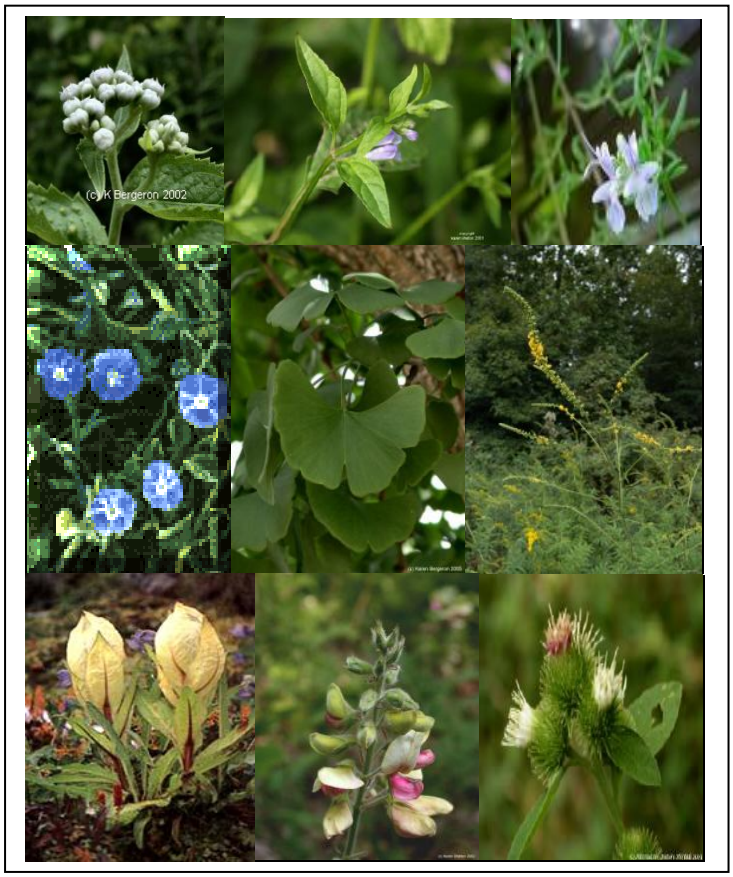
DIPLOMA IN
MANAGEMENT OF NON-WOOD FOREST PRODUCTS (MNWFP-10)

Course Title: Medicinal & Aromatic Plants (NWFP 02)



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CONTENTS

Unit 1: Traditional Knowledge of Medicinal And Aromatic Plants (Maps)

Unit Structure

1.1 Learning Objectives

After the completion of this unit student shall be able to:

- understand the traditional health care systems and practices in Himalaya
- know about tribal folk medicinal plants of Uttarakhand
- understand the challenges in national and international fronts
- explain traditional knowledge and Intellectual Property Right (IPR)
- collect information and data related to the various traditional methods using herbs, minerals, animal parts etc.
- describe the medicinal plants occurring in the Himalaya

- explain the minerals, animals and plants, and their produces which have application in folk and elite medicinal systems
- know the methods of usage of folk medicines.

1.2 Introduction

Traditional knowledge includes the beliefs, knowledge, practices, innovations, arts, spirituality, and other forms of cultural experiences and expressions of indigenous communities throughout the world. Traditional knowledge exist mainly in the form of songs, proverbs, stories, folklore, community laws, common or collective property and inventions, practices and rituals. This kind of knowledge is generally transmitted through specific cultural mechanisms such as those just listed above, and often through designated community knowledge holders, such as older people and *Vaidyas* etc. The knowledge is considered collective to the community, not private to one individual or small group. The traditional knowledge may be technical, social, organizational or cultural, obtained as part of the great human experiments for sustaining life and development. United Nation defines Traditional Knowledge Systems (TKS) as “Traditional knowledge or local knowledge is a record of human achievement in comprehending the problems of life and survival in a very adverse environment”. Laura Nader describes the purpose of studying TKS as “The point is to open up people’s mind to other ways of looking and questioning, to change attitudes about knowledge, to reframe the organization of science to formulate a way of thinking globally about traditions” (Nader 1996).

United Nations defines Traditional Knowledge System (TKS) as "a record of human achievement in comprehending the complexities of life and survival in often unfriendly environments. It may be technical, social, organizational, or cultural was obtained as part of the great human experiment of survival and development." Traditional knowledge provides the basis for problem-solving strategies for local communities, especially the poor.

1.3 Folk Knowledge in Western Hemisphere

Naked Science: Anthropological Inquiry Into Boundries, Power and Knowledge (Nader 1996). New York: Routledge has reported on the navigational skills of the atoll dwellers of western Caribbean islands. He says several things stand out about Caribbean navigational knowledge. It has all the features of a practical science. It contains a massive amount of

discrete information, which in the absence of writing and reference books, has to be committed to memory. Though the information is highly organized in a systematic way, the different ways of organizing it provide much redundancy as an aid to recall. It involves highly abstract thinking named for the stars and abstracted from their perceived motions, the use of 'drags', 'trigger fish' and so on. The numerous sayings of Ghagh and Bhadduri related with the agricultural practices and meteorology are well known which till today make guidelines for the traditional Indian agriculturists and researchers. The most significant difference between the western Arctic sciences is that in the latter systems humans are placed in the space of nature and are inseparable from nature, while Arctic science does not. One has to remember that the Inuit knowledge is formed through 'doing', 'hearing about it' and 'being there' - all interactive and personalized forms of knowledge transmission.

The indigenous systems and practices evolved around traditional values of resources that include subsistence values (food, clothing, housing, medicine, energy), socio-religious values (ritual, spiritual, education, aesthetical, psychological) and traditional practices of resource use (agri-diversity, wild-edibles, medicinal plants and ethno-veterinary uses etc). Myths and legends represent the heuristic attempts of our ancestors to explain the scientific observations they made around the world and to transmit such knowledge to the posterity. For example, the whole geological history of the Kashmir basin is accurately preserved in the legends about the *Satisar*. The braiding of Satluj is explained in terms of sage Vasistha trying to drown himself and the river breaking into hundreds of channels, hence called the *Satadru*. The late Pleistocene regression of the sea was conveyed by the legends of Parashurama in which he throws his *Parasu* (axe) to push back the sea, and so on (Agarwal 1997, 1999).

It is seldom realized that traditional knowledge systems preserve the wisdom gained through millennia of experience, direct observation and the word of mouth. The need of sustained investigation pertaining to traditional medicinal systems in general and medicinal plants in particular as practiced in tribal, aboriginal and remote areas has been increased manifold now days to explore new medicines for providing better and safe health care to the society. The other aspect of folklore and myths is that they are essentially the windows of our collective unconsciousness.

In India, traditional system of health care forms a means of livelihood and traditionally practiced knowledge which is acquired through experiential experiences for a very long time.

The study of traditional systems of knowledge requires a fair description of each of the systems i.e. description that does not start from the demarcation principle that western science alone can be regarded as knowledge based system. Nearly 80% of the world's population is dependent upon the traditional medicines for primary health care. Tribal medicines are the result of novel continued experimentation and innovation by indigenous people observing and using plants and animals, developing complex diagnosis and so on. These are the dynamic sets of practices, which can thrive, in a proper environment and with appropriate support. The traditional medicare in Himalaya, since long used by the local people, developed and given scientific shape by the sages, is a striking example of TKS. All the present day's recognized medical practices are evolved from the traditional or folk sciences used by man since the emergence of the humankind itself by using plants, animals and minerals occurring around. As the industrialization and modernization increased, the local traditional medical knowledge base started eroding. Plants, animals and minerals which were once abundant, have now become scarce and their traditional uses have also been forgotten. It has resulted into the forced movement of patients towards the more lucrative and attractively packaged alternatives, the allopathic medicines and system.

Elite Science

Elite sciences or the recognized systems of knowledge, which is known worldwide and are accepted systems. India is a country where several systems of health care have been in use for centuries. Among various accepted systems, some famous systems are Ayurveda, Yoga and Naturopathy, Unani, Siddha, Amchi or Tibeten system of medicines and also Allopathic system of medicine. At the base of all these systems, there is a substratum of folk knowledge of medicines, which is used regularly and is well known.

Interaction between the two

Evolving over a long period of time based on necessities and experiences, the Folk medicine system, in the central Himalayan region like elsewhere in the globe and mountain ecosystems in particular is an important natural resource that facilitates the developmental process in a cost effective, participatory and sustainable ways and plays an important role in resource conservation. Thus, it can be said that these elite sciences are developed from the Folk sciences through the millennia. The Folk sciences of India have been on the one hand appropriated by the Elite Sciences, and on the other have been depicted as being in

conflict with the progressive, rational and materialistic West. In the West, Folk and Elite sciences are often viewed as opposites, which contradict each other. However, India's TKS and Elite sciences did coexist in a mutually symbiotic and complimentary relationship. This is the major reason to properly study India's TKS. The *Ayurveda* was composed in the lower Ganga valley but Charak, its composer, was aware of the richness of the Himalayan medicinal flora. According to the Charak *Samhita* the whole Himalayan region can be stated to be the treasure trove of various medicinal plants (Agrawal 1997, Agrawal et al., 2007).

Charak is not only aware of this rich flora but has used several hundred Himalayan plants in the *Materia Medica* of the Ayurveda. It is obvious that medicinal properties of the local flora must have been studied and used by the indigenous medicinal systems. Some important and common medicinal plants are given below in Table 1.

Table 1. Some Himalayan medicinal plants used in Ayurveda

	Botanical names	Local names
1.	*Acacia catechu*	Khair
2.	*Achyranthes aspera*	Latjeera
3.	*Aconitum heterophyllum*	Atis
4.	*Acorus calamus*	Bach
5.	*Aegle marmelos*	Bel
6.	*Agave Americana*	Ram-bansh
7.	*Aesculus indica*	Pangar
8.	*Ajuga bracteosa*	Ratpatti,Ratpatia
9.	*Albizia lebbeck*	Siris
10.	*Allium cepa*	Pyaj,Pyaz
11.	*Allium sativum*	lehsan
12.	*Angelica glauca*	Gandhrayan
13.	*Artemisia indica*	Pati
14.	*Artemisia nilagirica*	Ghari-pati
15.	*Asparagus racemosus*	Satavari,Kairua
16.	*Azadirachta indica*	Neem
17.	*Bacopa monnieri*	Mandook-parni,Pan- bhrahmi
18.	*Bauhinia vahlii*	Malu,Maljhan
19.	*Bauhinia variegata*	Kachnar
20.	*Berberis aristata*	Kilmora,Rasut
21.	*Berginia ciliate*	Pashan-bhed

22.	*Berginia ligulata*	Pathar-chatta
23.	*Betula utilis*	Bhoj-patra
24.	*Boerhavia diffusa*	Punernava
25.	*Bombax ceiba*	Semal
26.	*Brassica rapa subsp.*	Sarson
27.	*Calotropis procera*	Ak
28.	*Cassia fistula*	Amaltas
29.	*Crocus sativus*	Kesar
30.	*Dactylorhiza hatagirea*	Salam-panja
31.	*Datura stramonium*	Dhatura
32.	*Dioscorea bulbifera*	Gethi
33.	*Eclipta prostrate*	Bhangru,Bhangri
34.	*Evolvulus alsinoides*	Sankha-pushpi
35.	*Ficus palmate*	Beru
36.	*Ficus religiosa*	Pipal
37.	*Glycyrrhiza glabra*	Muleti
38.	*Grewia optiva*	Bheemal
39.	*Juglans regia*	Akhrot
40.	*Mangifera indica*	Aam
41.	*Mentha arvensis*	Pudina
42.	*Ocimum canum*	Tulsi
43.	*Oxalis acetosella*	Chalmori
44.	*Phyllanthus emblica*	Amla
45.	*Potentilla flugens*	Bajradanti
46.	*Solanum nigrum*	Makoi
47.	*Swertia nervosa*	Chirayata
48.	*Taxus baccata*	Thuner
49.	*Terminalia bellirica*	Behera
50.	*Tinospora cordifolia*	Giloy
51.	*Urtica dioica*	Bichhughas
52.	*Viola betonicifolia*	Banfsa
53.	*Withania somnifera*	Ashwagandha
54.	*Zanthoxylum armatum*	Timur
55.	*Ziziphus mauritiana*	Ber

The Indian Himalayan region alone supports about 18,440 species of plants (Angiosperms: 8000 spp., Gymnosperm: 44 spp., Pteridophytes: 600 spp., Bryophytes: 1736 spp., Lichens: 1159 spp. and Fungi: 6900 spp.) of which about 45% are having medicinal properties. Among the vascular plants, there are about 1748 species of medicinal importance in Indian Himalayan Region (Samant *et al.* 1998).

Traditional Himalayan medicine is a good example of TKS, which has affected the lives of poor people around the globe. TKS is of particular relevance to the poor in the following sectors: agriculture, animal husbandry and ethnic veterinary medicine, management of natural resources, primary health care (PHC) and preventive medicine, psycho-social care, saving and lending, community development, poverty alleviation, etc.

1.4 Traditional Himalayan Medicine System

The Traditional Himalayan Medicine System (THMS) is a living example of TKS where rural communities receive treatment for various diseases even for incurable one through the traditional system of medicines. They also cure their animals through these traditional methods. These traditional methods are totally oral and non-documented. They use generally herbal products like resin, bark, root, leaves, fruits etc., minerals, animal products and *tantric* practices. In traditional knowledge system of medicines, herbal products are used to cure the diseases under natural therapies. According to the mode of application, the natural therapies are grouped into following three categories:

1. Herbal products used in systematized system of medicine like Ayurveda and Siddha.
2. Herbal products used in ethno-medicine or indigenous medicine like HMS based on oral tradition.
3. Herbal products used in modern medicine, based on active chemical principles of the herbal products.

1.4.1 Natural therapies

In India, the use of plants for the treatment of various diseases dates back to prehistoric times. This indigenous knowledge about medicinal plants and therapies was composed verbally and passed orally from generation to generation. Much later, some of this information was systematized in treatise forms like *Atharveda*, *Yajurveda*, *Charak Samhita*,

Sushrut Samhita, etc. These systematized systems of knowledge about medicinal plants and therapies are included under Ayurveda - the Indian Traditional Medicine System. Despite the development of rural health services, village people still use herbal native medicines to a large extent for treatment of common ailments like cough, cold and fever, headache and body-ache, constipation, dysentery, burns, cuts and scalds, boils and ulcers, skin diseases and respiratory troubles, etc. The herbal medicines are prescribed by the household ladies or older persons, *Pujari*, *Ojhas* (physicians practicing witchcraft) and by traditional herbalists.

1.3.2 Household ladies

The Indian household ladies use herbal drugs for most of the ordinary ailments of infants and children. The herbal drugs are mostly available to them from their kitchen stock, kitchen garden or village fields and from the village bazaar. The use of rhizome of *Curcuma domestica* (Haldi) for cuts, burns and scalds; the fruits of *Piper nigrum* (Black pepper, Kali-mirch or Gol-mirch) for coughs and colds; the fruits of *Trachyspermum ammi* (Ajawain); and resin of *Ferula* spp. (Heeng) for stomach troubles and whooping cough; the seeds of *Sesamum indicum* (Til) for ulcers and boils, etc., all are well known to Indian elderly housewives.

The use of infusions of the leaves of *Ocimum sanctum* (Tulsi) for coughs and colds and mild fever, fomentation with the hot leaves of *Ricinus communis* (Erand) and *Aloe barbadensis* (Geekuar) for relieving inflammations, swellings of joints and sprains, and many other home remedies are learnt traditionally in the home.

1.4.3 Elderly persons

In the villages the elderly persons, Pujari, Ojhas, and priests, *etc*., know quite a few herbal drugs, which grow near at hand and try them effectively without any hesitation against several common ailments and diseases. Their services are entirely free of cost.

1.3.4 Traditional herbalists

Traditional herbalists are professionals. They are mostly illiterate but have considerable knowledge of the herbal drugs and their uses. They keep stocks of crude drugs for sale and prescribe these for common ailments. The traditional herbalists maintain a small shop. There is another kind of herbalist, who is a wanderer. Among these there are two categories: those

who administer a ground mixture of herbal drugs, and those who prescribe and also supply the herbal drugs as such.

The first category of herbalists keeps their crude drugs in glass jars and often displays them at the roadside. Mostly they procure their drugs from established crude drug markets of Northern India. They administer drugs mainly for venereal ailments, and also as tonics and aphrodisiacs. The most common herbal drugs seen with them are the tuberous roots of *Dactylorhiza* spp. (Salam panja or Salam gatta), the roots of *Asparagus* spp. (Satawar), *Withania somnifera* (Ashwagandha), the fruits of *Tribulus terrestris* (Chota gokhru), and *Pedalium murex* (Bara gokhru), seeds of *Mucuna pruriens* (Kiwanch), *Entadapursaetha* (Chian, gila), stems of *Tinospora cordifolia* (Giloya), the tubers of *Pueraria tuberosa* (Vidari kanda), and others.

The second category of herbalists administers the herbal drugs directly without pounding; they keep only a limited number of crude drugs for day- to-day requirements. The drugs, which they commonly keep, are fruits of *Terminalia chebula* (Harrar), *T. belerica* (Bahera), *Emblica officinalis* (Awmla), *Helicteres isora* (Marorphali), bark of *Symplocos* sp. (Pathani lodhra), roots of *Withania somnifera* (Aswagandha nagori), and seeds and oleoresins of various plants.

In the hills, the herbalists are often seen also with crude drugs procured from the alpine regions, like *Rheum* spp. (Dolu), *Aconitum heterophyllum* (Atis), *Picrorhiza kurrooa* (Karu), *Angelica glauca* (Chora or Gandrayan), *Nardostachys jatamansi* (Mansi), and the aromatic leaves of *Allium govanianum* and other *Allium* spp. (Uambu), and many others.

1.5 Ancient Therapies of Folk Science

Folk Sciences are indigenous and due to increase in population, urbanization and continuous exploitation of herbal reserves and other natural resources, traditional knowledge is depleting day by day. There are some traditional systems of medicine, which are very effective. Some folk medicinal plants are also used to cure various diseases, which are incurable through allopathic medicines. Some of these old therapies are described here to understand the folk science or the non-literate medical systems.

(A) Fire Therapy: Damana (*Agnidagdha chikitsa* / Moxibustion)**:** At some places toothache treatment is given by touching the carious tooth for a moment with a lighted *Biri* (indigenous cigarette, tobacco wrapped in Tendu Leaf). In some parts of Kumaon, the dry leaves of

Bakaul *(Anaphalis contorta* and other species) are used to make burn-scar on the dorsal side of the palm of children. This scar remains throughout the life. It is believed that this treatment increases immunity as well as working efficiency of children. In order to treat dog bite, a burning piece of the stem of *Baigan (Solanum melongena)* is carefully applied to the wound and it is supposed to check Rabies. Cuts by rusted iron articles are treated with burning Ghee-batti (cloth dipped in ghee and burn) which is said to check Tetanus.

(B) *Ushna sek* (Heat/Hot fomentation therapy): Sprained areas or hair-line fractured bones are fomented with leaves of *Arandi (Ricinus communis), Dhatoor, Parijat*, bee-wax, honey, hot sand/loaf, cut-lemon, salt etc. Orange fruit or ginger roasted in hot-ash is given to treat cough and cold. Tunicated bulb of Lehsun *(Allium sativum*) heated with mustard oil is used for massage in rheumatism. Freshly cooked hot puffed bread *(Chapati)* is used to treat cracks developed along the nails of hands. The lukewarm decoction of *Ajwain* (seeds of *Trachyspermum ammi*) is rubbed down with a slight massage over the mammary glands (nipples) with the help of fine cloth to treat mastitis. Hot poultice: *Haldi (Curcuma domestica)* powder with mustard oil is rubbed over sore foot (locally known as 'kadno' or 'kadyo').

(C) Aroma Therapy: "Aroma therapy is based on treatments with essential oil and suited to the treatment of diseases of brain and nervous disorders". Inhaling smoke obtained by burning dried fruit of *Ghiya-turai (Luffa aegyptiaca)* is said to cure jaundice.

(D) *Sampark Chikitsa* (Contact therapy through herbs, animals, metals): Herbal: *Haldi* paste is applied throughout the body during marriage ceremony to remove the unwanted hair and to heal the cuts, bruises and wounds of the body. A paste of *Gurhal* flowers *(Hibiscus rosa-sinensis*) is applied with light massage over the naval of the woman to facilitate delivery. Similarly root of *Apamarg (Achyranthes aspera*) and *Kalihari (Gloriosa superba)* is also used for this purpose. Pine *(Pinus roxburghii*) resin is applied at the side of the eye (temple region) for curing redness in eyes. This resin is also applied, as a plaster on fractured legs of cattle. Juice of onion bulb is applied on the affected part to cure inflammation caused by honeybee stings. Viscous juice of *Gheekwar (Aloe barbadense*) leaf is applied on forehead to cure headache. During sprains, fresh leafy twig of *Bichhu (Urtica parviflora* and *U. dioica)* is applied over the affected parts.

Mineral/ Metal: Warm poultice of salt is applied on the sore part. To treat backache and waist pain, a sachet of salt is heated on iron plate and massaged gently. Fresh rhizome of

Haldi pounded with *Doob (Cynodon dactylon)* grass and calcium oxide powder (Kamet - a type of soil) is boiled with water and sprinkled over the sprain affected joints. *Singraf* (cinnabar) is also used externally by villagers for the treatment of various muscular diseases and disorders.

(E) *Suchikadaab* (Acupressure Therapy): *Rudrakhash* nuts *(*seeds of *Elaeocarpus sphaericus)* and magnet are worn by religious people to keep off evil sprit and to control blood pressure. Massage with mustard oil is used to develop pressure on the body.

1.6 Himalayan Medicinal Plants: A Distinct Biodiversity

Apart from other natural resources, the Himalaya is bestowed with rich biodiversity of medicinal plants. Due to climatic and topographic diversity, the representation of this group in this region is unique. The Indian Himalayan region is a rich repository of medicinal plants with a total of 1,748 species (Samant et al., 1998). Himalayan medicinal plants are largely being utilized in two ways, (1) domestic consumption by local inhabitants and (2) preparation of plant based drugs by pharmaceutical industries. Since the former is based on rich traditional knowledge, the approach of extraction of the resource from natural habitat is, by and large, systematic. However, the latter involves unabated exploitation of resource from the wild with total disregard of the status of the species. In recent years, increasing attention is being paid to medicinal plants value both due to their economic and conservation concerns (Dhar et al., 2002; Tewari et al., 2010). Over-exploitation of the rhizome and other parts for medicinal use and consequent degradation of natural habitats are reported to be the major threats to these plants. Seventeen species of the Himalayan medicinal plants are considered as most endangered and listed in the Red Data Book of Indian plants (Samant et al., 1998).

