

# Current status and future strategy for development of medicinal plants sector in Uttarakhand, India

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*As elsewhere, in the Indian Himalayan Region, ethnic communities in the state of Uttarakhand rely, to a large extent, on native plant species for sustenance of their traditional health-care system, both logistically as well as economically. However, the present scenario shows a decline in these traditional, plant-based health-care practices. These age-old practices are conservation-oriented and have tremendous potential to uplift the state economy. The excessive extraction of medicinal plant resources for use in the pharmaceutical industry has resulted in ruthless destruction of natural populations of medicinal plants. This work attempts to assess the current status of knowledge of medicinal plant resources of the state. It also focuses on the importance of documenting traditional knowledge and practices related to conservation and sustainable utilization of medicinal plants in Uttarakhand. A collaborative work plan involving scientists, government institutions and non-governmental organizations is suggested for preserving the traditional knowledge system and practices, conservation of medicinal plants and upliftment of the rural economy of this mountain state.*

THE mountain region in India is spread over 13 states in the Indian Himalayan Region (IHR) covering a geographical area of 500,000 km<sup>2</sup>. Over 51 million people (6% of the total population of India) live in the IHR<sup>1</sup>. Majority of them live in villages and belong to diverse cultures and communities. The large human populace with diverse life styles, beliefs, traditions and cultural heritage inhabiting Himalaya has learnt to utilize natural resources and products in various ways. The recently-carved mountain state of Uttarakhand located between latitude 29°5′–31°25′ N and longitude 77°45′–81°E covering an area of 51,124 km<sup>2</sup>, comprises thirteen districts. The Tons river separates the region from Himachal Pradesh in the northwest and Kali river delimits it from Nepal in the east. Starting from the foothills in the south the region extends up to the snow-clad peaks of the Himadri, marking the Indo-Tibetan boundary. Uttarakhand is largely a rugged, mountainous region where the altitude ranges from 300 to 7817 m asl. This altitudinal variation has resulted in a complex diversity in topography, meteorology, flora and fauna. It is home to a variety of ethnic communities living in harmony with the rich and unique biodiversity elements. Among the tribes, Bhotia, Rajees, Tharus and Boxas live in Uttarakhand.

As elsewhere in the IHR, Uttarakhand ethnic communities rely, to a large extent, on native plant species for obtaining various types of raw material. In the high altitudes, traditional health-care system is the only accessi-

ble form for majority of the population, both logistically and economically. Medicinal herbs are the main ingredients of local medicines and are thus of vital importance in traditional health-care<sup>2</sup>. In this context, however, the current trends suggest a decline in the traditional plant-based health-care practices. Two major factors are responsible for this erosion. One, the younger generation is showing disinterest and even abandoning the age-old medical practices due to the advent of modern technologies. Two, excessive extraction of herbal raw material from the wild has resulted in considerable depletion of the population of such species.

Nevertheless, the state policies and planning for Uttarakhand have clearly identified medicinal plants as a potential resource for uplifting state economy and generating employment for the unemployed youth. In this context medicinal plant cultivation is being cited as a success model for mountain development. Medicinal plants are viewed as a possible bridge between sustainable economic development, affordable health-care and conservation of vital biodiversity. As of now, policies and strategies to harness optimum potential of medicinal plants for sustainable development, are not addressed. This is a serious anomaly. At present, medicinal plant-related economic activities are seldom handled on a long-term basis.

Keeping this background in view, especially at a time when mountain development is receiving focused attention this year – the international year of mountains – 2002 – the present article attempts to (i) identify medicinal plant resource base of Uttarakhand, (ii) highlight the potential and role of medicinal plants in the state econ-

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omy, (iii) assess the value of documenting conservation and sustainable utilization of medicinal plants by traditional communities, (iv) reveal the effect of changing values and customs of tribal communities upon the traditional health-care system and surrounding biodiversity of medicinal plants, (v) assess the present state of knowledge, and (vi) suggest a coordinated effort for strengthening the medicinal plants sector in Uttaranchal.

