REVIEW ARTICLE

Aconitum: Need for sustainable exploitation (with special reference to Uttarakhand)

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Red Data Book has a long list of many endangered medicinal plants in which genus *Aconitum*, known as monkshood, wolfsbane, Devil's helmet or blue rocket, belonging to the family Ranunculaceae finds a key position. There are over 250 species of *Aconitum*. These herbaceous perennial plants are chiefly natives of the mountainous parts of the Northern Hemisphere and are characterised by significant and valuable medicinal properties. Illegal and unscientific extraction from the wild has made the important species of this genus endangered. This review focuses on the importance and medicinal uses of the genus (on the basis of literature cited from different Books and Journals and web, visits to the sites and questionnaires), which have been documented and practiced on the basis of traditional as well as scientific knowledge. The review further presents an insight on the role of conventional and modern biotechnological methods for the conservation of the said genus, with special reference to Uttarakhand. Further, it is suggested that the policies of government agencies in coordination with the local bodies, scientists, NGOs and end-users be implemented for the sustainable conservation of *Aconitum.*

Key words: *Aconitum*, biotechnology, conservation, endangered, medicinal plants, sustainable

INTRODUCTION

Since time immemorial, plants containing beneficial and medicinal properties have been known and used by human beings in some form or the other.[1] Our dependence on medicinal plants has in no way been minimised by the use of modern system of synthetic drug the use of which is not without side effects.[2] In northern India, *Aconitum* is the rarest genus with five species[3] of vital medicinal uses, out of which four species are already in different threat categories. Aconite, an alkaloid extracted from the different species of *Aconitum*, has long been used in the traditional medicines of Asia (India, Japan and China). The use of *Aconitum* for curing various aliments and the depleting status of the herb in the wild call for the need for implementing the conservation and cultivation practices. Thus, the present report reviews the importance and the current status of genus *Aconitum* with special reference to Uttarakhand and stresses the need to develop long-term conservation and regeneration strategy, so that continuous supply of the raw material to drug industries serving mankind could be maintained without causing further endangerment.

THREATENED MEDICINAL PLANTS OF UTTARAKHAND

One of the major medicinal plant raw materials producing Asian country is India where out of 17,000 species of higher plants, 7500 are known for medicinal uses. This is the highest proportion of plants known for their medical purposes in any country of the world for the existing flora of that respective country [Table 1]. The Himalayan region is rich in a variety of natural resources in which medicinal plants have important place.[4] The Indian Himalayan region supports over 1748 (32.2% of India) plant species of known medicinal value.[5] Rich plant diversity of the Himalayas – 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.[6]

Uttarakhand Himalayan region is famous for its rich medicinal plants resources. The climatic, topographic and soil diversity of this region has resulted in the occurrence of several valuable and economically important medicinal herbs of great therapeutic value.[7] Uttarakhand supports a large number of medicinal plants curing a wide range of disorders, which are extensively used by the pharmaceutical industry for preparation of drugs used in Indian System of Medicine [Table 2]. In Uttarakhand, about 701 species are used in different forms as medicine.[8] The degree of threat to natural population of these medicinal plants has increased due to many reasons, viz., overgrazing, prolonged seed dormancy, high seedling mortality and ecological constraints, but the main and important reason is unsustainable exploitation of the medicinal

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Table 1: Percentage of medicinal plants reported in World, India and Indian Himalayas

Country/region	Total number of native species in flora	No. of medicinal plant species reported	% of medicinal plants	Source
World	297,000	52,885	10	[32]
India	17,000	7,500	44	[33]
Indian Himalayas	8,000	1,748	22	[34]

Table 2: Some medicinal plant spp. of Uttarakhand: IUCN status, parts used and medicinal use

