	Quercetins, sitosterol, terpenes, phytols, fatty acids	Skin diseases, anorexia, fever, burning sensation To promote breast milk production, ingredient of Chyavanaprash
52	*Ipomoea obscura*	Paan Bel	Convolvulaceae	Roots, leaves	Ipobscurine A, C, D	Against dysentery, applied on sores and pustules
53	*Ipomoea staphylina*		Convolvulaceae	Stem latex	Saponins, anthraquinones	Respiratory disorders, purgative, anthelmintic, bronchitis

54	*Ipomoea pes-caprae*		Convolvulaceae	Leaves	Glochidone, isoquercitrin, betulinic acid	Anti-inflammatory, astringent, diuretic, and laxative, used in rheumatism
55	*Ipomoea pes-tigridis*	Panchpatia	Convolvulaceae	Leaves		For wound healing, bronchial spasm, pimples, snake-/dog bite
56	*Jasminum angustifolium*	Banmallika	Oleaceae	Roots		Anthelmintic, emetic, antidote
57	*Jasminum grandiflorum*	Malati	Oleaceae	Whole plant	Geraniol, nerol, vinyl acetate	Antiseptic, emollient, diuretic; roots are used for chronic constipation
58	*Jasminum malabaricum*	Mudgara	Oleaceae	Roots	Jasmonates, jasminoids, isoquercetin, rutin	Emmenagogue, blood purifier, hypotensive, antibacterial
59	*Jasminum multiflorum*	Kundah	Oleaceae	Leaves, flowers	Jasminin, oleanolic acid, jasminol	Refrigerant, laxative, cardiotonic, depurative, digestive
60	*Jasminum officinale*	Malti	Oleaceae	Leaves, flowers	Jasminoids, terpenoids, oleosides	Antiseptic, antispasmodic, aphrodisiac, parasiticide, tonic
61	*Kedrostis foetidissima*		Cucurbitaceae	Roots	Hexadecadienoic acid, methyl ester, docosanoic acid	In chest pain, asthma, urinary tract infections, diarrhea, small pox, skin disease
62	*Leptadenia reticulata*	Jivanti	Asclepiadaceae	Roots	Stigmasterol, tocopherols, alpha-amyrins, diosmetin, and luteolin	Skin infections, tonic, febrifuge
63	*Marsdenia brunoniana*		Asclepiadaceae	Leaves	Marstenacigenins A and D, Marsdin	Antidiabetic

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Table 2.1 (continued)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
64	*Marsdenia tenacissima*	Maruabel	Asclepiadaceae	Stem	Aglycones, polyoxpregnane, paclitaxel	Anticancer, antirheumatic, anti-cough
65	*Momordica charantia*	Karela	Cucurbitaceae	Fruits and seeds	Vicine, mycose, momorcharaside, cucurbitane triterpenoids	Antileprosy, anticancer, digestive, antidiabetic
66	*Mucuna pruriens*	Gonca	Fabaceae	Roots, leaves, fruits	Dopa glutathione, lecithin, gallic acid, prurieninine, prurienidine	Male infertility, nervous disorders, aphrodisiac. Also used in Parkinson's disease
67	*Oxalis corniculata*	Tripatti		Whole plant	Glyoxylic acid, vitexin, isovitexin	Blood purifier, antiepileptic, bone healer, antidiarrheal, treat sores
68	*Pachygone ovata*	Doodhlata	Menispermaceae	Roots	N-Methyl crotsparine reticuline and pachygonine	CNS stimulant, analgesic, and hyperthermic
69	*Passiflora foetida*	Jhumka lata	Passifloraceae	Leaves	Harmalol, vitexin, apigenin, maltol, passicol, lucenin	Emmenagogue, sedative, hypnotic, antispasmodic
70	*Pseudarthria viscida*	Shalaparni	Fabaceae	Whole plant	Leucopelargonidine derivatives	Thermogenic, emollient, anthelmintic, nervine, anti-inflammatory, diuretic, cardiotonic, insect bite
71	*Quisqualis indica*	Malti	Bignoniaceae	Seeds	Quisqualic acid, trigonelline, and phytosterols	Anthelmintic (against ascariasis) tonic, antipyretic, purgative

72	*Rhaphidophora heidi*	Ganeshkanda	Araceae	Stem juice, leaves	Rhaphidecursinol A and B, rhaphidecurperoxin, polysyphorin, grandisin	Antidote to snakebite and scorpion stings, antiabdominal cancer, digestive, refrigerant
73	*Rivea hypocrateriformis*	Kindu pata	Convolvulaceae	Stem and leaves	Polyphenols, catechins, and gallic acid	Hepatoprotective, analgesic, anti-inflammatory, used against asthma and piles
74	*Sarcostemma brunonianum*	Somavalli	Asclpiadaceae	Latex	Phytosterols, α- and β-amyrins, lupeol, β-sitosterol	Narcotic, emetic, antiviral, and rejuvenating
75	*Secamone emetica*	Kondam	Asclepiadaceae	Roots and leaves	Phytosterols, anthraquinones, coumarins, chalcones	Emetic, analgesic, antipyretic, also against leukorrhea
76	*Smilax zeylanica*	Ramdatun	Smilacaceae	Roots, leaves	Diosgenin, smilagenin, saponins	Antidiabetic, antihelminthic, antioxidant, antiepileptic, antigonorreal
77	*Stephania japonica*	Rajpatha	Menispermaceae	Leaves	Akanidine	Fever, diarrhea, dyspepsia, urinary diseases, antispasmodic activity on uterine spasms, skin diseases, cough, asthma-like symptoms, and kidney disorders
78	*Thunbergia fragrans*	Mui-lata	Acanthaceae	Roots and leaves	Flavonoids, apigenin, luteolin	Antidiarrheal, antirheumatic
79	*Tinospora cordifolia*	Giloy, guduchi	Menispermaceae	Whole plant	Tinosporin, columbine, palmarin, berberine, tinosporon, giloin	Antiperiodic, antispasmodic, antiosteoporotic, anti-inflammatory antiarthritic, and antiallergic