The results of the investigation will help in developing a strategy for conservation and utilization of the medicinal plants by promoting strong linkages among different types of institutions.

### Medicinal plant resource base

In India, the rich plant diversity of the Himalaya – over 8000 angiosperms, 44 gymnosperms, 600 pteridophytes, 1737 bryophytes, 1159 lichens, etc. – has been a source of medicine for millions of people in the country and elsewhere in the world<sup>3</sup>. The IHR supports over 1748 (32.2% of India) plant species of known medicinal value<sup>4</sup>. The unique diversity of medicinal plants in the region is manifested by the presence of a number of native (31%), endemic (15.5%) and threatened elements: 14% of total Red Data plant species of the IHR and 3.5% of total medicinal plants in different threat categories of Conservation Assessment and Management Plan (CAMP)<sup>4</sup>. The economic potential of the MPs in some parts of the IHR<sup>5</sup> and their contribution in providing novel biomolecules is recognized<sup>6</sup>. The geographical position of this region manifests rich biodiversity of medicinal plants having tremendous potential. Out of 17,500 flowering plants known to occur in India<sup>7</sup>, about 3000 are recognized for their medicinal use. They can be placed into the following three categories: (i) plants of codified knowledge (over 1500), used in organized systems of medicine like Ayurveda, Unani and Siddha, (ii) plants of empirical knowledge (3000), used in ethno medicine or folk medicine based on oral (undocumented) information being passed from generation to generation and (iii) plants of scientific knowledge (700), which have been investigated pharmacologically and chemically, and their active principles are used in modern medicine or are providing valuable leads for partial or total synthesis of new drugs<sup>8</sup>.

Traditional health-care, as practiced in the region, consists of two systems, viz. folk medicine and the codified systems of medicine. Folk medicine is ecosystem and ethnic community-specific. It is an oral tradition, purely empirical in nature. Systems like Ayurveda, Unani, Siddha and the Tibetan systems are expressions of codified traditional medicine. In Uttaranchal, about 701 species are used in different forms as medicine<sup>5</sup>. Among these, 35 species are placed into different threat categories by the CAMP Workshop, 1998 (Table 1).

### Potential of medicinal plants in state economy

Global estimates suggest that over three-fourths of the total world population cannot afford the products of allopathic medicine and thus have to rely upon the use of traditional medicines, which are largely derived from plants. Through scientific studies, only about 1% of the total known medicinal plant species (folk, ethno and traditional medicine) is acknowledged to have therapeutic value for human beings. The World Health Organization is encouraging, promoting and facilitating the effective use of herbal medicine in developing countries for health-care programmes. Besides, the demand for herbal drugs has reached a new high in recent years in the West as well. About 1400 herbal preparations are used widely, according to a recent survey in Member States of European Union. Such popularity in health-care, plant-derived products reflects their increasing acceptance among the elite as well.

India is one of the major raw material-producing nations of South Asia and within the country, the Himalaya supports a large number of such species. Export statistics available indicate that between 1992 and 1995 the country exported about 32,600 tonnes of crude drugs valued at \$US 46 million. Conservation, propagation and utilization of medicinal plants has, over the years, become a major thrust area of research activity throughout the country.

Uttaranchal supports a large number of medicinal plants, which are extensively used by the pharmaceutical industry for preparation of drugs used in Indian System of Medicine. These plants are either used as single (e.g. SHATAVARI from *Asparagus racemosus*) or multi-herb products (e.g. CHYAWANPRASH containing amla fruit and several herbs). The degree of threat to natural populations of such medicinal plants has increased because more than 90% of medicinal plant raw material for herbal industries in India and for export is drawn from natural habitats<sup>9</sup>.

