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Full Length Research Paper

Unabated loss of medicinal plant diversity in Himalaya: a serious socio-economic concern and urgency to salvage whatever is left

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Aconitum heterophyllum, A. chasmanthum, Atropa accuminata, A. beladdona, Arnebia benthamii, Gentian kurroo, Inula racemosa, I. royleana, Picrorhiza kurrooa, Podophyllum hexandrum, Rheum emodi **and** ***Saussurea costus*** **are few of the most important medicinal herbs of north western Himalayan region including Kashmir. These herbs are endemic to the region and confined to alpine-sub alpine habitats (2150m-4000m Amsl) which register near arctic severity for some part of the year. Ecologically these niches are unique and highly specialized. Any alterations are bound to affect the very survival of these herbs. Unfortunately, numerous anthropogenic influences have altered most of these habitats which has caused irreparable damage to this invaluable germplasm leading to the ecological and socio-economic consequences of immediate concern. Whatever is left now is faced with onslaught of indiscriminate exploitation for economic gains. These species reproduce both by vegetative as well as sexual means. The flowers are hermaphrodite. The sex tracks being temporarily isolated, the herbs outbreed and set copious quantities of seed. The sexual potential however, does not match the actual requirement for regeneration which would have otherwise ensured sustained supply of the drug to the industry. The reproductive fidelity of these herbs is lowered due to the existence of certain intrinsic constraints which include pollinator dependence in most cases for sexual success (pollinators may not be available under harsh environments), slow seed germination and seedling mortality etc. Limited recruitment on one hand and age old practice of ruthless drug extraction on the other have created a wide gap between plant regeneration and utility which is ever widening and has led to loss of many natural populations in the region. We have scrutinized these herbs for their reproductive strategies and seedling behaviour in order to plan large scale multiplication and conservation under ex situ conditions. Using various textural classes of soil with varied permutations and combinations of inorganic and organic fertilizers and irrigation regimes, the development of suitable agro-technique is under way to develop a cost effective technology for transfer to Private sector and conservation of these herbs into cash crops**

Keywords: Unabated Loss, Medicinal Plant, socio-economic, Himalaya

INTRODUCTION

In the present era the importance of medicinal herbs in health care has gained impetus once again even in advanced nations of the world. This resurgence of interest in the healing properties of plants is attributed to the growing realization of the wide spread toxicity and harmful side effects associated with the prolonged use of synthetic drugs. The medicinal herbs on the contrary exhibit remarkable efficacy in curing different ailments