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Table 2.1 (continued)

S. no.	Plant name	Common name	Family	Plant part used	Secondary metabolite	Medicinal use
80	*Toddalia asiatica*	Jangali kalimirch	Rutaceae	Roots, leaves, fruits	Alkaloid berberine, resin, toddaline, pimpinellin	Diaphoretic, digestive, expectorant, antipyretic
81	*Tragia involucrata*		Euphorbiaceae	Root		Diuretic, diaphoretic, cooling, depurative
82	*Tylophora indica*	Antamul	Asclepiadaceae	Roots, leaves	Tylophorine, desmethyl tylophorine, gamma-fagarine, kaempferol	Bronchial asthma and allergic rhinitis
83	*Vallaris solanacea*	Dodhibel	Apocynaceae	Latex, bark, seeds	Vallaroside, solanoside, caffeoylquinic acid	Analgesic, antidiarrheal, anti-inflammatory, antioxidant, digestive
84	*Ventilago madraspatana*	Pitti	Rhamnaceae	Bark		Digestive, carminative, stomachic, alexeteric, stimulant and tonic, depurative
85	*Vigna radiata*	Banurd	Fabaceae	Leaves, roots	Vitexin, isovitexin, phenolic acid	Digestive, emollient, galactagogue, anti-inflammatory, febrifuge
86	*Vigna trilobata*	Mungan	Fabaceae	Leaves	Friedelin, epifriedelin, stigmasterol, tryptophan	Sedative, antipyretic
87	*Vitis vinifera*	Draksha	Vitaceae	Dried ripe fruits	Leucoanthocyanins, rutin, quercetin, kaempferol, luteolin, gallic tannins	Refrigerant, laxative, emollient, cardiotonic, hemostatic, nervine
88	*Ximenia americana*		Oleaceae	Fruit, stem	Sambunigrin, gallic acid, gallotannins	Antirheumatic, antibacterial, antimalarial

Climbers are best suited for tropical and subtropical forests as compared to temperate forests (Bongers et al. 2005). In tropical rain forest, about 25–30 % of species diversity is due to climbers (Schnitzer and Bongers 2002). Different life-forms of climbers are found in tropical forests that determine a key physiognomic feature of tropical forests (Nabe-Nielsen 2001; Perez-Salicrup et al. 2001; Schnitzer and Bongers 2002). Tendril climbers are especially suitable to grow in between and/or throughout the forest canopies (Putz and Holbrook 1991), while most of the small climbers and a few large ones are suited to occupy the forest edges and forest fragments, as the tendril climbers require small diameter support to climb as compared to deep forest wherein generally the thicker stemmed plants are dominated (Schnitzer and Bongers 2002).

Austin studied the ethnobotany of weedy vines of Florida, while diversity and distribution of climbers in semi-deciduous rain forest, Ghana and Perak, Malaysia, were worked out by Patrick et al. (2008) and Ghollasimood et al. (2012), respectively. In India, Pandey et al. (2005) examined many climbers in their study of medicinal flora of Gujarat, while 81 climbers were recorded by Jangid and Sharma (2011) in Taluka Modasa, Sabarkantha District of Gujarat. Climbers of urban area of Ahmadabad and Gandhinagar and Saraswati river region of Patan district of North Gujarat were documented by Patel et al. (2013) and Seliya and Patel (2009), respectively. Ghosh and Mukherjee (2006) recorded 149 herbaceous climbers and 79 lianas from Nicobar and Andaman covering 55 families, while Mahajan (2006) reported 31 taxa used by tribal people of Nimar region (Madhya Pradesh) to cure various human ailments. Diversity of climbing flora of Thiruvananthapuram district, Monghyr district of Bihar, and Koch Bihar district of West Bengal was surveyed by Usha (2010), Singh (1990), and Bandopadhya and Mukherjee (2010), respectively. According to Ajaib et al. (2012), the local people of Kotli District, Azad Jammu, and Kashmir use 36 climbers/twiners of vascular plants for medicines, vegetables, and fodder. Bor and Raizada (1982) published a book *Some Beautiful Indian Climbers and Shrubs* with a series of papers appeared in the Jo*urnal of Bombay Natural History Society*. In Uttar Pradesh, the work was conducted by Siddiqui and Husain (1994), Khanna (2002), Maliya (2004), Narayan et al. (2008), Dwivedi et al. (2009), Singh et al. (2008), and Singh et al. (2010).

Adhikari et al. (2010) have reported the distribution, pattern, and potential for conservation of medicinal climbers in Uttaranchal state. After an extensive literature survey, they have listed a total of 88 medicinal climbers. They noticed that Cucurbitaceae, Vitaceae, and Fabaceae have more than ten species and regarded as the largest plant families. They have also analyzed various parts of climbers used in various ailments. Most of the medicinal climbers are found in subtropical region (83) followed by warm temperate (44) and cool temperate subalpine region (7), while the least number of medicinal climbers is found in alpine region (1). In all the species, plant parts used in various ailments are in the following order: leaves and roots (44 species each) > fruits (17 species) > seed (15 species). Mostly climbers are used in dysentery, diarrhea, fever, wounds, digestive complaints, skin diseases, rheumatism, bronchitis, and asthma. Later on, they surveyed the distribution pattern of 63 trees, 55 shrubs, 208 herbs, 34 climbers, 3 ferns, and 10 grasses (a total of 605 plants) belong to 94 families in Wildlife Institute of India campus, Dehradun (Adhikari et al. 2010).

Bandopadhya and Mukherjee (2010) have surveyed angiospermic climbers from the district of Koch Bihar (Cooch Behar) and recorded 94 species under 63 genera belonging to 32 families, of which 26 families with 56 genera and 80 species are dicotyledonous and 6 families with 7 genera and 14 species are monocotyledonous. Dicot families have 5.7 times more climbers than monocot families. Most of the species are found in Cucurbitaceae (21 species) followed by Vitaceae (11 species). However, there are 15 families represented by single species each. Most of the climbers are twiners (42 species) followed by tendril climbers (39 species), scramblers (6 species), ramblers (4 species), and root climbers (3 species). Local major ethnic communities, viz., Kheria, Oraon, Rabha, Rajbanshi, and Santal, use at least 50 of these species (i.e., 53.19 %) for various purposes. Of these, 32 species are used for human consumption, 27 species have medicinal uses, and 11 species are of multiple uses.