Medicinal plant species	IUCN status	Parts used	Medicinal properties/ diseases-disorders cured
Aconitum falconeri	EN	Roots/Tubers	Antipyretic, Paralysis, Sciatica, Gout, Diarrhea etc.
A.ferox	EN	Root hair/Roots	Antipyretic, Anti-rheumatic, Paralysis, Snake bite etc.
A.heterophyllum	EN	Roots/Tubers	Anti-inflammatory, Antipyretic, Diarrhea, Vomiting, Cough, Cold, Astringent,
A.violaceum	VU	Roots/Tubers	Antipyretic, Abdominal Pain, Antidote, Anti-inflammatory, Febrifuge
Arnebia benthamii	CR	Roots/Flowering shoots	Antipyretic, Antiseptic, Hair tonic, Cuts, Burns, Boils etc.
A.euchroma	EN	Roots	Antibacterial, Antipyretic, Contraceptive, Anticancerous, Cuts, Burns, Boils etc.
Saussurea costus	CR	Roots	Anodyne, Antibacterial, Antispasmodic, Aphrodisiac, Vermifuge, Skin etc.
S.obvallata	VU	Whole Plant/Roots	Antiseptic, Cough, Cold, Cuts, Burns, Boils etc.
S.gossypiphora	EN	Whole Plant/Roots	Antiseptic, Cough, Cold, Cuts, Burns etc.
Rheum webbianum	VU	Rhizome/Roots/Tubers	Purgative, Astringent, Blood purifier, Chronic constipation etc.
R.spiciforme	VU	Stem/Roots	Purgative, Astringent, Blood purifier, Chronic constipation etc.
R.moorcroftianum	VU	Stem/Roots/Flowers	Purgative, Astringent, Stomachache etc.
R.australe	VU	Roots	Antipyretic, Bone ache, Muscular ache, Boils etc.
Rhododendron lepidotum	VU	Leaves	Blood Purifier etc.
R.campanulatum	VU	Leaves/Dried twigs	Migraine, Cold, Chronic fever, Chronic rheumatism, Sciatica, Syphilis, Phthisis
R.anthopogon	VU	Leaves	Antiasthamatic, Headache, Bronchitis, Cold, Cough etc.
Polygonatum verticillatum	VU	Roots	Anti-rheumatic, Antioxidant etc.
P.multiflorum	VU	Roots	Antioxidant, Tonify the Kidney, Skin (UV-damage), Hair tonic.
Podophyllum hexandrum	EN	Stem/Roots	Anticancerous, Anti-tumor, Wounds, Cold, Cough etc.
Picrorhiza kurrooa	EN	Whole Plant/Fruits	Antipyretic, Anti-oxidant etc.
Malaxis muscifera	VU	Psuedobulbous Stem	Aphrodisiac, Antidysentric, Febrifuge, Anti-rheumatic, Seminal weakness, Internal/external hemorrhages etc.
Meconopsis aculeata	EN	Roots	Analgesic, Febrifuge, Anti-inflammatory etc.
Hyoscyamus niger	LR-NT	Whole plant/seeds	Anodyne, Anthelminthic, Antispasmodic, Anti-tumor, Anti-rheumatic, Diuretic
Hippophae rhamnoides	LR-NT	Fruits	Cardiac Disorders etc.
Fritillaria roylei	CR	Bulb	Antiasthamatic, Anti-rheumatic, Galactogogue, Ophthalmic, Oxytoxic, Febrifuge etc.
Ephedra gerardiana	EN	Whole plant/Stem/ Berries	Anti-rheumatic, Antiasthamatic, Diuretic, Febrifuge, Vasodilator, Cardio-tonic etc.
Dactylorhiza hatagirea	CR	Roots/Tuber	Astringent, Cough, Cold, Cuts, Wounds, Burns, Bone fracture.
Betula utilis	EN	Bark	Antiseptic, Carminative, Jaundice, Hysteria, Cuts, Wounds, Burns etc.
Bergenia stracheyi	VU	Roots/Leaves	Kidney stones, Gall stones, Power tonic, Swelling, Sores etc.
Artemisia maritime	EN	Flowering tops/Shoots	Worm tonic, Antipyretic, Appetizer etc.
Nardostachys jatamansi	CR	Whole plant/Root/Tuber	Epilepsy, Ulcers, Cardiac diseases, Skin diseases, Jaundice etc.
Swertia angustifolia	EN	Whole plant	Antipyretic, Antiasthamatic, Blood purifier, Febrifuge etc.
S. chirayita	CR	Whole plant	Antipyretic, Anti-malarial, Toothache, Headache, Tonic etc.
Taxus wallichiana	CR	Roots	Anti-cancerous
Taxus baccata	EN	Roots/Leaves	Anti-cancerous (ovarian cancer)

