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Conservation, Cultivation, and Sustainable Use of High Altitude Medicinal and Aromatic Plants for Socio-Economic Development: A Review

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Abstract: Human beings use plants for a multitude of purposes, of which, a globally prominent one is for their medicinal values. Medicinal plants serve as a major source of income for high-altitude inhabitants in the Himalayas, particularly in countries like India, Nepal, and Bhutan. However, people here harvest huge volumes of medicinal plants indiscriminately, risking their sustainability and causing anthropogenic threats. The global market demands for Uttarakhand's medicinal and aromatic plants are high, and several of these plants are exclusively found in Himalayan states. Himalayan states have a variety of agro-geo-climatic conditions that are ideal for medicinal and aromatic plants. Uttarakhand, being home to a diverse range of wildlife, as well as fragrant plants, has subtropical to tropical soils and agro-climatic conditions. The Alpine is a biodiversity hotspot with a diverse assortment of wild animals. But as a result of the low agricultural production, there is a lack of industrial growth leading to underdevelopment and poverty in such areas. Consequently, Himalayan inhabitants travel to the plains to take advantage of biodiversity to improve their lifestyle and socioeconomic status.

Keywords: High altitude Medicinal and Aromatic plants • Anthroprogenic threats • Agro-geo climatic condition • Alpine

Introduction

Agriculture in India has been a primal factor for it to become a powerhouse in the growth of the global economy. The climate, rainfall, and temperature in most of the parts of the country are suitable for one or another flora and fauna. From the Himalayas in the north to the seas in the south, there is a presence of vast biodiversity.

Uttarakhand, a state in northern India spanning from 28° 43' N to 31°27' N (latitude) and 77° 34' E to 81°02' E (longitude), is recognized for its abundant ecological and cultural variety (Nainwal et al., 2020). It came into being on November 9th, 2000 as the 27th state of India. Uttarakhand has its boundaries around the heart of Himalayas, marked by Kali River in the east and Sutlej River in the west. Nanda Devi (7890 meters) is the highest peak in the region of the state, followed by Kamet, Trishul and Panchachuli. Uttarakhand, also known as the herbal state of India, is famous for various travel destinations as well as Hindu temples and pilgrimage spread across the state.

The state can physio graphically be apportioned into three zones namely, the Himalaya, the Shivalik, and the Terai region. Mountains occupy almost the entire state (≈ 93%), with a mountainous forest cover of 64%. The state's geographical area of *53,483 km*^{2} is divided into 13 districts, 78 Tehsils and 95 development blocks, 2 revenue divisions, and 1 tribal division. About 19% of the total geographical region is covered in snow and glaciers permanently. The state has got 04 Conservation reserves, 06 National parks and 07 Wildlife sanctuaries. Banw-rauat, Bhotias, Bokshas, Gangwals, Jaunsaris, Koltas, Marchchas, Tolchas and Van-gujjars are the prominent

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communities of people dwelling in this state (Dwivedi et al., 2019).

Almost one-third of the plants found in Uttarakhand find their place in medicinal treatments. Pteridophytes, angiosperms, lichens, bryophytes and gymnosperms have been in the focus for research recently (Bargali et al., 2022). Non-Timber Forest Products (NTFPs) are major constituents of objects of trade in such regions (Sundriyal et al., 2021). NTFPs can be majorly categorized in 3 categories viz. medicinal plants, edible wild plants, and bamboo. These NTFPs are needed to be developed in a sustainable manner in order to conserve the biodiversity of such areas as well as a source of trade and income for the local dwellers

Figure 1: Map of Uttarakhand [2]