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without any serious effects. This is the reason why the WHO has time and again emphasized the need to revive the indigenous system of medicine based on locally available raw materials. The WHO reports that about 4 billion people rely on herbal medicine . More than 21,000 plants are said to be of medicinal use around the world of which about 2,000 are mentioned in the Ayur Veda (CCRAM report 1999). It has been estimated that of these 2000 drugs exclusively used in India, over 1800 are of plant origin (ICMR report 2000). Fortunately, Kashmir Himalaya hosts a remarkably rich wealth of medicinally important herbs. Ranging from cold desert of Ladakh through temperate zone of Kashmir valley to the sub tropical areas of Jammu province, the area offers congenial habitats for luxuriance of the species with wide ranging ecological requirements. The area has a fairly rich representation of plants utilitarian in nature a sizeable number of which find usage in the treatment of various ailments and are consumed directly or used as raw materials for extraction of active principles. It is worthy of note that about 40% of medicinal herbs inhabiting the area are used in the Indian pharmaceutical industry alone. Quite a few find use in the local medical system and some are highly valued in the foreign market. Till about 20 years ago the country used to export 374,921 Kgs of Kuth (Saussurea lappa) to Hong Kong, Singapore, Thailand, Vietnam, Japan, Sri Lanka and France. The medicinal plants inhabiting this part of Himalaya include some endemic elements too which are predominantly represented in Ranunculaceae, Apiaceae, Asteraceae and Lamiaceae etc. Many of these herbs are of a high pharmacological potential and commercially viable. Reportedly, truckloads of raw material in the form of vegetative propagules and even seeds used to be smuggled out of the region without any legislative imposition. The situation now is that hardly sporadic and single plants are traceable after long distances of trekking. Being indiscriminately used and over exploited from times immemorial their very survival in the region has been threatened and today majority are at the brink of extinction. It needs to be mentioned here that majority of these herbs are endemic to the region and ecologically very sensitive. Being confined to stringent alpine-sub alpine habitats which register near arctic severity for some part of the year coupled with high humidity all the year round, these herbs endure extremely specific ecological niches in this part of the Himalayas. Alterations in these specialised habitats are bound to be disastrous for the very survival of this precious natural resource. Cutting through the heart of our herbally rich forests and high altitude habitats for developmental programmes such as tourism and defence has altered the natural home of these sensitive species to cataclysmic proportions and caused an irreparable damage. Already a heavy toll of this wealth has been sacrificed. What is now left is difficult to tame, acclimatise, protect and conserve at newer and approachable habitats because of unique ecological requirements. The trend, if not reversed now will amount to loss of invaluable genes which are impossible to retrieve. This is the reason why over the past few years, this issue has attained highest priority at the hands of various Governmental and Scientific agencies. Van Vangun (*Podophyllum hexandrum*); Patis (*Aconitum heterophyllum*); Kuth (*Saussurea costus*); Koad (*Picrorhiza kurrooa*); Pambtsalan (*Rheum emodi*); Kahzaban (*Arnebia benthamii*); Krith (*Dioscorea deltoidea*); Dhoop (*Jurinea dolomacea*); and Kuroo (*Gentiana kurroo*) are few of such most important, extensively used and highly threatened medicinal herbs of the region. Species such as these have been identified by the DST, Govt. of India and other environment protection and nature conservation agencies as “special” and “high risk” group of plants. Their conservation and multiplication is indeed the foremost priority of the hour. There is a great need for scientific rigour not only to regenerate these vanishing species but also to create opportunities for supply of raw material to the drug industry on augmented and sustained basis. Currently 11 of the Indian medicinal plants are enlisted in the appendices of CITES which include the aforementioned species as well. Export of these herbs has been banned vide public notice number: 47PN (92-97) Dated March 30th 1994 and they have been enlisted in negative list of exports and imports policy 1997-2002 of the Govt. of India. It is apparent from this that the grim future of our medicinal plant wealth has been foreseen by various Govt. and non Govt. organisations of the country hence the imposition of legislation including the Kuth Act of J and K Govt. launched in the year 1974. Despite these protective measures at various levels from time to time to salvage this invaluable genetic resource and the country’s national wealth nothing seems to happen at the grassroots level. Exploitation of these herbs continues unabated. Apart from various Ayurvedic / Unani drug companies of the country such as Hamdard WAKF Laboratories Delhi; Dabur India Ltd. New Delhi; Himalaya Drug Company ,Banglore; Sadar Dawa Khana, Delhi; God Gift Laboratories, Faridabad etc, these herbs find multiple uses in the local medical systems and are either consumed directly or recklessly used as raw materials for extraction of active principles. The natural consequence of this is that we will lose the herbal wealth we have inherited from our ancestors leaving nothing as legacy for posterity. Realising the enormous magnitude of the problem the Department of Science and Technology, Govt. of India funded research in the Department of Botany of this University on Reproductive biology and recruitment strategies of some important and highly threatened medicinal herbs of the region. The numerous surveys and collections made by the teachers and research fellows of the Department during this period gave birth to the Medicinal Plant Reserve (MPR) here in the University. Over the years the departmental faculty has been putting considerable

efforts to further enrich the MPR by not only acclimatising the herbs transplanted here under simulated ex situ conditions but also multiplying them through seed as well as underground tubers/ rhizomes etc. Fortunately, the effort has yielded dividend and the plants have shown favourable response to the changed ecological conditions. They not only flower but also produce enough seed. This initial breakthrough encouraged us to shift from collection and acclimatisation under ex-situ conditions to their large scale multiplication back in their natural setting at Gulmarg at an altitude of 2500m where the conditions are extremely congenial for In situ conservation .Also the infra structural facilities are available for establishment of a High Altitude Medicinal Plant Reserve. The present project envisages utilising the knowledge generated about the reproductive strategies of these plants and their agro techniques at the Department of Botany, University of Kashmir for their large scale multiplication and establishment of Medicinal Plant Reserves at Gulmarg and Kashmir University.

MATERIAL AND METHODS

The germplasm of the alpine and sub-alpine species was collected in the form of seeds and vegetative propagules (Rhizomes, Root stock, bulb etc) from natural habitats of these species in higher reaches of Kashmir Himalaya. The seeds were washed with 0.1% mercuric chloride for 5-7 minutes and then with 70% alcohol for 1 minute. These were thoroughly rinsed with distilled water. After washing these were subjected to various treatments like Chilling for various duration, Hot water treatment, concentrated acid treatment, Sand paper scarification, Seed coat puncturing, Seed coat removal, GA-3 treatment etc. to enhance and accelerate seed germination and facilitate seedling survival. The results obtained in each case were compared with that of control for each species and best results were computed.

The vegetative propagules were planted in the botanical garden in fall and separated into different groups for planting under different edaphic conditions in spring. The natural habitats and environments of all the species taken up for domestication were studied in detail with respect to habitat preferences, Soil types, Soil organic matter, Soil pH (Brady, 1990; Jackson, 1973; Piper, 1966), exposure, moisture tolerance etc. in order to simulate these conditions at lower altitudes.

After establishment of the transplants at low altitudes, these were also subjected various organic (farmyard manure) and inorganic nutrients (N,P,K) in various doses in order to analyse the impact of these on productivity and yield. Different levels of exposure, irrigation, and combinations were tried to achieve success.