Muthumperumal and Parthasarathy (2009) reported a list of angiosperm climbers (175 climbing plant species that belong to 100 genera and 40 families), along with their climbing modes in tropical forests of south Eastern Ghats, Tamil Nadu, India. Later, they (Muthumperumal and Parthasarathy 2013) provided a detailed account on the diversity, distribution, and resource values of woody climbers in the similar area. A total of 143 liana species (DBH (diameter at breast height) ≥1.5 cm) and 32,033 liana individuals were recorded from 110 transects (0.5 ha each covering 55 ha area) in the study sites. The resource values of lianas were broadly categorized into ecological and economic importance. About 90 % (129) of liana species and 96 % (30,564) of liana individuals were established having ecological/economic values. Fruit rewards provided by 76 species and 20,325 individuals constituted the major resource of ecological importance. 82 species and 21,457 liana individuals are of economic importance as medicine and edible fruits and having edible and medicinal values, and yet others are used for different domestic purposes including furniture, fuel wood, rope making, etc. Ecologically, the prevalence of succulent diasporas in lianas of Indian Eastern Ghats indicates the animal dependence of many liana species for dispersal and underlines the need for a holistic and whole forest conservation approach in maintaining forest biodiversity (Muthumperumal and Parthasarathy 2013).

Agarwal (2013) studied the useful climbers of Fatehpur, Uttar Pradesh, India. In the studied area, angiospermic climbers are represented by 42 species under 29 genera belonging to 15 families (13 dicot and 02 monocot families). Some climbers are wild while others are cultivated. Among all families, Cucurbitaceae was found to be the most abundant having 16 species followed by Fabaceae and Convolvulaceae, both having 6 species and Oleaceae with 3 species. Cucurbitaceae is the most dominant family species as well as genera wise. All other families are represented by single species only (Agarwal 2013).

The diversity and distribution pattern of 59 angiosperm vine taxa (belonging to 44 genera) in the 6 tropical forests of Nilgiri Biosphere Reserve in the Western Ghats have been reported by Jayakumar and Nair (2013). The term "vine" is used for all perennial climbers like twiners, scramblers, tendril climbers, root climbers, hook climbers, and climbing palms. Most of the inventories on tropical vines were from the Neotropics (Putz 1983) and Southeast Asia (Putz and Chai 1987), and only a few are available from South Asia, especially from the Western Ghats of India (Reddy and Parthasarathy 2003). Their study was aimed to analyze two hypotheses (Pitman et al. 2001), i.e., obligatory hypothesis (most of the species of different vegetation types are dominated by limited number) and environmental determinism hypothesis (restricted distribution pattern in different vegetation types). Among six forms of climbers, twiners were the most significant in richness and abundance.

During 2008–2011, Suthari et al. surveyed forests of five districts (Adilabad, Nizamabad, Karimnagar, Warangal, and Khammam) of North Telangana in India where they found nine types of climber, mostly twiners (55.39 %), followed by tendril climbers (19.12 %), scramblers (15.68 %), and branch climbers (4.90 %). Root climbers are only 1.47 %, whereas leaf climbers, hook climbers, and watch-spring climbers are 0.98 %. Petiole climbers are least in number (0.50 %). 76 % climbers are wild and the rest either cultivated or naturalized. Because of its great variety of climbers which are used as medicinal, ornamental, edible fodder, fiber, and bio-fencing materials., North Telangana is now considered as a potential botanical province of natural resource (Suthari et al. 2014).

In neotropical rain forest of Yasuní National Park, Ecuador, lianas are significant in number (Nabe-Nielsen 2001). He recorded 606 climbers, belonging to 138 species. Sapindaceae and Leguminosae were most species-rich families.

2.11 List of Climbers (Medicinal and Ornamental) Facing Threat

Among threatened plants, climbers are more vulnerable to extinction because of their dependence on support structures or due to their low clutch size and predominantly outbreeding systems (*see* Putz 1983; Putz and Chai 1987). Considering spatial elusiveness and difficulties with climber systematics, their proportion among threatened plants may be far greater than shrubs. Over and above, the conservation of this element is further compounded as there are very few studies on them. Unless a systematic assessment is undertaken to understand intrinsic problems linked with species, and then linked with extrinsic factors operating on them, realistic solutions to conserve medicinal climbers would be a distinct dream. The lianas are already at disadvantageous position because of their growth form as biodiversity-insensitive forest management practices in the past have resulted in their selective removal/elimination as a part of silvicultural operations. Below is a list of some important medicinal and ornamental climbers facing the problem of being threatened.

2.11.1 Gymnema sylvestre R. Br.

Family: Asclepiadaceae
Threat status: Vulnerable

It is a vulnerable, slow-growing, perennial woody climber of tropical and subtropical regions. It is popularly called as "Gurmar" due to its distinctive property of temporarily destroying the taste of sweetness and is used in the treatment of diabetes. The leaves of the plant are used as antiviral, diuretic, antiallergic, hypoglycemic, hypolipidemic, and antibiotic and in stomach pains and in rheumatism. The antidiabetic, antisweet, and anti-inflammatory activities of *G. sylvestre* are due to the presence of gymnemic acids; the other phytoconstituents include flavones, anthraquinones, hentriacontane, resins, d-quercitol, lupeol, β-amyrin-related glycosides, and stigmasterol (Parijat et al. 2007). The various reports on its multiple uses attracted attention for utilization of the plant for gymnemic acid. Due to its indiscriminate collection for commercial purposes and to meet the requirements of the pharmaceutical industry, it is now considered as threatened. Conventional propagation is hampered due to its poor seed viability, low rate of germination, and poor rooting ability of vegetative cuttings.

