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Economic valuation of extractive conservation in a tropical deciduous forest in Madhya Pradesh, India

SEEMA PURUSHOTHAMAN, S. VISWANATH & C. KUNHIKANNAN

Tropical Forest Research Institute, Mandla Road, Jabalpur - 482021, Madhya Pradesh, India

Abstract: Incorporating locally prevalent extractive uses of a natural habitat into valuation methods may be appropriate in improving the efficacy and objectivity while justifying preservation. The consequences of a change in the marketing structure of medicinal plants caused by forest clearance for a multipurpose hydroelectric project across the river Narmada in the state of Madhya Pradesh was evaluated. Major loss of realizable pharmaceutical value in the submerged zone of a tropical dry deciduous forest upholds the relevance of sustainably managed conservation option over a development option with irreversible changes. Various costs and benefits relevant to the problem are quantified and compared. Multiplicity of benefits and economies of scale associated with *in-situ* preservation in a local economy offset the net benefits projected in the development option mainly due to shortfalls in targeted benefits and compensatory afforestation.

Resumen: Incorporar localmente los usos extractivos actuales de un habitat natural en los métodos de evaluación, puede ser apropiado para mejorar la eficacia y efectividad mientras se justifica la conservación. Se evaluaron las consecuencias de un cambio en la estructura de mercadeo de las plantas medicinales, causadas por el aclareo del bosque para un proyecto hidroeléctrico a través del río Narmada en el estado Madhya Pradesh. Las pérdidas mayores del valor farmacéutico en la zona sumergida de una selva baja caducifolia, resaltan la relevancia de la conservación con manejo sostenible sobre la opción del desarrollo con cambios irreversibles. Se cuantificaron y compararon varios costos y beneficios relevantes al problema. La multiplicidad de beneficios y su valor económico asociados con la conservación *in situ* en una economía local, compensan los beneficios netos proyectados en la opción de desarrollo.

Resumo: A incorporação dos usos prevalecentes quanto a produtos extractivistas do meio natural nos métodos de availação podem ser apropriados na melhoria da eficácia e objectividade necessária para a preservação. As consequências de uma mudança na estrutura do mercado das plantas medicinais, causada pelo abate florestal que resultou do projecto hidroeléctrico de fins múltiplos no rio Narmada, no Estado de Madhya Pradesh, foram avaliadas. Encontrou-se uma perda substantiva do valor farmacêutico realizável na zona submersa da floresta tropical seca decidua que confirma a relevância da opção pela gestão sustentada da conservação em confronto com a opção de desenvolvimento com mudanças irreversíveis. Os vários custos e benefícios relevantes para o problema foram quantificados e comparados. A multiplicidade dos benefícios e economias de escala associadas com a conservação *in situ* na economia local compensa os benefícios líquidos projectados na opção de desenvolvimento devido, principalmente, à quebra dos benefícios visados e à florestação compensatória.

Key words : Biodiversity, cost-benefit analysis, economic appraisal, *ex-situ* conservation, hydroelectric project, *in-situ* preservation, tropical dry deciduous forests.

Corresponding author : S. Viswanath, Institute of Forest Genetics and Tree Breeding, Forest Campus, R.S. Puram, Coimbatore - 641002, Tamil Nadu, India; (E-mail : ifgtb@satyam.net.in)

Introduction

The concern to slow the increasing rate of extinction of species has somehow bypassed a comprehensive outlook on ecosystem preservation. Since the rates of speciation and extinction in the natural environment is interrelated as well as linked with evolution and destruction of habitat ecosystems, conservation of biological diversity may be regarded as the fundamental basis for ecologically sustainable development. There may also be a rational argument for ecosystem preservation over and above mere captive protection of rare and endangered species due to economies of scale. In the current global scenario, the present case study seeks to improve decision making in contexts of economy-environment conflicts by improving the efficacy of existing tools to establish economic justifications for habitat preservation with the support of empirical evidence. It attempts at a comparative evaluation of *in-situ* preservation and *ex-situ* conservation methods. The *in-situ* preservation can maintain a critical level of biodiversity on which the viability and sustainability of natural ecosystems depend. This does not underestimate the dependence of conservation efforts on *ex-situ* lines when required, as in the case of intraspecific breeding for conservation and in circumstances like a natural calamity or oil spill triggering rapid deterioration of habitats.

