Utilisation of Ethnobotanical Resources and Saving the Declining Biodiversity in Tropical Wet Evergreen Forests of India

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Abstract

The present study on ethnobotanical resources of India, their utilisation patterns in tribal dominated areas, and ex-situ and in-situ conservation revealed possible sustainable approaches to save declining biodiversity. In India, tribes of five major regions adopted different usage patterns of the botanicals. While tribes of northeastern region used more herb species, western Indian tribes would prefer more tree and shrubby species; southern region's usage pattern targeted tree and herb species more or less equally. One interesting aspect of natural way of conservation of ethnobotanical resources by tribal communities became evident in different methods of harvesting which would ensure steady perennation of a species. In-situ and ex-situ conservation aspects of ethnobotanical resources under a natural ecosystem, a partly simulated ecosystem, and a conservation organised agrarian system indicated that some target species like *Rauvolfia serpentina, Withania somnifera,* and *Gloriosa superba* would survive very well under monoculture agrarian approaches and under mixed culture systems with botanicals like *Costus speciosus, Digitalis purpurea* and *Aloe barbadense,* although growth was restricted in the latter case. Use of umbrella species like *Emblica officinalis* and *Alstonia scholaris* helped partially in the performance of the target species. Economics of cultivation of all the species under agrarian system in in-situ and ex-situ conditions revealed possibilities of their commercial exploitation to a varying level of success. And lastly, target species like *Andrographis paniculata, Dioscorea prazeri, Bacopa monnieri* and *Centella asiatica* could better flourish in natural ecosystem under in-situ conditions and the conservation and cultivation of these species under controlled cultural practices did not prove to be economically feasible under ex-situ.

INTRODUCTION

With 3029 millions hectares land mass (2.46 % of global land mass) and 75.17 million hectares of forest coverage, India exhibits a wide range of climatic and topographic variations, embracing 8 % of the estimated biodiversity of the World. Of total 3500 medicinally important flowering plants in tropical India representing about 40 % of total flowering plants in this region, 300 medicinally important species have become rare and endangered. Tribal population in India is about 60 million that is 6 % of total Indian population. These tribes have developed a highly complex and very specific knowledge of nearly 2000 species of ethnobotanical interests and have practical understanding of the ecological relationship between human societies and their environment. They do not generally disturb the delicate forest ecosystem and have developed their own methods of conserving botanicals that are at the verge of extinction (Pushpangadam, 1995).

In the present study, utilisation patterns of ethnobotanical resources by tribal community of India in general and northeastern Himalayan region in particular (which accommodates nearly 50 percent of total tribal community of India) have been highlighted. Extensive field study of the Eastern Himalayan, tropical wet, evergreen forest region, accompanied by study of herbaria, museum material, published literature have provided considerable amount of data for analysis. The declining of biodiversity in tribal inhabitated regions was evident and saving the declining ecosystem by preservation of ethnobotanicals under in-situ and ex-situ conservation and/or conservation by

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organised agrarian system has been the main thrust of the study.

MATERIALS AND METHODS

Utilisation of Ethnobotanical Resources

A ten-year (1990-2000) period of study of ethnobotanicals in northeastern wet evergreen forest ecosystem was conducted by systematically enumerating the ethnobotanicals of all morphological forms (tree, shrub, herb, climber/creeper) in conjunction with field visits, aided by examination of herbaria and gathered knowledge of the tribes inhabiting the region (Pal & Jain, 1998); once every two years. In another study, nearly 14,000 ethnobotanical plants: 3000 trees; 3750 shrubs; 6750 herbs; 225 creepers/climbers were planted in 2 five hectare fallow plots (Plot A & Plot B). Plot A was located amidst natural forest ecosystem of a tropical, wet, evergreen forest. Plot B was located about 20 km from the former study area with more less comparable topography and ecology, and remained fallow for 5 years under *Crotalaria.*

Seedlings of botanicals raised in a nursery the previous year were planted in both plot A (in-situ) and plot B (ex-situ) at predetermined spacing. No cultural treatments were given and the plantations flourished under rain-fed conditions and remained in exclusion. Survival of perennial species was followed every six months to the tenth year (1990-2000). In the case of annuals, crops were raised every year, the first by broadcasting the seeds and in subsequent years from self sown seeds. Survival data of annuals were taken during appropriate months, when a particular species self-senesced. Climate and topographic conditions were humid with high summer temperature (38 °C-44 °C) and a short duration winter (Dec-Jan) with minimum temperature 8 °C-15 °C; soil was generally fertile with acidic pH; annual rainfall between 380 - 450 cm.