Apart from other Indian Himalayan states, some common medicinal and aromatic herbs collected for trading from hills of Uttaranchal state are (Gaur, 1999; Tewari et al., 2008): - Kutki (*Picrorhiza kurrooa* Royle), Jatamansi (*Nardostachys jatamansi* DC.), Atees (*Aconitum heterophyllum* Wall.), Gobriya/Bish (*Aconitum balfourii* Stapf), Salampanja (*Dactylorhiza hategerea*), Bhutkeshi (*Corydalis govaniana* Wall.), Bankakari (*Podophyllum hexandrum* Royle), Somlata (*Ephedra gerardiana* Wall.), Nirbishi (*Delphinum elatum* L.), Rewandchini (*Rheum emodi* Wall.ex Meisesn.), Chirata (*Swertia chirata* Buch.-Ham.), Daruharidra (*Berberis aristata* DC.), Kilmora (*Berberis asiatica* Roxb.), Padam (*Prunus cerasoides* D.Don), Banapsa (*Viola odorata* Linn), Samewa/Tagar (*Valeriana wallichii* DC.),

Pilijari/Mamiri (*Thalictrum foliolosum* DC.), Kapoor Kachri (*Hedychium spicatum* Buch-Ham), Pasanved (*Berginia ligulata* (Wall.) Engl.), Tejpat (*Cinnamomum tamala* Nees & Ebern.), Bach (*Acorus calamus* Linn.),Nairpati (*Skimmia laureola* Seib and Zucc.), Timur (*Zanthoxylum armatum* DC. Banajwain (*Thymus serphyllum* Linn), Jhora (*Juniperus communis* Linn), Billa/Dhup (*Juniperus macropoda* Boiss), Chora (*Angelica glauca* Edgew), Pudina (*Mentha sylvestris* Linn), Devdar (*Cedrus deodara* (Roxb.) Louddl), Chir (*Pinus roxburghii* Sarg.), Kuth (*Saussurea costus* C.B. Clarke.), Bantulsi (*Origanum vulgare* Linn.), Akhrot (*Juglans regia* Linn.), Bari (*Quercus incana* Roxb.), Bhang (*Cannabis sativa* L.), Bakain (*Melia azerdach* L.), Jeevak-Rishvak (*Malaxis accuminata* D.Don) and Kakoli-Ksheer kakoli (*Roscoea procera* Wall.) and many others.

1.7 Tribal-Folk Medicinal Plants of Uttarakhand

The association of plants as medicine with man is as old as the human civilization itself. A greater part of the plants as medicine have come through trial, error and selection by man, since very ancient times. It is also evident that through observing the animals, birds and other creatures using the plants for their ailments in the nature man further came to know the healing powers of plant growing in the nature. Such knowledge descended from generation to generation. Roots of many indigenous systems are embedded in the traditional knowledge of herbal medicines. During past few centuries, the coming up of the modern systems of medicines, the knowledge of herbal medicines preserved with masses especially in remote and tribal areas are being forgotten today. It is high time that such knowledge of use of plants for medicinal purposes inherited from generation especially by the tribals and people living in remote areas is recorded before it is last because of rapidly changing life-styles due to accessibility to modern developments and the tendency to discard old norms and values. It is observed that civilizations progress is destroying the environment as well as culture and that the modern civilization may become victim of its own progress (Pandey et al., 2006). Further under such circumstances the knowledge of therapeutic uses of plant progressed with the rural populations, tribal and people living in remote areas must be brought to records. Uttarakhand, which is a treasure of medicinal plants, naturally, inherits the vast knowledge of therapeutic uses of medicinal plants. Some important folk-tribal medicinal claims from Uttarakhand are given in Table 2.

Table 2. Medicinal plants used in traditional health-care system

Medicinal use	Medicinal plant
Antipyretic	*Picrorhiza kurrooa, Aconitum balfouri, Berberis asiatica, Bergenia ligulata* and *Viola odorata*
Antiseptic	*Saussurea obvallata, Arnebia benthamii, A. euchroma*
Astringent	*Rheum emodi, Dactylorhiza hatagirea*
Appetizer	*Angelica glauca, A. archangelica, Allium* spp.
Leukoderma	*Heracleum candicans, Swertia chirayita*
Jaundice	*Nardostachys jatamansi, Berberis aristata*
Cuts, burns, boils	*Arenebia benthamii*, *A. euchroma, Saussurea obvallata*
Conjunctivitis	*Delphinium elatum*
Cough and cold	*Aconitum heterophyllum, Saussurea obvallata*
Tonic	*Swertia chirayita*, *S. angustifolia*
Menstrual disorder	*Podophyllum hexandrum, Origanum vulgare, Polygonum tortuosum*
Dental use	*Zanthozylum alatum, Juglans regia*

Some important wild plants used in traditional system of medicine in Uttarakhand are given in Table 3.

Table 3. Wild plants used in traditional system of medicine

Botanical name	Vernacular name	Part used/mode of application Uses
Aconitum atrox	Mitha bish	Paste of rhizome fried in ghee Rheumatism, neuralgia, paralysis, rheumatic
A. heterophyllum	Atibish	Root powder mixed with honey and Fever, cough, chills, stomach disorders
Pistaciakhinjuk	(Kakarsingi)	diarrhoea
Actaea acuminata	Mamira	Decoction of roots Bronchial inflammation
Angelica glauca	Choru	Root stocks Flatulence, colic

Asparagus filicinus	Jhirni	Powder of dried tuberous roots Sexual debility and urinogenital disorder
Bergenia stracheyi	Shilpari	Root decoction and juice of leaves Kidney stones, sores, swellings and jaundice
Dactylorrhiza hatagirea	Salampanja	Powder of roots Cuts and wounds
Dioscorea bulbifera	Genthi	Tubers Bronchial cough
Dioscorea deltoidea	Tairu	Rhizomes Spermetonorrhoea
Euphorbia hirta	Dudhibari	Entire plant with curd Piles
Hedychium acuminatum	Kapoorkachri	Purified root powder Dyspepsia and piles
Megacarpaea polyandra	Barmoola	Roots Fever, stomach disorders
Picrorrhiza kurroo	Kutki	Root powder Sever coughing, fever and stomach disorder
Rhododendron anthopogon	Bhotiachai	Decoction of leaves Coryza and catarrh
Thymus linearis	Van ajwain	Extracts of leaves and floral buds Asthmatic cough
Valeriana jatamansii	Sameva	Roots Epilepsy, hysteria
Zanthoxylum acanthopodium	Timru	Seed-powder and stem bark Toothache, tooth decay

Source: Kandari & Gossain, 2001; Gairola & Biswas, 2008; Kumari et al., 2009; Negi, 2010

According to an estimate of the World Health Organization, approximately 80% of the people in developing countries depend on traditional medicine for primary health care needs; a major portion of these involves the use of medicinal plants.

1.8 CHALLENGES

Traditional medicine has been used in some communities for thousands of years. As traditional medicine practices are adopted by new populations, there are some challenges.

1.8.1 International diversity

Traditional medicine practices have been adopted in different cultures and regions without the parallel advance of international standards and methods for evaluation.

1.6.2 National policy and regulation

Not many countries have national policies for traditional medicine. Regulating traditional medicine products, practices and practitioners is difficult due to variations in definitions and categorizations of traditional medicine therapies. The disparity in regulations at the national level has implications for international access and distribution of products.

1.6.3 Safety, effectiveness and quality

Scientific evidence from tests done to evaluate the safety and effectiveness of traditional medicine products and practices is limited. The safety, effectiveness and quality of finished herbal medicine products depend on the quality of their source materials (which can include hundreds of natural constituents), and how elements are handled through production processes.

1.6.4 Knowledge and sustainability

Herbal materials for products are collected from wild plant populations and cultivated medicinal plants. Efforts to preserve both plant populations and knowledge on how to use them for medicinal purposes is needed to sustain traditional medicine.

1.6.5 Patient safety and use

Many people believe that because medicines are herbal (natural) or traditional they are safe (or carry no risk for harm). Increased patient awareness about safe usage is important, as well as more training, collaboration and communication among providers of traditional and other medicines.

1.6.6 WHO response

WHO and its Member States have promoted the use of traditional medicine in health care. It mainly aims to:

- support and integrate traditional medicine into national health systems in combination with national policy and regulation for products, practices and providers to ensure safety and quality;

- ensure the use of safe, effective and quality products and practices, based on available evidence;
- acknowledge traditional medicine as part of primary health care, to increase access to care and preserve knowledge and resources; and
- ensure patient safety by upgrading the skills and knowledge of traditional medicine providers.

1.9 Traditional Knowledge and IPR

In recent years concern has been expressed in relation to the recognition of traditional knowledge as prior art. Patents have been granted for traditional knowledge-related inventions, which did not fulfill the requirements of novelty and inventive step when compared with the relevant prior art. This prior art consisted of traditional knowledge that could not be identified by the patent-granting authority during the examination of the patent application.

Turmeric (Grandmother's Recipe)

Turmeric (Curcuma longa) is a plant of the ginger family yielding saffron-colored rhizomes used as a spice for flavoring Indian cooking. Its unique properties also make it an effective ingredient in medicines, cosmetics and as a color dye. As a medicine, it is traditionally used to heal wounds and rashes. In March 1995, two expatriate Indians at the University of Mississippi Medical Centre, Jackson, (Suman K Das and Hari Har P. Cohly) were granted a US patent for turmeric to be used to heal wounds.

The Indian Council for Scientific and Industrial Research (CSIR) filed a case with the US Patent Office challenging the patent on the grounds of "prior art", i.e. existing public knowledge. CSIR said turmeric has been used for thousands of years for healing wounds and rashes and therefore its use as a medicine was not a new invention. CSIR also presented an ancient Sanskrit text and a paper published in 1953 in the Journal of the Indian Medical Association. The US Patent Office upheld the objection and cancelled the patent. The turmeric case failed to meet the novelty criteria.

The development of new technology and the new use of traditional knowledge based products today is the major threat to the survival of many of the communities. The modern cultural industries as well as the manufacturing industries now commercially exploit the

traditional knowledge based products using new technology without the permission and sharing of profits with the communities. This is proved beyond doubt particularly in the field of medicines, agriculture etc. The bio- prospecting help the scientists in the modern pharmaceutical research laboratories to get the know how to develop new products or new use of existing products. Traditional knowledge is generally associated with biological resources and is invariably an intangible component of such a biological resource. Some countries have specific legislation protecting this kind of knowledge while some other countries feel their existing IPR regime protect such knowledge. A regional policy has to be developed for the protection of indigenous knowledge related to biodiversity and which includes agriculture, medicinal, ecological related knowledge; and also for the protection of other traditional knowledge relating to folklore.

1.10 International Initiatives

The Convention on Biological Diversity is the first international agreement acknowledging the role and contribution of indigenous and local communities in the conservation and sustainable use of biodiversity. The Convention imposes general obligations relevant to the conservation, sustainable use, sharing of information on, and equitable sharing of benefits derived from biodiversity. Each party has an obligation (subject to their particular national circumstances) to develop national legislation as far as possible and as appropriate in order to:

- respect, preserve and maintain knowledge, innovations and practices of indigenous and local Communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and
- promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices. Parties to the CBD are also obliged and encouraged to:
- protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements,

- develop and use indigenous and traditional technologies, in pursuance of the objectives of this Convention. Under the CBD, States are recognized as the owners of the natural biological resources in their territories including their genetic resources and thus have a sovereign right to exploit their natural resources and determine access. States have a responsibility under the CBD to facilitate access to, and benefit-sharing arising from the use of biological resources and to subject all access to prior informed consent according to mutually agreed terms.

1.11 Summary

- Traditional knowledge of medicinal and aromatic plants based on folk knowledge and indigenous system.
- The elite science and folk medicinal system is an important natural resource.
- Traditional Himalayan medicinal system is an living example of traditional knowledge system which include natural system, elderly person, herbalist.
- Ancient therapy of folk sciences include fire therapy, heat therapy, sampark chikitsa.
- Himalayan medicinal and tribal folk medicinal plants are as old as human civilization itself.
- Challenges to traditional medicinal plant is International diversity, policy, safty, knowledge and sustainability and WHO response.
- Patent is also required for traditional knowledge system of medicinal and aromatic plants.
- CBD is the first international agreement for indigenous system and sustainability of biodiversity.

Terminal Questions

1. Explain the relationship between traditional and folk knowledge with indigenous system.
2. What is elite science?
3. Describe medicinal plants used in traditional health care system.
4. Describe wild plants used in traditional system of medicine.

5. What are the challenges for traditional knowledge system?
6. Describe ancient therapies of folk science.

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Unit 2: Sustainability and Threats to Medicinal and Aromatic Plants (Maps)

Unit Structure

1.1 Learning Objectives

After the completion of this unit student shall be able to:

- To know the concept of sustainability with respect to MAPs
- To describe the present status of MAPs;
- To explain the various types of threats to plants in general and then specifically to MAPs;
- To explain the various measures necessary for sustainable use of medicinal plant resource.

2.2 Introduction

In everyday life we use plants, parts of plants and their extracts. A list of more than 21,000 plant species, which are globally used in medicine, has been compiled by the WHO. They are used in various ways: as food, medicines, in cosmetics industry, as colouring agents, detergents, perfumes and many other things. More than three-quarters of the world's population rely on local health practitioners and traditional medicines for their primary medical needs. They provide income and healthcare to thousands of people around the world.

WHAT IS SUSTAINABILIY?

As it applies to medicinal and aromatic plants and products made from them, sustainability involves providing a natural resources for human health needs in a manner that supports the health and diversity of the natural environment, and incorporates labour and wage practices that enable all people in the system to flourish, in a sustainable system, all life is supported and allowed to prosper.

The resurgence of public interest in plant-based medicine coupled with rapid expansion of pharmaceutical industries necessitated an increased demand of medicinal plants, leading to overexploitation that threatened the survival of many medicinal plants. But 15,000 species of medicinal plants are globally threatened from, amongst others, loss of habitat, overexploitation, invasive species and pollution. Many more are genetically depleted. To conserve this valuable natural resource, there is a need for governments to endorse a revised and updated Global Strategy for Plant Conservation which aims to halt the continuing loss of the world's plant diversity.

Further, the degree of threat to natural populations of medicinal plants has increased because more than 90% of the plant raw material for herbal industries in India is drawn from natural habitats. Not surprisingly, wild plant species used for medicinal purposes are receiving ever-increasing attention from the scientific community and commercial enterprises. At the same time, these species continue to support indigenous and local communities that have relied on them for centuries in their traditional medicines. But a number of factors now threaten wild medicinal plants – habitat destruction, over-harvesting and big business. In India, hundreds of medicinal plants like *Pterocarpus santalinus,*

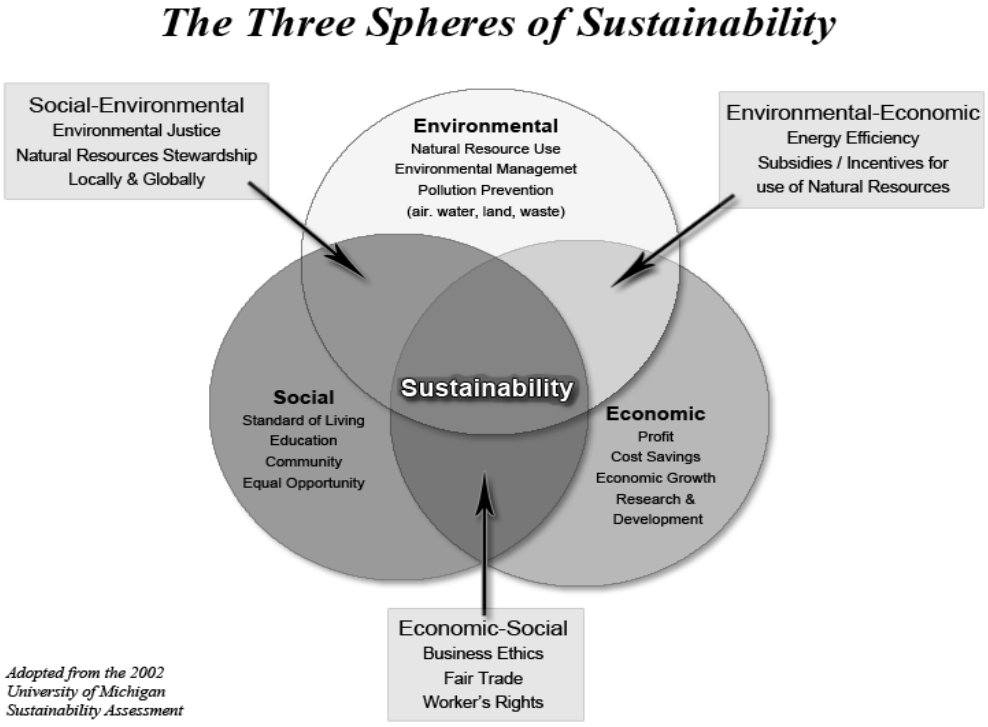
Commiphora wightii, Taxus wallichiana, Picrorhiza kurrooa, Salvadora persica and Dioscorea deltoidea, are at the risk of extinction due to overcollection to supply domestic and foreign medicinal markets, threatening the discovery of future cures for diseases. Action at several levels is urgently needed to conserve the dwindling plant species.

2.3 Three Dimentions of Sustainability

There are three dimensions of sustainability concerning medicinal plants:

2.3.1 Economical

The first has to do with improving human health with reasonable cost. Plant medicines are used around the world to help sustain human health. They are highly beneficial, largely safe, and increasingly well studied. As many pharmaceutical drugs are toxic, can cause adverse side effects, and produce fatalities. So a first and most critical aspect of sustainability has to do with providing safe, effective, low cost natural plant medicines that can be used in place of more dangerous drugs.



2.3.2 Environmental

A second dimension of sustainability concerns the environmental impact of medicinal plants. Harvesting of wild species, and cultivation of species, can be performed in ways that do not degrade the natural environment and may in fact improve soil fertility and other parameters

of environmental health. Organic farming practices, and properly planned methods of harvesting can keep the natural environment diverse, healthy and thriving. The use of wild species is often regulated or restricted by some form of environmental legislation. However, local farming communities are unlikely to know about relevant laws or regulations. Therefore action needs to be taken in the form of awareness campaigns or education programmes to ensure wider knowledge, on the part of local communities, individuals, local government, traders, agricultural extension officers, air officers, conservation agencies, industry and consumers, of legislation affecting the plants that are consumed or harvested. Local, national, regional and international treaties, conventions and agreements need to be respected

2.3.3 Social

A third dimension of sustainability and medicinal plants concerns native people and traditional cultures. Around the world we are losing cultural, linguistic and cognitive diversity as these people are displaced, absorbed into general humanity against their will. When fair wages are paid to native and traditional people, it provides them with economic power. This can help people to maintain custom and culture, to support themselves by engaging in activities consistent with their heritage, and better able to defend themselves against encroachment and adversarial practices on the part of mining, petroleum, agricultural and other industrial entities. Humane practices can help these people to flourish.

If the potential of wild plant resources is to be developed and sustainably used by local farmers, then ownership, whether communal or private, of the land and the resources must be clearly established. There is little incentive for farmers to engage in development activities if land tenure is weak or uncertain. Many rural households, especially those with little land of their own rely on common property areas for gathering wild plants or plant products that contribute to their household economies and complement agricultural production. Common lands also provide employment opportunities for those without land, for small farmers and farm workers and for those without land, for small farmers and farm workers and fro women and children.

The allocation of property rights is an important issue for local communities and affects their attitudes to both wild harvesting and home gardens. In the case of wild harvesting of medicinal plants, provided regulations resurging sustainable practices are applied, property

rights need to be guaranteed to the gatherers to ensure long-term exploitation of the resource. However, the rights must be allocated at the community level and not to individuals, though negotiated agreements with traditional healer associations or community leaders who can play an important part in monitoring or controlling the use of resources.

2.4 Present status

One of the consequences of habitat loss, fragmentation or degradation is the large number of wild species that are threatened with local or total extinction, including many that are used by farm households. The numbers are difficult to ascertain, but the 1997 IUCN red list of threatened plants (IUCN, 1998) lists 33,370 that are threatened to some degree, representing approximately 11 percent of described species. While some species are under imminent risk of total extinction, the threat of extinction much more commonly pertains to local populations of species. Such local extinctions are what concern farm households, not the overall situation of the species concerned, since the household's area of operations for agriculture and wild harvesting is usually circumscribed. Moreover, local populations are adapted to the particular environment, and substitutes are often not acceptable or not a swell adapted to local conditions.

80% of people in Africa use traditional medicine for primary healthcare. 323,000 households in Nepal alone are involved in the collection of wild medicinal plants to sell for their livelihoods. More than 8000 MAPs with healing and commercial utility have been scientifically catalogued worldwide. Unfortunately, the very foundation upon which the medicinal and aromatic plant species and the traditional health care system survive is threatened by various factors. The rate of deforestation has increased by 50% over the last ten years. The current area of intact forest is now estimated at between 10.9 and 11.8% of the original cover and 6.9% of the world's area. Threatening factors are changing the habitats of naturally occurring MAPs. Moreover, since the majority of the rural poor depends on traditional medicine for their health care needs, the present high pressure of unorganised market will have a detrimental effect on the health care delivery system. Important plant species will be lost to deforestation unless urgent measures are taken.

Current harvesting levels for many MAP species are significantly below maximum sustainable levels. It is also evident that some species are being unsustainably utilised. Of the 227 MAP species in trade seven are endangered, 49 are vulnerable and eight are rare.

While the resource assessment has identified 'at risk' species based upon the current market situation, it is important to note that the demand for a specific species can rise dramatically in a very short period of time, putting at risk, species which are currently considered to be safe. Buyers especially export oriented might therefore increase their demand for raw material and thus put additional pressure on plant populations. This might increase the risk for unsustainable harvesting. Increased demand and the low prices that collectors get for collected herbs lead to over-exploitation in order to secure income for their households.

The erosion of plant biodiversity is a matter of global concern. One by one, the building blocks of entire ecosystems are disappearing. The 2008 IUCN Red List shows that the number of threatened plant species is increasing gradually. The number of threatened plants is 8457, out of which 247 plants are found at different biodiversity hotspots in India. Many of them serve as sources of food, fuel, fibre, timber, medicine, etc. And function as integral parts of local agricultural production systems.

2.5 Threats to MAPs

A threatened species can be defined as one believed to be at significant risk of extinction in the foreseeable future due to stochastic or deterministic factors or a combination of both affecting its population, or by virtue of its inherent rarity. Two aspects in this definition are difficult to define: (i) what level of risk is significant and (ii) what part of the future is foreseeable.

Threatened species pose scientific, economic and moral challenges. Scientific, because their loss would disconnect evolutionary links that contribute to an understanding of plant life. Economic, because such species-or at least some to their genes-might prove useful in future, if not now. Moral, because human beings are to be blamed for behaving caused the extinction or endangerment of a component of Nature and a fellow being.

The problem of threat, depletion and extinction of plant taxa came to be better known by the general public largely through the United Nations Conference on the Human Environment held at Stockholm in 1992 and through the International Union for Conservation of Nature and Natural Resources (IUCN). The latter was instrumental in the establishment of the Threatened Plants Committee (TPC) with the objective of enlisting worldwide participation of plant scientists in collecting data on threatened plant species, their location and their preservation. Sir Peter Scott independently developed formulation of the Red Data Book

concept during the 1960s. The Red Data Book (RDB) categorises species at the threshold of risk according to the severity of the threats facing them and the estimated imminence of their loss.