To decide whether an area is to be preserved as a landscape intact with its biotic and abiotic components or altered by development, a comparison is required between economic risks in the former and environmental risks in the latter option. This requires a comprehensive monetary valuation taking into account possible alternatives specific to the location. Location specificity needs to be reflected in valuation since in any protected area there seems to be one or two prominent realisable values overcasting others. To realize one kind of value it often becomes imperative not to exploit others (e.g., conserving a wildlife habitat preventing extraction of other forest products). Species to be conserved are usually chosen after evaluating their genetic and economic peculiarities, natural functions in the ecosystem and success rate in conservation efforts. Choosing the means to preserve them on the other hand involves relative merits and costs of alternative methods (Montgomery *et al.* 1994). Though there are several methods of *ex-situ* conservation like germplasm/gene banks and arboretum etc., the maintenance cost may be exhorbitanatly high. For instance Ashton (1981) has worked out that the average annual maintenance cost of a plant in an arboretum comes to 64$. If the opportunity cost of land is not very high, *in-situ* preservation as perceived in this context for sustaining the habitat may appear as a less costlier option. More over it has also been shown that preserved areas can generate sustainable income to meet preservation expenditure (Blum 1993).

There are about 1500 to 2000 species with known medicinal worth in India which support an estimated 5000 indigenous drug manufactures, which make about 2000 preparations in different parts of the country. It is believed that 80% of the raw material requirement is met from the forests only (Chopra 1994). Indigenous drugs are just one among the many products derived from tropical forests. In the study area extracting medicinal herbs has been a prominent occupation for the indigenous people though their profit margin in this trade may not be comparable to the margins pocketed by middlemen and the pharmaceutical industry. According to Ministry for Environment and Forests (Nath 1994), the market value of allopathic medicines alone derived from plants was over 43 billion $ annually out of which less than 0.01% of profits has gone to the indigenous people who led the researchers to them.

Considering all these, the study was conducted with the following objectives : (1a) Compare *in-situ* preservation (IP) and *ex-situ* cultivation (EC) stemming from a developmental activity; (1b) Hypothesize $(B_{IP})/C_{IP}) > (B_{EC})/C_{EC})$, where IP : *In-situ* preservation, EC: *Ex-situ* conservation. B: Benefits, C: Costs; (2) Work out the net present value (NPV) of IP and EC; (3) Work out NPV of TNBD (Total Net Benefit of Development) per unit command area and NPV of IP per unit area of wilderness lost; (4) Calculate the environmental costs per hectare of command area.

Materials and methods

Conceptual issues

In the context of an irreversible change in a habitat ecosystem (in this case submergence due to damming of a river) the traditional popular use of forests in the region which is extraction of herbal raw materials, is taken as the major lost value of biological diversity. The two options of sustaining the supply of medicinal herbs considered are: (1) Scientifically managed extractive conservation (*in-situ*) which is crucial irrespective of the development or submergence option, and (2) A low cost multiplication of needed plants through cultivation (*ex-situ*) which is the next economically feasible alternative.

The alternative of multipurpose hydroelectric project to *in-situ* preservation should be scrutinised, keeping in mind its long gestation period. In the long run for irrigation project, a pattern of rising yield is generalised followed by a breakdown and a costly rehabilitation process in the aftermath (Barrow 1991). The study is designed to learn from a *post-ante* evaluation scenario so as to identify a reasonable approach to valuation in developmental decisions. *In-situ* preservation and *ex-situ* cultivation are compared in the backdrop of a developmental activity, using the tools of present worth and unit cost benefit ratio, ultimately aiming at a model which is operationally viable, technically feasible and objectively realistic. It may also enable us in estimating the end market value of the local use of species richness.

A model without too many loopholes is difficult to arrive at because a comprehensive approach risks duplication of values while a specifically focussed model tends to exclude other social costs. Floral diversity involves non-market values that are closely interwoven with market values. Economic rationale for efficiency suggests incurring lower costs by providing collective protection harvesting the economies of scale. When individual species become confined to captivity as in the case of *ex-situ* conservation of individual species, the aesthetic value that the species provides as a part of its natural habitat declines. Also the direct economic significance of a species to a dependent population is lost as the stocks deplete.