Declining biodiversity of ethnobotanicals was studied under in-situ environment for 10 years in five regions of tribal habitation. The number of ethnobotanical species in central and eastern zone, western and northwestern. zone, northeastern zone, southern zone and Oceanic Islands were identified along with the tribal concentration. Ecologically threatened botanicals in these regions were located for their utilisation pattern study.

Conservation of Ethnobotanicals

To study conservation of ethnobotanicals, about 25 hectares of clear felling land (5-hectare plot total 5 plots) of the North Bengal (NE region) was selected. The plot was about 60 km from eastern Himalayan wet evergreen tropical forest belt, with some ground flora of annual and perennial herbs and shrubs of *Cymbopogon, Adhatoda, Calotropis* and *Cassia* species.

1. Ex-Situ Studies. For the study about 10 hectares of clear felling land (5 hectare total 2 plots) of North Bengal (N.E. Region) was selected, about 60 km off from Eastern Himalayan wet evergreen tropical forest belt, with some ground flora of annuals/perennials of *Cymbopogon, Adhatoda, Cassia.*

In the studies, four tree species *(Alstonia scholaris, Terminalia belerica, Emblica officinalis, Terminalia indica),* four shrub/herb species *(Vitex negundo, Casia angusti-folia, Costus speciosus, Andrographis paniculata)* and one climber *species (Tinospora cordifolia)* of ethnobotanical values received particular attention. The habitat patterns of these species were identified in natural ecosystem and were simulated, as far as practicable. Saplings were raised from seeds where necessary; from rootstock cuttings, and in some cases, from tuber/rhizome pieces. The germplasm nursery was made ready in 1990. Survival data, growth data of saplings of nursery and of annuals, perennials and tree species were recorded at interval of three months. While selecting the saplings of individual species for ex-situ plantation, morphological and active principle variants (Indian Pharmacopoea, 1955) were studied and more or less uniform variants used. Performance data were monitored and total biomass yield of annual/biennial herbs, shrubs and climber species; and of trees, (foliage/branching intensity; girth of main trunk) were recorded. From second year onwards, statistically selected, good performing plants (of

perennials) were kept in a data collection process every half year and continued until the final data at the end of first year (annuals), second year (biennials), and nine years (perennials).

2. In-Situ Studies. In-situ studies included the same species from the nursery stock, but plantings were made in tropical wet evergreen forest ecosystems at the Eastern Himalayan foothills in two 5 hectare plots. The area selected did not have any felling activities during past 10-12 years (prior to 1990) and accommodated sporadically distributed, naturally regenerated economic and ethnobotanically important tree species *Melia, Alstonia, Saraca,* shrubs like *Artemisia, Solanum, Datura,* and herbs like *Rubia, Boerrhavia* and climbing species of *Dioscorea* and *Gymnema,* representing 6-10 % of mixed vegetation.

3. Conservation Methods by Tribes. Tribal communities in general adopt very restricted and selected harvesting methods and timing of biomass collection of ethnobotanical plant and plant parts are very carefully chosen. All these steps ensured a continued perennation of individual plants. In a separate study to correlate the levels of contents of active principles in harvested botanicals by tribes along with the contents in plant/parts during other developmental stages, total active principle contents were determined in the harvested plant and plant parts

4. De-Novo Conservation by Agrarian Methods in Ex-Situ & In-Situ Environment. Denovo ex-situ and in-situ conservation study was conducted by cultivating the species in North Bengal barind region (one 5 hectare plot) as well as foothill regions of tropical wet evergreen forest eco-system (one 5 hectare plot, a portion shallow wet) of N.E. India. Each species covered one hectare land and saplings were collected from germplasm nursery and ecophysiographic and topographical conditions of the cultivating area were identical. Both agrarian ex-situ and in-situ cultivation received necessary agro-technological inputs (Chatterjee, 2001). In ex-situ agrarian approaches, mixed and mono-culture of botanicals were included; under conditions of both with or without umbrella species of ethnobotanically important trees. Simulation of growth conditions under natural forest environment was created, as far as practicable. The agrarian cultural studies also covered the aspects of cost factor, yield factor, and financial returns for determining the cost/benefit ratio. Denovo in-situ agrarian conservation study' included two forest ecosystem variants:

(a) Tropical wet evergreen forest ecosystem, lying fallow for 3-4 years to study the target species *Andrographis paniculata* and *Dioscorea prazeri* (1 hectare each).
(b) Tropical wet evergreen forest ecosystem with water-logged shallow areas in which two one-acre plots with targets species *Bacopa monnieri* and *Cantella asiatica* that had been raised from stolons and planted 10-15 cm apart. Crops required 80-100 days to mature and naturally-dried whole herb was used to indicate the yield of biomass (1 hectare + 1 hectare).

RESULTS

Utilisation of Ethnobotanicals

Computing the data collected biannually for ten years and summarising morphological formwise (Table 1), it was revealed that herbaceous botanicals declined nearly 2.4 % shrubby botanicals declined nearly 2 %, and tree species declined nearly 1.9 %. Further, it was revealed (Table 2) that under simulated and planted in-situ conditions, survival percentage of ethnobotanicals was higher as compared with ex-situ conditions. In both in-situ and ex-situ conditions, and more so under ex-situ, shrubs/herbs species exhibited higher decline percentage, followed by climber/creeper and tree species (Table 2). Studies conducted in different tribal dominated regions revealed some distinct patterns of utilisation of ethnobotanical resources (Table 3). While North Eastern tribals showed higher usage of annuals/biennials, Western and North Western tribes preferred to use more of trees and shrubs. South region tribals were higher users of shrubs and climbers/creepers whereas Central and Eastern region tribes used all the four morpho-

logical forms. Tribals of Oceanic islands, were rather more conservative in use of ethnobotanicals allowing the species to remain in static form. Data also indicated that of 3.7 % of the total threatened species, nearly 38 % botanicals have become rare by overuse by the tribals and nearly 62 % of threatened species, due to factors of demographic stochasticity, environmental stochasticity and genetic stochasticity and to be more specific, due to eco-disturbing factors like habitat loss, habitat destruction, agriculture, urbanisation and other human factors.

Conservation of Ethnobotanicals

For conservation and sustainable use of ethnobotanicals tribes select time, methods and proper seasons for collection of medicinal plants. Tribes practice specific harvesting methods *(Amorphophallus)*, restricted peeling (*Saraca*), restricted plucking *(Asparagus)*, or give preference on specific harvesting period. All these processes revealed the fact that the main thrust of tribes had been directed to save the plants from unfruitful waste by destruction. Tribes preference of a specific harvesting period had been substantiated by occurrence of higher active principle contents as compared to other period harvest (Table 4) in ethnobotanicals like *A paniculata, D lanata, A. majus* and *R. serpentina.*

In regards to conservation in ex-situ and in-situ conditions (Table 5) survival percentage (as well as growth vigour) of tree species like *Alstonia* and *Emblica* in ex-situ, was shown to be higher by 10-15 %; however in in-situ conditions, *Terminalia* and *Tamarindus* showed higher survival (by about 8-10 %) with significantly better overall growth vigour. The shrubby species like *Costus* could better survive under in-situ whereas species like *Vitex* and *Cassia* flourished under ex-situ. In general for shrubby species, growth performance was better in ex-situ conditions. Herb species like *Andrographis* conclusively preferred in-situ conditions for higher survival (nearly 90 %) and better growth. In *Tinospora*, survival and growth vigour were more or less comparable in ex-situ and in-situ (Table 5).

Denovo ex-situ conservation by agrarian mono and mixed culture (Table 6) revealed that mixed culture reduced survival percentage marginally in *Rauvolfia*, but significantly in *Gloriosa.* The yield factor, although reduced, was not very significant and permitted cost/benefit ratio to be determined for both monoculture and mixed culture species (Table 6). Cost benefit ratio was highest in *R. serpentina* under monoculture and with mixed culture in *R. serpentina* and *C. specious* combination. In mixed culture, accompanying species could be grown successfully along with target species with a fairly good recovery of active biomass. Economics of cultivation revealed a shared but satisfactory cost benefit ratio.