Each species covered in the RDB is assigned a threat category largely based on analysis of the factors affecting its existence and the extent of the effect of these factors throughout the distributional range of the concerned species. Key factor include changes in distribution pattern and range, degree and type of threat, population biology etc. IUCN Red Categories are applied to species on a global scale and should not be confused with the threat categories assigned to species at the national level.

2.5.1 Responsible factors

The various mechanisms involved in the loss of medicinal plants fall into five major categories: overkill, habitat destruction, impacts of introduced weeds that later become invasive, pollution and secondary losses. Overkill denotes the uncontrolled organised collection and killing of plants. Habitat destruction can be brought about by an array of organised land conversion causes, such as agriculture, housing, construction of roads and dams, industrial development, gravel and sand quarrying, wetland draining and filling, slash- and –burn (shifting cultivation), tourism etc. Desertification can also be responsible for habitat destruction. Introduced pests, and invasive weeds cause impacts on ecosystems by displacing local taxa and by affecting community structure, biogeochemistry, fire regimes, erosion, geomorphology, hydrological cycle etc. Water table changes, trampling and overgrazing by animals, herbivory by smaller animals, unwanted competition between the introduced organisms and native ones, diseases and predation and disappearance of symbionts, pollinators and dispersers are other changes introduced directly or indirectly by exotic invasive organisms. Pollution can be caused by a number of factors, mostly human-generated. Land, water and air may all become polluted, markedly affecting the ecosystem components. Secondary losses may be induced by a combination of two or more of the aforesaid factors. Main factors causing threats to MAPs are Habitat loss, fragmentation and degradation

1) Habitat loss, fragmentation and degradation: Wild plants, by definition, grow in natural or semi-natural ecosystems in different biomes around the world. All these biomes have been greatly affected and modified by human activities such as the conversion of forested land to other uses (agriculture, pasture, urbanization, industrial and other uses) and the almost universal phenomenon of ecosystem fragmentation whereby activities such as agricultural development, forestry or urbanization remove large proportions of the natural ecosystem and replace them with a greatly modified matrix, within which small remnants of the native ecosystem remain, the current scale of human impacts on biodiversity is unprecedented and is increasing dramatically. Humans have transformed, modified, managed or utilized about half the land surface, and it is difficult to find any areas that can by described as pristine, undisturbed or virgin.

The Lost Ancient Plant We Could Use Today

As an example of the importance of preserving medicinal plants we can consider the case of silphion, a weed once used as a contraceptive. It was apparently so effective that the Ancient Greeks literally revered it. Now, with population growth seemingly out of control a plant like this could have immense significance. Unfortunately, the Greeks used so much of it, it became extinct.

Between 570 and 250 BC the majority of coins minted in ancient Cyrene, a cilty situated in what is now the eastern part of Libya, carried the embossed picture of the Silphion plant. This reflects the enormous economic importance this plant had for the city over four centuries.

The perennial roots and strongly ribbed annual stems of the Silphion plnat were eaten in the fresh state and were regarded as a perfume, flavouring agent and spice. The juice was employed medicinally against a wide range of symptoms and diseases, especially gynaecological ailments- it was a true “multi-purpose species” in the scene of modern economic botany.

It appears that Silphion was found only in the dry hinterland. Attempts to cultivate it seems to have failed, so wild plants remained the source of supply. No reasons have been given for its disappearance although overharvesting is considered to be at least one reason for the dramatic decline in its use and final extinction as an economic resource. What we have is an example of overharvesting and probable extinction of an ancient medicinal plant. Silphion reflects both the potential wealth though plant utilization and the possible risk and downfall though overharvesting.

Source: IUCN. Medicinal Plant Conservation Newsletter.1995

2) Overexploitation and over harvesting: A characteristic pattern of resource exploitation by many traditional farm communities is the radial depletion of woody plants surrounding villages or settlements, especially plants used for fuel wood or for medicinal purposes. This pattern of depletion can have serious social effects, especially on the poorest members of the community, who are forced to walk further or to pay more for fuel wood, plant materials for construction and craft work and medicinal plants.

The increase in the number of urban dwellers who still rely on traditional plant-based remedies has added to the pressure on wild resources and has led several species to face a serious risk of population loss and genetic erosion through unsustainable harvesting practices such as decortications.

In addition, many medicinal plants are reported to be at risk as a result of unethical practices by pharmaceutical companies, such as commissioning the collection of large quantities of plant material without regard to the sustainability of the populations. Overharvesting is sometimes encouraged by market requirements. There is a widely held perception that plants collected from the wild are more effective than cultivated ones. This idea is even sometimes used as a marketing strategy. It may, however, have the effect of allowing produces to charge higher prices.

Sustained harvesting from the wild of species for which there is a commercial demand may lead to genetic erosion. This is the case for several species, including *Aquilaria* spp., one of the most valuable non-timber forest products of Asia, has been reported from certain parts of its range such as India and Vietnam. The fungus-infested wood is stained by oleoresins and the oil derived from it is used in the production of incense, perfume and certain traditional medicines. There is strong demand from countries in the Near East, and there is evidence of illegal trade.

3) Global warming: Different plant species will respond differently to climate change. Some species will stay in place but adapt to new climatic conditions through selection or plasticity. Other species will move to higher latitudes or altitudes. Some species may become extinct. Because of this, plant community composition will be reorganised, new communities will emerge and others will be lost. One of the biggest concerns of this community reshuffling is the disruption of food webs and co evolved mutualisms, such as the relationships between a plant and its pollinator or seed disperser. If species that rely on each other no longer co-

occur in the same time or space, both may be driven to extinction. Diseases, pests, and invasive species may spread into new ranges putting more pressure on fragile communities. Maintaining bio-diverse communities will become an even greater conservation priority.

In an era of rapid climate change, species have three basic alternatives, they can: 1) migrate to appropriate environmental conditions; 2) adapt to the new environmental conditions; or 3) become extinct. In a changing environment, 'weedy' species with fast generation times and wide ecological tolerances are more likely to adapt or migrate quickly and are more likely to flourish. Conservative species with specific habitat requirements or long generation times are more prone to the threat of extinction. At present an estimated one-quarter of vascular plant species are under threat in the wild.

With predicted temperature increases, changing hydrological cycles and other factors of climate change, as many as half of all plant species may be lost over the next century. This is a catastrophic scenario given the fundamental importance of plants to life on earth. As yet there is a lack of published information on plant extinctions directly due to climate change but with baseline information now being collected on the distribution, threat status and ecology of various plant groups, monitoring schemes can be established. Plant species restricted to high-risk habitats, including island or coastal habitats are likely to be the first casualties of climate change. Plant conservation action needs to be increased now to ensure that options are available for the future**.**

2.5.1.4 Introduced and invasive species

One of the greatest threats to natural and semi-natural vegetation, which is often overlooked, is the deliberate human introduction of species - of trees and fodder crops, for example- which have largely replaced the native ecosystems. Introduced species may also be a threat to productive systems. Examples are the introduced tropical grasses which have become, since the 1840s, major agents in facilitating deforestation in Central and South America, and the trees and shrubs introduced into the very diverse Fynbos and Daroo formations of South Africa, which have had a devastating effect, putting at risk over 50 percent of the component species. Many grasslands in both temperate and tropical regions- in Australia, California, Africa and Central and South America –are seriously affected by alien invasive species.

2.6 Sustaining the Resource Base

2.6.1 Immediate action: Ex-situ Conservation

Several medicinal plants are already threatened, rare, or endangered. In addition, the 'precautionary principle' applies to those whose status is currently is currently unknown and to segments of gene pools. There is an immediate need to consolidated and officially link the existing herbal gardens and gene banks, as well as reference specimens in herbaria, to ensure that the 540 species of highest importance in the major classical systems, as well as those supplied to the international market, are protected in ex-situ reserves. This requires strategic planning since the range of germ-plasm obtained for each species must be representative. Plant collections need to evolve from being species reference collections to being genetic resources collections.

2.6.2 Long term action

1) Promoting Cultivation and Selection of Superior Genotypes: The low number of medicinal plants currently being cultivated should be increased, in order to meet the demands of industry for continuous and uniform material supplies, and to take some of the pressure off medicinal plants originating from natural ecosystems. The selection of plants for cultivation must be market-driven. At present, commercial varieties have been developed for about 16 species, most of which are cultivated for export. Much more needs to be done to select superior genotypes of many more species.

To achieve this initiative, it will be necessary to make extensive use of the network of nurseries and gardens in the country, in order to establish high quality plant supply systems. Greater dissemination of information to farmers, and should involve the agricultural extension organizations since these serve as a primary interface with farmers.

2) Promoting Responsible, Sustainable wild-Harvesting: Wild-harvesting practices are presently highly unsustainable and are likely to remain so. The lack of sufficient information and of relevant scientific procedures are important contributing factor to this situation, as is the absence of any land rights regulation, which provide local communities with access to and some degree of control over their resources. There is thus a need to provide solutions to these constraints, as well as guidelines and incentives for sustainable wild-harvesting.

Additionally, an examination of the networks of traders and volume of illegal trade suggests that the provision of socio-economic and market information may be the primary need.

3) *In-situ* conservation: It will be necessary, based on an understanding of where medicinal plants are currently distributed, to develop novel programs for their in-situ conservation and to designate specific genetic reserves. This intervention also applies to timber species as well as wild relatives of crops. Current government activities relating to protected areas may need to be modifies in order to accommodate these species. The implementation of Joint Forest Management schemes in these areas would be the logical approach to use, given the viability of medicinal plants for generating income as well as rehabilitating degraded lands.

The approach adopted should encompass existing initiatives introduced by organization such as different NGOs, Medicinal Plant Conservation Areas Network. In addition, these in-situ conservation areas should be made to serve several functions, such as the provision of education and awareness-building, as well as training for sustainable harvesting methods.

4) Filling Information Gaps

a) Distribution of Resources: It will be critical to understand the actual distribution of the resources and to research their genetic diversity for policy and strategies formulation. This is a long-term process and a research framework needs to be developed to this end.

b) Market status of Certain Crops: The other major information gap continues to relate to the lack of socio-economic information. It will be vital for cultivation efforts to identify, in collaboration with local industry, which medicinal plants are in greatest demand and are suitable for cultivation. This first step is essential and research will be needed to gauge the demand and profit-making potential of plants. In addition, prior to the introduction of the plants into cultivation, research will be necessary to clarify how market linkage can be most effectively, established in order to assess the gains to the produces. This is a significant gap which has to be addressed.

c) Agro-Technical Packages for Intercropping and Farm Forestry

For the identified plants of major market significance, agro-technical packages need to be developed for cultivation and propagation. In general, most medicinal plants when cultivated have been sole crops in restricted ecological regions. Farm forestry and intercropping systems will have to be devised, as has already been done for the major species cultivated

for export, and there will have to be shift to a more farm-centred approach which recognizes, that in most cases, medicinal plants will only constitute one of many crop types adopted by farmers.

5) Policy Considerations

a) Domestic Policy: There are two areas in which policy should to be reconsidered: firstly, in terms of delegating control of resources to local people, and secondly, in terms of its implementation and enforceability.

As regards this second area, policies frequently lack evaluation and follow up. Thus, for example, the Forest Policy, proclaiming tribal rights to forests, is yet to receive official sanctioning through the passing of Acts, while the fact that many of the supposedly regulated plant species have not been identified in manuals, means that their collection cannot be determined and therefore stopped. Also, forest policy which requires that forest lands should not be used for agricultural activities of any kind may be usefully amended in some cases to allow for medicinal plants cultivation, within farm and agroforestry systems.

b) In Accordance with Conventions: There are a number of Conventions related to the medical plants resource base. CITES and CBD are obvious examples. The latter has many policy implications concerning the medicinal plants sector. These should be resolved in such a way that any nation does not become monopolistic and recognizes its interdependence with other countries. This gives the strong representation of introduced materials amongst the raw plant materials exported, and any nation will continue to benefit from advances made in medicinal plant research in other countries.

2.7 Methods To Use MAPs in a Sustainable Way

The importance of conserving wild plant resources such as medicinal plants must not be ignored by us. Medicinal plants secure the livelihood and healthcare of thousands. They are also the key to the conservation of whole habitats which underpin healthy resilient ecosystems, and which can help combat serious problems we face such as soil erosion and flooding, as well as mitigate the effects of climate change. To guarantee sustainable use of wild plants in the region, a consistent control and monitoring system has to be built up. It should comprise three levels, co-operatively accomplished by collectors and collectors' organisations, Forest and National Park Service, and scientific programmes. Realizing that naturally occurring MAPs are threatened, several measures should be undertaken, such as:

1. Systematic and reasonable collecting. Sustainable collecting can be achieved if it is done appropriately, where proper harvesting techniques and appropriate methods of post-harvest treatment mutually benefit the collector and local processor providing incentives for conservation of species for future collection.
2. Reduction of pressure on collecting. Cultivation, whether small or large scale, backyard garden or subsistence, can reduce the pressure on collecting MP in the wild.
3. Medicinal plants that are protected by national and international laws, such as those listed in national “red” lists, may be collected only by relevant permission according to national and / or international laws. The provisions of the Convention on International Trade in Endangered Species of Wild Flora must be complied with.
4. The cultivation, collection and harvesting of medicinal plants, as well as the post-harvest processing of medicinal plant materials, must be carried out in accordance with legal and environmental requirements and with the ethical codes or norms of the community and country in which the activities take place. The provisions of the Convention on Biological Diversity must be respected.
5. Alongside measures to conserve forests and agriculture, the importance of sustaining wild-collected medicinal plants and their habitats is not forgotten. The key to conserving medicinal plants lies in involving indigenous and local communities because they are the ones who know and value plant resources the most.
6. Support “forest farming” of species for which commercially cultivated raw material does not exist. Between two-thirds and three-fourths of medicinal herbs sold are still sourced mainly from wild populations. Avoid introducing and growing non-native plants that may pose a threat to native flora and ecosystems.
7. Be aware of signs of increasing demands for and / or diminishing supplies of species obtained from wild sources. If demand exceeds supply for such a species, be proactive and use other parts of the plant that are renewable and that meet your medicinal efficacy and safety standards.

8. Understanding the biological and ecological constraints of species before collecting plants from the wild. Harvesting plants early in a growing season should be avoided to allow plants to fruit and produce viable seed for replanting similarly number of healthy plants should be left in a patch or stand for regeneration and those parts of plant should be harvested that are renewable and won't result in the destruction of a plant.

A recent story

The most recent medicinal plant to come under threat is Nothatodytes foetida, a small tree found in the rainforests of southern India and Sri Lanka. Extracts from the wood are used in cancer-fighting drugs in Europe. Twigs are available in India for only U.S. $ 0.26 (Rs.9) per kg, whereas the extract after processing is sold by pharmaceutical companies for U.S. $ 15,000 per kg on the world market. Vast quantities of the tree are being cut, pulverized, and exported in powder form with the result that increasing tracts of forest are being laid to waste

This plant is not included in the Ayurveda pharmacopoeia which partly explains its abundance until recently. However, at the rate it is being exploited, it will soon become another threatened Indian medicinal plant species.

Source: A.B. Damania.per com.

9. Trade's impacts aside, there are other forces that pose a threat to the availability and quality of medicinal plants from which so many of us benefit therapeutically and economically. Some of these threats include loss of prime habitat and the introduction, invasion and proliferation of exotic species outcompeting and choking native medicinal flora

10. Poverty is another cause of biodiversity loss. Conservation programmes can never be successful if poverty plagues the country. The overexploitation of wild medicinal plants cannot be reduced unless efforts are clearly linked to increasing food security for the large and growing low-income, food-insecure populations.

11. Efforts should be made to mobilize local people to conserve areas of high biodiversity, and thereby improve the natural resource assets of rural populations. By engaging local people to conserve biodiversity, a broad-based, long-term strategy can be formulated for the conservation of globally threatened biodiversity.

12. Registration and control of collected amounts for all plant species, including standardized information from collectors on the area of collection and estimation of population densities, conservation status and vulnerability

13. Detailed population monitoring of rare species and species with unclear conservation status by scientific and expert studies; testing and control of harvesting methods may be necessary for comprehensive monitoring to detect changes in the vegetation (biotopes, plant communities and structure)

2.8 Summary

The world-wide increasing demands for medicinal plants and the unregulated medicinal plant commerce resulted in an increase of wild collection. This often combines with destructive harvesting techniques, over-exploitation and unmonitored trade. Besides destructive harvesting and over-exploitation, habitat loss and habitat change are primary threats for medicinal plant species in regions where habitat loss and habitat change are major threats to medicinal plant species. Economic instability is another factor often known to result in increased use of wildlife resources and increased trade in endangered species.

If harvesting and trade are sustainable and controlled, they may be beneficial both for the local economy and for habitat conservation. Sustainable wild collection combined with fair trade is a practicable way to encourage people to conserve their natural resources and at the same time gain economic benefits. To this end international labels need to incorporate sustainable wild collection criteria in their certification schemes. Especially in the importing countries, the sensitivity and demand for fairly and sustainably harvested products needs to be increased urgently. This cannot be a task only for environment and development NGOs but must also be a task for other groups, including traders, processors, consumers, or governments and legislation. Sustainability may thus increase among local people the awareness for the need to conserve the species and their habitats.

Medicinal plants are highly valued by communities all over the world. It is essential in the next decade that we work towards sustainable collection of this valuable resource, not only for nature conservation but for the well-being and livelihoods of indigenous local communities who depend on those resources. This new Strategy would help ensure their long term future.

While government official and technical experts are often considered as key decision-makers, in the case of sustainable use and conservation of biodiversity, the ultimate decision-makers are the farmers and rural communities that use and depend upon biological resources for their income and survival.

Terminal Questions

1. What do you understand by the concept of sustainability?
2. What are three dimensions of sustainability? Please explain giving suitable examples.
3. Describe the present status of medicinal and aromatic plants.
4. What do you understand by Red Data Book?
5. What are the five major factors responsible for the loss of medicinal plants?
6. Explain habitat loss, fragmentation and degradation.
7. Explain global warming and its effect on plant diversity.

Unit 3: Medicinal Plant Resources of India

Unit Structure

3.1 Learning Objectives

After completing this unit you will be able to:

- explain the medicinal plant resources of India.
- acquire the information on herbalism.
- understand the medicines of herbal origin and also the conservation aspect of medicinal and aromatic plants.
- Understand future prospects of medicinal and aromatic plants (MAPs).

3.2 Introduction

From prehistoric days, plants are used for shelter, food and medicine. The use of plants for medicinal purposes is as old as our civilization. The first known written record of curative plants was of Sumerian herbal of 2200 BC. In the 5th century BC, Greek doctor Hippocrates list out some 400 herbs in common use. Dioscorides, in the Ist century AD, wrote a herbal by using 600 plants which ultimately became the base for many later works. Herbs have been used for uncounted time for various purposes like healing the sick and infirm. Most of the people still continue to use various kinds of herbs to get health related benefits out of it. People thought that herbs maintain body in tune with nature. Many scientific studies are still continued with modern research following the lead of old folklore and herbal uses to help finding new western medicine. Man has also been aware of the effects of Herbs on the body,

mind and emotion. Of the 2,50,000 higher plant species on earth, more than 80,000 are medicinally important. India is one of the world's 12 biodiversity centres with the presence of over 45000 different plant species. India's diversity is unmatched due to the presence of 16 different agro-climatic zones, 10 vegetation zones, 25 biotic provinces and 426 biomes (habitats of specific species). Of these, about 15000-20000 plants have good medicinal value. However, only 7000-7500 species are used for their medicinal values by traditional communities. In India, drugs of herbal origin have been used in traditional systems of medicines such as *Unani* and *Ayurveda* since ancient times. The *Ayurveda* system of medicine uses about 700 species, *Unani* 700, *Siddha* 600, Amchi 600 and modern medicine around 30 species. The drugs are derived either from the whole plant or from different organs, like leaves, stem, bark, root, flower, seed, etc. Some drugs are prepared from excretory plant product such as gum, resins and latex. Even the Allopathic system of medicine has adopted a number of plant-derived drugs

3.3 Indian Tradition

Tradition of medicinal plants use in India is about 4000 years old. Even today millions of people across the country depend on this tradition, which includes two streams - the codified system and the folk system. Ethnic communities all over the country practice folk system. It has been transferred orally from generation to generation. The codified systems include Ayurveda, Siddha, Unani and Tibetan. Plants have formed an inseparable component of all these systems of medicine, for cure of ailments, freedom from illness and for a healthy life. If we look at the Ayurveda, about 1400 plants are documented in various texts. In Charaka Samhita, Sushruta Samhita and Ashtang Hridaya we can find more than 600 plants. Rig Veda (4500 to about 1600 BC) is perhaps the oldest document where medicinal plants have been described. Atharva Veda, which is more recent, also describes medicinal uses of large number of plants. Another treatise Dravya Guna Shastra provides information about medicinal plants from pharmacological point of view. Similarly, Unani and other systems of medicine practiced in India are largely dependent on medicinal plants. An important factor in wider acceptance of herbal based formulations is the growing recognition that natural products are non-narcotic and almost without side effects. The Indian systems of treatment lay adequate stress on balanced diet and on inclusion of specific items in food to provide immunity against diseases. Also, number of plants products with medicinal properties form

constituents of food. For example, all these systems emphasize on fibers and roughage in food. Now it is proved that absence of adequate fibers in food causes constipation leading to various problems including cancer. Similarly, vegetables and fruits have been strongly recommended as part of daily diet. Modern research has proved their efficacy as source of vitamins, minerals etc. which can protect against infections and diseases. Even spices are being found to have medicinal properties. For example, capsicum, garlic, turmeric, onion, ginger, black pepper, cinnamon, curry leaf etc. have been found to protect against various health problems as well provide cure from certain diseases.

In the folk system too plants are used for their medicinal properties and for their food and nutritional value. People living in and around forests and in rural areas use number of plant products from the wild or their immediate surroundings. Due to this age old practice people have been leading reasonably healthy life although on account of poverty and other related factors their diet remains deficient. For example, bael grows wild in forests and close to villages. People have been using its pulp as food supplement. Modern research has proved that it is rich in tannins and mucilage. It is highly nutritious and a potent laxative. The fruit pulp controls diarrhea, dysentery, giardiasis etc. It also gives strength to stomach, liver and heart. Similarly, amla has been used as such or for 'chutney', pickle, 'murabba' etc. 'Charaka Samhita' records it as the most potent rejuvenating agent. Modern studies have proved that amla is extremely rich in vitamin C and Pectin, containing more than 150 times vitamin C compared to apple. The fruit also contains tannins, which protect vitamin C against being denatured during storage and processing. Amla pectin reduces serum cholesterol and inhibits platelets aggregation, providing protection to heart. The fruit helps formation of blood, it has lipalytic properties providing cure for liver disorders, indigestion and hyperacidity. Amla is an effective anti-ageing agent. It replaces worn out tissues with new ones. Another suitable example is tamarind. Tamarind is used in curries, chutneys, sauces etc. also, fruit pulp is consumed as such. Unripe fruit is used for seasoning of food. Pulp is rich in iron, calcium, potassium, phosphorous, riboflavin, thiamine, niacin, carbohydrates, fiber, invert sugar etc. Vitamin C is present in substantial quantity in green fruits. Glycosides and certain alkaloids have also been found in fruit and other parts of the tree. Similarly, use of onion, garlic, turmeric, ginger etc. as food constituents has provided protection against various problems.