RESULTS

The experimental design for transplants was devised on the principal of randomisation, replication and standardisation with respect to soil type, exposure, irrigation, and nutrient application. Since the domestication of wild growing alpine species of medicinal plants is not an easy and well established process, different people advocate different approaches varying from In situ to Ex situ to In vitro methods. However, the experimental layout is also fundamental and determining factor. Since the history of medicinal domestication is very recent there is no definite method for achieving quality results in different species.

Status and usage of some important medicinal plants of commercial potential

During the last ten years, the regular field surveys and documentation has revealed an important information regarding the local herbal wealth, their usage, status and commercial potential which has been compiled. This data reveals commercial potential of the medicinal plants of Kashmir as well as illustrates the significance of establishing herbal garden for their conservation. The status of the plants was assessed by comparing the distribution pattern, density and competitive stress faced by the species, overexploitation and comparing that with the available information. The information regarding some selected plants is presented below:

The symbols used for current status are:
CR = Critically Endangered;
EN = Endangered ;
VU= Vulnerable ;
LR= Low Risk;
nt = Near threatened;
cd = Conservation dependent;
lc = Least Concern;
DD = Data deficient;
NE = Not evaluated)

DISCUSSION

The sub-alpine and other allied species acclimatize quickly and produce flowers and viable seeds shortly after transplantation. Once an introduced species completes its life cycle in the new habitat it is believed to have fully adjusted to the new environment. The completion of the life cycle by these introduced species had opened a new chapter of possibilities in the domestication of alpine and sub-alpine species. This domestication will serve two fold purposes that of conservation and sustained supply of raw material.

It is a known fact that the medicinal activity of these drug plants is essentially due to the presence of certain of active principles which in essence are secondary

Table 1. The sites surveyed during the last 10 years for collection and documentation of medicinal plant related information.

Collection Site	Altitude	Latitude/ Longitude	Direction from Srinagar
Gulmarg	2310m – 2650m	34° 04′ N 74° 20′ E	North West
Khilanmarg	2900m – 3100m	34° 04′ N 74° 20′ E	North West
Apharwat	3100m - 3300m	34° 04′ N 74° 20′ E	North West
Sonamarg	2750m – 3100m	34° 30′ N 75° 23′ E	North East
Phalgam	2850m – 4000m	34° 02′ N 75° 23′ E	South East
Shesnag	2400m – 4500m	34° 30′ N 75° 30′ E	South East
Amarnath cave	3200m – 4400m	34° 30′ N 75° 30′ E	South East
Thajwas Glacier	3800m – 3900m	34° 30′ N 75° 30′ E	North East
Ferozpur	2125m – 2150m	34° 04′ N 74° 20′ E	North West
Kokernag	2100m – 2200m	33° 36′ N 75° 20′ E	South East
Aharbal	2400m – 2450m	33° 34′ N 75° 20′ E	South West
Naranag	2450m - 2500m	34° 30′ N 75° 30′ E	North West
Yusmarg	2700m – 2900m	34° 32′ N 74° 55′ E	South West
Verinag	2800m - 3100m	33° 32′ N 75° 18′ E	South East
Barimarg	3200m – 3500m	34° 30′ N 75° 30′ E	North East
Rajouri (including Pirpanchal range, Dogra, Chandimud and Surankot)	1900m – 3800m	33° 34′ N 75° 20′ E	South West
Rayil	3200m – 3800m	34° 02′ N 75° 23′ E	South West
Zoji La, Gumri and adjoining areas	2900m – 3500m	35° 30′ N 76° 30′ E	North East
Kargil District (Drass, Karu, Pandrass, Meenamarg, Padam, Panikhar, Parakchak, Zanaskar)	2750m – 3700m	35° 04′ N 77° 20′ E	North East
Leh District (Shey, Thiksey, Choglamsar, Himis, Phyang, Nubra valley, Changthang, Chumathang, Numa, Khardung La, Khalatsi, Saspul, Lamayuru, Fotu La, Nimu)	2900m - 6400m	36° 30′ N 79° 04′ E	North East

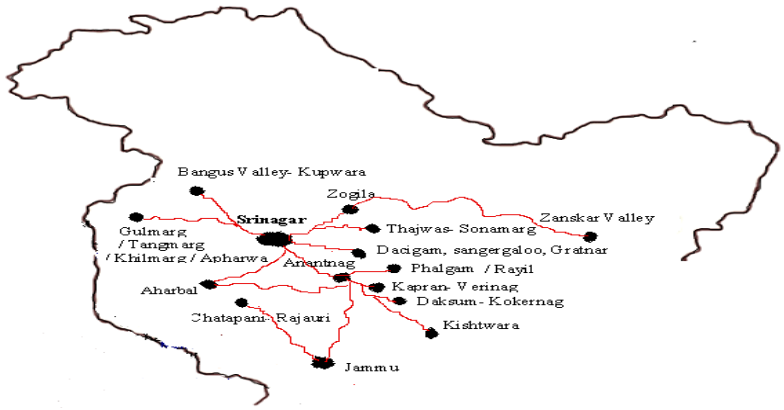

Fig 1. The alpine and sub alpine sites of Kashmir surveyed during the last 10 years for medicinal plant assessment