Under ex-situ conservation, all three species *(C. speciosus, C. roseus* and *A. barbadense*) had shown fairly high survival percentage, good growth and yield of utilisable biomass. In *Catharanthus* and *Aloe*, growth performance and yield were maximum without umbrella species whereas in the case of *Costus*, use of umbrella species like *Cassia tora* had imparted enhanced growth performance of the target species and yield of rhizome was also significantly higher (Table 7). Cost of cultivation up to harvesting stage was highest in *Aloe* and comparatively lesser in *Costus.* Cost benefit ratio was highest in *Catharanthus* and significantly less in *Aloe.* In general terms, use of umbrella species did not improve the performance parameters of target species; excepting combination of *Costus/Cassia* and of the three umbrella species, C. *tora* proved to be of maximum utility followed by *E. officinalis.*

In in-situ denovo agrarian conservation under tropical wet evergreen forest ecosystem (fallow and waterlogged), survival percentage was satisfactory excepting *Centella asiatica.* In-situ conservation of the species proved congenial to the plants with average 50 – 70 % yield benefit *(Andrographis* and *Dioscorea)* and about 30 – 40 % yield benefit *(Bacopa* and *Centella)* over ex-situ agrarian method. Cost benefit analysis revealed good returns; particularly in two target species, *Andrographis* and *Dioscorea* (Table 8).

DISCUSSION

Studies revealed that declining ethnobotanical biodiversity as a result of varying usage patterns by tribal communities of different regions of India could be partially sustained. Studies also demonstrated the tribes were committed to means of harvesting methods that ensured a natural conservation process, thus pointing out the fact that tribes could be considered as living tools for sustainable perennation of their medicating species. In-situ and ex-situ conservation of ethnobotanical resources under natural ecosystem, partly simulated ecosystem and conservation by organised agrarian system, indicated that while target species would well survive under monoculture agrarian approaches mixed culture with other targeted botanicals could also be grown. Use of umbrella species would also provide partial success in conservation of target species. Economics of cultivation of some targeted species under agrarian system in in-situ and ex-situ conditions revealed possibilities of their commercial exploitation to a varying level of success. And lastly, some target species would better flourish in natural eco-system under in-situ conditions and their ex-situ agrarian culture would not be economically feasible.

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Tables

Table 1. Declining biodiversity of ethnobotanicals in India (1990-2000).

Year	% Occurrence			
	Trees	Shrubs	Herbs	Climbers/Creeper
1990	8.36	9.40	10.26	2.35
2000	8.20	9.20	10.00	2.25
% decline during the period	-1.91	-2.12	-2.53	-2.29

Table 2. Ex-situ and in-situ survival of ethnobotanical plants under Tropical wet evergreen forest ecosystem (ex-situ fallow; in-situ forest ecosystem).
Area: 5 hectare plots: Period: 1990-2000 Total mixed planting: 14000.

Method of Conservation	Planting – 1990 (%)			Rate of Survival – 2000 (%)		
	Trees	Shrubs	Herbs/ Climbers	Trees	Shrubs	Herbs/ Climbers
Ex-situ	8.00	14.25	4.10	6.00	8.50	1.50
				(-2.00)	(-5.75)	(-2.60)
In-situ	8.60	13.80	4.30	8.00	11.80	3.50
				(-0.60)	(-2.00)	(-0.80)

(figures within parenthesis indicate % decline of survival)

Table 3. Decline in ethnobotanical plants in tribal predominated five regions (1990-2000).

Tribal regions &	Tribals	Threat	decline (-) of ethnobotanical flora (%)			
Ethnobotanical sp.	(%)	Species	Trees	Shrubs	Herbs	Climbers
Central and Eastern (640)	58.10	17	-0.81	-1.23	-0.55	-0.90
North Eastern (535)	17.80	12	0	0	-0.40	-0.33
West & N West (401)	29.50	19	-1.60	-2.80	0	0
Southern (34)	5.40	11	0	-0.17	0	-1.22
Oceanic Islands (11)	0.12	2	0	0	0	0

Over use: 23 spp Eco-system disturb: 38spp

Table 4. Active contents during harvesting stages by tribes or during other stages.