3.4 Herbalism

The plants of which part or whole can be used in medicinal treatments, culinary preparations (as seasonings), nutritional supplementation, or used as a coloring or cosmetic agent. Fresh herbals and medicinal plants can be acquired by gathering them in wild conditions, growing them in your own personal garden, or buying them from other gardeners and health food stores. From the germ theory of disease and the advent of antibiotics to combat various infections, it appeared as if infectious diseases were a thing of the past. With the realization that chemical medicines are not always "magic bullets" and may carry serious side effects, herbalism and ancient medicines are making a comeback. Our challenge now is to ensure that valued botanicals should remain abundant for future generations. There are several ways to prepare herbs for consumption and use in medicinal remedies. When herbs are prepared by steeping in boiling water to be drunk as a tea, they are known as an **infusion**. If these dried herbs get simmered in hot water, they are called as **decoction**. If these are incorporated with other ingredients and made into cream, they are viewed as **herbal ointment**. Sometimes used as Herbal compress where piece of cloth is soaked in an infusion or decoction and is wrapped and applied externally. If herbs are used to cleanse and heal externally, they are called **herbal wash**. Herbal infusions and decoctions can also be used as herbal bath for relaxation and healing. Always follow the recommended dosages on your preparations and recipes because over-use of herbs can defeat the purpose for which you are using them. Some of the most beneficial herbs can prove to be toxic if over used. In 1970, the Indian Medical Central Council Act which aims to standardize qualifications for Ayurveda and provide accredited institutions for its study and research was passed by the Parliament of India. In India, over 100 colleges offer degrees in traditional Ayurvedic medicine. The state-sponsored Central Council for Research in Ayurveda and Siddha (CCRAS) is the premier institution for promotion of traditional medicine in India. The studies conducted by this institution encompass clinical, drug, literary and family welfare research. The Bachelor of Ayurveda, Medicine & Surgery (BAMS) degree is the basic five-and-a-half year course of graduation. It includes eighteen different subjects comprising courses on anatomy with cadaver dissections, physiology, pharmacology, pathology, modern clinical medicine & clinical surgery, pediatrics, along with subjects on ayurveda like *Charaka Samhita*, history and evolution of Ayurveda, identification and usage of herbs (*dravyaguna*), and ayurvedic philosophy in diagnostics and treatment.

3.5 Modern Medicine from Higher Plants

Medicinal plants play a vital role for the development of new drugs. During 1950-1970 approximately 100 plants based new drugs were introduced in the USA drug market including deserpidine, reseinnamine, reserpine, vinblastine and vincristine, which are derived from higher plants. From 1971 to 1990 new drugs such as ectoposide, E-guggulsterone, teniposide, nabilone, plaunotol, Z-guggulsterone, lectinan, artemisinin and ginkgolides appeared all over the world. 2% of drugs were introduced from 1991 to 1995. Plant based drugs provide outstanding contribution to modern therapeutics; for example: serpentine isolated from the root of Indian plant *Rauwolfia serpentina* in 1953, was a revolutionary event in the treatment of hypertension and lowering of blood pressure. Phophyllotoxin is a constituent of *Phodophyllum emodi* currently used against testicular, small cell lung cancer and lymphomas. Plant derived drugs are used to cure mental illness, skin diseases, tuberculosis, diabetes, jaundice, hypertension and cancer. Medicinal plants play an important role in the development of potent therapeutic agents. Plant derived drugs came into use in the modern medicine through the uses of plant material as indigenous cure in folklore or traditional systems of medicine. More than 64 plants have been found to possess significant antibacterial properties; and more than 24 plants have been found to possess antidiabetic properties. Among ancient civilizations, India has been known to be rich repository of medicinal plants. The forest in India is the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw materials for manufacture of drugs and perfumery products. About 8,000 herbal remedies have been codified in Ayurveda. The *Rigveda* (5000 BC) has recorded 67 medicinal plants, *Yajurveda* 81 species, *Atharvaveda* (4500-2500 BC) 290 species, *Charak Samhita* (700 BC) and *Sushrut Samhita* (200 BC) had described properties and uses of 1100 and 1270 species respectively, in compounding of drugs and these are still used in the classical formulations, in the Ayurvedic system of medicine.

Unfortunately, much of the ancient knowledge and many valuable plants are being lost at an alarming rate. With the rapid depletion of forests, impairing the availability of raw drugs, Ayurveda, like other systems of herbal medicines has reached a very critical phase. About 50% of the tropical forests, the treasure house of plant and animal diversity have already been destroyed. In India, forest cover is disappearing at an annual rate 1.5mha/yr. What is left at present is only 8% as against a mandatory 33% of the geographical area. Many

valuable medicinal plants are under the verge of extinction. *The Red Data Book of India* has 427 entries of endangered species of which 28 are considered extinct, 124 endangered, 81 vulnerable, 100 rare and 34 insufficiently known species (Thomas, 1997).

Common medicinal plants of India

Aloe Vera (*Aloe Vera*)
Amaltas (*Cassia fistula*)
Arjun Tree (*Terminalia arjuna*)
Arrowleaf Dock (*Rumex hastatus*)
Ashwagandha (*Withania somnifera*)
Barringtonia (*Barringtonia acutangula*)
Bellyache Bush (*Jatropha gossypiifolia*)
Bhringaraj (*Eclipta prostrata/erecta/alba*)
Bird's Head Birthwort (*Aristolochia ornithocephala*)
Black Nightshade (*Solanum nigrum*)
Brahmi (*Bacopa monnieri*)
Castor Oil Plant (*Ricinus communis*)
Catnip (*Nepeta cataria*)
Chaste Tree (*Vitex negundo*)
Chebulic Myrobalan (*Terminalia chebula*)
Chicory (*Cichorium intybus*)
Chinese Cucumber (*Momordica cochinchinensis*)
Chir Pine (*Pinus roxburghii*)
Chirayita (*Swertia chirayita*)
Chitra (*Berberis aristata/chitria*)
Chitrak (*Plumbago zeylanica*)
Chives (*Allium schoenoprasum*)
Common Crape Myrtle (*Lagerstroemia indica*)
Common Leucas (*Leucas aspera*)
Common Rock Jasmine (*Androsace sarmentosa*)
Curry Leaf (*Murraya koenigii*)
Dwarf Morning Glory (*Evolvulus alsinoides*)
Dwarf Rhododendron (*Rhododendron anthopogon*)
East Indian Arrowroot (*Curcuma angustifolia*)
Eucalyptus (*Eucalyptus* spp.)
Fever Nut (*Caesalpinia bonducella*)
Feverfew (*Tanacetum parthenium*)
Fire Flame Bush (*Woodfordia fruticosa*)
Flax (*Linum usitatissimum*)
Garden Asparagus (*Asparagus officinalis*)
Gaub (*Diospyros malabarica*)
Giant Potato (*Ipomoea mauritiana*)
Glory Bower (*Clerodendrum inerme*)
Goat Weed (*Ageratum conyzoides*)
Gulbel (*Tinospora cordifolia*)
Henbane (*Hyoscyamus niger*)
Hill Glory Bower (*Clerodendrum viscosum*)
Hill Turmeric (*Curcuma pseudomontana*)
Himalaya Onion (*Allium wallichii*)
Himalayan Bugle (*Ajuga lupulina*)
Himalayan Milk Vetch (*Astragalus floridus*)
Himalayan Thorowax (*Bupleurum candollei*)
Hophead (*Barleria lupulina*)
Horned Lousewort (*Pedicularis bicornuta*)
Horse Mint (*Mentha longifolia*)
Horse Nettle (*Solanum carolinense* L.)
Indian Barberry (*Berberis lycium*)
Indian Mallow (*Abutilon indicum*)
Indian Nightshade (*Solanum indicum*)
Indian Pennywort (*Centella asiatica*)
Indian Squirrel Tail (*Colebrookea oppositifolia*)

Indian Valerian (*Valeriana hardwickii*)
Indian Wormwood (*Artemisia nilagirica*)
Jackal Jujube (*Ziziphus oenoplia*)
Jeevak (*Malaxis acuminata*)
Kakronda (*Blumea lacera*)
Kali Musli (*Curculigo orchioides*)
Kamala Tree (*Mallotus philippensis*)
Kasturi Kamal (*Saussurea gossypiphora*)
Kumarika (*Smilax ovalifolia*)
Lal Chitrak (*Plumbago indica*)
Leafless Mistletoe (*Viscum articulatum*)
Little Ironweed (*Vernonia cinerea*)
Long Pepper (*Piper longum*)
Malabar Nut (*Adhatoda vasica*)
Malay Apple (*Syzygium malaccense*)
Mousetail Plant (*Phyllanthus myrtifolius*)
Nepal Dock (*Rumex nepalensis*)
Nettle Leaved Lindenbergia (*Lindenbergia indica*)
Opium Poppy (*Papaver somniferum*)
Oriental Pepper (*Polygonum orientale*)
Perennial Buckwheat (*Fagopyrum dibotrys*)
Persian Lilac (*Melia azedarach*)
Phalsa (*Grewia asiatica*)
Pink Catmint (*Nepeta* spp.)
Queen Crape Myrtle (*Lagerstroemia speciosa*)
Quick Weed (*Galinsoga parviflora*)
Red Spiderling (*Boerhavia diffusa*)
Rue (*Ruta graveolens*)
Sarpagandha (*Rauvolfia/Rauwolfia serpentina*)
Satawari (*Asparagus racemosus*)
Shisham (*Dalbergia sissoo*)
Snow Lotus (*Saussurea tridactyla*)
South Indian Mahua (*Madhuca longifolia*)
Spanish Needles (*Bidens biternata*)
Spiked Ginger Lily (*Hedychium spicatum*)
Stinking Cassia (*Senna tora*)
Takoli (*Dalbergia lanceolaria*)
Triangular Spurge (*Euphorbia antiquorum*)
Tulsi (*Ocimum sanctum*)
Vervain (*Verbena officinalis*)
Water Willow (*Justicia procumbens*)
West Indian Indigo (*Indigofera suffruticosa*)
Wild Snake Root (*Rauvolfia tetraphylla*)
Wild Turmeric (*Curcuma aromatica*)
Winged Prickly Ash (*Zanthoxylum armatum*)
Yellow Jasmine (*Jasminum humile*)

3.6 Medicinal Plants and Industry

Medicinal plants based industry in the country has an annual turnover of about Rs. 42,000/- million per year and it is estimated to grow at the rate of about 20 per cent per year. There are hundreds of manufacturers and exporters in the country who are benefiting and large numbers of people are getting direct and indirect employment in these activities. About 800 to 900 medicinal plants are in all India trade, about 700 are obtained from the forests and many of these are harvested in large quantities. Common examples are neem, amla, asoka, harara, gulancha, khas, ashwagandha, sarpgandha, etc. Due to excessive and unscientific

harvesting, large numbers of medicinal plant species are under threat. It is quite likely that very soon these plants may become endangered. List of medicinal plants that are under different degrees of threat is quite long. Some of these are: *Acorus calamus* (Vacha), *Coscinium fenestratum* (Jhar-haldi), *Gloriosa superba* (Kalihari), *Janakia arayalpathra* (Amruthapala), champa, pipli, sarpgandha, bael asoka, arjun, etc. *Plectranthus vettiveroide* (Valak) is a species, which is already extinct from the wild. A National Medicinal Plants Board has been constituted. The Central Board has selected 28 plant species for development and promotion in first phase. Incentives are also available for cultivation of medicinal plants to ease pressure on the wild resource. Similar Boards are being constituted at State level. The large protected areas are protecting total biodiversity present, including the medicinal plants. Also, Botanical Gardens conserve plants, including the medicinal ones. Another initiative is to declare Biosphere Reserves. This initiative facilitates conservation of representative landscapes and areas with rich biodiversity. The Wildlife (Protection) Act was amended in 1991 to include specified plants. The Act prohibits collection of specific plants from forest or from specified areas except for education, research or preparation of herbarium etc. Thus, medicinal plants, which are under threat, can be protected. Another initiative is to declare forest areas rich in medicinal plants as Medicinal Plants Conservation Areas (MPCAs), which are legally protected. Plants cannot be removed from there for trade. Fifty-five such MPCAs exist now. Four National Gene Banks have also been set up for collection and conservation of important medicinal and aromatic plants of the country. These banks maintain the plants as live materials, seeds, and genetic material and also under cryogenic conditions.

3.7 Biodiversity Act

To protect the rich biodiversity of the country and associated knowledge the Biological Diversity Act, 2002 was framed. It provides for a National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs) in local bodies. Foreign nationals/organizations have to obtain prior approval of NBA for using biological resources and/or associated knowledge. Indian industries have to give prior intimation to the concerned SBB before obtaining any biological resource for commercial use. SBB may restrict the activity. Indian citizens/entities including ‘vaids’, ‘hakims’ etc. have free access to the resources for their own use, for medicinal preparations and for research.

Also, a Traditional Knowledge Digital Library for documentation of traditional knowledge available in the country is being created.

In India, many forms of alternative medicines are available for those who do not want conventional medicine or who cannot be helped by conventional medicine. Ayurveda and Kabiraji (herbal medicine) are two important forms of alternative medicine that is widely available in India. Ayurvedic form of medicine is believed to be existent in India for thousands of years. It employs various techniques and things to provide healing or relief to the ailing patients. One of the things that ayurveda use are medications of plant origin.

Many herbs and spices used in Indian cooking, such as onion, garlic, ginger, turmeric, clove, cardamom, cinnamomum, cumin, coriander, fenugreek, fennel, ajowan (ajwain), anise, amchur, bay leaf, hing (asa-foetida) etc., are known to have medicinal properties. Ayurvedic medicine uses all of these either in diet or as medicine. Besides, the many medicinal plants that are found in India (and elsewhere) are routinely used by the practitioners of Ayurveda. Some of these medicinal plants have been featured on Indian postage stamps. The first set of stamps showing medicinal plants came out in 1997. The set had four stamps showing four different medicinal plants - Tulsi (*Ocimum sanctum*), Haridra (*Curcuma longa*), Sarpagandha (*Rauvolfia serpentina*), and Ghritkumari (*Aloe barbadensis*). Then in the year 2003, The Indian Posts and Telegraph Department issued another set of stamps showing four more medicinal plants. They are Amla (*Emblica officinallis*), Ashwagandha (*Withania somnifera*), Brahmi (*Bacopa monnieri*), and Guggulu (*Commiphora wightii*).

A very common and well-known medicinal plant of India is Neem or Margosa (*Azadirachta indica*). Neem is being used by Ayurvedic practioners in India for thousands of years for such a wide range of ailments that in Sanskrit it is often called *sarva roga nibarak* ("healer of all ailments"). In many tropical countries, Neem is often referred to as "the village pharmacy." Practically, every part of the Neem tree (seeds, leaves, flowers and bark) are used in Ayurvedic medicine. In Indian sub-continent, poor villagers use the chewed Neem twig to brush their teeth. The Neem oil is used to prepare cosmetics like soaps, shampoos, balms, creams, toothpastes etc. Ayurveda uses Neem in various forms to treat skin ailments to diabetes to cancer and everything in between. In fact, the medicinal properties of Neem is so powerful and so diversified that it is being researched by modern scientists not only in India but all over the world including USA.

3.8 Market Potential of Phytomedicine

Medicinal plants play an important role in supporting healthcare system in India. According to the World Health Organization (WHO), 80% of the rural population in developing countries utilizes locally available medicinal plants for their primary healthcare needs. About 7000 to 7500 species of medicinal plants are in current use by local communities all over India. About 90% of the country's medicinal plants are found in forest habitats. Only 10% of the medicinal plants are distributed among other landscape elements like open grasslands, agricultural pastures and in and around fresh water bodies, etc. It may be noted that India is one amongst those nations, which possess a historical track record of having made a significant global contribution by virtue of its traditional knowledge of the medicinal plants. In the 21st century, given the global resurgence of the consumer interest in natural products, India's rich medicinal plant heritage of 8000 species and an estimated 40,000 herbal formulations, if conserved and sustainably utilized has global relevance. Thus, there is an urgent need to conserve the wild populations of medicinal plant diversity in prioritized forest regions of India. Conservation of medicinal plants will contribute to self-reliance of millions for India's own health needs. The demand for medicinal plants is growing at a rapid pace. In 1947, the annual turnover of the herbal industry was Rs. 2,000 million. The Indian herbal industry's annual turnover was Rs. 40,000 million by the end of 2000. This is why India supplies 12% of the world's requirements of medicinal plants. Today, 90% of the medicinal plants consumed domestically and exported are collected from the wild, and only 70 out of around 700 species in the trade are obtained purely from cultivated sources.

The estimation of total phytomedicine sale reported in country wise European Union was about US$ 6 billion in 1991 and $ 4 billion in 1996, of which almost half were sold in Germany $ 3 billion, in France $ 1.6 billion, in Italy $ 0.6 billion and in Japan $ 1.5 billion. The present global market is said to be US 250 billion. In India the sale of total herbal products is estimated at $ 1 billion and the export of herbal crude extract is about $ 80 million, of which 50% is contributed by Ayurvedic classical preparations. Plant derived drugs are important in Germany and Russia. Particularly, herbal drugs are imported by several countries for their usage of traditional medicinal preparation from various parts of the country.

Table 1. Percentage of herbal drugs imported by various countries for drug preparation

China	USA	Australia	India	South Korea	Taiwan	Indonesia
45%	15.6%	10.5%	3.7%	1.4%	1.7%	8.1%

Table 2. Medicinal plants of Uttarakhand

1	Commercially important medicinal plants	
Plants (Botanical name)	**Common name**	**Chemical constituents**
Aconitum chasmanthum	Bantalnag	Aconiting, chasmacontine, Chasmonthine
Aconitum heterophyllum	Aconite/Atis	Atisine, heteratisin & hetisine
Acorus calamus	Bach	Asargone
Adhatoda vasica	Vasaka	Vasicine & vasicinone
Artemisia maritama	Kirmala	Santonin
Asparagus adscendens	Safed musli	Asparagin
Azadirachta indica	Neem	Nimbin, nimbinin, nimbidin, azadirachtin, salannin
Berberies aristata	Rasaut	Berberine
Bergenia ciliate	Pashanbed	Sitosterol, bergenin
Cassia fistula	Amaltas	Fosticacodom, rhein, sennoside A & B
Centella asiatica	Brahma manduki	Brahmoside, brahminoside, asiatic acid
Colchicum luteum	Hirantutiya	Colchicine
Daphne papyracea	Satpura	Daphnin
Datura metel	Dhatura	Scopolamine, hyoscyamine atropine
Datura stramonium	Dhatura	Atropine, hycocine, hyoscyamine
Dioscorea deltoidea	Kins	Diosgenin
Ephedra nebrodenis	Ephedra	Ephedrine

Evolvulus alsinoides	Sankhapushpi	Betaine, evolvine
Fagopyrum esculentum	Kotu	Rutin
Gloriosa superba	Kalihari	Chelidonic acid, colchicine, lumicolchicine
Holarrhena antidysenterica	Kurchi	Conessine, holarrhimine, Kurchine, conarrhimine
Nardostachys jatamansi	Jatamansi	Jatamansone & jatamansic acid
Physochlaina praealta	Nandru	Hyoscyamine & hyoscine
Picrorhiza kurrooa	Kuru	Picrorhizin, kutkin
Podophyllum hexandrum	Papra	Podophyllin, podophyllotoxin, podophyllic acid
Rheum emodi	Rhubarb	Emodin, physcione, chrysophanol
Swertia chirayita	Chiryaita	Ophelic acid, chiratin, amarogentin
Urginea indica	Jangli Piyaz	Scillarens A & B
Viola odorata	Banafsha	Rutin, cyanin, methyl salicylate, odoratine
Withania somnifera	Ashwagandha	Withasomine, withaferin A & withanolide

2	**Commercially exploited aromatic plants**

Plants	Chemical constituents
Bach*, Acorus calamus*	Asarone, calamenol, calamine
Bel, *Aegle marmelos*	L-phellandrene, citronellal, para-cymene, citral
Angelica archangelica	L-pinene, phellandrene, osthole, terpenes & sesquiterpenes, L-phellandrene, para-cymene
Chura,*Angelica glauca*	L-pinene, L-phellandrene, Selinene, L-cadinene
Zira, *Carum carvi*	Carvone, a terpene & traces of carvacrol

Tej Pat, *Cinnamomum tamala*	Cinnamic aldehyde, linapool
Ferula, *Jaeschkeana*	Azulenes, pinene, cadinene
Aaraar, *Juniperus communis*	Friots, pinenes
Dunp, *Juniperus macropoda*	Cedrol, limonene, 4-terpineol
Jatamansi, *Nardostachys jatamans*	Jatamansone & Jatamansic acid
Kuth, *Saussurea costus*	Dihydro costus lactone, costunolids,costol
Ner, *Skimmia laureola*	Linalyl acetate, linalool
Stinking Roger, *Tagetes minuta*	Aromadendrene, tagetone
Banajwain, *Thymus linearis*	Carvacrol, para-cymene, gama-terpinene
Tejbal, *Zanthoxylum alatum*	L-phellandrene, traces of linalool, a
Indian lichens chrilla, *Parmelia nepalensis* *P. nilgherrensis, Ramalina subcomplanta* and *Usnea lucea*	Resinoids

Source: Kumari et al., 2009

3.9 Conclusion

Chinese, Indian, Arabian and other traditional systems of medicines make extensive use of about 5000 plants. India is proud to be rich in biological diversity and tenth among the plant rich countries of Asia, sixth as far as centres of diversity especially agrodiversity are concerned. Nearly three fourth of the drugs and perfumery products used in the world are available in natural state in the country. India possesses almost 8% of the estimated biodiversity of the world with around 1,26,000 species. It is one of the 12-mega biodiversity centres with 2 hot spots of biodiversity in Western Ghats and north-eastern region. The sacred groves are a miniature ecosystem conserving biodiversity in its pristine form. There are about 400 families in the world of flowering plants, at least 315 are represented in India. According to WHO, around 21,000 plant species have the potential for being used as medicinal plants. About 5000 species have been studied. There are at least 121 major plant

drugs of known structure, but none of them is currently produced through synthetic means. For developing phytomedicines as a major area of concern, it would be essential to adopt a holistic interdisciplinary approach, have a scientific basis of the understanding of the plant systems, new innovations and their conservation for utilisation in future on a sustainable basis (Sharma, 1997).

In India, more than 70% of the population use herbal drugs for their health. There is a vast experience-based evidence for many of these drugs. There are also a number of Institutes/Universities in India carrying our research on herbal drugs and medicinal plants. Using 'reverse pharmacological' approach, several Institutes carry out basic and clinical research on the potential health benefits of herbal drugs. There are many successful examples in this direction. These herbal drugs and Indian medicinal plants are also rich sources of beneficial compounds including antioxidants and components that can be used in functional foods. Newer approaches utilizing collaborative research and modern technology in combination with established traditional health principles will yield rich dividends in the near future in improving health, especially among people who do not have access to the use of costlier western systems of medicine.

Future prospects: The following program objectives of the MSSRF serve as a model for similar programs in other parts of India, or elsewhere in the world.