2.11.2 Gnetum ula Brongn.

Family: Gnetaceae
Threat status: Rare and endangered

Gnetum is the only genus included under Gnetales. It is of special interest to morphologists and systematists because it is considered to be the highest evolved among gymnosperms and showing close similarities to angiosperms than to *Ephedra* or *Welwitschia. G. ula* is found in Western Ghats, Nilgiris, and hills at Coromandel Coast. It is also found in Andaman and Nicobar Islands. Habitat loss is the major reason of its endangered status.

2.11.3 Nepenthes khasiana Hook. F.

Family: Nepenthaceae
Threat status: Endangered

In India, single species of *Nepenthes*, i.e., *N. khasiana*, is found. It belongs to the monotypic family Nepenthaceae. It is an insectivorous plant found in Northeast India. This species captures insects with the help of their curious and attractive pitchers and digests the proteins of trapped insects, thereby supplementing nitrogenous salts. Local inhabitants used the fluid of the unopened pitcher of *N. khasiana* to cure stomach troubles, diabetes, leprosy, gynecological problems, and cataract and as an eye drop for redness and itching (Rao et al. 1969; Kumar et al. 1980; Joseph and Joseph 1986). Habitat destruction, deforestation, urban development, developmental projects, road laying and modern agriculture, and fragmentation of large contiguous populations into isolated small and scattered ones have rendered the species increasingly vulnerable to environmental stochasticity, which would ultimately lead to its extinction. Due to its attractive beauty, this plant has attracted horticultural interest (Mukerjee et al. 1984; Khoshbakht and Hammer 2007). The plant's existence is threatened because of its collection and export by the local plant collectors to other states of India on account of the fascinating beauty of its pitcher (Bhau et al. 2009). The species has been classified as a threatened species and is included in the list of rare and threatened taxa of India (Jain and Baishya 1977; Jain and Sastri 1980). The population of *N. khasiana* has dwindled in the last few decades due to deforestation and forest fires, excessive collection for trade, and slash-and-burn agricultural practice locally known as "Jhum" cultivation.

2.11.4 *Decalepis hamiltonii* Wight and Arn

Family: Asclepiadaceae
Threat status: Endangered

D. hamiltonii commonly is a medicinal liana. It possesses tuberous roots (Anonymous 2003a). It occurs in the Deccan peninsula and forest areas of Western Ghats of India. The roots are used as a flavoring principle (Murti and Seshadri 1941). The tuberous roots are aromatic due to the presence of 2-hydroxy-4-methoxybenzaldehyde (2H4MB). Root extract is used as a blood purifier (Jacob 1937) and food preservative and in the preparation of nutraceutical and pharmaceutical products (Naveen and Khanum 2010). Roots have antidiabetic, hepatoprotective, and antiatherosclerotic properties (Naveen and Khanum 2010; Harish and Shivanandappa 2010). Destructive harvesting for the collection of aromatic roots, self-incompatibility, extended flowering pattern, pollinator limitation, absence of seed dormancy, and abortion of a considerable percentage of seedlings prior to establishment are the reasons for its endangered status (Giridhar et al. 2005; Raju 2010).

2.11.5 *Tylophora indica* (Burm. f.) Merrill

Family: Asclepiadaceae
Threat status: Threatened

T. indica, commonly called as "Antamul" or "Indian ipecac," is a medicinal liana. It occurs on hilly slopes and the outskirts of the forests of eastern and southern

India (Anonymous 2003b). Roots and leaves are medicinally important due to the presence of tylophorine, tylophorinine, and tylophorinidine (Gopalkrishnan et al. 1979; Mulchandani et al. 1971). It is used in the treatment of bronchial asthma, inflammation, bronchitis, rheumatism, allergies, and dermatitis (Anonymous 2003b). It is also used for psoriasis, seborrhea, anaphylaxis, and leucopenia and it is an inhibitor of the Schultz-Dale reaction. Ruthless collection and improper cultivation are responsible for its habitat loss and threatened status.

2.11.6 Caesalpinia bonduc (L.) Roxb.

Family: Leguminosae (subfamily Caesalpinioideae)
Threat status: Endangered

It is a medicinal liana, also known as bonduc nut or fever nut. It occurs in tropical and subtropical regions of the world. Stem, leaf rachis, and pods are covered by various yellow hooked prickles (Anonymous 1976). Leaf, bark, seeds, and roots have antipyretic, antidiuretic, anthelmintic, antiasthmatic, antibacterial, antifungal, antiestrogenic, antiamoebic, anticonvulsant, hepatoprotective, antioxidant, and antiviral properties due to the presence of diterpenoids, triterpenoids, flavonoids, and steroids (Neogi and Nayak 1958; Dhar et al. 1968; Gayaraja et al. 1978; Purushothaman et al. 1982; Adesina 1995; Peter et al. 1997; Simin et al. 2000; Gupta et al. 2003; Ata and Gale 2009; Arif et al. 2009).

Seeds and stem cuttings are used for conventional propagation. It is on the verge of extinction due to unsuccessful vegetative propagation through seasonal cuttings, habitat destruction, and overexploitation of seeds that call for urgent conservation (Krishnamoorthy 1993; Hutton 2001).

2.11.7 Celastrus paniculatus Willd.

Family: Celastraceae
Threat status: Vulnerable

It is a medicinal liana known by other names such as Jyotismati, climbing staff tree, the black oil plant, or the intellect tree distributed up to an altitude of 1200 m (Rajesekharan and Ganeshan 2002). Medicinal properties are due to various sesquiterpene alkaloids like celapagine, celapanigine, and celapanine. Celastrine has powerful stimulant action on the brain and helps to improve memory (Anonymous 1992). Various plant parts used to cure sore throat, headache, anemia, colic, syphilis, and carbuncle. This is used as a constituent of the indigenous drug (tonic) “Geriforte.” Root bark has antimalarial property (Rastogi and Mehrotra 1998). However, root powder is used for cancer cure (Parotta 2001). The seeds are used to cure abdominal disorders, leprosy, fever, beriberi, and sores (Warrier et al. 1994;

Prajapati et al. 2003). Poor seed germination (11.5 %) and collection of the plants prior to seed set are the reasons for their low existence in the wild (Rekha et al. 2005).