CR - Critically endangered; VU - Vulnerable; EN - Endangered; LR–NT - Lower risk near threatened

plants for the drug industry and local medicinal use. More than 90% of raw material is drawn from natural habitats.[9] Thirty-five species of medicinal plants found in Uttarakhand have been placed into different threat categories by the CAMP Workshop, 1998.[10] The medicinal plant sector in Uttarakhand can provide an important source of income to the rural population, especially because returns from traditional crops are declining.[11] Unique climate of

Uttarakhand, its locally available expertise, motivated farmers, NGOs and a supportive government policy provide a strong base to take advantage of the growing national and international demand for medicinal plants.[12,13] In recent years, the demand for medicinal and aromatic plants has grown rapidly because of accelerated local, national and international interest. *Aconitum* is the centre of attraction in the field of herbal medicines because of its property of curing a wide range of diseases and hence the pressure on its natural habitat has increased.

Due to unsustainable extraction of raw material coupled with many other wrong and illegal practices, four species of *Aconitum* of Uttarakhand have been enlisted in a different threat category by International Union for the Conservation of Natural Resources (IUCN) in the Red Data Book [Table 2].

ACONITUM

Out of many important medicinal plants cultivated in Uttarakhand, *Aconitum* species finds a key position for conservation and cultivation. The genus *Aconitum* belongs to the family Ranunculaceae. These herbaceous perennial plants are chiefly natives of the mountainous parts of the Northern Hemisphere, growing in moisture retentive but well draining soils on mountain meadows. These plants are tall, with erect stem being crowned by racemes of large and eye-catching blue, purple, white, yellow or pink zygomorphic flowers with numerous stamens. The root is best harvested in the autumn as soon as the plant dies down and is dried for later use.[14] There are over 250 species of *Aconitum*.[15] *Aconitum* in northwest Himalayas is represented by 10 species and two varieties. This is one of the important genuses that have been enlisted in Red Data Book. Some of the important species of *Aconitum* are *Aconitum balfourii, Aconitum japonicum, Aconitum heterophyllum, Aconitum napellus, Aconitum ferox, Aconitum violaceum, Aconitum dienorrhizum, Aconitum carmichaeli, Aconitum chasmanthum* and *Aconitum bisma*. In Uttarakhand, different species of *Aconitum* are being cultivated in Chamoli, Pithoragarh, Milam (Munsiyari), Deoban (Chakrata), Uttarkashi and Berinaag. Wild extraction of *Aconitum* is prohibited in these areas; still the genus has become endangered due to many factors which have been discussed later in this review.

CHEMICAL CONSTITUENTS AND MEDICINAL USES

All *Aconitum* species contain several poisonous compounds, including enough cardiac poison, that it was used on spears and arrows for hunting and battle in ancient times.[16] *Aconitum* has a long history of its use as a poison, with cases going back thousands of years.[17] Previously, Aconite was more known as a poison rather than a medicine. With advancement in scientific knowledge, the pre-treated tuber of the species with reduced toxicity was started to be used as a herbal drug.[18]

The tubers contain toxic diterpene alkaloids such as aconitine, hypaconitine, and mesaconitine, which easily turn into less toxic alkaloids such as benzoylaconine, aconine, and pyroaconine by heating or alkaline treatment through deacetylation, debenzoylation or oxidation reaction.[19] Currently, the processed tubers are widely and safely used for the treatment of pain, neuronal disorders and inflammation, with no problematic or annoying adverse effects.[20-23] It is also used for curing hysteria, throat infection, dyspepsia, abdominal pain and diabetes. In the indigenous system of the medicine, this plant is considered as a valuable febrifuge, nervine tonic especially in combating debility after malaria and haemoplegia [Table 2].

The seeds of this plant are also used in medicine, mainly as a stimulant, aromatic, emmenagogue, galactagogue, stomachic, carminative, antipyretic and anathematic. Chewing the seeds removes bad breath. Research has also established that the essential oil has antibacterial properties, which inhibit the growth of harmful intestinal bacteria.