- Establish a Research, Training and Capacity Building Centre at Koraput for strengthening in situ and ex situ conservation and for undertaking validation and identification of active bio-molecules, as well as for safeguarding the IPR of tribal families.
- Initiate a Herbal Literacy Movement and organise for this purpose "Health Clubs" among school and college students.
- Foster conservation of genetic resources of medicinal plants and also promote genetic enhancement through participatory breeding.
- Establish linkages with markets so that the cultivation of medicinal plants, including medicinal rices, becomes market driven, with assured income security for tribal families.
- Develop propagation methods in order to ensure that high quality and pure seed and planting materials are available to the cultivators.

- Foster a community Gene, Seed, Grain and Water Bank Movement.
- Establish Village Knowledge Centres with specific focus on the medicinal plants.
- Promote participatory research and breeding and participatory knowledge management involving scientists and tribal families.
- Establish a Herbal Biovalley in the Koraput District for providing opportunities for the cultivation and processing of medicinal plants and medicinal rices by self-help groups (SHGs).

3.10 Summary

- Curative plants started around 2200 BC.
- 7000 to 7500 plant species are used for medicinal value by traditional community in India.
- Medicinal plant uses in India started 4000 years ago.
- Herbalism is a common practice in India.
- Rs. 42000 million is estimated in our country for MAPs.
- Biodiversity act 2002 was framed to protect the biodiversity including medicinal plants.
- 315 families of angiosperms are reported to occur in India.

Terminal Questions

1. Describe the medicinal resource of India.
2. What is herbalism?
3. How many plants were used in Indian traditional system?
4. How many modem medicines are obtained from higher plants?
5. What is the cost of phytomedicine?
6. What is biodiversity act? Please explain.

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Unit 4: Collection and Processing of Medicinal and Aromatic Plants (MAPs)

Unit Structure

4.1 Learning Objectives

After reading this unit, student shall be able to understand:

- the need for good collection and processing practice for MAPs;
- Present status of collection of medicinal plants from wild;
- Preparation for collection of wild plants from natural resources;
- Guidelines for collection of different plant parts viz. leaves, roots, bark etc.;
- Post harvest processing of MAPs

4.2 Introduction

The world is witnessing a change in the health seeking behaviour as more and more people are seeking health remedies through the use of traditional and herbal medicines. There is an increasing use of the natural products even in the developed world. This has put an immense pressure on natural resources leading to adulteration in herbal products, unsustainable collections from natural forests resulting in adverse effect on human health, uncertain availability of a large number of medicinal plants species and their decline in the

wild. Examples of adulteration of medicinal plant/ herbal drugs with toxic herbal drugs demonstrate the need to establish good manufacturing practice for herbal starting materials.

The quality of the finished products, however to a large extent, depends upon the quality of the raw material and it is for this reason that development of Good Field Collection Practices for medicinal plants is essential for improving the quality of the final products.

Therefore, there is a need for standards for the production and processing of medicinal plants/ herbal drugs as these are critical steps in production steps of a good health product that are needed to ensure good quality final product.

Equally important aspects are that medicinal plants should be collected and processed hygienically, in order to reduce microbiological load to a minimum, handled with care so that medicinal plants should not get adversely affected during collection, processing and storage.

All these points are discussed here in this chapter which will help to understand different steps involved in collection and processing of MAPs and need measures which are necessary for a good sustainable practice.

4.3 Present status

The starting materials for all herbal medicinal products are herbal drugs i.e., mostly parts of plants or plant organs of medicinally used species and usually in the dried form. According to the WHO there are 21, 000 plant species listed are being medicinally used as plant drugs and between 70 - 90 % of these are commercially obtained by collecting the drugs in the natural habitat. For native people in remote areas and those who cannot afford to buy expensive western drugs, traditional medications are the only means to cure illnesses. Such systems depend almost exclusively on MPs, with about 90% being collected from the forest.

Similarly, Essential oil production has been divided into cultivated & wild-gathered woody perennial sources (trees, bushes) accounting for approx 65% of the world output, out of which cultivated herbal sources accounting for only 30.6%.

While the demand for medicinal plants is growing, some of them are increasingly being threatened in their natural habitat. For meeting the future needs conservation and cultivation of medicinal plant is being encouraged. However, of more than 400 plant species used for production of medicines by Indian Industry, less than 20 are currently under the cultivation in the country.

Over 70% of the plant collections involve destructive harvesting because of the use of parts like roots, bark, wood, stem and the whole plant in case of herbs. This poses a definite threat to the genetic stocks and to the diversity of medicinal plants if biodiversity is not sustainably used.

Some reported adverse events following the use of certain herbal medicines have been associated with a variety of possible explanations, including the inadvertent use of the wrong plant species, adulteration with undeclared other medicines and / or potent substances, contamination with undeclared toxic and / or hazardous substances, overdose, inappropriate use by health-care providers or consumers, and interaction with other medicines, resulting in an adverse drug interaction. Among those attributable to the poor quality of finished products, some clearly result from the use of raw medicinal plant materials that are not of a sufficiently high quality standard.

However, quality control for the cultivation and collection of medicinal plants as the raw materials for herbal medicines may be more demanding than that for food production. For this reason, some countries have recently developed guidelines on good agricultural practices for medicinal plants. Since their guidelines were established to meet the requirements of specific regions or countries, they may not be universally applicable or acceptable. A few countries have formulated legislation to conserve MPs. Some examples include: (i) Administrative regulation for “Protection of Wild Medicinal Plant Resources”, in China since 1987; (ii) An “Action Plan for Conservaton of Biodiversity”, in Sri Lanka including conservation of MPs as a project; and (iii) All wild MPs have been banned for export from India since 1993.

Table 1. Some medicinal plants collected exclusively from wild

Species	**Family**
Aesculus indica	Hippocastanaceae
Alocasia macrorrhiza	Araceae
Alstonia scholaris	Apocynaceae
Amomum sp	Zingiberaceae
Amorphophallus rivieri	Araceae

Artemisia maritime	Asteraceae
Artocarpus lakoocha	Moraceae
Blumea balsamifera	Asteraceae
Catharanthus roseus	Apocynaceae
Cassia alata	Caesalpiniaceae
Cinchona ledgeriana	Rubiaceae
Coscinium usitatum	Menispermaceae
Costus speciosus	Zingiberaceae
Dioscorea deltoidea	Dioscoraceae
Drymaria fortunae	Caryophyllaceae
Embelia ribes	Euphorbiaceae
Ephedra gerardiana	Gnetaceae
Glycyrrhiza glabra	Fabaceae
Kaempferia galangal	Zingiberaceae
Lagerstroemia speciosa	Lythraceae
Leonurus heterophyllus	Lamiaceae
Moringa oleifera	Moringaceae
Rauvolfia serpentine	Apocynaceae
Schefflera elleptica	Araliaceae
Smilax glabra	Lamiaceae
Sterculia lygnophora	Steculiaceae
Styrax tonkinensis	Styracaceae
Swietenia macrophylla	Meliaceae
Vitex negundo	Verbenaceae
Zanthium strumarium	Asteraceae

4.4 Reasons for collection from natural habitats

The plant species grows slowly under cultivation- The first argument encompasses all plant species which need more than 5 years to reach maturity or the stage of harvesting. Into this category belong trees, perennials and bushes.

The plant species is hardly amenable to agriculture: Many species are not amenable for agriculture for a variety of reasons, e.g. symbiotic relationships with other plants like in Viscum, Santalum etc.

Domestication faces difficulties: Inculturing might also prove difficult, especially with plants which developed the survival strategy of irregular flowering and seed formation, irregular germination parameters etc. Baptisia tinctoria is such a species where it took 15 years of agricultural research and high expenses to get a culture started.

Collecting is more economic than domestication: The more appropriate for use in the production of drugs is through cultivation of medicinal plants but only at the higher cost. The total tonnage needed is uninteresting from a monetary point of view and collecting is a more economic alternative. In the majority of cases, companies cultivate only those plant species, which they use in large quantity or in the production of derivatives and isolates, for which standardisation is essential and quality is critical putting an extra cost to producers as well as consumers.

4.5 Different Methods of Collection

Permits and permission to collect: Whether wild harvest occurs on public or private property, the harvester must conform to rules established by centre, state and local governments. If harvesting on state-owned public lands, contact should be made to the appropriate state office before harvesting. All rules that apply to permitted harvests on public lands like- requests for submission of harvest data; fee payment; and any other rules should be comply with. In addition collector should posses all required permits and licenses while collecting.

Site selection: It is just as important that sites be evaluated to ensure that the collected materials are likely to be of good quality and free of contamination from pollution and other negative environmental influences. Choice of collection site can impact marketability of the collected material.

Species habitat: Normal habitat for the species and collection sites to target healthy stands of plants growing in their normal range should be chosen wisely. Information compiled in evaluating a site history should be considered, and refrain from harvesting if there is any history that indicates that the site may harbour environmental hazards.

Collection equipment: Equipment used in harvesting of wild-harvested crops (including mechanical equipment, buckets and other containers, tarps, hand tools, brooms and brushes, etc.) must be suitable for its purpose, properly maintained, and clean.

Training: Ensuring that all personnel are properly trained in the use of the collection equipment, especially mechanized equipment, and that equipment is operated in a manner that ensures the safety of the operators and avoids or minimizes damage to the collected material.

Identification: Wild plant harvesters must have sufficient training and experience to ensure that all harvested plants are correctly identified. Also, buying agents who purchase collected materials are often a good source of information on identification of plants and plant materials. Whenever necessary, engaging the services of a qualified botanist or taxonomist who has the requisite skills for providing positive identification of the harvested species is a must.

Abundance: Collection should be done only from abundant stands of the harvest species. Avoid harvesting from stands where the plant is sparse or that are outside of the species' normal range. Refrain from harvesting in the same location as earlier harvests until the population is sufficiently re-established.

4.6 Guidelines for Sustainable Collection Practice

One has to consider also some dangers originating in the collection practice. The two main problems are extinction and elimination of genetic variety. Overharvesting of natural resources can lead to extinction of the plant in an entire plant population.

Many of the plants that are used in consumer products are produced by collectors who gather these products from woods, fields, seashores, and other habitats. Local customs from one country to another impose varying degrees of oversight and management of collectors. Only a few wild species are collected by organized groups of harvesters.

Regardless of whether collectors operate individually or under some degree of supervision, good collection practice is essential for providing accurately identified and good quality botanical raw material from wild-harvest sources and for protecting the species from unsustainable harvest.

India has well documented traditional systems of medicine like Ayurveda, Unani and Siddha with a high degree of societal demand. The dependence of these systems on medicinal plants necessitates the implementation of certain guidelines and their wide dissemination so as to promote appropriate harvesting. This would contribute to improved quality and sustainable management of medicinal plants resources.

1. For harvests of barks from trees or shrubs the tree should not be “girdled” by removing the bark all the way around the tree, unless the tree has been or is to be removed for other purposes, e.g., for timber harvest, or is otherwise to be destroyed.
2. Whenever possible and acceptable for meeting quality standards, harvest bark from branches of the tree rather than from its trunk.
3. Whenever possible and applicable to the particular species, prune trees and shrubs in a manner that encourages bark-producing growth, for example, by coppicing, which involves periodic cutting to encourage growth of suckers. For harvests that involve taking the entire plant (e.g., roots).
4. Limit harvest in any population to leave a portion sufficient for regeneration of that population.
5. Harvest by thinning plants instead of collecting all of the plants along the margins or in one particular part of a colony.
6. Harvest only after the fruit has ripened and the seed has been released if the species is seed propagated.
7. When harvesting roots of perennials Leave some plants from each life stage (seedling, juvenile, mature); Collect only plants that are mature enough to have produced viable seed.
8. For species that can regenerate from portions of roots or root crowns, leave a portion of the root in the ground or replant whole or divided crowns, as appropriate.

9. Consider pruning of trees and woody plants to enhance leaf and flower (and therefore fruit and seed) production.
10. Minimize habitat disruption. Avoid trampling of surrounding plants and use appropriate equipment for harvest. Take care to repair any unavoidable impacts (for example, by filling holes after digging roots).
11. Be aware of land-use and zoning activities in collection areas and provide input to community leaders to protect these habitats. Also, report any signs of trespassing, property damage or habitat loss in collection areas.

4.7 Quality Control during Collection

Collected plant drugs, especially those used under their vernacular name, are very prone to be mislabelled, so that the aspect of analytical determination of identity becomes important. The best example is the well known drug Zarzaparilla, which is either a *Smilax* species or at least in Peru, the root of *Rumex obtusifolius*. Thus pharmacognostic analysis, coupled with knowledge about possible alternatives and synonym drugs, is the key operation in determining the exact identity of material. One example, which happened in the US and luckily did not result in fatalities, may illustrate the importance of pharmacognostic analysis. Herbal tea of *Plantago lanceolata* leaves was containing leaves of *Atropa belladonna*, superficially not to distinguish in the cut stage. A simple microscopic analysis could have detected the difference, since these toxic Belladonna leaves show plenty of crystals of Ca-oxalate in the parenchymatic cells and also a specific, wavy cuticula on the epidermis. Such mislabelling is mostly unintentional, since the collectors (and processors) are in many cases poorly educated people going by the native name in collecting.

Another aspect of quality, which should be considered with emphasis, is foreign matter. Collected drugs tend to contain a higher percentage of sand, grass, non-drug parts of the species etc, than allowed by the general notices of the pharmacopoiea. Therefore, specific care should be taken in performing those tests described for this purpose. Generally, heavy metals, unusual microbial contamination and pesticide levels are of no or only minor importance. They are rather more frequent in crops from fertilized agricultural fields. Each of these issues must also be addressed in post-harvest operations to comply with good agricultural and collection practice.

4.8 Processing of Maps

After an herb is harvested, whether as an agricultural product on a farm or as a wildcrafted material in a non-cultivated setting, the care with which the material is handled has a considerable impact on product quality. Immediate post-harvest practices must stabilize the harvest to prevent degradation of the fresh material, which is particularly vulnerable due to the naturally-occurring moisture content of plants. Later steps, such as washing, cutting, dehydrating, refrigerating or freezing, packaging, and storing, must also be properly undertaken so that product quality is preserved throughout the chain of custody, from the field to the point of manufacture.

At the time of actual harvest and immediately following harvest, the herbal crop must be handled, stored, and consolidated in a manner that ensures that the collected material does not degrade in transit. Threats to product quality include, among others, cross contamination from other crops and materials, insect or other infestation, product compaction, exposure to the elements, and temperature build-up and overheating. These matters are relevant to both good agricultural practice and good collection practice. The following practices are relevant to the handling operations.

4.8.1. Primary processing (Handling during and immediately after harvest)

- Place all harvested materials in suitable containers. Harvest containers must be clean. Do not fill or stack sacks or other harvest containers to levels that will result in compacting of harvested materials.
- Protect the harvested material from animals, and from exposure to the elements that can adversely affect the harvested material, such as excessive direct sunlight, rainfall, etc.
- Minimize the transit time from the point of harvest to the location used for consolidation and cleaning.
- Ensure that both the temperature and moisture of the harvested material is controlled throughout post-harvest handling as needed to prevent degradation.
- Many harvested materials, especially roots, need to be washed immediately after harvest to remove dirt and soil from the crop. Cleaning is also needed to remove any foreign matter that may have been inadvertently mixed in with the harvest.

- Arrange and handle washed harvest material in a manner that ensures adequate drying of the material.
- Removal of foreign matter. Inspect for and remove all visible foreign matter and sub-standard material. Foreign matter includes plant material from other species or from other parts of the harvested species; soil and rocks; insects and other animals; and wire, glass, paper, tools or tool parts, and other man-made objects. Sub-standard material includes, for example, discoloured leaves or flowers; immature, overripe, or badly bruised fruits; or any other material that would cause the crop to fail to meet its specifications.
- Conduct the inspection for foreign matter and sub-standard material while the crop is sufficiently well displayed to allow for their ready visibility (e.g., on a conveyor, or spread out on tables, screens, or tarps).

4.8.2. Secondary processing:

a) Dehydration: Many of the plants that are grown or collected for use in herbal products must be properly dried prior to use, and drying of plant materials is often performed by the same individuals and companies that harvest the plants. Drying conditions can either preserve or degrade naturally occurring plant compounds and can greatly affect the quality of the traded material. Insufficient drying can result in microbial or mold growth, while either insufficient or excessive drying can result in compound degradation. Adherence to proper dehydration conditions is therefore an essential part of post-harvest handling operations.

b) Cutting and milling: Plant material can be traded in a number of forms, including whole, chopped, cut and sifted, teabag cut, shredded, and powder. Cutting of plant materials can occur either before or after dehydration, while milling to powder is always undertaken after drying. Cutting and milling operations must be conducted with practices that ensure that the material's quality and purity is maintained.

c) Packaging and storage: The use of adequate packaging equipment and materials will affect the quality of packaged herbal crops, as will storage conditions. The following practices are relevant to packaging (including drums, boxes, bags and all other packaging) and storage operations for bulk herbs.

d) Distillation

i) Steam Distillation: Different processing methods are required to extract essential oils from different plants. Most oils are extracted using steam distillation, during which the plant material is permeated with steam. As the plant tissues break down, the essential oils and water vapour are released, then collected and cooled. The volatile essential oil condenses, separates and is easily isolated.

In this process the steam is prepared in a separate chamber and piped into the tank. This is more expensive than the other methods. This is especially good for plant materials with high boiling point oils. In this method the temperature and pressure can be increased for certain oils.

The rate of distillation and yield of oil are high and the quality of the oil is good.

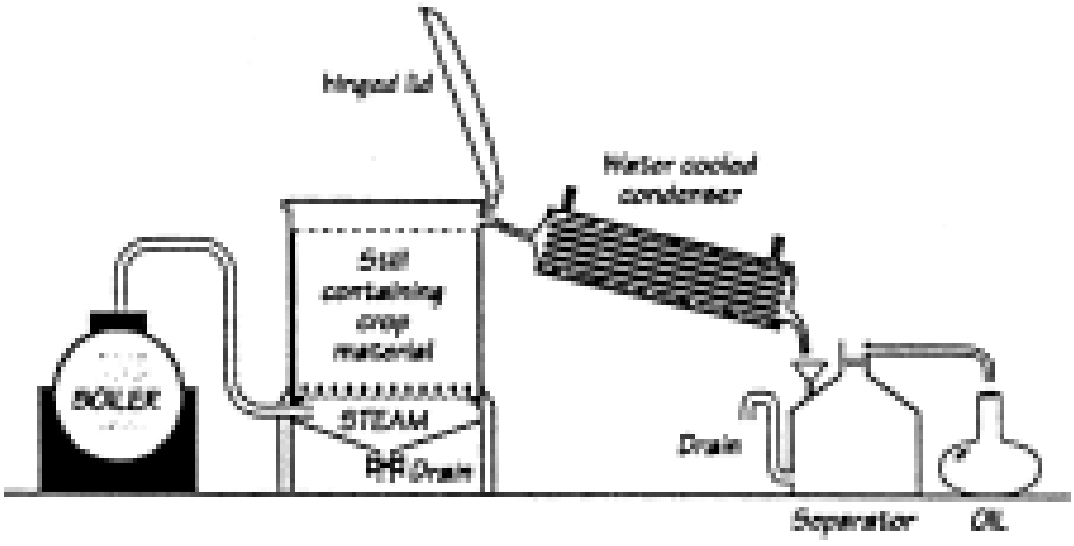

Fig. Basic still design for steam distillation

ii) Water Distillation

This is the simplest and usually cheapest distillation method. The plant material is immersed in water and boiled. The steam and oil vapour is condensed and the oil is separated from the water. This method is suitable for flower blossoms and finely powdered plant material.

The distillation temperature should be about 100°C. Care needs to be taken to prevent the plant material being damaged by contacting the overheated still walls. The pressure in the still should be atmospheric. The distillation time depends on the plant material being

processed. Prolonged distillation produces only a small amount of extra oil, but does add unwanted high boiling compounds and oxidation products.

iii) Solvent Distillation: Essential oils can be extracted using solvents. Hydro-distillation is not suitable for various products like delicately odoured oils.

Solvent extraction is used when the odorous properties of delicate flower and plant material would be altered or destroyed by steam or water distillation or when a plant, for instance rose absolute and jasmine contains very little oil, making steam or water distillation impractical.

Solvent extraction produces a concrete which in turn is refined into an absolute. To produce a concrete, the plant material is gradually saturated with a hydrocarbon solvent. The solvent dissolves the plants constituents including essential oils, fatty acids and waxes. After the solvent is distilled off the remaining constituents make up the concrete. The essential oil is extracted from the other constituents with alcohol. The fatty acids and waxes are not alcohol soluble so they're left behind. A secondary distillation then removes the alcohol, leaving the absolute oil behind.

iv) Supercritical CO2 Extraction (SCFE): Supercritical carbon dioxide extraction uses carbon dioxide under extremely high pressure to extract essential oils, fragrance products, herbal extracts and spice extracts. The organic material is placed in a stainless steel tank and, as carbon dioxide is injected into the tank, pressure inside the tank builds. Under high pressure, the carbon dioxide turns into a liquid and acts as a bonding agent to extract the essential oils from the plants. When the pressure is decreased, the carbon dioxide returns to a gaseous state. Because Carbon Dioxide is relatively inert, contaminations free process.

Many carbon dioxide extractions have fresher, cleaner, and crisper aromas than steam-distilled essential oils, and they smell more similar to the living plants. Scientific studies show that carbon dioxide extraction produces essential oils that are very potent and have great therapeutic benefits. This extraction method uses lower temperatures than steam distillation, making it gentler on the plants. It produces higher yields and makes some materials, especially gums and resins, easier to handle. Many essential oils that cannot be extracted by steam distillation are obtainable with carbon dioxide extraction. In the future, many botanicals that are not now available may possibly be obtained through carbon dioxide extraction.

v) Bulk Packaging and Labelling

Processed medicinal plant materials should be packaged as quickly as possible to prevent deterioration of the product and to protect against unnecessary exposure to potential pest attacks and other sources of contamination.

Facilitate efficient and hygienic operations by allowing a regulated flow in processing from the arrival of the raw medicinal plant materials at the premises to the dispatch of the processed medicinal plant materials;

4.8.3 Ideal condition for processing

The following elements should be considered when establishing a quality assurance system and be adapted to the different steps of production and production sites.

- Facilities should preferably be located in areas that are free from objectionable odours, smoke, dust or other contaminants, and are not subject to flooding.
- Roadways and areas serving the establishment, within its boundaries or in the immediate vicinity, should have a hard paved surface suitable for wheeled vehicles. There should be adequate drainage, and provision should be made for cleaning.
- Building should be designed to provide adequate working space and storage room to allow for satisfactory performance of all operations; facilitate efficient and hygienic operations by allowing a regulated flow in processing from the arrival of the raw medicinal plant materials at the premises to the dispatch of the processed medicinal plant materials; Permit appropriate control of temperature and humidity; Permit the separation by partition or other means of processes that may cause cross contamination; Permit easy and adequate cleaning and facilitate proper supervision of hygiene; Prevent the entry of environmental contaminants such as smoke, dust, etc.; Prevent the entrance and harbouring of pests, livestock and domesticated animals; Where appropriate, prevent direct sunlight from entering a particular section.
- An ample supply of water, under adequate pressure and at suitable temperature, should be available with appropriate facilities for its storage, where necessary, adn distribution, and with proper protection against contamination.