In this context, medicinal plants of Uttaranchal can open avenues of economic growth in the emerging world market. Further, it has been realized that medicinal plants of the IHR offer an advantage in having much greater possibilities of providing novel biomolecules in view of the environmental stress they are subjected to<sup>7</sup>. Economic potential of several medicinal plants, however, has not been exploited; for example, the extract of roots of *Arnebia euchroma* widely used in traditional Chinese medicine is reported to have potent anti human immunodeficiency virus activity<sup>10</sup>; podophyllotoxin content in Himalayan mayapple is high (4.3%) compared with other species of *Podophyllum*, notably *P. peltatum* (0.25%), the most common species in the American subcontinent<sup>11</sup>, and Himalayan pseudoginseng has better adaptogenic profile than Korean ginseng. These leads assume importance in promoting cultivation of medicinal plants in

**Table 1.** Threatened medicinal plants of Uttarakhand (modified after the CAMP Workshop, 1998)

Species	IUCN (status)	Population studies	Cultivation	Level of difficulty in propagation	GBPIHED initiative (1995 – till date)
<i>Aconitum heterophyllum</i>	EN	No	Yes	III	Conventional and <i>in vitro</i> propagation
<i>A. violaceum</i>	VU	No	No	II	—
<i>Arnebia benthamii</i>	CR	No	No	III	Population study, reproductive effort, conventional and <i>in vitro</i> propagation
<i>A. euchroma</i>	EN	No	No	III	Population study, conventional and <i>in vitro</i> propagation
<i>Saussurea costus</i>	CR	Yes	Yes	I	Conventional propagation
<i>S. obvallata</i>	VU	Yes	Yes	III	Population study, conventional and <i>in vitro</i> propagation
<i>S. gossypiphora</i>	EN	No	No	Not assessed	—
<i>Rheum webbianum</i>	VU	Yes	No	II	—
<i>R. spiciforme</i>	VU	Yes	No	II	—
<i>R. moorcroftianum</i>	VU	No	Yes	II	—
<i>R. australe</i>	VU	Yes	Yes	II	—
<i>Rhododendron lepidotum</i>	VU	No	No	Not assessed	—
<i>R. campanulatum</i>	VU	No	Yes	I	—
<i>R. anthopogon</i>	VU	No	No	Not assessed	—
<i>Polygonatum verticillatum</i>	VU	Yes	No	III	—
<i>P. multiflorum</i>	VU	No	No	III	—
<i>Podophyllum hexandrum</i>	EN	Yes	Yes	II	Population study, conventional and <i>in vitro</i> propagation
<i>Physoclaina praialta</i>	VU	No	No	II	—
<i>Picrorhiza kurroo</i>	EN	No	Yes	I	—
<i>Malaxis muscifera</i>	VU	Yes	No	III	—
<i>Meconopsis aculeata</i>	EN	Yes	Yes	II	—
<i>Jurinea dolomiaea</i>	EN	No	No	II	—
<i>Hyoscyamus niger</i>	LR-NT	Yes	Yes	I	—
<i>Hippophae rhamnoides</i>	LR-NT	Yes	No	I	—
<i>Gentiana kurroo</i>	EN	Yes	No	II	—
<i>Fritillaria roylei</i>	CR	Yes	No	II	—
<i>Ephedra gerardiana</i>	EN	Yes	Yes	II	—
<i>Dactylorhiza hatagirea</i>	CR	No	Yes	III	—
<i>Betula utilis</i>	EN	Yes	No	II	—
<i>Bergenia stracheyi</i>	VU	Yes	Yes	II	—
<i>Artemisia maritime</i>	EN	No	No	II	—
<i>Nardostachys jatamansi</i>	CR	Yes	No	Not assessed	Population study
<i>Swertia angustifolia</i>	EN	Yes	No	III	Population study, conventional and <i>in vitro</i> propagation
<i>S. chirayita</i>	CR	Yes	Yes	Not assessed	Population study and conventional propagation
<i>Taxus wallichiana</i>	CR	No	Yes	II	Population study, conventional and <i>in vitro</i> propagation

CR, Critically endangered; VU, Vulnerable; EN, Endangered; LR-NT, Lower risk near threatened. Level of difficulty: I, Least; II, Moderate; III, Very difficult.