Aconite is an ingredient of Tribhuvankirti, an Ayurvedic preparation for treating a "cold in the head" and fever.[24] *A. heterophyllum* is found as the main active ingredient of the herbal formulation Diarex Vet with other important medicinal plants and has been effectively used in cases of indigestion, flatulence and diarrhoea of varying aetiologies including bacterial, fungal and protozoal.[25]

Chemical analysis has revealed that tuberous roots of *Aconitum* contain the following alkaloids: benzoylmecasonine, aconitine, hypaconitine, heteratisine, heterophyllisine, heterophylline, heterophyllidine, atidine, isotisine, hetidine, hetsinone and benzoylheteratisine, and the plant contains the following alkaloids: heteratisine, heterophyllisine, atidine, isotisine, hetidine, hetsinone and benzoylheteratisine.[26]

WHAT LED *ACONITUM* TO BE UNDER THREAT CATEGORY

Uttarakhand is one of India's poorest states; in 2001, per capita income was 33% lower than the Indian average (US$ 240).[27] Only 12% of the total land area of Uttarakhand is under cultivation due to inaccessibility and poor soil quality. Due to declining returns from traditional crops, farmers relying on farm production in Uttarakhand are only able to survive for 8–9 months a year. For the rest of the year, they depend on non-farm income such as the collection and sale of medicinal plants.[11] Focussing only on financial gains,

these farmers have started exploiting the natural wealth without considering traditional methods and mechanism, resulting in illegitimate trade. In spite of various policy measures, excessive illegal collection of medicinal plant continues to take place on a larger scale, which also includes the collection of species considered endangered.

All these practices are common with *Aconitum* in Uttarakhand. Large scale collection has led *Aconitum* towards depletion. This is reflected in a significant decrease in the amount of material a person can collect in a day. For example, in the Johar valley in the Pithoragarh district, collectors reported that until 5 years ago, they were able to collect about 200 g of dry Atish (*A. heterophyllum)* in 1 day. Now they do not get more than 70–100 g a day.[12,13] There are number of reasons of excessive collection of *Aconitum* spp. from its wild habitat in Uttarakhand. Firstly, a wide range of ailments is cured by different extracts from *Aconitum* spp., so the commercial demand is very high. Secondly, high demand of this medicinal herb forces or attracts the collectors, basically farmers, for extracting it from their wild habitat unsustainably for gaining more income in lesser time without considering future harms. Another reason coupled with the above two reasons is that the cultivation of *Aconitum* spp. is done on a very small scale because of the availability of small area for cultivation of medicinal plants, low germination percentage and inhibition of the growth of nearby vegetation, especially legumes.

Not following proper extraction mechanism and cultivation practices may lead to various consequences. As the resources are depleting, traditional knowledge of preparing drugs and curing of various ailments will be lost and in addition there will be hike in the price of raw material (*Aconitum* spp.), which will directly influence the price of drugs prepared from this valuable herb. Consequently, these much expensive drugs will be out of reach of common man. So there is an urgent need of designing a protocol to overcome all the constraints on the organised cultivation and conservation practices, and to reduce pressure on its wild habitat maintaining continuous supply of raw material. In the present review, role of different government policies and methods opted for conservation practices have been discussed. In addition, we have tried to discuss the scope to enhance these conservation practices by some modification.

Medicinal plants are potential renewable natural resources if used sustainably. As the *Aconitum* spp. of Uttarakhand are under endangered category, its conservation and sustainable utilisation must involve long-term programmes. A holistic and systematic approach envisaging interaction between social, economic and ecological system will be a most desirable one.

ROLE OF LOCAL TRADITION IN CONSERVATION

Traditional communities of Uttarakhand may play a vital role in the conservation of *Aconitum* spp. Knowingly or unknowingly, people have evolved strategies for doing so in the form of rituals, beliefs and taboos. Various traditional harvesting methods described in one of the studies suggest that they are efficient to sustainably utilise the natural resources.[10] One among them is that Goddess "Nanda Devi" worshipped by the inhabitants of alpine zone in Uttarakhand would be displeased if someone collects flowers after or before the festive season "Nanda Ashtami". Similarly, collection of vegetation from Bughiyals (Alpine meadows) is also restricted by some strict rules and regulations to prevent over-harvesting. These rules appear to be harsh so that people cannot stay for long. Only selected men said to be selected by the Goddess herself can go to these Bughiyals. There are many other examples where traditional rituals and customs made by local inhabitants are playing a vital role in the conservation of medicinal plants species of Uttarakhand. Applying all these customs on the extraction of *Aconitum* spp., its sustainable development can be achieved. In addition, following subsequent measures will ensure its regeneration and conservation.