2.11.8 *Clitoria ternatea* Linn.

Family: Fabaceae
Threat: Rare

C. ternatea is a rare medicinal climber with blue or white flowers. It is commonly known as butterfly pea. It occurs in tropical parts of Asia, Madagascar, and the Philippines (Anonymous 1988). It is used as a forage crop. The root, stem, and flowers are highly useful against snakebite and scorpion sting (Morris 1999). The root is used to cure indigestion, constipation, arthritis, and eye ailments. The plant extract has antistress, antidepressant, and anticonvulsant properties (Jain et al. 2003). Conventional propagation through seeds is unreliable due to poor germination and death of young seedlings under natural conditions (Anonymous 1988; Rout 2005). Due to unsustainable collection of wild plants, it is listed as a rare species by the International Union for Conservation of Nature and Natural Resources (IUCNNR) (Panday et al. 1993).

2.11.9 *Stemona tuberosa* Lour.

Family: Stemonaceae
Threat status: Rare

S. tuberosa is a perennial liana of dry hills of Northeast India, Myanmar, Bangladesh, Thailand, Vietnam, Laos, Cambodia, and the Philippines (Tsi and Duyfjes 2000). It is a good source of 14 stemona alkaloids (Pilli and de Oliveira 2000). Tuberous roots are used for the treatment of bronchitis, pertussis, and tuberculosis (Jacobi and Lee 1997). In Bangladesh, the tribal people of Chittagong Hill Tracts (CHT) use tuberous roots and leaves of this plant for the treatment of intestinal worm, cough, and mental disorders. Although seeds and rootstocks are used for vegetative propagation, overexploitation of tuberous roots for collection is the main cause for its rare status in the wild.

2.11.10 *Kedrostis foetidissima* (Jacq.) Cogn.

Family: Cucurbitaceae
Threat status: Rare

K. foetidissima is known as Appokovay in Tamil and occurs in tropical South Africa and Asia (through India to Southeast Asia) (Mathew 1991). Leaves are medicinally important and used for the treatment of asthma, chest pain, breast cancer (Cheone and Motadi 2012), cold, urinary tract infection, diarrhea, and HIV (Otieno et al. 2008). Roots are used for piles and sore throat (Kirthikar and Basu 1975).

2.11.11 Oxystelma esculentum (L. f.) Sm.

Family: Asclepiadaceae
Threat status: Rare

Oxystelma esculentum (L. *f.*) Sm. (Asclepiadaceae) was first collected on 19 August 1854 by Schimper, W., Kew No# 2305, from Ethiopia and kept in the Royal Botanic Gardens (Kew, London, England, UK, K000234398). According to the Royal Botanical Gardens, the species is also found in South Africa and some areas of China, India, Sri Lanka, Java, and Shimoga. Literature on this plant argued that the plant is rare.

2.11.12 Clematis gouriana Roxb.

Family: Ranunculaceae
Threat status: Rare

C. gouriana is a rare medicinal liana of Western Ghats in India (Saldanha 1984). Roots and stem are used for the treatment of malaria, headache, psoriasis, and dermatitis. Leaves and stem are also used for the treatment of wounds, psoriasis, dermatitis, and cardiac disorders (Nandkarni 1954). Unsustainable collection from the wild is the main reason for its depletion in nature.

2.11.13 Wattakaka volubilis (Linn. f.) Stapf

Family: Asclepiadaceae
Threat status: Rare

W. volubilis (“Kotippalai” in Tamil) is a rare medicinal liana of warmer regions of India (Annamalai 2004). Every part of the plant is medicinally important and used to treat rheumatic pain, cold fever, and cough (Pullaiah 2002; Sarkia et al. 2006). Roots and young stem are used for the treatment of snakebite and headache in women after delivery. These parts are also used as emetic and expectorant. Leaves have anti-inflammatory properties (Sahu et al. 2002). Sahu et al. (2002) and Panda et al. (2003) reported anticancerous activity of alcoholic extract against sarcoma 180 and melanoma B-16 in mice. Due to highly abortive seeds and unsustainable collection, the plants in the wild become depleting.

2.11.14 Sarcostemma brevistigma Wight

Family: Asclepiadaceae
Threat status: Rare

S. brevistigma (somlata) is a leafless, succulent, perennial trailing shrub or liana. It occurs in tropical regions of the world. It grows well in southern and northern part of India. Conventional propagation is done by stem cuttings but most of the cuttings degenerate quickly. Therefore, only conventional propagation is not sufficient to meet the demand of pharmaceutical industries. The extract of twig has uterine relaxant effect (Kumar et al. 2006). This plant species has anti-inflammatory (Lalitha et al. 2003), spasmolytic (Kumar et al. 2007), hepatoprotective (Sethuraman et al. 2003), and analgesic (Lalitha et al. 2002) activities due to the presence of various biologically active nonreducing disaccharides brevobiose (Khare et al. 1980a), tigmobiose (Khare et al. 1980b), and sarcobiose (Khare et al. 1980c) and the pregnane ester triglycoside brevine (Oberai et al. 1985). Due to its highest concentration of hydrocarbons (>3–3.6 %), it is one of the good sources of fuel (Augustus et al. 2002).

2.11.15 Stemona tuberosa Lour.

Family: Stemonaceae
Threat status: Rare

S. tuberosa is a perennial medicinal liana of dry climate. It is found in the hilly areas of Northeast India, Bangladesh, Myanmar, Thailand, Vietnam, Laos, Cambodia, and the Philippines (Tsi and Duyfjes 2000). A total of 14 alkaloids are found in *S. tuberosa* which are useful in treating bronchitis, pertussis, and tuberculosis (Jacobi and Lee 1997; Pilli and de Oliveira 2000). In nature, propagation is done by seeds and rootstocks. Indiscriminate destruction of forest for the collection for the tuberous roots is the main reason for its rare status.