- Adequate natural or artificial lighting should be fitted throughout the facility. Where appropriate, the lighting should not alter colours and the intensity should be not less than 540 lux at all inspection points; 220 lux in work rooms; 110 lux in other areas.

4.9 Quality Control during Processing

The next stage is the quality control during processing and manufacturing. This is a very important step which will ensure quality during the manufacturing process. It is also felt that in order to ensure availability of genuine, authentic medicinal plants, it would be better to have a centralized agency for marketing of the medicinal plants and it may be made mandatory for all to purchase, the certified material only from authorised agencies like Forest Development Corporation or the National Board for Medicinal Plants.

The good collection and processing steps for MAPs will improve quality ethos in the manufacture of pharmaceutical products and thereby help improve the medicine, both nationally and globally.

4.10 Summary

There is a global upsurge in the use of traditional and complementary systems of medicine along with changes in health seeking behaviour. Medicinal and aromatic plants (MAPs) played a significant role in various ancient traditional systems of medication such as Ayurvedic and Unanic in India, Chinese traditional medicine and their derivatives. Today, MAPs still plays an important role in developing countries in Asia, both in preventive and curative treatments, despite advances in modern western medicine.

It is well known that an age-old tradition of plant based health-care in the form of Ayurveda, Siddha and Unani and other systems of medicine. More than 90% of the formulations under these systems are plant based with a very small percentage of formulations having minerals, metals and animal products as ingredients. Almost 90 percent of the raw materials of medicinal plants used are sourced from natural forests. But collection in wild habitats, present special problem, especially with regard to confusion with similar plants, environmental damage, lack of trained personnel etc.

To develop Good Field Collection and Processing Practices for medicinal plants, which are mainly collected from the wild, one has to follow certain guidelines. These guidelines, which should be backed up by capacity building and independent certification, contribute to

alleviating harvesting and quality of plant raw materials used in the manufacture of traditional herbal medicines as well as modern pharmaceutical products.

Collection practices of MAPs should ensure the long-term survival of wild populations and their associated habitats. Management plants for collection should provide a framework for collection should provide a framework for setting sustainable harvest levels and describe appropriate collection practices that are suitable for each medicinal plant species and plant part used (roots, leaves, fruits, etc.). Collection of medicinal plants raises a number of complex environmental and social issues that must be addressed locally on a case-by-case basis.

Terminal Questions

1. Which medicinal plants are exclusively collected from the wild?
2. What are the main reasons of wildcolection of MAPS?
3. Explain different methods of MAP collection from the wild?
4. What do you understand by sustainable collection practices? Mention in brief guidelines on sustainable collection practices.
5. Explain post harvest processing of MAPs.
6. Explain the primary and secondary processing.

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Unit 5: Survey and Assessment of Medicinal and Aromatic Plants

Unit Structure

5.1 Learning Objectives

After the completion of this unit student shall be able to know:

- Survey and inventory of MAPs.
- Collection and preservation of MAPs specimens.
- Data recording, analysis and interpretation
- Preparation of distribution and density maps.

5.2 Introduction

In India, of the 17,000 species of higher plants, 7500 are known for medicinal uses. This proportion of medicinal plants is the highest proportion of plants known for their medical purposes in any country of the world. The immense natural resources of India offered unique opportunity to the indigenous people for the use of different medicinal and aromatic plants (MAPs). Local people have extensive knowledge of the properties and use of plant resources prevalent in the nature. Medicinal and aromatic plants come under the class of Non-Timber

Forest Products (NTFPs), which have been extensively used since long ago when the human life started. Local people use a number of plants for food, spices, fiber, medicine, religious purpose, handicrafts and many other purposes. These days Medicinal and Aromatic Plants(MAPs) not only fulfill the need of local people but also provides raw materials for various industries. Market for MAPs as raw materials has increased gradually in recent years due to the growing international market for herbal products in India. Multinational pharmaceutical companies are looking for active substances in these plants for the cure of various diseases where modern synthetic medicines are perceived to be less effective. Resin and dyes are receiving increasing attention worldwide. Due to the spurt in the trade of medicinal and aromatic plants and a revival of the traditional methods of healing there has been a great pressure on the biodiversity of natural ecosystems. At present there are more than 10000 licensed pharmacies practicing the India system of medicine, whose requirements have to be met. In addition to these, there are thousands of local '*Vaidyas'*, herbal healers, bonesetters and tribal doctors who practice this system of medicine. With this scenario, there is always a possibility to exploit the raw material for immediate monetary gains without considering the sustainability aspects. To know the available stock in the wild, there is a need to survey and assess the medicinal and aromatic plants. The fundamental questions that management authorities should be able to answer while planning sustainable management MAPs at operational level are: what is the existing growing stock and the productivity per unit of time and area? What is the quantity or amount of sustainable yield that can be prescribed for harvesting? What specific sustainable harvesting techniques in terms of seasons, methods and tools are appropriate for each of the products in question?

5.3 Survey and Inventory

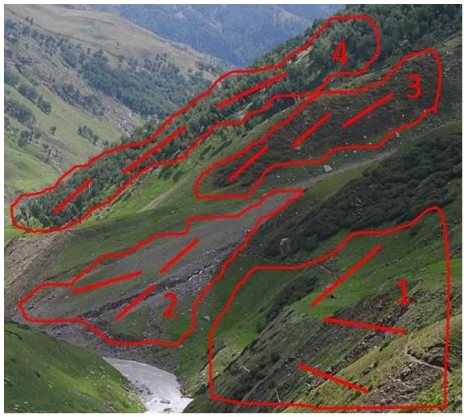
The basic aim of the survey and inventory of medicinal and aromatic plants is to enable us to learn and document the qualitative and quantitative aspects, location, and abundance of MAPs species within the management area. Inventory of MAPs deals with the basic questions such as: which species of MAPs we have, where are they distributed, and what is the quantum (number and weight) available in the given range? Other relevant questions are: which species are locally used, which are harvested at commercial scale, how frequently are each of the species found? Following are the basic steps for inventory:

5.3.1 Field reconnaissance

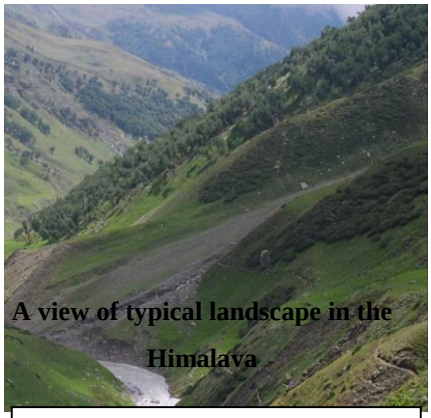
The first step in any resource inventory is to carry out reconnaissance of the area proposed for survey and mapping. During reconnaissance a checklist of locally and commercially used plants available in the area, the forest types, existing trails and size of the area should be recorded. During field survey plant specimen which are locally used as medicine and whose name is not clear must be collected and preserved. It is also better to take one or two photographs of the plants for further identification.

5.3.2 Stratification

Based on the initial reconnaissance and knowledge of the area each survey area should be divided into smaller units (Figure 1). The strata could be based on the landform and terrain (e.g. flat, hilly, undulating, river valley), disturbance regime (e.g. highly disturb, moderately disturb or least disturb areas), altitude and vegetation types (e.g. dense forest, open forest, scrub, grasslands). Stratification is very important because plant species are distributed within specific habitat and landforms.



Strata 1-4 represents different habiata types. The transects can be laid in each stratum according to landform and feasibility of survey



A view of typical landscape in the Himalava

Figure 1. Stratification, Transect layout and Sampling plots *Source: Rawat et. al. 2004*

5.3.3 Trail / Transect selection and marking

Sampling within each stratum should be done along the trail or transects. Ideally transect should be laid in random direction but in a rugged and hilly terrain, it is not feasible to lay straight line transect. Length of one transect should be one km for forested area and half km in the alpine meadows. However, number of the transects in each area will depend on the size of the area. The beginning and the end of transect should be marked both on the maps

as well as in the field. The sample plots would be located on either side of the trail at alternative points.

5.3.4 Laying of the sample plots

Most of the ecologist advocate for random plots to be laid within each strata. However for the survey of specific species especially in a hilly and undulating terrain it is better to estimate the number within the pre-decided plots. Systematic sampling allows detection of variations within the strata and allows us to sample such variation more evenly. The size of the sample plots for estimating MAPs would be as follows:

- 10 m radius plot (314 sq. m area) for counting of the number of medicinal trees such as Thuner (*Taxus*), Harar (Terminalia chebula), Bahera (Terminalia bellirica), Bel (Aegle marmelos). These plot would be used for recording trees (more than 20cm girth and 3 m in height) from which various plants parts (e.g. fruits, leaves and barks) could be harvested.
- 5 m radius plot (78.57 sq. m area) for shrubby or climber MAPs. This plot would also be used to count all seedlings, sapling and pole size individuals of medicinal trees.
- Four rectangular quadrates (1m x 1m) for herbaceous MAPs. The smaller plots for shrubs and herbs will be laid within the larger (10 radius plot) using same centre.

5.4 COLLECTION AND PRESERVATION OF MAPs SPECIMENS

5.4.1 Collection

- Collect at least 2 samples of each medicinal and aromatic plant. The sample should be mature and preferably along with a flower and a fruit. One should not collect diseased, infected or inappropriate plant material. In case of trees and climbers, one twig with leaves and a flower is enough for identification. Roots, underground parts, cones or fruits such as acorns, pods, nuts and berries could be stored separately in paper bags. The habit, habitat, flower colour, locality, interesting features etc. should be noted down in the field notebook. Some tools are rather important during the collection of plants for herbarium: A small knife, scissors, thorn-proof gloves and a small handy spade could be of great help. The collected specimens should be put

into a strong bag made of cloth or polythene as the function of these containers being to protect plants from damage during your outing.

5.4.2 Pressing and drying

The specimens are kept gently within newspaper sheets. Parts of a flower are very carefully spread without causing any overlapping of the original shape. If the specimens are long, then it needs to be folded. Climbers can be pressed coiled or bent. Remove the soil from the roots before pressing the plant. The standard size of the press is 30 x 45 cm (Figure 2, 3 & 4).

Figure 2. Pressing of specimen in press board.

After the plants are in the press, the secret of producing specimens with natural-coloured flowers and foliage lies in rapid drying. This also prevent discoloration, fungal growth and dropping of leaves. Ideal time for drying the average plant is two to three days. It is a good idea to dry the specimens by changing the newspaper sheets or blotters in shade. Change the newspaper sheets or blotters daily. Fleshy plants should be changed twice a day for the first two days. Changed specimens that are neatly pressed under the plant press can be kept under the fan or in the sun 1 or 2 hours.

5.4.3. Poisoning, mounting and labeling

Poisoning the specimens is another important step before mounting in order to prevent any possible fungal or bacterial attack in future. The solution used for this purpose consists of Mercuric Chloride, Ammonium Chloride and Ethyl Alcohol. The quantity of chemical used at a time depends upon the number of specimens that have to be poisoned. Dissolve 150 gms of Mercuric Chloride and 350 gms of Ammonium Chloride in little water. Keep the quantity of water to bare minimum. To this add 10 litres of 96% alcohol. Application of the chemicals can be done by gently brushing them on the specimens. After poisoning, the specimens may remain in press for another day or two in order not to get the leaves and flowers wrinkled.

Mounting is the process by which a specimen is attached to a herbarium sheet and a label affixed at the lower right corner. Specimens are mounted on sheets of standard size herbarium paper (29 X 43 cm). The specimen may be attached by various methods. A common method involves smearing a glass plate with a water-soluble paste, placing the specimen on the paste, and ten transferring the glued plant to the mounting sheet. Small paper envelopes called fragment packets are attached to the sheet to hold seeds, extra flowers, or any part of the specimen.

Figure 3. Steps of pressing

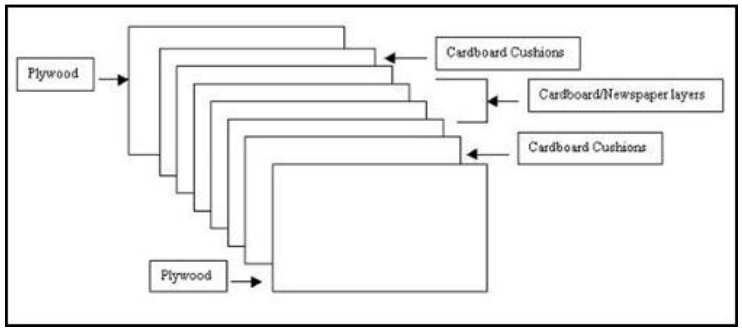


Figure 4. Basic Structure of press

Herbarium label is an important and essential part of permanent plant specimens. The size and shape of label may vary slightly but will usually be rectangular and will measure around 10 x 15 cm (4 x 6 in.). The best position for the main label is generally thought to be the bottom right; this makes the label easier to read when kept in genus covers which open on the right hand side.

5.5 DATA RECORDING, ANALYSIS AND INTERPRETATION

5.5.1 Data recording

Medicinal and aromatic plants will be counted rapidly within the sample plots by a team of 2-3 persons. Prior to recording the data, a format should be prepared to record this data (Table 1). Besides the plant abundance environmental data such as altitude, aspects, slope, soil characteristics, associated species, topography, presence of perennial water channel and human pressures such as grazing, uprooting, and fire should be recorded.

5.5.2 Data analysis

Data on the presence or absence of MAPs, and availability of MAPs in a particular area, forest type or habitat can be shown in terms of density, frequency and cover of each transect or plots.

Frequency: Frequency is the number of sampling units in which a particular species occur. If a species occurs in all the sampled plots, the frequency is said to be 100% and if it doesn't occur in any of the sample plots it is 0%. Frequency of species can be compared across transects, areas and management units.

$$\text{Frequency (F) (\%)} = \frac{\text{No. of plots in which individual species occurred}}{\text{Total number of plots sampled}} \times 100$$

Density: Density is the number of individual of a species per unit area. It expresses the numerical strength of the presence of MAPs species in a management area, forest and particular habitat type. This is easy to estimate in case of trees, shrubs and herbs but difficult in creeping or mat forming herbs. Density of trees and shrubs is normally shown in terms of number per hectare and for herbs it is number per square meter.

$$\text{Tree density (per ha)} = \frac{\text{Total no. of medicinal trees in all the plots}}{\text{Total number of plots} \times 314} \times 10000$$

$$\text{Density of woody plants (shrubs and climbers per ha)} = \frac{\text{Total numbers of medicinal plants in all the plots}}{\text{Total numbers of plots} \times 78.57} \times 10000$$

$$\text{Density of herbs (per m}^2\text{)} = \frac{\text{Total number of individuals in the all the plots}}{\text{Total number of plots}}$$

Cover

For spreading and mat forming medicinal plants, cover (in terms of % area covered on ground) is a better measure of estimating availability. It is also useful for mapping and monitoring if the measurements are taken within the fixed transects and plots.

5.5.3 Data interpretation

Interpretation of the results of an inventory requires skill and experience. The data of density, frequency and cover are the indirect measures of the MAPs in an area because most of the species are sold in the terms of dry weight. Estimating dry weight in the field is a cumbersome process and would involve destructive sampling. Hence the results of the density, frequency and cover need to be interpreted carefully. In the state of Uttarakhand most of the herbs in the high altitudes are perennial. The thickness of the tubers and rhizomes would indicate the amount (dry weight or biomass) is available per plant. Therefore interpretation of density and frequency will have to be done carefully before availability of these plants is reveled to the collector.

5.6 Preparation of Distribution and Density Maps

Data collected through survey/inventory need to be analyzed and portrayed in the form of simple tables and maps. The maps depicting presence/ absence, distribution, and abundance of MAPs become handy in conservation and management planning. The following steps are needed for the preparation of a medicinal pant distribution/ density maps:

5.6.1 Preparation of base map

This should be made for each block or compartment using survey of India (SOI) topo sheets of 1:50,000 scale. For the smaller areas larger scales (1:25,000 scale) would be better. Using the tracing paper the outline of the range, block, compartment, major drainage, roads, trails, landmarks and geographical coordinates (latitudes and longitudes) should be drawn. This would serve as a base map.

5.6.2 Ancillary data

On the base map following parameters can be shown using different colours: Major strata/ vegetation types, administrative units, alignment of trails/ transects and location of villages, drainage and important landmarks.

5.6.3 Plotting distribution and density of MAPs

Presence/absence, major cover, density classes of MAPs be plotted on the base map in various ways. Now days Remote Sensing has become an important and effective tool for preparation of broad vegetation cover maps and further stratification of the area which may serve as base map for further refinement of the species distribution maps.

5.7 Summary

- Survey and assessment is important aspects in order to know the available stock of medicinal and aromatic plants in the wild.
- The reconnaissance survey gives the primary data of the MAPs in a particular area, forest type and habitat for rapid mapping and assessing medicinal and aromatic plants.
- Stratification is very important because plant species are distributed within specific habitat and landforms and the strata should be based on the land form and terrain, disturbance regime, altitude and vegetation types.
- In each stratified zone for MAPs, sampling transects are laid in random direction. Minimum length of one transect for forested area should be one km and for alpine meadows should be half km and number of transects in each area will depend on the size of the area.
- Generally most of the ecologists recommend that random plots should be laid within each stratum, but in the hilly terrain, it is better to estimate within the pre-decided plots. The size of the sample plots for estimating MAPs would be 10 m radius for trees, 5 m radius plot for shrubby or climber and Four rectangular quadrates (1m x 1m) for herbaceous MAPs.
- Herbarium specimen is a must for those plants whose names are not clear during the field survey. Proper herbarium techniques should follow.

- For collecting information of a particular sample plot, a standard data format should be prepared for recording all the relevant information.
- Data on the presence or absence of MAPs, and availability of MAPs in a particular area, forest type or habitat can be shown in terms of density, frequency and cover of each transect or plots.
- Data collected through survey/inventory needs to be analyzed and portrayed in the form of simple tables and maps. The maps depicting presence/ absence, distribution, and abundance of MAPs become handy in conservation and management planning.

Terminal Questions

1. Mention why survey and assessment are important and write in detail about the methods of collection of MAPs?
2. Explain in detail about the process of preparation of herbarium specimens of medicinal and aromatic plants about its process?
3. Why stratification is important for survey and inventory?
4. How can we do quantitative assessment of medicinal and aromatic plants?
5. Write about data recording, analysis and interpretation?
6. How to prepare density and distribution maps?

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Table 1. Format of a standard data sheet

DATA SHEET

Name of the forest division……..

Date……

Altitude……Terrain: Flat/ Undulating/ Gentel slope/ Steep/ Very steep

Topography: Valley/ Bouldery/ Rocky/ Marsy area/ Ridges

Vegetation: Dense forest/ Open forest/ Bushy/ open scrub/ grasslands/ alpine meadows

Human use pattern:…….

1. Woody MAPs (Trees in 10 m r plots and Shrubs in 5 m r plots)

Species name	Plot number										Remarks
	1	2	3	4	5	6	7	8	9	10	
1											
2											
3											
4											
5											
6											
7											

% Cover (for spreading herbs) or Number of Herbs in m quadrates (4 quadrates at each sampling station)

Species Name	Plot number																			
	1				2				3				4				5			
1	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv
2																				
3																				
4																				
5																				
6																				
7																				

Species Name	Plot number																			
	6				**7**				**8**				**9**				**10**			
1	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv	i	ii	iii	iv
2																				
3																				
4																				
5																				
6																				
7																				

Unit 6: Sustainable Harvest and Management of Medicinal and Aromatic Plants

Unit Structure

6.1 Learning Objectives

In this unit you will be able to understand the following things:

- Sustainable harvesting of MAPs
- International and National regulations for MAPs.
- Various harvesting management.
- Post harvesting management

6.2 Introduction

In everyday life we use plants, parts of plants and their extracts. They are used in various ways: as food, medicines, in cosmetics industry, as colouring agents, detergents, perfumes and many other things. Medicinal and aromatic plants (MAPs) have been an important resource for human health care from prehistoric times to the present day. India has a rich

heritage of plant based healthcare systems like Ayurveda, Unani and Siddha with a very high degree of societal acceptance. It is reported that in India, 4,635 ethnic communities, including over one million folk healers, use around 8,000 species of medicinal plants. There is a global upsurge in the use of traditional and complementary systems of medicine. This is primarily due to the fact that these systems of medicine, being largely plant based, are generally safe, efficacious and affordable. The increasing demand of natural/herbal products world over, therefore, creates a need not only for conserving medicinal plants but also judicious utilization due to the large potential they have to offer in the service human kind as health care products. Over exploitation is leading to unsustainable collections from natural forests resulting in uncertain availability of a large number of medicinal plants species and their decline in the wild. Almost 90 percent of the raw materials of medicinal plants used by the manufacturing units are sourced from natural forests, often with little regard to environmental and social considerations, often resulting in the harvest of much in excess of sustainable limits.

6.2 Sustainable harvest

Sustainable harvesting means the use of plant resources at such levels and in such ways of harvesting that the plants are able to continue to supply the desired produce in perpetuity. The basic idea behind sustainable harvesting is that a biological resource should be harvested within the limits of its capacity for self-renewal.

Sustainable use has been defined by Convention on Biological Diversity (CBD) as ' *The use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations*'.

6.3 HARVESTING OF MAPs

Medicinal and aromatic plants should be harvested during the optimal season or time period to ensure that the production of medicinal plant materials and finished herbal products are of the best possible quality. However, it is well known that the concentration of biologically active constituents varies with the stage of plant growth and development. The best time for harvest (quality peak season/time of day) should be determined according to the quality and quantity of biologically active constituents rather than the total vegetative yield of the targeted medicinal plant parts. Damaged plants or parts of plants need to be excluded. During

harvest, care should be taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials. Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity. If harvesting occurs in wet conditions, the harvested material should be transported immediately to an indoor drying facility to expedite drying so as to prevent any possible deleterious effects due to increased moisture levels, which promote microbial fermentation and mould. Cutting devices, harvesters, and other machines should be kept clean and adjusted to reduce damage and contamination from soil and other materials. They should be stored in an uncontaminated, dry place or facility free from insects, rodents, birds and other pests and should be inaccessible to livestock and domestic animals.

Contact with soil should be avoided to the extent possible so as to minimize the microbial load of harvested medicinal plant materials. Wherever necessary, large drop cloths, preferably made of clean muslin, may be used as an interface between the harvested plants and the soil. If the underground parts (such as the roots) are used, any adhering soil should be removed from the medicinal plant materials as soon as they are harvested. The harvested raw medicinal plant materials should be transported promptly in clean and dry conditions. They may be placed in clean baskets, dry sacks, trailers, hoppers or other well-aerated containers and carried to a central point for transport to the processing facility. All containers used at harvest should be kept clean and free from contamination by previously harvested medicinal plants and other foreign matter. If plastic containers are used, particular attention should be paid to any possible retention of moisture that could lead to the growth of mould. When containers are not in use, they should be kept in dry conditions, in an area that is protected from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Any mechanical damage or compacting of the raw medicinal plant materials, as a consequence should be avoided, e.g. of overfilling or stacking of sacks or bags that may result in composting or otherwise diminish quality. Decomposed medicinal plant materials should be identified and discarded during harvest, post-harvest inspections and processing, in order to avoid microbial contamination and loss of product quality.