Uttaranchal (and elsewhere in the Himalaya) as an income-generating activity.

### Conservation and utilization by traditional communities

Convention on Biological Diversity (CBD) states that indigenous people play a vital role in environment management and development through their traditional practices. It requires nations to protect the traditional knowledge and customary practices related to the use of biological resources<sup>12</sup>. Knowingly or unknowingly, people have evolved strategies for doing so in the form of rituals, beliefs and taboos. The traditional utilization techniques of the communities inhabiting the study area not only utilize the plants for domestic consumption but at the same time express high conservation ethos. Ecological management techniques practiced by certain tribes are far superior to so-called modern means of conservation<sup>13</sup>. The concept of conservation of biodiversity is inbuilt and interwoven in the traditional and religious belief of the ethnic communities. This is an area of research that presents a variety of opportunities for conservation, sustainable development and health-care.

Rural inhabitants possess incredible knowledge of a number of plant-based formulations, which served mankind for a long time. This knowledge is generated through millennia of experimentation, observation and trial and error methods, and is more eco-friendly. It is a system of knowledge in which humans are a part of nature, as nature is part of their being. Therefore, it is based on the principle of symbiotic relationship rather than exploitation of nature. The use of phyto medicines in remedying various human ailments is well established (Table 2). Besides plants, some fossils popularly known as Laphthal stones (Figure 1) found in the Laphthal region near the Indo-Tibet border are used in breast-

related problems. The pointed stones are rubbed on the hard surface and the resulting powder is applied to the affected parts. This aspect, if adequately studied, can have the potential to solve the problem of modern-day breast cancer.

Most of the plants used in the primary health-care system in Uttaranchal are drawn from the alpine zone locally called 'Bughiyal' (Figure 1). Extensive visits to high-altitude areas during the investigation revealed that the inhabitants consider some of these alpine meadows as the

**Table 2.** Common ailments and medicinal plants used in traditional health-care system

Ailment	Common medicinal plant
Antipyretic	<i>Picrorhiza kurrooa</i> , <i>Aconitum balfourii</i> , <i>Berberis asiatica</i> , <i>Bergenia ligulata</i> and <i>Viola odorata</i>
Antiseptic	<i>Saussurea obvallata</i> , <i>Arnebia benthamii</i> , <i>A. euchroma</i>
Astringent	<i>Rheum emodi</i> , <i>Orchis latifolia</i>
Appetizer	<i>Angelica glauca</i> , <i>A. archangelica</i> , <i>Allium</i> sp.
Leukoderma	<i>Heracleum candicans</i> , <i>Swertia chirayita</i>
Jaundice	<i>Nardostachys jatamansi</i> , <i>Berberis aristata</i>
Cuts, burns, boils	<i>A. benthamii</i> , <i>A. euchroma</i> , <i>S. obvallata</i>
Conjunctivitis	<i>Delphinium elatum</i>
Cough and cold	<i>Aconitum heterophyllum</i> , <i>S. obvallata</i>
Tonic	<i>S. chirayita</i> , <i>S. angustifolia</i>
Menstrual disorder	<i>Podophyllum hexandrum</i> , <i>Organum vulgare</i> , <i>Polygonum tortuosum</i>



**Figure 1.** a, Alpine meadow (Bughiyal); b, *Arnebia benthamii* in wild; c, Extraction from wild, and d, Laphthal fossils.

abode of God. Over the years, local inhabitants have developed their own mechanism of harvesting natural resources during 'Nanda Ashtami', a well-known festival in the high altitudes of Garhwal Himalaya (Uttaranchal). During this time only selected villagers called 'Jagaryas' can go to alpine areas and collect flowers. After offering these to the Goddess Nanda, a local diety, further collections are allowed. No one is allowed to collect flowers prior to this ritual. And if someone does so, it is believed that the Goddess would be displeased, which could result in natural calamities like flash flood, earthquake, landslide or drought. The most interesting fact is that this festival falls in the second fortnight of September or first fortnight of October – the time of seed set for most of the high-altitude medicinal plants. This mechanism can be attributed to avoid harvesting prior to seed set, thereby ensuring maintenance of variations.