2.11.16 Abrus precatorius L.

Family: Fabaceae

Threat status: Rare

A. precatorius (Kunch) is a deciduous medicinal liana with shiny scarlet red seeds with a black spot at one end. Various alkaloids such as glycerrhizin, precol, abrol, abrasine, abrin A, and abrin B have medicinal properties (Joshi 2000; Ghani 2003). Seeds, leaves, and roots are used to induce abortion and for the treatment of skin diseases (Kirtikar and Basu 1980). Nowadays plant species is facing the problem of potential extinction due to Jhum cultivation.

2.11.17 Aristolochia tagala Champ.

Family: Aristolochiaceae
Threat status: Rare

Aristolochia is a broad genus of tropical and subtropical countries with about 120 species. *A. tagala* is a rare, sun-loving woody climber of India, Sri Lanka, China, Malaysia, Myanmar, Indochina, Thailand and the Solomon Islands, and Queensland in Australia. The plant is valuable for its bioactive compound aristolochic acid (Wu et al. 2004). The aromatic roots are used to treat snakebites, bone fracture, rheumatism, and malaria (Biswas 2006). Roots are also used as a tonic and carminative. Leaves are used to treat colic fits and bowel complaints. Due to indiscriminate collection of roots and low viability of seeds, this plant species has become rare in the wild.

2.12 Strategies Used for Biodiversity Conservation

Plant germplasm collection and its conservation are an integral part of ensuring the availability of plant genetic materials for present and future breeding programs of important horticultural and agricultural plant crops and preservation of rare and endangered species and of heritage plants. The laudable attempts made (Singh et al. 2006) for biodiversity conservation are as follows (Fig. 2.1).

2.12.1 Reduction of Anthropogenic Pressures

Increasing population and its demands pose remarkable threat to taxa important to human being. About 70 % of identified medicinal plants of Indian Himalaya are under threat due to destructive harvesting. Cultivation of such plants elsewhere would contribute to their conservation.

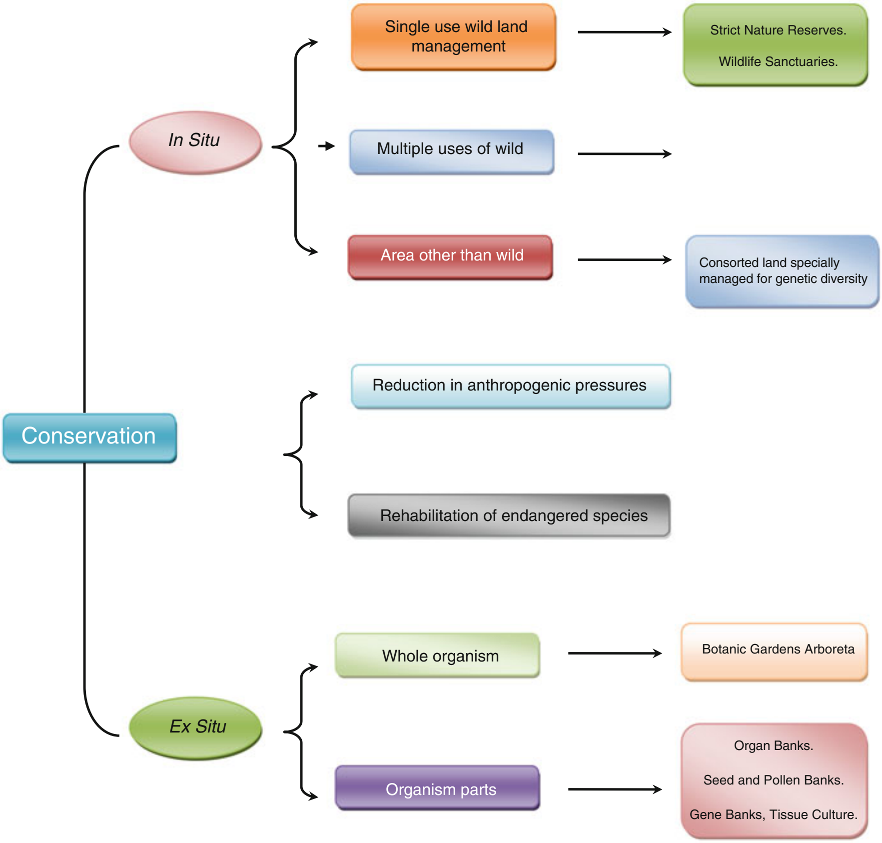

Fig. 2.1 Different strategies used for biodiversity conservation

2.12.2 Rehabilitation/Reintroduction of Endangered Species

Deliberate reintroduction of any extinct/endangered species into its native habitat is known as rehabilitation. It is comparatively labor intensive and a difficult way of conservation (Maunder 1992). It requires specific knowledge about species and its surrounding. This strategy includes:

- Analysis of factors responsible for species declination
- Ideas for habitat conservation, captive breeding, restriction of harvesting, etc.
- Reintroduction programs of a species in the original site of living
- Augmentation programs to increase the existing population size and genetic diversity of a species
- Programs for the introduction for a species into a new area

During 2000–2007, about 100–350 plants of 8 endemic medicinal species of Western Ghats (*Decalepis arayalpathra*, *Mahonia leschenaultii*, *Heracleum* *candolleanum*, *Calophyllum apetalum*, and *Blepharistemma membranifolia*) have been successfully reintroduced into their native habitats at Biotechnology and Bioinformatics Division of TBGRI. After 1–2 years, 78–95 % establishment success was noticed into their natural habitats.

2.12.3 In Situ Strategy

In situ strategy involves the preservation of germplasm in their natural environment by establishing biosphere reserves, national parks, gene sanctuaries, etc. This strategy emphasizes the conservation at original site of biodiversity, i.e., in the wild. Conservation of overall diversity of genes, populations, species, communities, and ecological processes comes under this strategy. There are 37,000 protected areas in the world (World Conservation Monitoring Centre, WCMC). India has 17 biosphere reserves and 19 Ramsar wetlands. Among the protected areas, India has 102 national parks and 490 sanctuaries expanded in 1.53 lac km^2. In situ preservation facilitates evolution and ecological balance, but it is prone to natural calamities and requires a large space.