6.4 International And National Regulation

The various international treaties and conventions related to conservation of biodiversity signed by India must be respected while collecting any medicinal plant produce from the

wild. The collection managers and collectors should be educated on the provision of Convention on International Trade in Endangered Species (CITES). The 1993 (WHO/IUCN/WWF) Guidelines on the Conservation of Medicinal Plants (WHO 1993) and the 2004 WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants (WHO 2003) provide general guidance and principles for the development of a global framework of practice standards for medicinal and aromatic plants. These guidelines do not provide, concrete principles and criteria for the conservation and sustainable use of medicinal plants. In 2007 International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP) has been prepared by the Medicinal Plant Specialist Group (MPSG) of the Species Survival Commission (SSC), IUCN.

Indian regulations are Forest Act 1927, The Wildlife (Protection) Act 1972, The Forest (Conservation) Act 1980, The Biological Diversity Act 2002 and The Scheduled Tribes & Other Traditional Forest-Dwellers (Recognition of Forest Rights) Act 2006 should follow. In some state of India, the ROR (Register of Regulations) of local regulations enacted by The Madhya Pradesh Sustainable Harvesting Act 2005, The Andhra Pradesh Red Sanders Wood Possession Rules 1989, The Himachal Pradesh Forest Produce Transit (Land Routes) Rules, 1977, The Tamil Nadu Sandalwood Transit Rules, 1967, and The Maharashtra Forest Produce (Regulation of Trade) Act, 1969 etc.

6.5 Harvesting Management

Often it is one or more part like root, bark, stem, leaves, flowers, fruits, and seeds of the species, which constitute the officially accepted produce. Only in a few cases is the whole plant is used as a medicinal plant produce. While the general guidelines for harvesting and post-harvest management are applicable to any collected part, the specific plant parts need additional care. Ancient science, like Ayurveda, recommends collecting different parts of the plants in different seasons. This was perhaps done keeping in view the optimum activity of herbs when harvested at a specific season. Further, collecting the parts from the plant at a season when it causes the minimum harm to the plant is also important. Some of the important points, which need to be taken care of while harvesting various categories, are given below.

6.5.1 Underground parts

The roots of annual plants must be dug when the plants are well developed and mature. Roots of perennials should be harvested late in the fall or early in the spring. Roots of biennial should be collected in either the fall of the first year or spring of the second year. The root material that is rich in essential oils should be handled carefully to prevent bruising of the epidermis, where the oils typically reside, which could result in loss of essential oil or its degradation. Where taproot is the desired produce and needs to be uprooted, harm to other plant species in the vicinity should be minimized. Underground parts should be collected with minimum possible digging by using appropriate tools. When roots of species that are propagated vegetatively in nature are collected, enough underground part should be left at site to allow regeneration. It must be ensured that underground parts are thoroughly washed and thereafter dried to reduce the moisture content before packing the produce.

6.5.2 Annual herbs or whole plants

When collecting whole herbaceous plant, or its aerial parts, the harvesting should be done at flower bud or flowering stage but prior to any visual decline in any of the plant parts. Whole population in a given area should never be harvested. Adequate population should be left in nature for regeneration to facilitate future collections. Use of mathematical procedures including computer software to estimate collection of individuals from a population may be resorted to when the target area is large to ensure even harvesting throughout the habitat. Annuals, especially small herbs, creepers, grasses are more prone to contamination as well as cross-contamination. It is easier to sort the annuals immediately after the collection rather than after drying. Aromatic plants and delicate parts like pistils or stamens of the other plants should not be dried in direct sunlight. If these are collected in wet conditions, they should be shifted to the shade as soon as the external moisture has been removed.

6.5.3 Stem Bark

Stem bark should not be harvested when the tree is under new growth (like spring season). As far as possible, the bark should be collected from mature branches of the trees leaving the main trunk intact. Bark from entire branch or trunk should not be taken at one time. Girdling of trees or branches by removing the bark all the way around should not be done, unless the tree is to be felled for other purposes like, timber. Bark should be stripped longitudinally (partially along the length of the stem) to allow smooth conduction of water and

nutrients. Stem bark should not be collected again from same tree unless adequate time has been allowed for it to be reformed completely. It should not be collected from immature trees or branches. The bark should be split in pieces of appropriate size to ensure complete drying. Unless otherwise required in specific cases, barks should be dried in direct sunlight.

6.5.4 Stem or wood

Only select mature branches of a tree or shrub should be harvested at a time. The branches from the same plant should not be harvested every year. Where the trunk is used as medicinal produce, the main axis should be harvested. The produce should be cut in smaller pieces to facilitate faster drying, packaging and storage of the produce. In case of wood, the material can be made into small chips or shavings to facilitate drying and packaging. Unless otherwise required in specific cases, stems and woods should be dried in direct sunlight.

6.5.5 Leaves

The leaves of herbaceous plants should be collected before their flowering, unless otherwise specified. As far as possible, leaves should be collected from mature trees. Where bioactive contents in the leaves do not fluctuate with age, the collection could be extended to later stage also. The source plant should not be ripped off the leaves completely. Certain percentage of leaves should be left to ensure normal physiological processes of the plant. Trees, shrubs or their branches should not be chopped to facilitate the collection of otherwise inaccessible leaves. Tender leaves should not be harvested unless they constitute the officially recognized produce. Leaves turned pale, those infected, deficient and unhealthy should be discarded. Generally leaves should not be dried in direct sunlight, unless they have external moisture, in which case they may initially be dried in direct sunlight for some time and then can be shifted to shade or indirect sunlight as soon as the external moisture is wiped dry. The produce should be turned periodically while drying to facilitate faster and even drying. Packing of the leaves should be done after ensuring the complete drying. Even a small amount of moisture present in some leaves, may invite fungal contamination and spoilage of the whole lot. Leaf material rich in essential oil must be handled carefully to avoid bruising of the leaves that could result in the loss of essential oil or its degradation. The leaves should be harvested during the season when growth and leaf production is the highest. When environmental conditions are stressful for the plants leaf harvesting should be postponed or should be harvested in less quantity. If the leaf size is decreasing the rate

of harvest should be lowered as it indicates stressful condition. The rate of harvest should be decreased if there is heavy pressure from grazing, fire or other incidents that may negatively affect the plants.

6.5.6 Flower and floral parts

Flowers must be harvested when they have just opened or shortly afterwards to capture its aroma. The flower buds must be collected before the buds open and in the early morning hours. In such cases, the material should be shaken in order to facilitate and encourage the departure of insects. The flowers rich in essential oils must be handled carefully to prevent bruising that could result in essential oil degradation. All the flowers from perennials like shrubs, trees and climbers should not be harvested completely. Similarly, flowers from a complete population of annual plants should not be collected at a time. Enough flowers must be left over the plants to allow the natural process of pollination, fertilization, fruit/seed formation and dispersal. Floral parts like stigma, anthers, petals etc should be collected at appropriate time of their maturity to ensure the availability of desired active substance. The delicate flowers and floral parts should not be dried in direct sun light. Medicinal plant produce consisting of flowers and floral parts should be packed in moisture resistant well-protected containers, away from direct sun light.

6.5.7 Fruits and seeds

Fruits and seeds should be collected only on maturity unless immature ones constitute the medicinal produce (e.g. *Phyllanthus emblica*, *Aegle marmelos*) except the fruit of family Apiaceae that dehisce on drying should be collected before maturation without doubt. In case of shrubs and trees, all the fruits from individual plant should not be collected at a time and few healthy ones for further multiplication of the species should be left behind. Similarly, the whole population of annuals should not be ripped off all the fruits and seeds at a time. Trees, shrubs or their branches should not be cut for ease of collection of fruits and seeds. Immature, infected and deformed fruits should be separated and discarded appropriately. If the medicinal plant produce consists of fresh fruits (e.g. *Phyllanthus emblica*) the same should be transported to cold storage or pulping units immediately after harvesting. Wherever required, seeds should be removed completely from the fruit rind before they are traded. As per the need of the produce, fruits may be split or cut into small pieces to facilitate drying and packaging. Complete drying of fruits should be ensured before they are packed.

Randomly selected individuals fruits should be dissected to ensure that there is no inherent moisture left.

6.5.8 Gums and resins

Harvester should ensure minimum harm to the mother plant while collecting the exudates. Only a few small longitudinal incisions should be made to collect the exudates and the exposed parts should be treated appropriately to avoid any fungal or bacterial infestation after the exudates have been collected. Incisions that are too close to the ground or easily approachable by the cattle and wild animals should be avoided. The collection container should be designed in a way to prevent rain, bird droppings and any other such possible contaminations. Where there is a likelihood of some foreign matter being mixed with the collected gums and resins, it should be carefully removed. Source tree or shrub should be allowed appropriate recovery period before collecting the exudates from them again. Most of the gums and resins, being inflammable, should be packed in appropriate containers and stored at isolated places. The containers of resins like Damar (*Shorea robusta*) and Saral (*Pinus longifolia*) should be labeled as "Inflammable Material", while on transit and storage. No fire should be ignited near the base of the tree to increase gum/resin flow. Younger trees should not be tapped. The girth of the trees has to be decided below which tapping of gum/resin will not be allowed. Flow of gum is more in hot weather. Therefore, tapping in such species, should be done between June-October.

6.5.9 Others (Galls, Lac etc.)

Galls should be collected only from stipulated species. Harvester must ensure that no live insects are present inside the galls Post harvest management of galls should be done at an isolated place and the content should be packed and stored appropriately so as to avoid possible infestation of other produce.

6.6 Post Harvest Management

6.6.1 Cleaning and shorting

Soil attached to the harvested produce should be washed with potable water. After the pre-processing ways of scrapping, peeling or brushing, the produce should be washed with potable water before drying. Clean and remove any organic or inorganic matter stuck to it and any part of the mother plant that does not constitute official medicinal plant produce.

The produce should be cut into smaller pieces in a manner that enhances the drying while retaining the visual appearance of the produce.

6.6.2 Drying

Before shipping or storage the medicinal plants should be properly dried. The optimum moisture content of medicinal plant produce should be documented. Medicinal plants can be dried in a number of ways: in the open air (shaded from direct sunlight); placed in thin layers on drying frames, wire-screened rooms or buildings; by direct sunlight, if appropriate; in drying ovens/rooms and solar dryers; by indirect fire; baking; lyophilization; microwave; or infrared devices. When possible, temperature and humidity should be controlled to avoid damage to the active chemical constituents. The method and temperature used for drying may have a considerable impact on the quality of the resulting medicinal plant materials. For example, shade drying is preferred to maintain or minimize loss of colour of leaves and flowers; and lower temperatures should be employed in the case of medicinal plant materials containing volatile substances. The drying conditions should be recorded. Drying medicinal plant material directly on bare ground should be avoided. If a concrete or cement surface is used, medicinal plant materials should be laid on a tarpaulin or other appropriate cloth or sheeting. Insects, rodents, birds and other pests, and livestock and domestic animals should be kept away from drying sites. For indoor drying, the duration of drying, drying temperature, humidity and other conditions should be determined on the basis of the plant part concerned (root, leaf, stem, bark, flower, etc.) and any volatile natural constituents, such as essential oils. If possible, the source of heat for direct drying (fire) should be limited to butane, propane or natural gas, and temperatures should be kept below 60 °C.6 If other sources of fire are used, contact between those materials, smoke and medicinal plant material should be avoided.

6.6.3 Packaging and labelling

The harvested plant materials should be packaged as quickly as possible to prevent deterioration of the product and to protect against unnecessary exposure to potential pest attacks and other sources of contamination. Materials used for packaging should be non-polluting, clean, dry, in undamaged condition and should conform to the quality requirements for the medicinal plant materials concerned. Fragile medicinal plant materials should be

packaged in rigid containers. Whenever possible, the packaging used should be agreed upon between the supplier and the buyer.

Table 1. Recommended packaging for medicinal produce

Type of the produce	Packaging options
Roots, stems, wood and woody bark	Gunny bags June bags Woven Sacks
Annual whole herbs, creepers, twiners, Leaves, ect.	Woven sacks with low density liner Jute bags
Fleshy materials-fleshy rhizomes (e.g. Shatavari), fruits, fruit rinds (Kokum butter) of flowers (Mahua)	Jute bags with high gauge polyethylene liners Woven sacks with high gauge polyethylene liners
Delicate flowers and floral parts – Anthers, Stigma, Petals etc. Gums and resins	Corrugated box with polyethylene liners Card-board box with woven sacks Air-tight Plastic drums Corrugated box with polyethylene liners
Aromatic plant produces	Air tight High Density Polyethylene (HDPE) containers Fiber board drums with polyethylene liners containers

Source: National Medicinal Plant Board (NMPB-GFCPMP-01), New Delhi

All packaging materials should be stored in a clean and dry place that is free from pests and inaccessible to livestock, domestic animals and other sources of contamination.

A label affixed to the packaging should clearly indicate the scientific name of the medicinal plant, the plant part, the place of origin (cultivation or collection site), the cultivation or collection date and the names of the growers/collectors and the processor, and quantitative information. The label should also contain information indicating quality approval and comply with other national and/or regional labelling requirements. The label should bear a number that clearly identifies the production batch.

Table. 2. Information on container label

1. Name of the produce	2. Grade if any
3. Quantity	4. Lot No. 5. Lot size
5. Month of collection	6. Collected from
7. Date of receipt (from Collector)	8.Transit Pass (TP) no.
Signature of the Store Manager	Date:

Source: National Medicinal Plant Board (NMPB-GFCPMP-01), New Delhi

6.6.4 Storage

Medicinal plant produce should never be stored in open areas and in or near cattle sheds. The storage area should be free from pests. The storehouse should have provision for keeping approved, rejected and untested lots separately with appropriate signboards. Never stack the containers/ packages, especially gunny bags, jute bags, woven sacks, corrugated box etc. directly on the floor. There should be provision for separate climate (temperature and humidity) controlled facility to store hygroscopic material and volatile material. Inflammable materials should be clearly labeled on each container and stored at an isolated place in closed containers.

Table 1. Harvesting time of selected medicinal plants

Name of the herb	Hindi name	Parts used	Season for Collection			
			Feb to April	May To July	Aug to Oct	Nov To Jan
Acacia nilotica	Babool	Bark			√	
Aconitum ferox	Ativisha	Rhizome			√	
Aconitum heterophyllum	Atish	Rhizome			√	
Adhatoda vasica	Adusa	Leaves	√			
Aegle marmelos	Bel	Fruit		√		
		Bark	√			
Asparagus racemosus	Shatawari	Root			√	
Azadirachta indica	Neem	Leaves		√		
		Bark				√

Berberis aristata	Kilmora	Root/stem			√	
Butea monosperma	Palash	Seeda	√			
Calotropis procera	Aak	Leaves	√			
Calotropis gigantea	Aak	Leaves	√			
Cassia fistula	Amaltas	Fruit		√		
Cedrus deodara	Devdar	Wood		√		
Centella asiatica	Mandookparni	Leaves			√	
Cinnamomum tamala	Tejpatra	Leaves	√			√
Cinnamomum verum	Dalchini	Bark		√	√	
Commiphora wightii	Guggulu	Gum-resin				√
Crocus sativus	Keshar	Stigma				√
Curculigo orchioides	Kali Mushli	Rhizome	√	√		
Dioscorea bulbifera	Varahikand	Tuber				
Eclipta prostrata	Bhringraj	Whole plant		√		
Ferula asfoetida	Heeng	Gum-resin	√	√		
Ficus religiosa	Peepal	Bark			√	√
Hedychium spicatum	Karpoorkachri	Rhizome	√			
Inula racemosa	Pushkarmool	Root			√	
Mimosa pudica	Lajwanti	Whole plant	√			
Myrica esculenta	Kaiphal	Bark		√	√	
Nardostachys jatamansi	Jatamanshi	Rhizome				√
Oroxylum indicum	Syonaka	Barks				√
Phyllanthus emblica	Amla	Fruit/Seed				√
Picrorrhiza kurroa	Kutki	Rhizome			√	
Plantago ovata	Isabgol	Seed	√			
Podophyllum hexandrum	Bankakri	Rhizome		√		
Premna integrifolia	Agnimantha	Stem			√	√
Rauwolfia serpentina	Sarpgandha	Root		√	√	
Rheum australe	Dolu	Root			√	
Rubia cordifolia	Manjishtha	Stem			√	√
Saussurea costus	Kutha	Root			√	
Sida cordifolia	Bala	Leaves	√			√
Swertia chirayita	Chirata	Whole plant			√	
Syzygium cumini	Jamun	Seed		√		
		Bark			√	
Terminalia bellirica	Bahera	Fruit	√			
Terminalia chebula	Harad	Fruit	√			
Tinospora cordifolia	Guduchi	Stem	√			
Valeriana jatamansi	Tagar	Root			√	

Viola serpens	Vanafsha	Flower				√
Withania somnifera	Ashwagandha	Roots	√			
Zingiber officinalis	Adrak	Rhizome				√

Source: Dabur Research Foundation & TRAFFIC India, General guidelines for harvesting and processing Ayurvedic Medicinal Plants (AMP's)

6.7 Summary

- Over 90 percent of the raw materials of medicinal plants used by the manufacturing units are sourced from natural forests, often with little regard to environmental and social considerations, often resulting in the harvest of much in excess of sustainable limits.
- Sustainable harvesting means the use of plant resources at such levels and in such ways of harvesting that the plants are able to continue to supply the desired produce in perpetuity.
- Medicinal and aromatic plants should be harvested during the optimal season or time period to ensure the production of medicinal plant materials and finished herbal products of the best possible quality.
- During harvest, care should be taken to ensure that no foreign matter, weeds or toxic plants are mixed with the harvested medicinal plant materials. Medicinal plants should be harvested under the best possible conditions, avoiding dew, rain or exceptionally high humidity.
- There are various National and International regulation authorities and laws for collection of medicinal and aromatic plants e.g. Convention on International Trade in Endangered Species (CITES), World Health organization (WHO), International Union for Conservation of Nature and ISSC-MAP. Indian regulations, which are Forest, Wildlife Protection Act 1972, The Forest Conservation Act 1980, The Biological Diversity Act 2002 and The Scheduled Tribes & Other Traditional Forest-Dwellers Act 2006 should be followed.

Terminal Questions

1. What do you understand by sustainable harvesting?
2. What is the need of sustainable harvesting?
3. What are the national and international regulations for MAPs?
4. Write detailed on the harvesting management practices on MAPs?
5. Write detailed note about post harvesting management?
6. How to harvest gum and resins from medicinal plants?

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Unit 7: *In-Situ* and *Ex-Situ* Conservation of Medicinal and Aromatic Plants

Unit Structure

7.1 Learning Objectives

In this unit you will be able to understand the following things:

- Protecting medicinal and aromatic plants.
- Challenges in MAPs sector
- In situ conservation of MAPs
- Ex situ conservation of MAPs
- Legal Framework for Conservation
- Medicinal plant conservation centres

7.2 Introduction

India is one of the world's top 12 mega-diversity countries with 10 biogeographic regions. In addition to these, it has over 40 sites that are known for their high endemism and genetic

diversity. The climatic and altitudinal variations, coupled with varied ecological habitats of this country, have contributed to the development of immensely rich vegetation with a unique diversity in medicinal and aromatic plants which provides an important source of raw materials for traditional medicine systems as well as for pharmaceutical industries in the country and abroad. As a result of the increasing demand for medicinal plants, most of which is still met by wild collection, a constant pressure is created on existing resources, leading to continuous depletion of some of the species in the forests. To add to this problem, forestland is losing its natural flora at an alarming rate-1.5 m.ha. Every year – and what is left at present is only 8% against a mandatory 33% of the geographical area. Medicinal and aromatic plant resources in the country are threatened by over exploitation to meet the demand of herbal industries. As per the information received from the Ministry of Environment and Forests, about 95% of medicinal plants used by the herbal industries are harvested from the wild primarily from forests. The world conservation strategy (IUCN, UNEP & WWF, 1980) defines conservations as "the management of human use of the biodiversity so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generations". The above definition invokes two complementary components "conservation" and "sustainability". The primary goals of biodiversity conservation as envisaged in the World Conservation Strategy can be summarised as follows: Maintenance of essential ecological processes and life support systems on which human survival and economic activities depend, Preservation of species and genetic diversity and sustainable use of species and ecosystems, which support millions of rural communities as well as major industries. Medicinal and aromatic plants are potential renewable natural resources. Therefore, the conservation and sustainable utilisation of medicinal and aromatic plants must necessarily involve a long term, integrated, scientifically oriented action programme. This should involve the pertinent aspects of protection, preservation, maintenance, exploitation, conservation and sustainable utilization. A holistic and systematic approach envisaging interaction between social, economic and ecological systems will be a more desirable one. The most widely accepted scientific technologies of biodiversity conservation are the in-situ and ex-situ methods.

7.3 Need for Conservation

In 1970 the Indian Government banned the export of wild-growing 'Sarpagandha' because of its overexploitation from its natural habitat. This ban still holds except when special government permission is obtained. Since a very large proportion of plants used by these industries are collected from the wild. The threat is higher wherever the collection is destructive (i.e. whole plant, root, stem and bark). At present medicinal and aromatic plants are excessively harvested from the natural habitat and traded without proper management and control. As a result due to overharvesting for trade, habitat encroachment, loss of habitat, forest fire and grazing many important medicinal and aromatic plants are at the verge of disappearance. Indian herbal industry has an annual turnover of about 300 million US dollars. Several tones of medicinal plants are harvested every year from about 165,000 ha of forest land and most of the collection of MAP is done indiscriminately and not in the accordance with any regulatory procedure or recognised management practices. The collection of MAPs must be guided by an accurate knowledge of the biology of the species concerned, and steps must be taken to avoid over-exploitation as well as the collection of rare and endangered species. Thus the ultimate goal of conservation is to preserve the natural habitats of vulnerable medicinal plant species and to achieve their sustainable exploitation in less vulnerable areas.

Table 1. Prioritized species of medicinal plants for research and development according to the National Medicinal Plants Board, Government of India

S.L.	Botanical Name	Hindi Name
1	*Aconitum ferox*	Vatsnabh
2	*Aconitum heterophyllum*	Atees
3	*Aegle marmelos*	Bel
4	*Andrographis paniculata*	Kalmegh
5	*Asparagus racemosus*	Shatavari
6	*Bacopa monnieri*	Brahmi
7	*Berberis aristata*	Kingora
8	*Cassia angustifolia*	Senna
9	*Chlorophytum tuberosum*	Safed musli
10	*Coleus barbatus*	Patharchur
11	*Commiphora wightii*	Guggul

12	*Crocus sativus*	Kesar
13	*Embelia ribes*	Jheum
14	*Garcinia indica*	Kokam
15	*Gloriosa superba*	Kalihari
16	*Glycyrrhiza glabra*	Mulethi
17	*Gymnema sylvestre*	Gudmar
18	*Nardostachys jatamansi*	Jatamansi
19	*Ocimum sanctum*	Tulsi
20	*Phyllanthus amarus*	Bhui amla
21	*Phyllanthus emblica*	Amla
22	*Picrorhiza kurrooa*	Katuki
23	*Piper longum*	Pippal
24	*Plantago major*	Isabgol
25	*Rauvolfia serpentina*	Sarpagandha
26	*Santalum album*	Chandan
27	*Saraca asoca*	Ashok
28	*Saussurea costus*	Kut
29	*Swertia chirayita*	Chirata
30	*Valeriana jatamansi*	Tagar

7.4 Challenges in MAPs Sector

The continuous increase in human population is one of the causes for concern when it comes to meeting the daily requirements of food and medicine, as the economy and livelihoods of human societies living in developing countries primarily depend on forest products. This phenomenon is leading to continuous erosion of forest and the forest products, thus making it a challenge to meet the requirements as well as to conserve useful bio-resources.