- Individuals from different patches should be harvested rotationally after the seed set. Rotation should be based on the life cycle of the species to ensure completion of the cycle.
- As the seeds of *Aconitum* spp. are highly dormant, the cultivators should be trained by researchers and scientists who are experts in this field (through government) as to how to enhance its germination potential.
- Seeds obtained should be spread after proper treatment as per the guidance of experts at the place of harvest, for ensured regeneration.
- Government should aid these farmers financially for increasing their percent land under medicinal plant cultivation and for getting planting material from a concerned registered and government recognised agencies, e.g. nurseries.

In-situ Conservation

The most widely accepted scientific technologies of biodiversity conservation are the *in-situ* conservation and cultivation methods.[28] This is the best and cost-effective way of protecting biological and genetic diversity because here the wild species or stock of biological community is protected and preserved in its natural habitat. Establishment of Biosphere Reserves, National Parks, Wild Life Sanctuaries, Sacred Groves and many Protected Areas forms the examples of *in-situ* conservation. *In-situ* conservation of *Aconitum* spp. in Uttarakhand will prevent premature extinctions due to human activities. But only

Table 3: Studies on *Aconitum* spp. under different area in recent years

Studies	Results	Source
Micro-propagation	Clonal multiplication of *A. carmichaeli* by tip-tissue culture technique was done and alkaloid content of clonally propagated plant showed less variation than those of the normally grown plants	[35]
	Microtubering in *A. carmichaeli* was enhanced at 15°C under dark rather than at 10–20°C	[36]
	Relative similarity between somatic embryo in callus and sexual embryo *in situ* in *A. heterophyllum* was obtained	[37]
	In-vitro propagation of *A. atrox* was conducted successfully at a lower elevation using tuber segments	[38]
	Successful callus initiation at 0.5 mg/l NAA and 0.25 mg/l BAP was achieved with best shoot proliferation at 0.5 mg/l NAA and BAP in *A. heterophyllum*	[27]
Seed germination	Chemical stimulation of seed germination in *A. heterophyllum* and *A. balfourii* was done and resulted in significant enhancement of germination	[39]
	Chilling but no other treatment could improve seeds germination in *A. heterophyllum* at a lower altitude	[40]
	A. heterophyllum successfully adapted in conditions other than natural habitat after giving hot water treatment to seeds	[41]
Phytochemical analysis	Alkaloid contents (mesaconitine/hypaconitine) were higher at 20°C than at 10–15°C	[36]
	Impact on cultivation on active constituent of *A. heterophyllum* was determined and it was found that there is minor statistically significant difference	[42]
	Two new norditerpenoid alkaloids, namely spicatine A and spicatine B, as well as 11 known norditerpenoid alkaloids were isolated from the $CHCl_3$ portion of the 90% ethanol extract of the roots of *Aconitum spicatum*	[43]
	Preparative high-speed counter-current chromatography (HSCCC) coupled with evaporative light scattering detection (ELSD) was employed for the isolation and purification of alkaloids from the roots of *Aconitum coreanum* (Lèvl.) Rapaics	[44]
	Two flavonoids, liquiritin and liquiritigenin, were extracted from the processed Aconiti tuber	[45]
	Two new aconitine-type norditerpenoid alkaloids, 6-dehydroacetylsepaconitine and 13-hydroxylappaconitine, along with three known norditerpenoid alkaloids, were isolated from the roots of the *A. heterophyllum* Wall. These compounds exhibited significant antibacterial activity	[46]
	Two new diterpenoid alkaloids, heterophyllinine-A (1) and heterophyllinine-B (2), along with two known alkaloids, were isolated from the roots of *A. heterophyllum* Wall. The structures were deduced on the basis of spectral data	[47]
Pharmacological/ Biological	Therapeutic v/s toxic potential was derived on the basis of side ester chain in aconitine	[23]
	Aconitine causes persistent activation of Na^+ channels in heart, skeletal muscles, CNS by blocking their inactivation	[23,48,49]
	Crude methanolic extract (90%) of *A. chasmanthum* showed antibacterial and antifungal activity	[50]
	Heterophyllinine-A and heterophyllinine-B inhibit BChe (butylcholinestrase) casing Alzheimer disease more specifically than AChe (acetylcholinestrase) causing muscle contraction	[47]
Molecular	Twenty primers were screened for the genetic analysis of *Aconitum* and 14 were selected giving 51 polymorphic bands. Also flavanoid profiles of species and subspecies of *Aconitum* shows significant correlation with genetic study.	[51]
	Its topology is congruent well with the subgrouping of the subgenus *Aconitum* based on the morphology of seeds and of petals, suggesting that seed and petal morphology may reflect well the phylogenetic relationships within the subgenus, but other morphological characters might be unreliable	[52]
	Giemsa C banding pattern showed that ancient Sudetic taxon of *Aconitum* may have contributed to the genome of Carpathian taxon, which was then supported by molecular ISSR + RAPD pattern that points to introgression between the Sudetic *Aconitum plicatum* and Carpathian *Aconitum firmum* subsp. *maninese*	[53]