- **Important National Parks and Wildlife Sanctuaries In India**

  Andhra Pradesh – Pakhal, Povharam, Kawal, Kolleru, Pelicanary wildlife sanctuary
  Arunachal Pradesh – Namdapha Wildlife Sanctuaries
  Assam – Kaziranga National Park, Manas Wildlife Sanctuary
  Bihar – Hazaribagh National Park
  Gujarat – Gir National Park
  Karnataka – Bandipur National Park, Silent Valley National Park
  Kerala – Periyar Wildlife Sanctuary, Wayanad Wildlife Sanctuary
  Orissa – Chilka Lake Bird Sanctuary
  Tamil Nadu – Mudumalai Wildlife Sanctuary, Vedanthangal Bird Sanctuary
  Uttar Pradesh – Corbett National Park
  West Bengal – Jaldapara Wildlife Sanctuary

- **Important Biosphere Reserves of India (Table 2.2).**

2.12.4 Ex Situ Strategy

This strategy says that conservation work should be done outside the natural habitat in the form of botanical and zoological gardens, conservation stand, seed and seedling banks, pollen banks, germplasm banks, tissue culture banks, gene/DNA banks, and techniques involve tissue culture, cryopreservation, incorporation of diseases, pest and stress tolerance traits through genetic transformation, and ecological

Table 2.2 Important biosphere reserves of India

Name of biosphere reserve	Location
Great Rann of Kutch	Gujarat
Nokrek	Meghalaya
Manas	Assam
Gulf of Mannar	Tamil Nadu
Sundarban	West Bengal
Nanda Devi	Uttarakhand
Nilgiri	Tamil Nadu, Kerala, and Karnataka
Dehang-Debang	Assam
Pachmarhi	Madhya Pradesh
Achanakmar-Amarkantak	Madhya Pradesh and Chhattisgarh
Kanchenjunga	Sikkim
Agasthyamalai Biosphere Reserve	Kerala and Tamil Nadu
Great Nicobar Biosphere Reserve	Andaman and Nicobar
Dibru-Saikhowa	Assam
Cold Desert	Himachal Pradesh
Seshachalam Hills	Andhra Pradesh
Similipal	Orissa

restoration of rare plant species and their population. Over the last 30 years, there has been significant increase in the number of plant collections and in accessions in ex situ storage centers throughout the world. Ex situ conservation provides a better degree of protection to germplasm compared to in situ conservation. In India, the National Bureau of Plant Genetic Resources (NBPGR) is actively engaged for conservation of cultivated plants and their wild relatives. However, both ex situ and in situ conservation are complementary but should not be viewed as alternatives (Wang et al. 1993).

2.12.4.1 Plant Tissue Culture and Micropropagation

The concept of plant tissue culture is proposed by Haberlandt (1902) that depends upon the "totipotency" nature of plant cells unequivocally demonstrated by Steward et al. (1958). Micropropagation is one of the most useful aspects where plant tissue culture technique has found its widest practical application. It refers to the rapid production of large number of identical clones within a short duration in available small space. Bhatt (1997) has also described micropropagation as a rapid and successful technique for asexual propagation of plants. This is generally obtained by in vitro methods involving culturing of meristem, shoot tip culture, and stimulation of axillary or lateral meristems or through culture of non-meristematic explants (leaf, petiole, root, etc.).

The modern technology of micropropagation provides numerous advantages over conventional propagation methods like mass production of true-to-type and disease-free plants of elite species in highly speedy manner irrespective of the season requiring smaller space and tissue source. Thus, it provides a reliable technique for in vitro conservation of various rare, endangered, threatened germplasm (Sahai et al. 2010; Sharma et al. 2014). Plant tissue culture offers tremendous advantages for the conservation of vegetatively propagated plant species with recalcitrant seed species for a long vegetative period prior to seed set and sterile individuals possessing useful traits. Biodiversity hotspots around the globe are at risk, and in vitro propagation methods have been used for rescuing and conserving endangered plants in many countries, including Australia, Malaysia, and South Africa. However, micropropagation technology is more costly than conventional propagation methods, and unit cost per plant becomes unaffordable compelling to adopt strategies to cut down the production cost for lowering the cost per plant (IAEA-TECDOC-1384 2004).

2.12.4.2 Slow-Growth Cultures

Slow-growth procedure is a way to keep the plant materials alive for 1–15 years under in vitro conditions. By using this valuable strategy, many tissue culture-raised medicinal plants of Western Ghats like *Zingiber* spp. and *Curcuma* spp. have been conserved in the in vitro repository of NBPGR, New Delhi, and Indian Institute of Spices Research, Kozhikode, respectively.

2.12.4.3 Cryopreservation

Germplasm storage at ultra-low temperature of liquid nitrogen (−196 °C) is known as “cryopreservation.” At this temperature, all cellular divisions and metabolic events are stopped. The plant material can thus be stored without alteration for extended periods, with limited maintenance (George and Sherrington 1984; Matsumoto et al. 1994; Grospietsch et al. 1999). Except for orthodox seeds, dormant buds, and some pollen, higher plant structures cannot generally survive the transition to and from the storage temperature without protection. Samples are submitted to a cryoprotective treatment before freezing, and substances such as dimethylsulfoxide (DMSO), sorbitol, mannitol, sucrose, and polyethylene glycol are usually applied. Sakai (1960) reported for the first time the survival of mulberry twigs in liquid nitrogen after dehydration mediated by extra-organ freezing.

A typical cryopreservation procedure has been established and consists of the following stages: (i) pregrowth, (ii) chemical cryoprotection, (iii) slow dehydrative cooling, (iv) storage in liquid nitrogen, (v) rapid thawing, and (vi) recovery. The exact treatments given at each stage will vary with culture system (Withers and Street 1977; Kartha 1985). Till date, cryopreservation is the only strategy used for long-term germplasm conservation. Recent years’ various medicinal plants of the Western Ghats have been successfully cryopreserved by using cryogenic strategies such as vitrification and encapsulation-dehydration.