7.4.1 Rising demand

The World Health Organization (WHO) has estimated the present demand for medicinal plants is approximately US $14 billion per year. The demand for medicinal plant-based raw materials is growing at the rate of 15 to 25% annually, and according to an estimate of WHO, the demand for medicinal plants is likely to increase more than US $5 trillion in 2050. The projected escalating demand of medicinal plants has led to the over-harvesting of many

plants from wild, which subsequently results in the loss of their existing populations. For example, Aconitum heterophyllum, Nardostachys grandiflora, Dactylorhiza hatagirea, Polygonatum verticillatum, Gloriosa superba, Arnebia benthamii and Megacarpoea polyandra are other examples of north Indian medicinal plant species which have been overexploited and have subsequently been placed today in the rare and endangered categories. Furthermore, rising demand with shrinking habitats may lead to the local extinction of many medicinal plant species.

7.4.2 Increasing rarity

There are many potential causes of rarity in medicinal plant species, such as habitat specificity, narrow range of distribution, land use disturbances, introduction of non-natives, habitat alteration, climatic changes, heavy livestock grazing, explosion of human population, fragmentation and degradation of population, population bottleneck, and genetic drift. The continuous exploitation of several medicinal plant species from the wild and substantial loss of their habitats during past 15 years have resulted in population decline of many high value medicinal plant species over the years.

7.4.3 Strengthening legalized market system

The marketing system in medicinal plants sector is largely unregulated and inequitable. The medicinal plant collectors are generally the marginal farmers and labourers. They get cash income to meet their basic requirements for food, health and children education by selling these medicinal plants. They are often unaware about the real market prices of many medicinal plant species. Besides government agencies, there are numbers of stakeholders ranging from herb gatherers, local middlemen, urban traders, wholesalers, manufacturers, exporters and herbal healers in the medicinal plants trade sector. Many medicinal plant species are traded through illegal channels. The medicinal plant sector is basically less documented and inadequately regulated.

7.5 *In-Situ* Conservation

In-situ conservation, the conservation of species in their natural habitats, is considered the most appropriate way of conserving MAPs. In has been well established that the best and cost-effective way of protecting the existing biological and genetic diversity is the 'in-situ' or on the site conservation wherein a wild species or stock of a biological community is

protected and preserved in its natural habitat. Establishment of biosphere reserves, national parks, wild life sanctuaries, sacred groves and other protected areas form the examples of 'in-situ' methods of conservation. In India 4.5% of its total geographical area constitutes of a protected area network, comprising 15 Biosphere Reserves, 97 national parks, 503 wild life sanctuaries. This network encompasses various biogeographic zones and biomes that are rich in biotic diversity, including medicinal and aromatic plants. In addition to these, number of sacred groves in the different parts of the country particularly in the South, West and Eastern parts are also active centres on in-situ conservation of medicinal plants. Such conservation area network can attribute significantly towards the conservation and sustainable management of biological resources of our country. In-situ conservation of medicinal plants in India can be accomplished through the active support and participation of people who dwell in or near and around the protected forest areas. Involving the local mass in all phases of conservation programmes, such as planning, policy decision process, implementation etc. will be a significant component in achieving efficient management and utilization of medicinal plant resources.

Medicinal plants conservation in India was initiated in 1993 under a Danida supported project in the three southern states, viz., Karnataka, Kerala and Tamil Nadu. The development of the in situ Medicinal Plants Conservation Areas (MPCAs) comprised of identification and demarcation of the MPCAs, people's participation in the conservation activities and plans for management of the conservation areas.

7.5.1 Through Medicinal Plant Conservation Areas (MPCAs)

This is to conserve medicinal plants within their ecosystems. The size of these areas, to be called Medicinal Plants Conservation Areas (MPCAs) will be such that the habitat and a viable biological community are represented according to the theory of island biogeography. MPCAs were established in forests traditionally valued as medicinal plants repositories, easily accessible, relatively less disturbed, forming compact micro-watersheds and not very much used by local people to meet their livelihood needs. MPCAs were selected on the basis of Rapid Assessment. Threats to the medicinal plants were done through Conservation Assessment and Management Prioritisation (CAMP) workshop at the state level. The workshop aimed at assigning the IUCN's quantitative Red list system to categorize each species to a degree of endangerment based on the estimates of the threats to the population

and their habitat. Foundation of Revitalisation of Local Health Traditions (FRLHT) has been establishment with a network of medicinal plants conservation areas (MPCAs) in the Orissa, Rajasthan, West Bengal and Madhya Pradesh states. These sites were selected in each state so as to cover the different forest types, distribution and abundance of medicinal plants as well as the habitats important for them. In these 4 states, a total of 42 sites were selected for establishing the MPCAs for critically endangered and endangered species. In the state of Uttarakhand there are no designated MPCAs reported.

7.5.2 Strengthening MAPs conservation within PA's

A protected area is a geographically defined area that is designated or regulated and managed to achieve specific conservation objectives. This includes national parks and nature reserves, sustainable use reserves, wilderness areas and heritage sites. Most of the protected areas in India have a focused attention on the preservation of faunal diversity except for a few protected areas such as the Valley of Flowers in North West Himalaya and the Tipi Orchid Sanctuary in North East Himalaya. There is not a single protected area focusing on the conservation of medicinal plants. Thus, there is an urgent need for identification and notification of areas for the conservation of medicinal plants on a priority basis.

In Uttarakhand, at present there are 12 protected areas (6 National Parks and 6 Sanctuaries) covering about 21 % of the forested area. Most of the PA's in the Himalayan foothills are known for large mammals and hence focus of conservation in such areas is on mammals and their habitats. Generally the PA's at higher altitudes (>3000 m) are better known for the diversity of medicinal and aromatic plants. However, most the PA's deal primarily with the protection of wild animals from poaching and no special efforts are made for the conservation and management of medicinal plants in such areas. Most of the PA's don't really have proper systematic inventory and monitoring of MAPs. Promotion of medicinal plants' nurseries and cultivation of medicinal plants under the eco-development activities of areas around the PAs especially in Nanda Devi National Park is notable.

Table. 2 Protected areas of Uttarakhand

Sl. No.	District	National park/wildlife sanctuary	Area (km²)
1	Nainital	Corbett National Park	520.8
2	Uttarkashi	Gangotri National Park	1552
3	Uttarkashi	Govind National Park	472.08
4	Chamoli	Nanda Devi National Park	630
5	Dehradun	Rajaji National Park	820
6	Chamoli	Valley of Flowers National Park	87.5
7	Pithoragarh	Askot Wildlife Sanctuary	593.93
8	Almora	Binsar Wildlife Sanctuary	45.59
9	Uttarkashi	Govind Pashu Vihar Wildlife Sanctuary	481
10	Chamoli/ Rudraprayag	Kedarnath Wildlife Sanctuary	957
11	Dehradun	Mussoorie Wildlife Sanctuary	10.82
12	Pauri	Sonanadi Wildlife Sanctuary	301.76

(Source: Forest Department, Govt. of U.K.)

7.6 *Ex-Situ* Conservation

Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. Conservation of medicinal plants can be accomplished by the ex-situ i.e. outside natural habitat by Gene banks, e.g. seed banks, field banks, in vitro plant tissue, artificial propagation of plants, with possible reintroduction into the wild; and botanic gardens for research and public awareness, development of nurseries and Home Gardens.

7.6.1 Botanical gardens

Botanical gardens or botanic gardens are generally well-tended parks displaying a wide range of medicinal and aromatic plants labelled with their botanical names. Botanical gardens can play a key role in ex-situ conservation of plants, especially for those facing imminent threat of extinction. Several gardens in the world are specialised in cultivation and study of medicinal and aromatic plants, while some contain a special medicinal and aromatic plant garden or harbour special collection of medicinal and aromatic plants. India has a network of about 140 botanical gardens, which include 33 botanical gardens attached to 33 universities botany departments. Tropical Botanical Gardens & Research Institute (TGBRI), located in a degraded forest region of Western Ghats Mountains in Kerala has an excellent example of ex-situ conservation of plant diversity in India. The field gene bank programme

launched by TBGRI from 1992-1999 is now well acclaimed as a very effective method of conservation of medicinal and aromatic plant genetic resources. This field gene bank of medicinal and aromatic plants at TBGRI, Thiruvananthapuram is essentially a blend of the ex situ and in-situ situations. In the state of Uttarakhand, a number of medicinal plants gardens and nurseries have been developed for the ex-situ conservation of medicinal and aromatic plants.

Table. 3 List of medicinal plants gardens/nurseries in Uttaranchal

Sl. No.	Managed by	District	Location of Important gardens/nurseries	Average size (in ha.)
1	Forest Department	Pithoragarh	Odmatha	0.55
		Champawat	Bastia	0.68
		Bageshwar	Kapkot	0.5
		Almora	Golna	0.5
			Soni	0.35
		Nainital	Kainchi	0.35
			Kaladhungi	0.75
		U.S. Nagar	Tanda (Sanjay Van)	1
		Tehri	Leesa Deepo	1.5
			Kaddukhal	0.3
			Chirvatia	0.2
			Ranichauri	0.25
			Ghumati Dhar	0.2
			Gangi	0.2
			Badiyar Gaon	1.25
			Vanspati Van Koti	0.2
			Pilva	0.45
			Rawara	0.6
			Chhaam	0.1
			Muni ki Reti	1
		Uttarkashi	Harshil	0.35
			Songaarh	0.2
			Nalad	0.5
			Dhontri	0.1
			Chorangikhal	0.01
			Raithal	0.2

		Chamoli	Mandal	1.1
			Mandal	1.2
			Auli	0.5
2	FRI, Dehradun	Dehradun	Dehradun	1.4
			Chakrata	2
3	Co-operative Department	Almora	Ranikhet	1
		Dehradun	Sahaspur	0.5
		Nainital	Bhowali	0.5
4	DARL, Pithoragarh	Chamoli	Auli, Joshimath	NA
		Uttarkashi	Harshil	NA
5	IMPCL, Mohan	Nainital	Mohan	2
6	CIMAP	U.S. Nagar	Nagla	NA
		Bageshwar	Purara, Baijnath	NA
7	NBPGR, Bhowali	Nainital	Bhowali	0.2
8	CCRAS, Tarikhet	Almora	Tarikhet	2.8
			Chamba	0.6
9	HRDI, Gopeshwar	Chamoli	Mandal	3
		Dehradun	Selaqui	1.75
10	HAPPRC, Srinagar	Rudraprayag	Pothibasa	1
			Tungnath	3
11	NGO, SHER, Dehradun	Uttarkashi	Shirola top	3
			Bhunsa	1
12	INHERE, Masi	Almora	Masi	0.5
13	Community	Haridwar	Shanti Kunj, Gaytri Kunj	2.8
14	Community	Chamoli	Ghesh	0.4
15	Gurukul Kangri	Haridwar	Gurukul Kangri	0.16

(**Source:** Forest Department Govt. of U.A., HAPPRC, HRDI, DRL, SHER, FRI and INHERE)

7.6.2 Establishment of Herbal Gardens

The principal aim of the "Herbal Garden" is to preserve and promote the medicinal values of the various plants that grow wildly in our surroundings and whose properties are beneficial in maintaining a balance between man and nature. There are 4 herbal gardens established by the Forest Department of Uttarakhand with the objectives to conserve the rare species which are not easily available and not familiar to traditional medicine students and traditional

medicine practitioners, to obtain authentic raw materials (medicinal plants) required for production of traditional drugs from Department of Traditional Medicine and to demonstrate practical training for traditional medicine students regarding the systematic plantation of medicinal plants, the methods of collection and to observe the rare species (Table 4).

Table. 4 Lists of Herbal Gardens of Uttarakhand

Sl. No.	Place/ name of herbal gardens	Area (ha)
1	Sushila Tiwari Herbal Garden, Rishikesh	10.35
2	Herbal Garden Kaladhungi, Nainital	1.0
3	Sanjay Van Tanda, Nainital	1.50
4	Songar Herbal Garden, Songar	2.50

7.6.3 Kitchen gardens

A kitchen garden can be created by planting different medicinal and aromatic herbs that we use on a daily basis in our backyards with the help of the available fresh water as well as the kitchen and bathroom wastewater. This will not only facilitate prevention of stagnation of unused water which will be hazardous to our health through environmental pollution, but can also be useful for successful production of our own requirement of some 'daily-use' medicinal plants. The culinary use of herbs may result in positive medical side effects. In addition to these, plants grown within the garden are sometimes specifically targeted to cure common illnesses or maladies such as colds, headaches, or anxiety.

7.6.4 Seed and germplasm collection

The basic aim of the germplasm collection is to conserve medicinal and aromatic plants and make them available for future use. Conservation of threatened germplasm includes seed banks, field preservation, tissue culture, and cryopreservation. Seed storage is considered the ideal method. Seeds are considered orthodox, can be dried and are able to be preserved at sub-zero temperatures (–20°C), while recalcitrant seeds, including most tropical species, lose their seed viability when subjected to the same conditions. Maintenance of the germplasm in field collections is costly, requires large areas, and can be affected by adverse environmental conditions. Tissue culture or cryopreservation techniques can be also considered in some cases. Before sensible conservation decisions can be made, a basic

understanding of the taxonomy, genetic diversity, geographic distribution, ecological adaptation and ethnobotany of a plant group as well as of the geography, ecology, climate and human communities of the target region is essential. Following points are important for seed and germplasm collection: 1. When, Where and How to collect germplasm? 2. How threatened is the germplasm? 3. Where should the genetic reserves be best placed and how they would need to be monitored and managed? 4. The relative contribution of ex-situ and in-situ approaches to an overall conservation strategy.

The state of Uttarakhand needs to have both centralized and decentralized seed and propagule collection centres, which would house the known source of the germplasm for further propagation and cultivation. Trained workers should only collect seeds and propagules from the selected reserved forests, sanctuaries, MPCA's, and herbal gardens. It would be extremely important to follow the standard procedure of sanitation, labelling of the source and certification of the germplasm at such centres.

7.6.5 Through Biotechnological techniques

The biotechnological tools are important to select, multiply and conserve the critical genotypes of medicinal plants. In-vitro regeneration holds tremendous potential for the production of high-quality plant-based medicine.

Tissue culture: Tissue culture involves the production of new plants from pieces of tissue placed on sterile nutrient growth medium. The cell clumps (known as a *callus*) that develop eventually grow into tiny plantlets with roots and stems. When these plantlets are transplanted into the soil, they grow into full-sized plants. This technology has been successfully used for the commercial production of medicinal and aromatic plants and to conserve the germplasm of rare and endangered species.

Cryopreservation: The cryopreservation of *in-vitro* cultures of medicinal and aromatic plants is a useful technique. Cryopreservation is long-term conservation method in liquid nitrogen (–196 °C) in which cell division and metabolic and biochemical processes are arrested. A large number of cultured materials can be stored in liquid nitrogen. Since whole plants can regenerate from frozen culture, cryopreservation provides an opportunity for conservation of endangered medicinal plants. Cryopreservation has been used successfully to store a range of tissue types, including meristems, anthers/pollens, embryos, calli and even protoplasts.

Bioreactors: Bioreactors are the key step towards commercial production of secondary metabolites by plant biotechnology. The fundamental requirement in all this is a good yield of the compound and the reduced cost when compared to the natural synthesis by the plants. Bioreactors offer optimal conditions for large-scale plant production for commercial manufacture.

Genetic transformation: Genetic transformation is a powerful tool for enhancing the productivity of novel secondary metabolites. Transformation is currently used for genetic manipulation of more than 120 species of at least 35 families including a number of medicinal and aromatic plants. The genetic transformation of *Atropa belladona* has been reported using *Agrobacterium tumefaciens*, with an improved alkaloid composition. Agrobacterium mediated transformation of *Echinacea purpurea* has been demonstrated using leaf explants.

7.7 Legal Framework for Conservation

Two national laws mainly provide the legal framework for the conservation of nature and natural resources in India: The Indian Forest Act (1927 with amendments), and the Wildlife Protection Act (1972). The Forest Act primarily provides for the establishment of Reserved Forests and Protected Forests under the State, while the Wildlife Protection Act is concerned with Wildlife Sanctuaries and National Parks. However, there are presently no specific laws or regulations in India concerning the exploitation of any plants apart from certain species of trees. Outside a national park, any plant can be made extinct without breaking the law. In addition to the national legislation, there are also laws and regulations issued by the state Governments. An act called 'The Biological Diversity Bill, 2000' (bill no 93 of 2000) was passed by the Indian Parliament in 2002 to provide for conservation and sustainable use of biological diversity, and for equitable sharing of the benefits arising out of biological resources. The outcome of this bill is expected to contribute positively to the regulation of conservation, collection and trade of medicinal plants. In the state of Uttarakhand Forest Department of the state will have to identify two major areas in each Forest Division; namely the conservation area and the developmental area. The conservation areas will be selected based on their rich medicinal plants diversity and marked for in-situ conservation and complete protection in the concerned Forest Division. The State Medicinal Plant Board of Uttarakhand was constituted in 2001. Herbal Research and Development Institute (HRDI),

Gopeshwer is the nodal agency for the Board. Other than these institutions, there is also a Bhesaj Sangh, which is a cooperative mechanism for the regulation of medicinal plants collection and trade in the state. These are district level collectors' cooperatives functioning under the Horticulture department. At present there are district level Bhesaj Sanghs operating in 12 of the 13 districts of the state, with Udham Singh Nagar district being the only exception.

7.8 Medicinal Plant Conservation Centres

In India, many government and non-government organizations have had the focused attention on improving the MAPs sector. Activities at the national level are being carried out in a number of organisations, of which major institutions funded by the Government of India are playing the important roles. The Council of Scientific and Industrial Research (CSIR) institutes involved in such programmes are Central Institute of Medicinal and Aromatic Plants (CIMAP), National Botanical Research Institute (NBRI), Central Drug Research Institute (CDRI) and the Regional Research Laboratories (RRLs) at Jammu, Bhubaneswar, Jorhat, Palampur, Bhopal and Thiruvananthapuram. The Indian Council of Agricultural Research (ICAR) implements an All India Coordinated Research Project on Medicinal and Aromatic Plants in association with the National Bureau of Plant Genetic Research (NBPGR), National Research Center for Medicinal and Aromatic Plants (NRCMAP) and Indian Institute of Horticultural Research (IIHR). The activities of Botanical Survey of India (BSI), supported by the Department of Environment and Forests, Government of India, include establishment of regional circles and experimental gardens at different geographic regions of India, viz., Dehradun (Northern Circle), Allahabad (Central Circle), Shillong (Eastern Circle), Pune (Western Circle), Coimbatore (Southern Circle) and Port Blair (Andaman and Nicobar). Three other stations are at Jodhpur (Arid Zone), Gangtok (Sikkim–Himalaya Circle) and Itanagar (Arunachal Pradesh Field Station). The Indian Council of Forest Research (ICFRE) has undertaken a programme for developing 'Vanaspati Van' (i.e. Reserve Forest) and cultivation of medicinal plants. G.B.Pant Institute of Himalayan Environment and Development, an institute of the Ministry of Environment and Forest, Government of India, conserves the biological diversity of North-Western Himalayan region. Herbal Research and Development Institute (HRDI),Gopeshwar is actively engaged in the research and development of Himalayan MAPs. Tropical Botanical Garden and Research

Institute (TBGRI) in Kerala has undertaken a major programme on the conservation and sustainable use of the medicinal plant wealth of peninsular India. Major activities of TBGRI include development of display garden, field gene bank, in vitro gene bank and seed gene bank. This is a part of the G-15 GBMAP (Gene Bank for Medicinal and Aromatic Plants) programme sponsored by the Department of Biotechnology (DBT), Government of India.

7.9 Summary

- Due to overexploitation from natural habitats many medicinal and aromatic plants are in verge of disappearance. According to the Red List of threatened Species 44 plant species are critically endangered, 113 endangered and 87 vulnerable in India.
- The World Health Organization (WHO) has estimated the present demand for medicinal plants is approximately US $14 billion per year. The demand for medicinal plant-based raw materials is growing at the rate of 15 to 25% annually, and according to an estimate of WHO, the demand for medicinal plants is likely to increase more than US $5 trillion in 2050.
- The conservation and sustainable utilisation of medicinal and aromatic plants must necessarily involve a long term, integrated and scientifically oriented action programme. The most widely accepted scientific technologies of biodiversity conservation are the in-situ and ex-situ methods.
- The collection of MAPs must be guided by an accurate knowledge of the biology of the species concerned, and steps must be taken to avoid over-exploitation and the collection of rare and endangered species.
- In-situ conservation is the conservation of species in their natural habitats. Establishment of biosphere reserves, national parks, wild life sanctuaries, sacred groves and other protected areas forms examples of 'in-situ' methods of conservation. India has a total 15 Biosphere Reserves, 97 national parks, 503 wild life sanctuaries.
- Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. Conservation of medicinal plants can be accomplished by the ex-situ i.e. outside natural habitat by Gene banks, e.g. seed banks, field banks, in vitro plant tissue, artificial propagation of plants with possible

reintroduction into the wild and botanic gardens for research and public awareness, development of nurseries and Home Gardens.

- Two national laws mainly provide the legal framework for the conservation of nature and natural resources in India: The Indian Forest Act (1927 with amendments), and the Wildlife Protection Act (1972). The Forest Act primarily provides for the establishment of Reserved Forests and Protected Forests under the State, while the Wildlife Protection Act is concerned with Wildlife Sanctuaries and National Parks.
- In India, many government and non-government organizations have had their focused attention on Medicinal plant conservation e.g. CSIR, CIMAP, NBRI, CDRI, RRLs, ICAR, NBPGR, NRCMAP, IIRH, BSI, ICFRE and TBGRI.
- Awareness of conservation issues and of the importance of sustainable utilization needs to be raised among all stakeholders. Local people need to be supported and encouraged to take the necessary steps to protect this valuable resource.

Terminal Questions

1. What are the causes of the depletion of wild populations of medicinal plants species?

2. What can be done to ensure the effective conservation of medicinal plant species?

3. Explain how in situ and ex situ conservation methods are used to maintain MAPs.

4. What is in-situ conservation and give some examples?

5. What is ex-situ conservation and how it is useful for medicinal and aromatic plant conservation?

6. Write a detailed note of the in-situ and ex-situ conservation of MAPs?

7. What is a protected area? How many protected areas are there in the state of Uttarakhand and give an example of noteworthy medicinal and aromatic plant conservation?

8. Write 10 medicinal and aromatic plant species name which are Prioritized species for conservation?

9. How can germplasm collection help in the MAPs conservation?

10. What are the major centres of India that involve in the MAPs conservation and research?

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