NAA - Naphthylacetic acid, BAP - 6-Benzylaminopurine

simultaneous practice of *in-situ* conservation and cultivation will ensure the reduction of pressure on its wild habitat and continuous supply of its raw material.

ROLE OF BIOTECHNOLOGY IN CONSERVATION

Aconitum, being a valuable medicinal plant of Uttarakhand, provides a wide area of research. Studies on different aspects of this medicinal plant species system have been and are being conducted [Table 3]. Biotechnology offers a great tool for exploring various aspects of the *Aconitum* spp. and can play an imperative role in its conservation. It may involve *ex-situ* or *in-vitro* modes of conservation.

Ex-situ conservation means literally, "off-site conservation in intensively managed conditions". Conventional seed storage is believed to be a safe, an effective and inexpensive method of *ex-situ* conservation of endangered medicinal plant genetic resources, which not only maintains its viability but also its vigour without hampering the genetic makeup. So far much attention has been paid towards *ex-situ* conservation of agricultural plants but now wild medicinal

plants are also focussed on for their conservation. *Aconitum* spp. is a high altitude plant, due to which its propagation through seeds at low altitude is restricted towing to the ecological factors, e.g. soil fertility, soil textures, pH, humidity, etc. and dormancy of seeds. So, giving presowing treatments, e.g. chilling or hot water treatment or with different chemicals [Table 3], seed germination in *Aconitum* spp. can be enhanced and its cultivation can be practiced at low altitude also.

Seed availability is mandatory for *ex-situ* conservation but due to diminishing population of *Aconitum* spp., shortage of seeds restricts these species for *ex-situ* conservation. Tissue culture opens up new area for conserving threatened *Aconitum* spp. as small amount of plant material can generate a large number of disease-free propagules which can be reintroduced in their native habitat. Organised cultivation of the plant is therefore necessary to ensure the quality and continuous supply of drug. Applying *in-vitro* propagation and simultaneously molecular marker technology to *Aconitum* spp. can endow with a platform for conserving valuable species. Identification of DNA markers that can correlate DNA fingerprinting data with the quantity of selected markers associated with that particular plant have extensive applications in the quality control of raw material.[29] Researches have been done for standardising protocols for *in-vitro* propagation and molecular analysis of *Aconitum* spp. [Table 3]. But still much of the research has been left to make these protocols feasible on a commercial scale with an aim to protect *Aconitum* spp. in its wild habitat and uninterrupted supply of its raw material.