Table 2. Plant species collected, their status and usage

S/N	Botanical Name	Local Name	Current Status	Ethno-botanical/Medicinal Uses
1.	***Achillea millefolium***	Pahal Kutch	***VU***	The leaves and flower heads are used on inflammed gums and tooth ache
2.	***Aconitum heterophyllum***	Patis	***CR***	Generally recommended for gastric disorders and high fevers. The root powder is used against tooth ache
3.	***Althea officinalis***	Sazmool	***NE***	The extract root is used to cure urinary tract infections. It is also use against fever and cold.
4.	***Arisaema jacquemontiana***	Surp	***NE***	Considered to be toxic. The tubers are collected and chopped and used as a poultice on chronic boils and cutaneous eruptions
5.	***Arnebia benthamii***	Kahzaban	***CR***	Given against high fevers and respiratory tract infections. It is useful in heart ailments
6.	***Artemisia absinthium***	Tethwen	***NE***	The dried aerial herb is used as home remedy against roundworms, as pest repellent and against intermittent fevers
7.	***Asparagus racemosus***	Mosli	***DD***	The extract young stems and foliage is used externally to cure arthritic pains. The rhizomes are used as vegetable
8.	***Artemisia maritima***	Murin	***VU***	The leaf extract is given against intermittent and remittent fevers and also against skin eruptions
9.	***Atropa acuminata***	Meit Brand	***CR***	Root paste is applied on boils. Leaves are used in sedation
10.	***Bergenia ligulata***	Zakhmi-hayat	***Ic***	Roots reported to cure fevers, diarrhoea and cough. Root paste is used to cure wounds
11.	***Datura starmonium***	Datur	***VU***	The decoction of leaves and petals as poultice is used to cure cutaneous eruptions, as antiseptic on wounds . Seeds are used for hallucination
12.	***Colchicum luteum***	Virkum Posh	***VU***	The water extract of corms and poultice of crushed corm is used to relieve pains of gout
13.	***Digitalis lanata***	Karepate	***NE***	The drug is a known cardiac stimulant. It is also used an ornamental
14.	***Digitalis purpurea***	Karepate	***NE***	The powder of leaves is used a cardiac stimulant. The plant is also used as a source of important glucoside Digoxin
15.	***Dioscorea deltoidea***	Kreench	***CR***	The rhizomes are used as source of steroidal hormone.
16.	***Ferula jaeschkaena***	Gure Krandel	***VU***	Traditionally used to wash hair The gum resin applied to wounds and bruises .
17.	***Fritillaria roylei***	Prenik	***CR***	Bulbs are used as antipyretic, expectorant and lactagogue. It is reported to be a remedy for 80 diseases
18.	***Gentian kurroo***	Gentian	***CR***	It is used as a bitter tonic, gastric stimulant , in fevers and urinary tract infections
19.	***Heracleum candicans***	Krandel	***DD***	The root extract is used against cutaneous eruptions, sunburns and as anti-leucodermal
20.	***Hyoscyamus niger***	Bazar Bang	***nt***	Used for diabetes. Dried leaves and flowers are smoked for hallucination. Leaves are sedative, anodyne and antiseptic
21.	***Inula racemosa***	Poshkar	***CR***	The roots are antihelmintic, antiseptic, expectorant and diuretic
22.	***Junniperus communis*** ***Jurinea dolomiaea***	Junniper	***VU***	Infusion of berries used as diuretic, against cancer, indurations and polyps and as nutritive diet
23.		Dhoop	***LR***	Roots considered stimulant and antipyretic, also used in colic
24.	***Marrubium vulgare***	Tropar	***NE***	Extract of leaves is used against eye infections and skin rashes

metabolites synthesized by these herbs in response to stress conditions. However, there is always a possibility of diminished production of these secondary metabolites when the stress levels is relieved at lower altitudes or when domesticated . Recently at our centre, the active principle in Podophyllum hexandrum showed a marked decrease when cultivated at low altitudes (Beigh, et al 2001). This reduction can be attributed to the absence of stress factor under low altitude conditions. Such a decrease nullifies the gains made in domestication and large scale multiplication of the herb at lower altitudes and have bearing on the economic potential of these herbs. However, still more important and significant is the vigorous growth shown by these species at low altitudes under domestication which can to an extent compensate the reduction in the active principle. It also opens up possibilities of simulating stress conditions by means of limited irrigation, continued exposure , lesser spacing between plants as well as increasing competition by mixed culturing etc. so that the active principle levels are increased to optimum.

It may be concluded that domestication is the appropriate strategy, which can be resorted to achieve Ex situ conservation as well to generate raw material at an industrial scale so that collection and extraction pressure on the natural populations is reduced. Since there is always a possibility of drastic reduction in the active principle, domestication should always be tried at different altitudes and under different eco-edaphic conditions to harness better yields of quality for conservation as well as prosperity.