Forests of Uttarakhand comprise of Tropical/ Subtropical Moist Forest (up to 1000 meters), Subtropical Pine Forest (from 1000 to 2000 meters), Himalayan Moist Temperate Forest (from 2000 to 3000 meters), Sub-Alpine Forests (from 3500 to 4000 meters) and Alpine Forests (from 4000 to 5000 meters). As per Forest Survey of India, the forests can be majorly categorized in 9 categories listing as tropical moist deciduous forests, tropical dry deciduous forests, subtropical pine forests, Himalayan moist temperate forests, Himalayan dry temperate forests, sub-alpine forests, moist alpine scrub, dry alpine scrub, and tree outside forests (Bargali et al., 2022). Medicinal and Aromatic Plants (MAPs) are becoming increasingly popular as raw materials for pharmaceuticals and traditional health-care systems around the world (Phondani et al., 2016). However, sustainability of MAPs and some other endemic plants has become a grave matter of concern due to anthropogenic causes as more than three-fourth of the total population exploits nature for its survival. Green consumerism, in a way, has promoted the exploitation of these resources for a business

model, but conservation and sustainable development is still overlooked.

Conservation and Sustainable Usage of Medicinal Plants

Globally, an estimated 60,000 species are used for their medicinal, nutritional, and aromatic properties, and around 500,000 tons of materials from such species are traded annually. In India, medicine is estimated to be worth 1.7 million metric tons, with 960 plants in active trade. Uttarakhand boasts a strength of 938 NTFPs having diversified applications viz. medicinal plants (701), wild edibles (155), oil yielding (32), soap and detergent (22), insecticide/pesticides (15) and fiber (13), etc. (Negi et at., 2011). But, in Uttarakhand, with limited resources for agriculture and a lack of possibilities for livelihood, the majority of people are marginalized. The cultivation and long-term usage of high-altitude medicinal and aromatic plants for socioeconomic development need to be promoted for more rural employment and a stronger state economy, creating better prospects for industrial development and to halt population decline, particularly in steep districts. Consequently, Uttarakhand, with more than 2000 different medicinal plants, 3.66 million hectares of cultivable wasteland, and 324 medicinal and aromatic plants worth 200 metric tons yearly, can prosper and develop to new heights.

Uttarakhand, a state in northern India spanning from 28◦ 430 N to 31◦ 270N (latitude) and 77◦ 340 E to 81◦ 020 E (longitude), is recognized for its abundant ecological and cultural variety (Nainwal et al., 2020). The rural community in the research area is located at an altitude between 800 m and 1800 m. In May and June, the average temperature is at its highest and it is at their lowest in January. From June through September, there is a lot of rain, making up about 61% of the yearly rainfall. In general, the landscape consists of tall hills with steep slopes. For the field study, the Participatory Rural Appraisal approach was used (Bisht et al., 2006; Sahoo et al., 2010; Phondani et al., 2011). Each village cluster's MAP reliance as well as the income sources, family sizes, and landholdings of each household were collected. During the years 2008 to 2013, information on the viability of MAP cultivation, market demands, conservation status, ethnobotanical uses, etc. in the study area was gathered through cluster level meetings, group discussions, and individual interviews with each household. Based on consumer acceptance, flexibility, ease of cultivation, market demands, and economic potential, MAPs were chosen. Additionally, data was produced regarding the duration of the collection, the volume of the collection, and the difficulties the villagers encountered when collecting MAPs from the wild. According to Phondani et al., (2014), ethnobotanical data was gathered using three basic methods: (1) an interview with the informant while visiting the forest; (2) an inventory of plant specimens and subsequent interviews with informants asking for the names and uses of the plants collected; and (3) interactive discussions with various stakeholders including traditional herbal healers (i.e., vaidyas), Ayurvedacharya, farmers, traders, scientists, forest officers, and medicos. Target groups and local farmers were chosen based on their interest in growing MAPs and on the average household income. Through the use of a participatory approach, five mother nurseries of MAPs were created in each of the three village clusters for the purposes of capacity building, demonstration, the preservation of germplasm, and the distribution of seedlings to farmers. Farmers were given training in the cultivation, harvesting, and selling of a few MAP species.