ROLE OF DIFFERENT GOVERNMENT POLICIES IN CONSERVATION

Uttarakhand has declared itself as a herbal state. It has planned to develop medicinal plant sector as a priority area. Different agencies are involved in the conservation programmes, e.g., Herbal Research and Development Institute (HRDI) at Gopeshwar in Chamoli district, different forest departments, wildlife institutes, protected areas, nurseries, arboretum and preservation plots, etc. Promotion of medicinal plants, nurseries and cultivation of medicinal plant under eco-development activities of area around the protected areas, especially in Nanda Devi National Park, is notable. HRDI has been appointed as a nodal agency for the development of medicinal plant sector in Uttarakhand. Van Panchayats allot a fixed area of forest adjacent to the village to each family to protect them on a rotational basis. Likewise, Bhesaj Sangh is a cooperative mechanism for the regulation of medicinal plant collection and trade in the state. Similarly, State Medicinal Plant Board (SMPB) of Uttarakhand was constituted on the lines of National Medicinal Plant Board (NMPB). Resultantly, all the medicinal plant related projects of the state for funding from NMPB would require routing through SMPB.[30] Central Scheme for Development and Cultivation of Medicinal Plants was implemented to encourage the cultivation of medicinal plants through government supported organisations that were engaged in and had expertise in this field. The intention behind this activity was to engage different organisations in cultivation of different valuable and threatened medicinal plants and also develop agro techniques for their cultivation. But after a few years of implementation of this scheme, it was observed that medicinal plant garden, set up under this scheme, served the demonstration purpose only. No systematic effort has been made in the past for developing the practices for cultivation of medicinal plants for providing raw material of standardised ingredients. Existing government policies are also not in favour of traditional healers and herb-based pharmaceutical industries. After a ban on collection of *Aconitum* spp. from the wild, local medical practitioners and herb-based pharmaceutical industries are facing the problems of not obtaining the appropriate plant parts of desired quantity for preparation of drugs. Banning collection from wild alone cannot reduce pressure on its wild habitat of *Aconitum* spp. Simultaneous encouragement of cultivation and other conservation practices along with prohibition of wild extraction could prove a boon in conserving this valuable species.

NEED FOR SYNCHRONISED EFFORT

"Strength lies in Unity", this proverb should be followed while aiming for conservation of any endangered species. No agency or technology can conserve the valuable medicinal plants solitarily. Coordinating all the organisations, government and technology for planning strategy of conservation could give a best result.

Local users have good knowledge of sustainable harvesting, which should be practiced and employed in conservation process. Government, being the central body, should assist and have control on different stakeholders dealing with conservation process [Figure 1]. All the state policy planning bodies, NGOs and different technologies (*in-situ*, *ex-situ* and *in-vitro* propagation) standardised by scientists should prepare manuscripts containing all action plans required for sustainable cultivation and conservation of medicinal plant species, with priority given to *Aconitum* spp. and other threatened medicinal plants. Strict policies should be made to prohibit wild extraction by local collectors, traders and herb-based drug industries. Keeping in view the high demand of *Aconitum* spp. and other medicinal plants, farming of these valuable and endangered medicinal plants should be promoted by following all the steps mentioned in Figure 1. *In-vitro* propagation of *Aconitum* spp., standardised by scientists should be promoted, so that large number of propagules from minimum of plant material in lesser time can be made available for extraction of active constituents