Medicinal Plant Status as per CAMP data

When the data regarding the medicinal plants was compiled and a comparison carried out with our studies and the data published after CAMP workshop on medicinal plant assessment 2003 and 2004, it showed similarity in terms of destruction of natural habitat which is continuously causing the species extinction and many important plants at present are at the risk of extinction:

Critically endangered: (CR)
- *Aconitum chasmanthum*
- *Arnebia benthamii*
- *Dactylorhiza hatagarica*
- *Fritillaria roylei*
- *Gentiana kurroo*
- *Saussurea costus*

Endangered: (EN)
- *Aconitum dienorrhizum*
- *A. heterophyllum*
- *Angelica glauca*
- *Arnebia euchroma*
- *Artemesia maritima*
- *Betula utilis*
- *Ephedra gerardiana*
- *Jurinea dolomiaea*
- *Meconopsis aculeata*
- *Picrorhiza kurroa*
- *Podophyllum hexandrum*

Vulnerable: (VU)
- *Aconitum violaceum*
- *Allium stracheyi*
- *Bergenia stracheyi*
- *Ferula jaeschkeana*
- *Heracleum lanatum*
- *Malaxis muscifera*
- *Physochlaena praelta*
- *Polygonatum multiflorum*
- *P. Verticillatum*
- *Rheum australe*
- *R. moorcroftianum*
- *R. spiciforme*
- *R. webbianum*
- *Rhododendron anthopogon*
- *R. campanulatum*
- *R. lepidotum*
- *Saussurea gossypiphora*
- *Saussurea obvallata*

Low Risk- Near threatened: (LR-NR)
- *Hippophae rhamnoides*
- *Hyoscyamus niger*

Low Risk-Least Concern: (LR-LC)
- *Selinum tenuifolium*
- *S. varigatum*

Data Deficient: (DD)
- *Ferula narthex*

Not Evaluated: (NE)
- *Inula racemosa*
- *Nardostachys grandiflora*

The data analysis and its comparison with the natural habitats revealed some basic causes of habitat destruction and species extinction which are graphically shown graphically. :At present the efforts are being made to develop specific strategies and programs so that the important and endangered above referred herbs of medicinal and commercial importance are scrutinized for their breeding systems and modes of propagation both sexual and asexual in natural populations. The important cultivation and multiplication sites have been developed at low altitude (1490m- Botanical Garden, Kashmir University) and at high altitude (2400m- Herbal Garden, Gulmarg, Kashmir) to maintain, multiply and conserve their germ-plasm using asexual (underground rhizomes, tubers etc.) and sexual (seeds) propagules. Effective agro-techniques are being developed for pilot production of these herbs using various soil types, environmental conditions and watering regimes.

Conservation and R and D measures that need to be recommended to the government, research institutes and pharmaceutical industries, NGOs and other nature conservation and environmental protection agencies for implementation are:

- Detailed understanding of the reproductive biology of the herb which will help in management of its mass

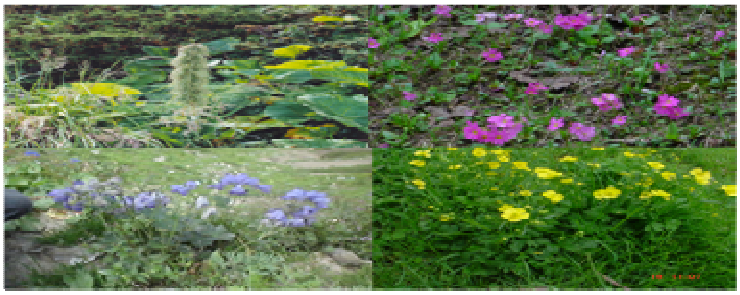

Plate 1. Dense natural Habitats of important medicinal plants- A history now?

Plate 2. Destruction of natural habitats revealing the speedy loss of species diversity