Species (active content)	Harvest by tribes (% content)	Other period harvest (% content)
A. paniculata (Andrographolide)	Active flower stage (L 3.80)	Post flower stage (L 2.90)
D. lanata (Total glycosides)	Active fruit stage (1.10)	Active flower stage (L 1.00)
A. Majus (Xanthotoxin)	Early fruit (Green fruit 0.90)	Late fruit (Ripe fruits 0.77)
R. serpentina (Total alkaloids)	Late fruit stage (R 2.10)	Early fruit stage (R 1.80)

L – Leaves R - Roots

Table 5. Conservation of ethnobotanicals (ex-situ & in-situ) in tropical wet evergreen ecosystem of trees (1990-2000), shrubs (1996-2000), herbs (1998-2000).

Species	Planted		% Survival		Growth Vigour	
	ex-situ	in-situ	ex-situ	in-situ	ex-situ	in-situ
A. scholaris	140	160	63.6	53.0	+++	++
T. belerica	200	200	63.0	70.0	++	+++
E. officinalis	200	200	93.0	80.0	+++	++
T. indica	200	200	62.0	70.0	++	+++
V. negundo	175	160	71.4	43.1	+++	++
C. angustifolia	250	300	48.4	26.6	++	+
C. speciosus	210	200	71.9	90.0	+++	+++
A. paniculata	600	500	37.0	89.6	+++	+++
T. cordifolia	150	140	52.6	49.8	++	++

+++ Good growth ++ Average growth + Poor growth

Table 6. Ex-situ denovo agrarian conservation of ethnobotanicals (mono and mixed cultures) (Umbrella *E. officinalis* and *C. tora*).

Culture Mode	Target Species	Accompanying Species	Population Density/Ha	Survival %	Yield MT/ha	Cost:Benefit ratio
Mono Culture	*R. serpentina*	---	50,000	70	1.75	1:3.75
	W. somnifera	---	46,000	65	1.25	1:0.50
	G. superba	---	40,000	72	0.38	1:0.54
Mixed Culture	*R. serpentina*	*C. speciosus*	25,000 (+25000)	68/75	0.81/3.75	1:1.85/1:0.90
	W. somnifera	*D. purpurea*	22,000 (+22000)	55/64	0.43/2.75	1:0.38/1:0.80
	G. superba	*A. barbadense*	18,000 (+25000)	44/52	0.18/3.80	1:0.35/1:0.15

L.S.D at 5% level : yield – 0.08

Table 7. Ex-situ de-novo agrarian conservation of ethnobotanicals (-/+ umbrella).

Target species (TP)	Umbrella spp (UP)	% survival (TP)	Yield MT/Ha (TP)	Cost Cult.	USDA/Ha Harvest	Cost/Ben ratio
Costus speciosus	*Emblica* sp	69	8.0	535	305	1:0.80
(rhizomes)	*Cassia* sp	70	12.0	500	300	1:1.40
	Alstonia sp	62	8.5	540	310	1:0.85
		75	10.5	510	300	1:1.30
Catharanthus	*Emblica* sp	65	1.8	1410	680	1:0.53
roseus (leaves)	*Cassia* sp	76	2.2	1400	620	1:1.65
	Alstonia sp	68	1.8	1430	680	1:0.52
		82	2.5	1460	670	1:1.90
Aloe	*Emblica* sp	70	9.5	3480	1600	1:0.18
Barbadense	*Cassia* sp	72	10.2	3200	1590	1:0.20
(leaves)	*Alstonia* sp	69	9.0	3550	1610	1:0.15
		79	11.0	3250	1630	1:0.30

L.S.D at 5%, yield - 0.25

Table 8. In-situ denovo agrarian conservation of ethnobotanicals under tropical wet evergreen forest ecosystem.

Forest ecosystem	Target sp.	Population/ ha	Survival (%)	Yield /ha	(+) over ex-situ agrarian	Cost: benefit ratio
Fallow	*A. paniculata*	53,800	70	3.6	(+) 65-70	1:1.80
Fallow	*D. prazeri*	48,600	78	8.2	(+) 55-60	1:1.65
Watershallow	*B. monnieri*	38,500	75	0.17	(+)40-45	1:0.65
Watershallow	*C. asiatica*	43,700	62	1.6	(+)35-40	1:0.70