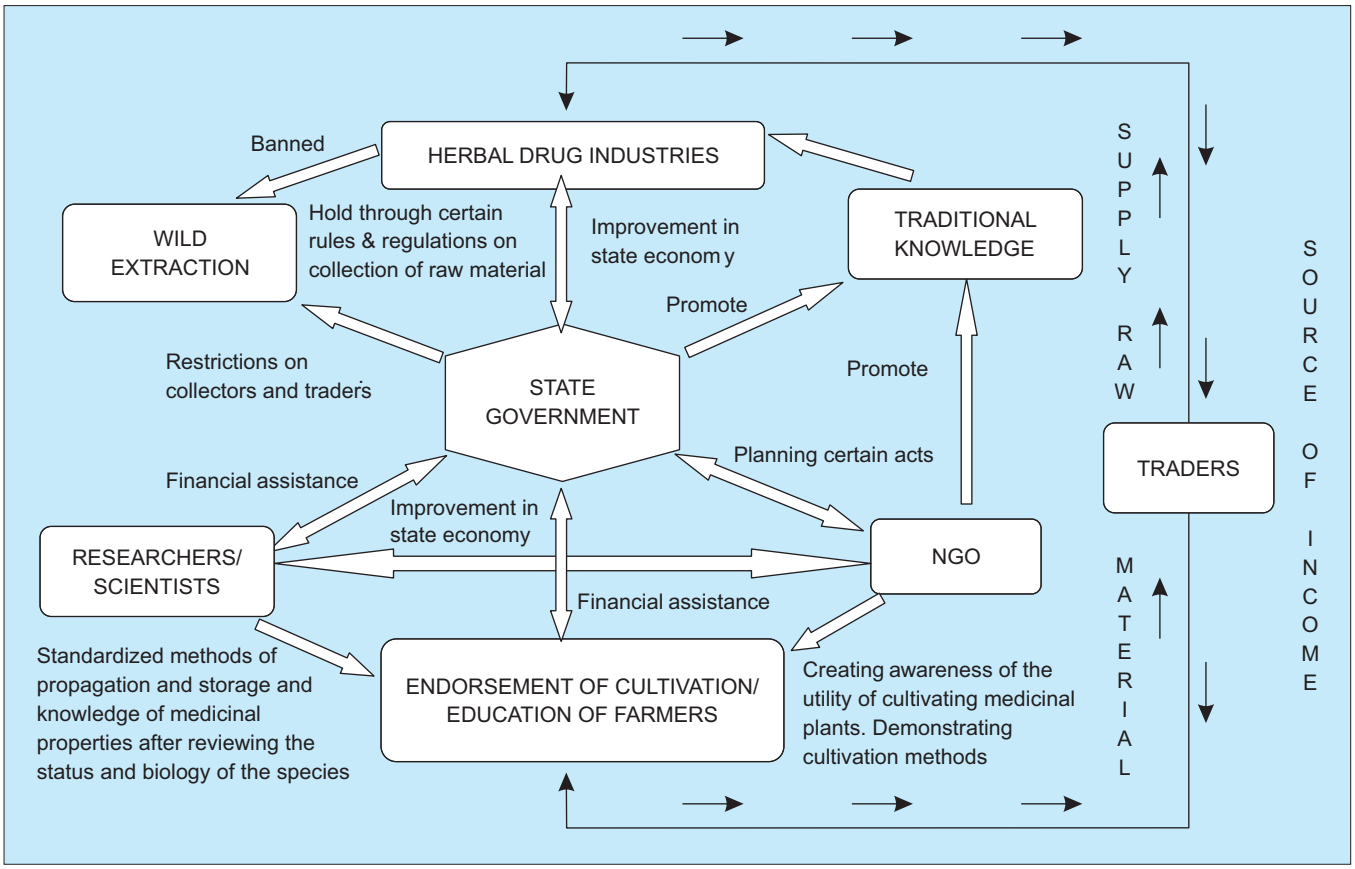

Figure 1: Schematic representation of the role of different concerned groups and organisations in conservation

as well as for planting them in their native site, thereby lessening the pressure on their wild habitat.

As mentioned before, herbal drugs are safer with less or no side effects as compared to allopathic medicines. Different active constituents extracted from *Aconitum* spp. alleviate frequently or commonly occurring diseases like fever, cough, cold, diarrhoea, pain, vomiting, and using pricey allopathic medicine may cause endless side effects. So, by increasing the production of *Aconitum* spp., active constituents can be made available for preparation of drugs which will be cost effective also.

Besides, conserving our natural resources may benefit us in many ways, as by appropriately following all the steps of Figure 1, not only conservation of *Aconitum* spp. can be achieved but also the economy of the Uttarakhand State will be raised and financial status of farmers will improve. In a study conducted in the Nanda Devi Biosphere Reserve, Uttarakhand, per hectare input cost for the cultivation of medicinal plants was calculated. The income generated or the output cost was calculated by multiplying the market cost of each medicinal plant per kilogram by the total yield per hectare. They showed that in the majority of the cases, the ratio between input cost and the output cost is 10–12, so villagers will earn 10–12 times the amount they put in.[31] Such efforts will have an indirect impact, lessening the pressure on the overexploitation of wild species of medicinal plants. As *Aconitum* spp. is in great demand not only locally or nationally but also internationally, for its broad-spectrum medicinal properties; promoting its propagation on large scale will directly increase the foreign exchange, hence the economy of state as well as of nation will improve.

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