During the field visits with local inhabitants and through semi-structured interviews, it was learnt that there are certain traditional rules and regulations one has to follow while entering these Bughiyals for vegetation collection. In order to prevent over-harvesting, these rules appear to be harsh so that people cannot stay for long. Only selected men can go to these Bughiyals. These persons are said to be selected by the Goddess herself and it is believed that they act as a mediator between the supernatural powers and the local inhabitants. People going for collections need to start early in the morning with an empty stomach. They are required to wear a white cotton dhoti, in spite of the cold conditions. This mechanism ensures that they do not stay for long in the natural habitat of medicinal plants thereby preventing over-exploitation. It is interesting to note that this practice least disturbs pollination activities, because such activities are supposed to be minimum during morning hours.

Another example of efficiently managing the resources is revealed by the fact that the inhabitants are not allowed to visit the site during growing season with their shoes on. With shoes off, people would be cautious and careful to place their steps, causing less damage to the sprouting vegetation. There is a common belief that wearing colourful clothes and making noises displeases the goddess 'Van Devi', which could lead to serious punishment of the offender. Wearing colourful clothes and making noise disturbs the pollinators, which can adversely affect regeneration potential of such species.

A traditional mechanism for sustainable harvesting from the wild has also been evolved. Inhabitants are required to leave a sample of produce as an offering to the goddess in a temple situated at the entrance of the village while returning from the forest. Anyone found violating the rule is punished. This practice ensures sustainable harvesting of the resource from the wild.

The individuals from different patches were harvested rotationally after seed set. The rotation was based on the

life cycle of the species to ensure completion of the cycle. The seeds obtained were spread at the place of harvest, ensuring regeneration. The villagers revealed that if the roots of species like *Arnebia benthamii*, *Angelica glauca*, and *Dactyloriza hatagirea* are not harvested after seed set, they decompose and the valuable raw material is lost. This was confirmed by harvesting of a few individuals by the authors. In case such practices are documented it can serve as a guide for devising sustainable harvesting mechanisms.

The concept of maintaining biodiversity registers<sup>14</sup> was prevalent in ancient times. Herbarium specimens providing information on use were found with some persons. Vaidyas maintain their diary, which contains information on formulations in coded language. Traditional Vaidyas do not disclose the identity of composite drugs to common people. This is, perhaps one of the initiatives to conserve medicinal plants. Another school of thought suggests that the identity of drugs is not disclosed in the public domain for safeguarding Intellectual Property Rights.

Traditional harvesting methods suggest that they were efficient to sustainably utilize the resource.

### Erosion of traditional knowledge base

Increasing demand of medicinal wealth of alpine has resulted into trade, legitimate as well as illegal. Traditional harvesting methods have declined and clandestine extraction prevails year round. Focusing only on financial gains, local people have started exploiting this natural wealth without considering traditional methods and mechanisms. All this has resulted in considerable depletion of habitat and medicinal plant population. In view of the restrictions on extraction of medicinal plants coupled with the influence of modernization, inhabitants increasingly use allopathic drugs. And, as a result, traditional healers are losing their popularity.

Traditional health-care system, which used to be the lifeline of remote, high-altitude areas, is on the verge of extinction. The number of traditional birth-attendants, bone-attendants, bone-setters, herbal healers and wandering monks, which used to be the common sight earlier, is decreasing gradually. The wealth of information, which is preserved as an unwritten materia medica of the tribal folk is slowly fading, and oral tradition of passing on knowledge from generation to generation is decreasing. There are many cases in which the know-how still remains a secret. This could be related to information on the occurrence, characteristics, therapeutic effects, processing methods and use of plant species for treatment. In most cases the traditional medical prescriptions usually contain a large number of ingredients, varying in their proportion according to the condition of the patients. As a 'family secret' these multi-drug prescriptions are orally

transmitted from generation to generation. This knowledge base is usually not shared among other inhabitants, perhaps because it might lead to misuse. It is a common belief among the traditional healers that earning money from a secret formula can make the prescription less effective.