Materials, Methods, and Procedures

Methods: Since the last two decades, sincere efforts have been made in the dimension of exploring the MAPs, endangered plants and ethno-botany. Some of the well-known medicinal plants enlisted on various online databases and found in Uttarakhand are Jangali bhindi, Baj Jangli-jira, Bel, Panker, Goat Weed, Pyaj, Indian wild pear, Bakal, Catmint, Safed Musli, Shatavari, Kambal, Kilmorha, Sirparha, Pissumar, Punarnava,, Saimul, Sallai, Achar, Dhak, Palash, Kamraj, Chowkhara, Daya, Aak, Karunda, Malkangani, Kumkum, Kanchara, Kankowa, Lasura, Bhotia badam, Bihi, Dhatur, Dhatura, Soriul, Banpyaja, Kusum, Timil, Bedu, Laljari, Ban Nimbu, Silver Oak, Aphe, Vaikal, Kapurkachari, Atanda, Dhodhi, Brahmni, Talmakhana, Chhingewali, Nil kanthi, Hapusha, Bhasma, Sanjwanboata, Chimi, Gunjhinganj, Guma, Kakoli, Maida, Dekrain, Pipermint, Masipatha, Shikanta, Kaphal, Vishkanya, Siyari, Vantulsi, Chilmora, Salmosi, Amla, Pippali, Isabgol, Salparni, Chitavar, Mahameda, Meda, Khubani, Dadim, Ghigharu, Blackcurrant, Ein, Dog Rose, Kunja, Kaural, Lalanchu, Amloraha, Jangali palak, Chalmora, Black Nightshade, Brahati, Mishri, Denusha, Kukun dara, Chitrika, Gulakhari, Chirata, Jamun, Arjun, Van Ajwain, Singhara, Bara Mamas, Shishuna, Babul, Kalber, Urad dal, Nirgundi, Jungle Angoor, Timur, Ber, etc. (Dwivedi et al., 2019). These are used in abundance by the local people for treatment of short- and long-term disease. These plants serve as a boon in inaccessible areas from a healthcare perspective. In (Joshi et al., 2014), authors had conducted a local evaluation and assessment with help of few hundred people, including farmers, local vaidyas and sellers in Pithoragarh district by using periodic surveys. They concluded that promotion of structured harvesting of MAPs can uplift the social capital and standard of lives and can deal with the sustainable development of these plants. Uttarakhand has only ≈14 % of cultivable land available to the agriculture dependent population. Low rural income has been an outcome of such problems faced by the population, but the state has got a potential to be transformed into a herbal state because of its relatively higher literacy rates. Roots, stems, barks, heartwood, leaves, flowers, fruits, and exudates of plants such as lemon grass, tulsi, cintrolla, Japanese mint, geranium, naramotha, palmarosa, marigold and khuas can be produced on a commercial level and be used to develop further agribusiness. The initiatives of Herbal Research and Development Institute (HRDI), Gopeshwar and Center for Aromatic Plants (CAP), Dehradun have certainly set some examples in this dimension and need more concern of state authorities. The target groups and local farmers were chosen for growing MAPs based on their will and household income. In all village clusters, 5 mother nurseries of MAPs were constructed through a participatory method for capacity building, demonstration, germplasm conservation, and seedlings farmers' distribution. Farmers were given training in the cultivation, harvesting, and sale of specific MAPs. Weeding and irrigation were ensured regularly during dry seasons to maximize seed germination and seedling development. Cuttings of stems, roots, and rhizomes, as well as slips, were also done. At various time intervals, data on percentage germination, sprouting, rooting, survival percentage, number of days from sprouting to flowering, plant height, and yield of useful plant components were collected. The cost-benefit analysis of cultivated MAPs was calculated in $/hectare/year, based on local market price, which includes the cultivation cost of all species in different village clusters.

Materials

Around the world, an estimated 60,000 species are used for their therapeutic, nutritive, and

fragrant characteristics, and each year more species are discovered, materials from such species are traded in excess of 500,000 tons. Herbal therapies are the most prevalent kind of traditional medicine and are quite profitable on the global market. Few companies control the pharmaceutical plant market. Germany, the United States, and Japan are three nations with international commerce hubs. Although the majority of pharmaceutical factories are not processed at all or merely minimally when exported from underdeveloped countries. The trade also provides a source of income to millions of households involved in collection, with women often playing the key role in, and supply industrial production of a broad range of health and household goods. Although there is a lack of precise data, Information at hand suggests that trade is growing.