2.12.4.4 Synseed Technology

In order to achieve germplasm conservation through plant tissue culture, it is necessary to reduce the frequency of subcultures so as to reduce the chances of contamination. This could be achieved by cryopreservation. The technique of cryopreservation has found its wide applicability in preserving biological materials and has a good potential for long-term storage of germplasm referred as "in vitro-based gene bank" (Cho et al. 2002; Tripathi et al. 2007; Normah and Makeen 2008). However, long-term storage of plants in liquid nitrogen, without regular subcultures, allows one to rationalize the production of nuclear stocks and maintains gene collections as storage tissue, but it cannot be applied to all genotypes. In this regard, a fascinating tissue culture technique, namely, "artificial seed" technology, has been first publicly addressed by Murashige in 1977 at a conference; since then, different approaches have been actively pursued to make it a viable technology for practical use. Till date, this technique has been adopted for synseed preparation in different plant species such as medicinal or ornamental horticultural plants (Sharma et al. 2013).

Artificial seeds are also known as manufactured seeds, synthetic seeds, or synseeds. Originally artificial seed is an encapsulated somatic embryo (Murashige 1978). Later on, Gray and Purohit (1991) extended this definition and suggested that "any somatic embryo that is engineered for its practical use in commercial plant production is known as synseed." Bapat et al. (1987) were the first who proposed the use of in vitro-derived propagules for the preparation of synseed rather than somatic embryo. According to Pond and Cameron (2003), the term "artificial seed" can be used for unencapsulated (naked) somatic embryos (either hydrated or desiccated).

Synseed technology is an emerging area of plant biotechnology for ex situ conservation of germplasm and their exchange among countries in a convenient and economic way. It is highly beneficial for rare, elite, sterile, and genetically engineered genotypes. Year-around production, ease of handling, and direct delivery of genetically uniform germplasm to field or greenhouse are the main advantages of encapsulation technology. The direct delivery of encapsulated material will save many subcultures to obtain plantlets (Maruyama et al. 1997; Bapat and Mhatre 2005).

Rajkumar and Rajanna (2011) provided a report on ex situ conservation of climbing plants at the University of Agricultural Sciences, Bangalore, Karnataka. The ex situ conservation center for climbing plants was established in 1973 at the Botanical Garden, University of Agricultural Sciences, GKVK, Bangalore, covering a total area of 65 acres. The garden is divided into 10 blocks with Block 1 earmarked for medicinal plants. Medicinal climbing plants were collected from all over Karnataka. A total of 50 plants species belonging to 44 genera and 26 families have been conserved in climbing plants in the Botanical Garden. These climbing plants are used by various tribals and local people to cure different ailments ranging from simple injuries, wounds, cuts, fever, diarrhea, ulcers, swelling, bone fractures, potency, antidote, skin care, night blindness, toothache, asthma, cough, and cold. Based on the data collected by consulting various ethnic groups and local people, an analysis

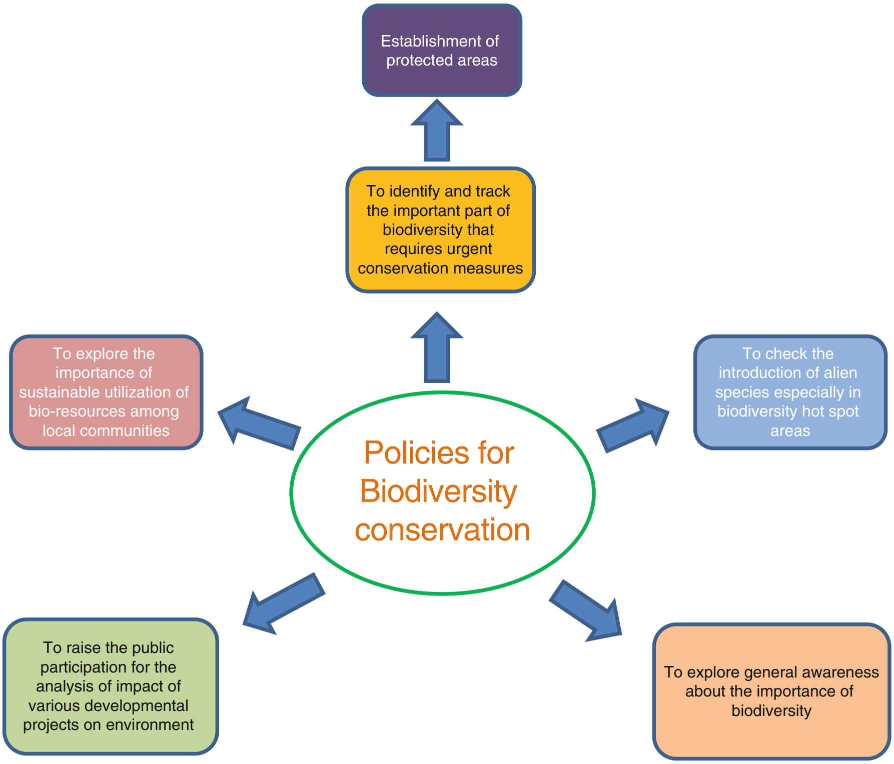

Fig. 2.2 Depiction of Policies to be adopted for the Biodiversity Conservation

has been done on the use of different parts of plants as a source of medicine. The analysis showed that leaves, bark, and roots are the major source of medicine. The medicinal plants with root as medicinal part need to be given more attention for conservation as collection of such plants will lead to the endangeredness of those plants. These informations need to be disseminated in the public for sustainable utilization.

2.13 Policies for Biodiversity Conservation

Biodiversity conservation plays a very important role in disaster management. Nowadays, various software tools are utilized globally to identify conservation area networks for the representation and persistence of biodiversity features. For biodiversity conservation, the policies depicted in Fig. 2.2 could be utilized effectively.

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