The illegal extraction of medicinal plants has become common now. This has happened at a time when most of the well-known high-altitude medicinal plants of the Himalaya are threatened. After a ban on collections, local medical practitioners are facing the problem of obtaining appropriate plant parts of desired quantity for curing various ailments. As a result, the age-old tradition is on the verge of extinction due to these regulations and erosion of social values. Existing government policies are also not in favour of traditional healers. In India, generally the traditional healers are referred to as quacks. The people most affected due to near extinction of traditional health-care system are those living in remote high-altitude areas, who are still far away from modern means of communication and transportation.

### Present state of knowledge

Major contributions of medicinal plants in the Himalaya relate to documentation of inventories, which include information on the list of species, part(s) used and distribution range. An exhaustive compendium of medicinal plants of the country and their biological activity is available<sup>15</sup>. Plants used in folk medicines are listed<sup>16</sup>. Lists of Himalayan medicinal plants of different states are also available. Status of selected taxa such as *Coptis teeta*<sup>17,18</sup>, *Panax* spp.<sup>19,20</sup>, *Taxus baccata*<sup>21</sup>, *Aconitum heterophyllum*<sup>22</sup>, *Podophyllum hexandrum*<sup>23,24</sup> and *Nardostachys jatamansi*<sup>25</sup> are also reported. Important contributions have also been made in preparing a catalogue of species used in the pharmaceutical industry<sup>26–28</sup> and to document the commercial exploitation of selected medicinal plants from the wild<sup>29–31</sup>.

*In vitro* propagation and conservation of some endangered medicinal species of India have been reviewed<sup>32</sup>. In recent years, *in vitro* culture protocols of some Himala-

yan medicinal plants have been standardized. These include *P. hexandrum*<sup>33</sup>, *N. jatamansi*<sup>34</sup>, *Rheum emodi*<sup>35</sup>, *Valeriana wallichii*<sup>36,37</sup> and *A. heterophyllum*<sup>38</sup>. Similarly, induction of somatic embryogenesis and organogenesis is reported in *Bunium persicum*<sup>39</sup>. Micropropagation and flowering in *Artemesia annua*<sup>40</sup> and *in vitro* regeneration in *Asparagus verticillatus*<sup>41</sup> and several other species are reported. Preliminary investigations on cultivation of *P. hexandrum* are also reported<sup>42</sup>. Seed germination studies in a number of medicinal plants of the region have been undertaken. These include *Swertia chirayita*<sup>43</sup>, *Potentilla* sp.<sup>44</sup> and *P. hexandrum*<sup>45,46</sup>. A few studies on the assessment of secondary metabolite content of the species have been undertaken<sup>47–49</sup>.

In Uttarakhand, for the past 25 years, the government has imposed a ban on extraction of 11 medicinal plants; their collection and trade is strictly prohibited. Besides, 50 species are subject to partial ban, restricting trade. The quantum of extraction of most of the medicinal plants is not known. Data are available only for some medicinal plants (Table 3).

### Need for a coordinated effort

Considering the resurgence of interest in natural products for curing several chronic ailments, the demand on plant-based drugs is bound to increase. This scenario, therefore, calls for in-depth and extensive investigation on the extent of availability and natural recruitment processes of high-value Himalayan medicinal plants used extensively for the preparation of drugs in various systems of medicine. Such a study will help in planning a strategy to offset the expected widening of gap between demand and supply (availability) of raw material.