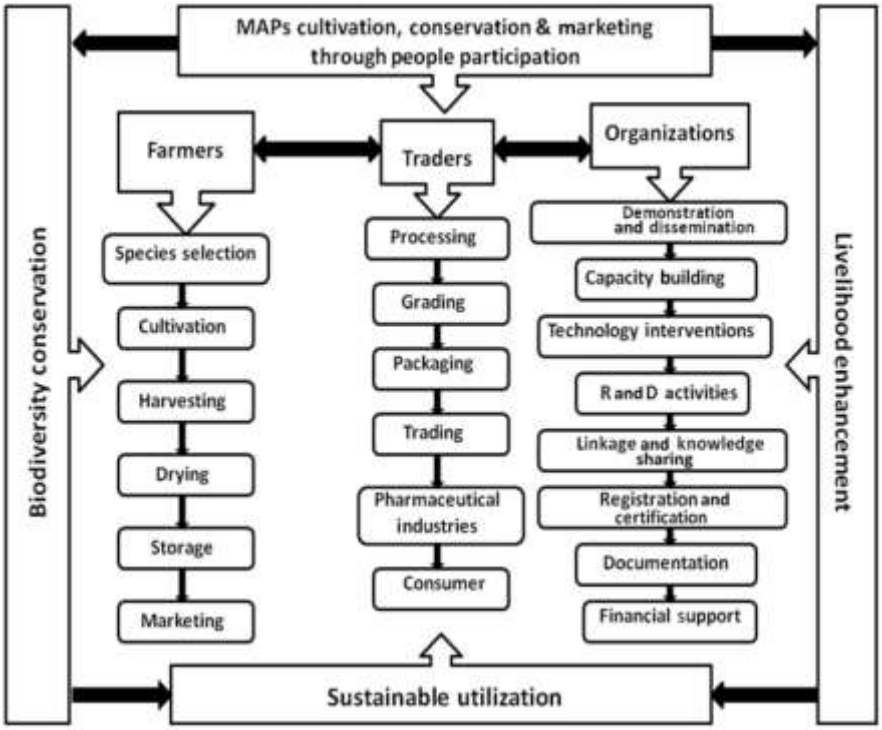

Figure 3: Typical method of preservation of MAPs (Nainwal et al., 2020)

Table 1: Some important properties of commonly found MAPs

Sr.	Name, Botanical name &Family	Medicinal importance	Parts used	Found in areas
1.	*Withania somnifera* Ashwagandha Solanaceae	Bronchial Asthma, Insomnia	Roots	Rudraprayag, Uttarkashi, Jaunsar
2.	*Rhododendron arboretum* Burans Ericaceae	Heart disease, Liver disease, Antidiabetic	Flower	Tehri, Uttrkashi, Chamoli
3.	*Rubus ellipticus* Hisalu	Coughs, Fevers, Colic, Sore throat	Fruit	Tehri, Pithoragarh, Chamoli, Almora