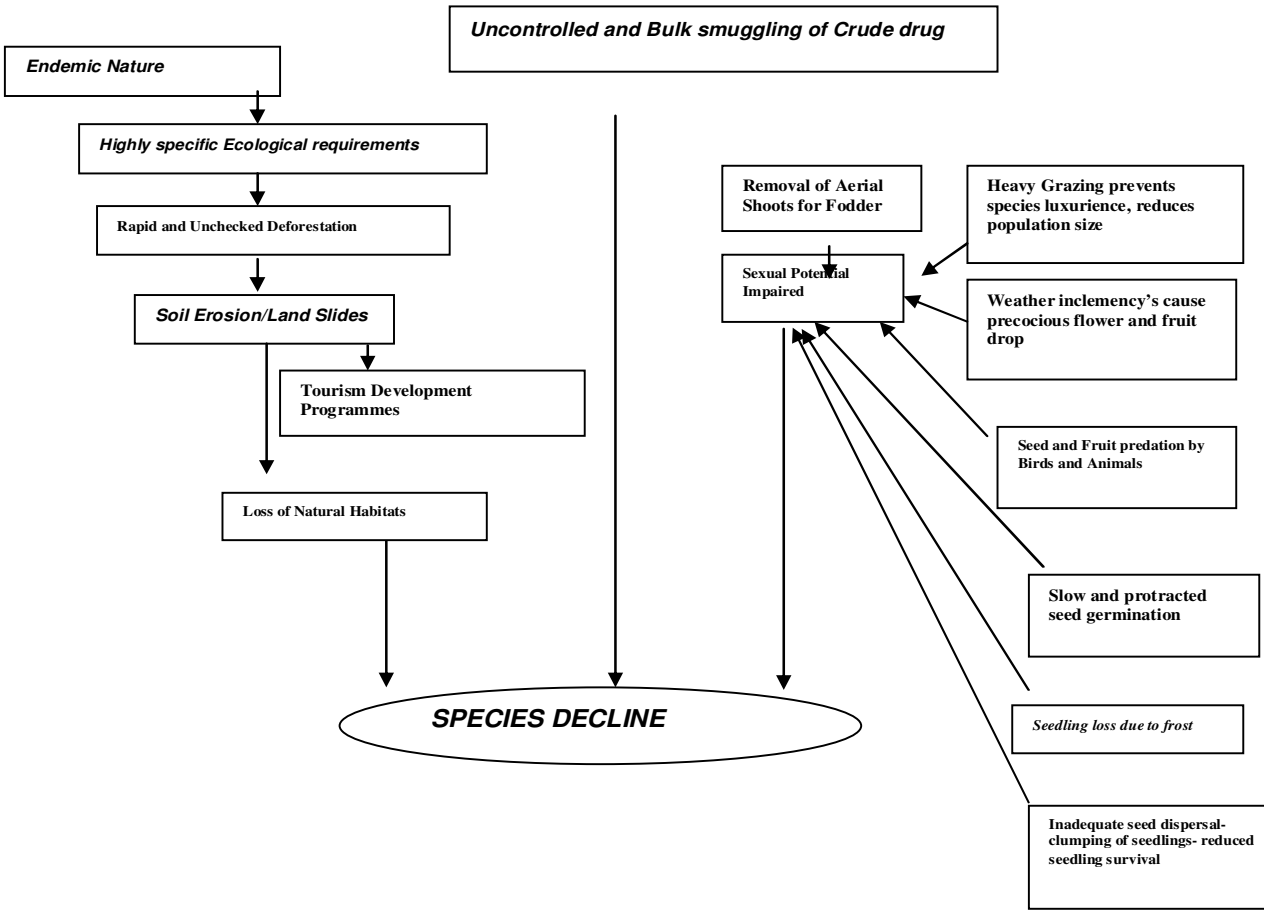

Figure 2. Graphic Representation of the Species Decline

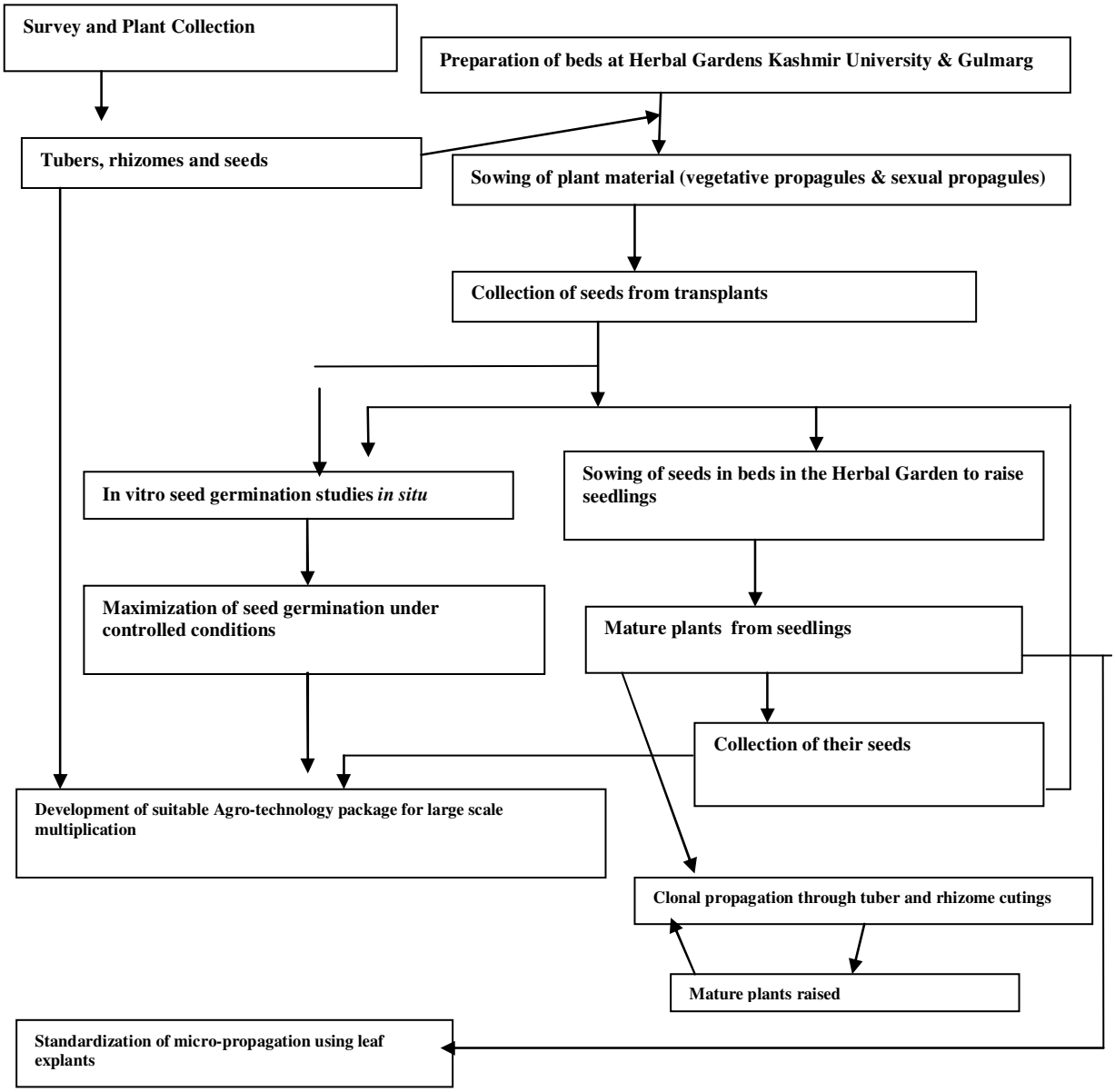

Chart 1

multiplication and conservation

- Assessment of genetic diversity across the entire northwest Himalayan range using DNA based molecular marking.
- In situ conservation, for which suitable areas in its natural habitats need to be identified, demarcated and protected as germplasm reserves. The northwestern Himalayan.
- Ex situ conservation under simulated conditions in properly managed herbal gardens and development of protocols for large scale multiplication and micropropagation.
- Development and standardization of cost effective agro-techniques for mass multiplication of the herb
- Establishment of cryo-preservation facilities
- Mass awareness through mobilization of media about ethno-botany and pharmaceutical importance of such herbs
- Imposition of legislative measures for effective control on extraction of raw material.
- Chemical documentation of the medicinal potential of the herb

CONCLUSION

The need to conserve and cultivate medicinal plants has been emphasized time and again over the last couple