Besides, the traditional knowledge system needs to be studied, documented, preserved and used for the benefit of humankind, before it is lost forever. This will require a holistic approach, and involvement and participation of local inhabitants. Since local users often have a good understanding of how sustainable harvesting should be practiced, strategies of benefit-sharing mechanisms for sustainable utilization of medicinal plants in conformity

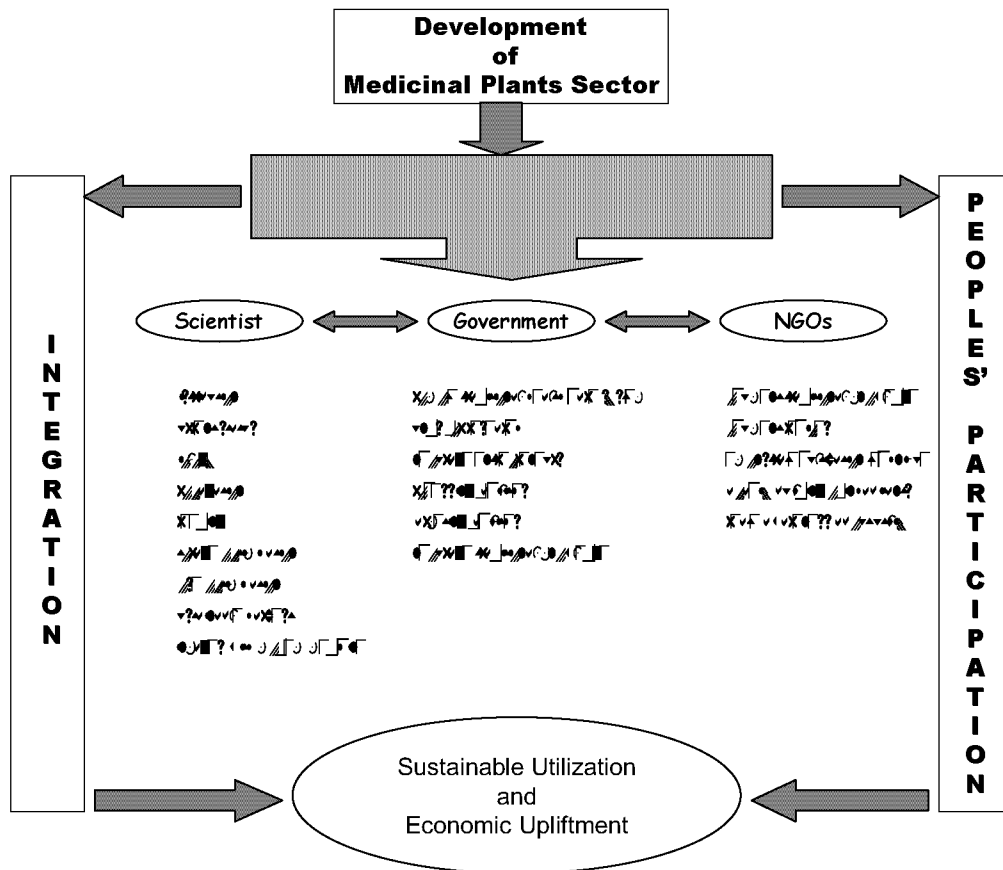
**Table 3.** Quantity of important medicinal herbs collected in Chamoli Garhwal in Uttarakhand

Species	Part used	Cost (Rs/quintal)	Collection (in quintal)				
			1996–97	1997–98	1998–99	1999–00	2000–01
<i>Parmelia ramitchadalis</i>	Whole	2500	3850	5000	4350	4100	3950
<i>Acorus calamus</i>	Rhizome	1500	100	130	113	120	160
<i>Trichosanthes tricuspidata</i>	Seed	6000	10	10	12	10	15
<i>Cinnamomum tamala</i>	Leaf	2000	40	60	65	70	75
Total collection (in quintal)			4000	5200	4540	4300	4200
Total value (lakhs of rupees)			87	118	112	106	106

Source: District Bhesaj Sahkari Vikas Sangh Limited, Chamoli.