	Rosaceae			
4.	*Jurinea macrocephala* Guggal Asteraceae	Toothache, Cough, Fever & for warmth.	Stem. bark	All Garhwal and Kumaon mandal
5.	*Ficus palmate* Bedu Moraceae	Antiperiodic Antidiarrheal lungs disease.	Fruit	Nainital, Pithoragarh
6.	*Aesculus indica* Kanor Hippocastanaceae	Rheumatic pain	Seeds	Pauri, Khirsu, Adhwani
7.	*Ajuga macrosperma* Bhugu Lamiaceae	Malarial fever and Tonic	Leaves	Chelusain, Sara
8.	*Gallium asperuloides* Kur Rubiaceae	Astringent	Leaves	Binsar, Nainthani, Chamoli, Bharsar
9.	*Hedychium accuminitum* Ban haldi Zingerberaceae	Dyspepsia, Snake bite, Inflammation	Rhizome	Thailisain
10.	*Chirita bifolia* Karaiti Gesneriaceae	Fever	Leaves	Binsar
11.	*Euphorbia prolifera* Chaounpolu Euphorbiaceae	Constipation	Roots	Pauri, Thailisain
12.	*Mentha piperita* Podina Lamiaceae	Indigestion malarial fever	Leaves	Sara, Chelusain,Thailisain
13.	*Neolitsea pallens* Bilaru Lauraceae	Scabies & Eczema	Fruit	Bharsar, Chakisain
14.	*Solanum nigrum* Makai Solanaceae	Liver, Piles, Dysentery & Eye Ailments	Fruit	Kotdwar, Srinagar
15.	*Solanum incanum* Banbhatuja Solanaceae	Skin disease	Leaves	Kalagarh, Thailisain
16.	*Urtica dioica* Bichhu buti Urticaceae	Bodyache, Jaundice,antiseptic	Leaves & Roots	Dugadda, Srinagar
17.	*Viburnum cotnifolium* Guya Caprifoliaceae	Heptic and Digestive problem	Bark	Adhwani, Bharsar, Maroda
18.	*Vitex negundo* Siwaien Verbenaceae	Arthritis and Rheunatism	Leaves & Fruit	Kotdwar, Thailisain

19.	*Fagopyrum tataricum* Phaparo Polygonaceae	Colic pain	Seeds	Binsar, Chakisan
20.	*Emilia sonchifolia* Dudhi Asteraceae	Eye infammation	Leaves	Srinagar, Thailisain
21.	*Pinus wallichiana* Chilla Pinaceae	Rheumatic pain	Resin	Pauri, Dudhatoli
22.	*Polygala crotalariodes* Nardoin Polyglaceae	Antidote to snake bite	Roots	Binsar
23.	*Jasminum humile* Surmarhi Oleaceae	Skin, Blood and Heart disease	Whole plant	Adhwani, Binsar
24.	*Rhamnus virgatus* Chentulee Rhamnaceae	Eczema and Ringworm	Bark	Bharsar, Kaleshwar, Deuli, Dugadda
25.	*Ocimum tenuiflorum* Tulsi Lamiaceae	Fever, Cold, Cough, Colitis, Urinary troubles and Vomiting	Leaves	Srinagar

Overview of Medicinal Importance of Some Unique Plant Species

Ashwagandha is used in herbalism and is sold as a dietary supplement. It is cultivated in many of the drier regions of India. It can be produced by propagating from seed in the early spring. Burans is an evergreen shrub or small tree with a showy display of bright red flowers. It is a state tree of Uttarakhand and state flower of Nagaland. Cultivation of burans requires moist environment. Medicinal use of burans is for heart and liver disease and as an antidiabetic. Tulsi is regarded as a sacred plant, worshipped, and used in several religious ceremonies and it is believed to be instant remedy of all types of disorders, often conserved. Podina used in various medicines and for flavoring, as source of menthol oil. These plants play a vital role in our life.

Discussions

Past research works demonstrate that the government and researchers lacked interest in preserving MAPs due to comparatively less exploration and awareness. However, recent research proves that active measures have been taken to preserve these plants. Now, more intense efforts and detailed explorations ought to be done in this direction. This will give us a lot of benefits in future in order to preserve the MAPs.

Conclusion

It is possible to create a MAPs Program for in-situ and ex-situ conservation, ethnobotany, characterization, and evaluation to promote their long-term use. Wild harvesting of non-wood forest products (NWFP) requires appropriate training. Also, the implementation of the Fair Wild standard is a goal. Established networks allow for the expansion and use of knowledge about this essential pool of genetic material, as well as thorough morphological characterization and biochemical evaluation. Future MAP efforts will be enabled and supported by the obtained integrated and complementary knowledge,

which is linked to the understanding and management of biodiversity and genetic resource conservation. The reservoir of unknown potentialities of plants should be explored and protected for the benefit of current and future generations.

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