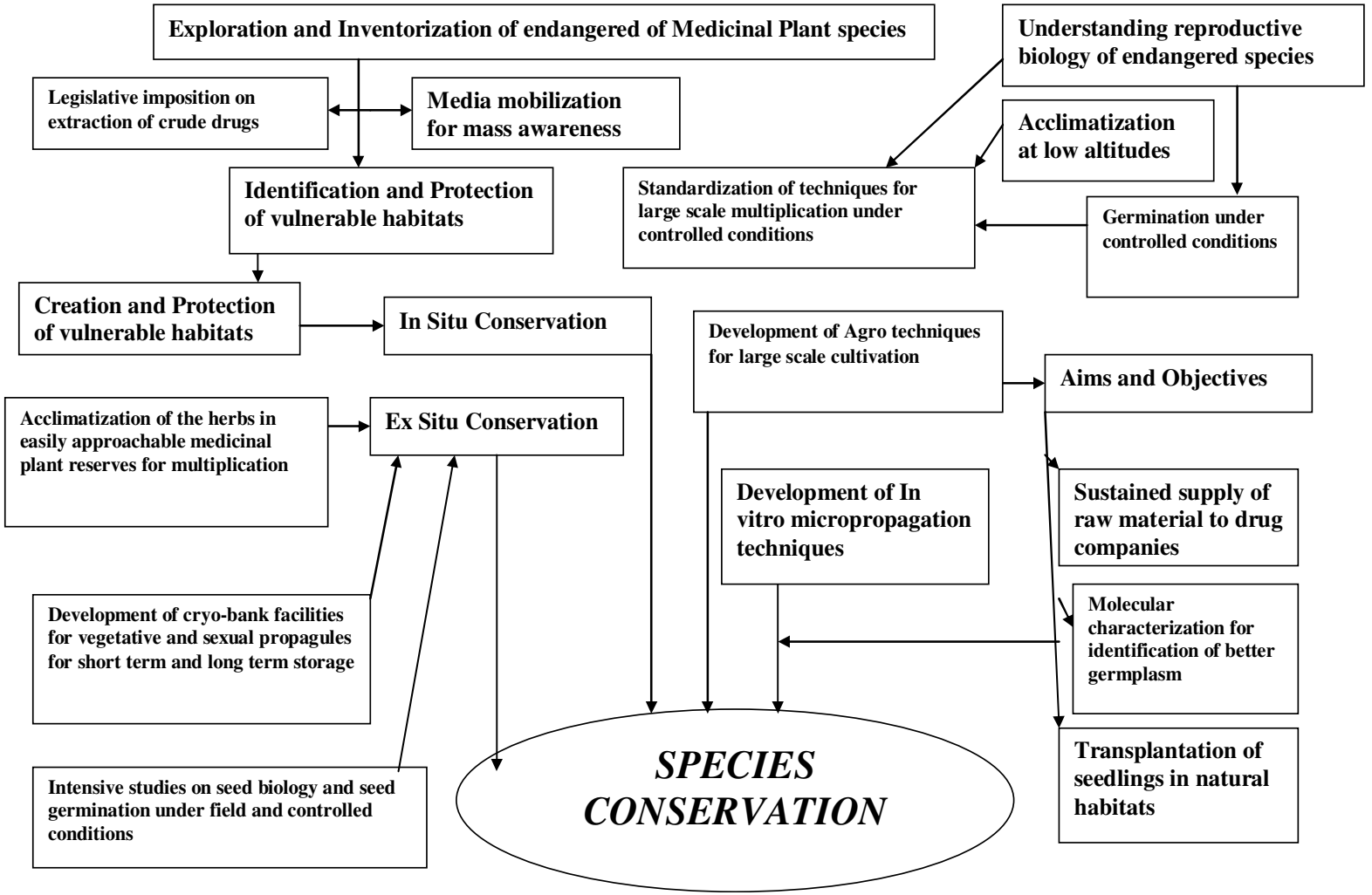

Figure 2. Graphic representation of Conservation protocol development for important medicinal plants

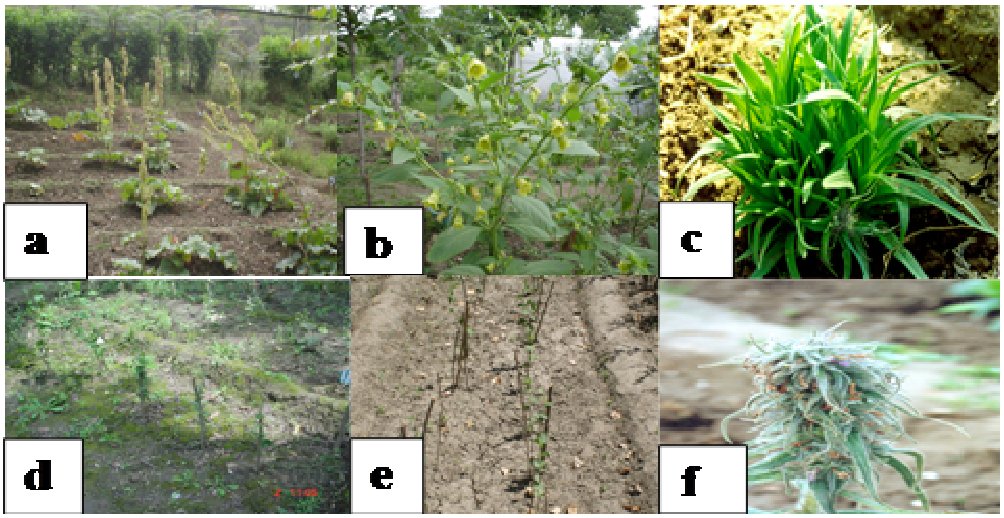

Plate 3. Standardization of cultivation practices and commercial cultivation under ex situ conditions
a. Rheum emodi b. *Atropa acuminate* c. *Arnebia benthamii* (vegetative phase) d. *Aconitum heterophyllum* e. *Aconitum chasmanthum* f. *Arnebia benthamii* (flowering phase)

decades. This is largely due to the ruthless exploitation and extraction of medicinal herbs from their natural habitats, extensive deforestation, construction activities in the vicinity of the natural abode of these herbs as well as other anthropogenic causes like grazing, collection of herbage for fodder, shifting cultivation etc. These pressures have lead to a sharp decline in the population number as well as size of important medicinal plants of the Himalayas. The presents paper analysis the approaches that could be effective in reversing this trend through domestication of these herbs at lower altitudes to meet the local demands as well as those of various drug companies for the crude drug. This will also help in creating a germplasm bank for future exploitation.

Using such methods and strategies the Medicinal plant section of the we have been able to develop a proper plan and programme which has culminated in establishment of two important sections at Srinagar and Gulmarg for domestication, conservation and commercial production of selected medicinal plants along following lines.

- Reactivate the "Kuth Act" for protection of natural wealth of medicinal Plants of Kashmir Himalayas
- Educate locals in the vicinity of dense habitats to protect the herbal wealth as well as try to domesticate these for commercial cultivation
- The Govt. and other interested institutions should provide proper guidance, financial as well as infrastructural assistance to desiring and deserving people/centres to start the commercial production of medicinal plant as well as protecting the natural wealth
- The concerned institutions should provide free education to the younger generation so that the herbal wealth of Kashmir Himalaya is protected as long as one desires
- For commercial cultivation selection of the Plant material and the desirable conditions should be drafted after proper consultation with concerned experts as well as authorities.

The whole can be summarized in the form of chart 1.

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