**Table 4.** Organizations working on medicinal plants research in Uttarakhand

Organization	Major areas of activity
Forest Research Institute, Dehradun	Documentation, propagation and germplasm conservation
Botanical Survey of India, Northern Circle, Dehradun	Survey, documentation, assessment and germplasm conservation
Uttarakhand Jado Booti Sodh Sansthan, Gopeshwar	Agrotechnology
Wildlife Institute of India, Dehradun	Population study
Govind Ballabh Pant Institute of Himalayan Environment and Development, Almora	Population study, propagation, agrotechnology, germplasm conservation and biochemistry
Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	Agrotechnology, biochemistry, breeding and genetics, diseases and pests, microbiology and physiology
Kumaun University, Nainital	Documentation, population study, propagation and active principles
Hemwati Nandan Bahuguna Garhwal University, Srinagar Garhwal	Documentation, propagation, active principles and pharmacology
Horticulture Experiment and Training Centre, Chabhattia, Ranikhet	Breeding, genetics, integrated pest management and agrotechnology
High Altitude Plant Physiology Research Centre, (H.N.B. Garhwal University), Srinagar Garhwal	Active principles, agrotechnology, population study and germplasm conservation
Central Institute of Medicinal and Aromatic Plants, Regional Centre, Nagla	Agrotechnology, breeding and genetics, diseases and pests, and phytochemistry
National Bureau of Plant Genetic Resources, Bhowali	Breeding and genetics, agrotechnology, plant collection, survey and taxonomy
Herbs Development Scheme Co-operative Department, Ranikhet	Procurement and marketing
Indian Institute of Ayurveda for Drug Research, Tarikhet, Ranikhet	Survey, agrotechnology, diseases and pests, drug research and formulation
Gurukul Kangri State Ayurvedic College, Haridwar	Drug research and formulation
Centre for Minor Forest Products for Rural Development and Environmental Conservation, Dehradun	Agrotechnology
Defence Agrotechnological Research Laboratory, Pithoragarh	Ethnomedicine



**Figure 2.** Flow chart showing potential role of various stakeholders in development of medicinal plant sector in Uttarakhand.



with the provisions of CBD need to be developed. For achieving this, there is a need to inculcate greater awareness about the benefits of medicinal plants among different sections of the society. The present scenario offers a unique opportunity for government representatives, scientists and NGOs to work in coordination, to devise mechanisms to promote traditional health-care system and engage rural inhabitants in conservation, cultivation, processing and marketing of raw material. Collaborative research and integrated effort are necessary to save the treasure-house of medicinal plants and the unwritten materia medica from extinction. For overall sustainable development of Uttaranchal, the traditional knowledge system could prove valuable. At this stage, a strategy for future need is to be developed. However, implementing the strategy is far from easy at a time when medicinal plant business is fluid, undocumented, and largely unregulated. Much about it is unclear, and will remain that way for sometime. But regardless of the difficulties, a beginning must be made to address this important but neglected area. On priority, the strategy must address the conservation of wild medicinal plants, threatened with extinction.

All the institutions involved in medicinal plants research (see Table 4), NGOs, policy planning bodies and various stakeholders should, in coordination, prepare a state-level action plan for conservation and sustainable utilization of medicinal plants. Initially, this would require preparation of a detailed inventory related to distribution, uses, status, cultivation practices and traditional knowledge. As earlier mentioned, threatened plants must be addressed on priority. Subsequently, threat analysis of the other species needs to be conducted and conservation efforts need to be directed before they enter a 'threat' status. Research guidelines for developing species recovery programmes need to be evolved. At present, farming of medicinal plants is insignificant, scattered and largely informal. Keeping in view the increasing global population and consequent rise in demand for medicinal plants, one feasible option would be to regard medicinal plants as under-utilized crops. This would promote farming of the species, which will help a great deal to offset pressure on natural wild types. Cultivation will also help in the production of uniform material for obtaining quality products, consistently. Cultivation should be a major part of any strategy. These steps (Figure 2), if properly implemented, will not only protect the medicinal plants and medicinal plant-based knowledge, but will also help in boosting rural economy of this mountain state.

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