An economic appraisal of the consequences of a change in the marketing structure of pharmaceutical plants caused by a development project is expected to reflect major lost realizable economic value in the submerged forests of the tropical dry deciduous tracts taken for study. The location has proven potential for medicinal herbs and their collection has been going on in the past, though in an unorganized manner. There is still vast untapped potential for developing drugs from wild plants occurring in tropical forests. The irreversibility of wilderness development has already been treated explicitly in present value estimation in a continuous time frame (Krutilla & Fisher 1975). Present value estimates for evolving an optimal strategy to preserve mangrove forests have also been worked out (Ruitenbeek 1994a). Studies involving (Templet & Stephen 1994) multivariate methods to empirically analyze economic welfare in a polluted environment have been attempted elsewhere. The lacunae in research efforts are glaring not only for a comprehensive audit of river valley projects, but also for establishing the dichotomy between pre-construction projections and post construction realities (D'Souza *et al*. 1998). A method to evolve an operational model for such empirical analysis of economic welfare where conflicting preferences complicate decision making is explored in the present study.

Study site

The study site is located near Jabalpur in the central Indian state of Madhya Pradesh. In order to build the biggest hydro electrical project in this state, across the river Narmada at Bargi, 8478 ha of tropical forests were cleared with the objective of deriving huge benefits in terms of irrigation, power and fisheries. Construction of the dam (Rani Avanti Bai Sagar Pariyojana - Bargi) commenced in 1971. Apart from one of the two irrigation canals, the project is nearly complete. Located 43 km away from the town of Jabalpur, its catchment area stretches to 14556 km^2. Length of the dam comes to 827 m with a height of 427 m. The total submergence area is 30860 ha, of which 8478 ha were considered forests. Full storage capacity of the dam is 3920 million m^3. It has an envisaged annual irrigation potential of 219,800 ha, of which 18000 ha have been achieved so far. Electricity generation was started in 1986. The project has so far displaced 5475 families (Govt. of M.P. 1994). The submerged forests can be classified as belonging to the category of tropical dry deciduous forests (Champion & Seth 1968). The study area receives an annual rainfall of 1200 mm, with undulating topography and soils, which are mostly alluvial, deep and liable to erosion. The Tropic of Cancer passes almost through the middle of the area. Situated at the junction of Vindhya and Satpura mountain ranges, the region forms part of the Great Central Indian Watershed.

It was visualized that nearly three times the area of the submerged forestlands would be afforested and the displaced villagers would be adequately rehabilitated with handsome compensation. However, at present the disenchanted oustees are still agitating for a better deal even after a decade of displacement. Instead of an initially estimated 101 villages, 162 villages together with 26 resettlement sites came under the submergence zone (Silvy & Patidar 1998). The impressive targets in terms of expected benefits were thought to justify the ecological disturbances and displacement of human settlements.

Tropical dry deciduous forest tracts comprise nearly 30% of the geographical area of Madhya Pradesh (which incidentally is the state with the largest area under forests in India) and make up about 28.6% of total forest types found in the country. Forests in this central belt are home for majority of the 15.4 million indigenous population. Development policies have obviously interrupted their dwelling habitats and forced them to either intensify their prevailing efforts to eke out a living or forced them to migrate to cities in search of labour. The forests in the region, regarded as a treasure trove of medicinal plants, collection of plant parts has been a major occupation (Mishra 1994). Recent establishment of a multipurpose hydel project submerged nearly 8500 ha of such forestland. Considering the pharmaceutical potential of the flora of these forests, the impact of submerging them viz., the lost pharmaceutical value is being scrutinized here. It is also attempted to compute the net benefit of the hydro electric project in the long-run while incurring the additional indirect costs in cultivating the plant species needed by the pharmaceutical industry and deprived by submersion.

Valuation methodology

A preliminary survey of the dam site was conducted in mid 1994. Thereafter an ethnobotanical survey of the catchment area was conducted to assess the diversity of medicinal plants. A botanical inventory of the species in the dry deciduous forests in the catchment area of Bargi dam was prepared selecting representative forest patches. Working plans of East Mandla, West Mandla, Jabalpur, and North Seoni forest divisions provided data on catchment areas of Bargi dam which helped in choosing representative patches for floristic studies. Considering the vegetation type, its heterogeneity and size of the forest area, the quadrat method was employed for vegetation analysis following Poffenberger *et al.* (1992). To study tree species thirty quadrats of size 50 x 20 m were laid out in a 350 hectare forest patch in Barha reserve forest falling in the catchment area. For each tree quadrat two 5 x 5 m quadrats were laid out for studying shrubs and regenerating tree seedlings while two 1 x 1 m quadrats within the shrub quadrat served for analysing herbs. The observations were monitored over a two year period in 1994-95. Taxonomic studies revealed that out of the 124 plant species recorded in the study area, 68 had recorded therapeutic value, out of which 26 were trees and 42 came under the category of herbs and shrubs (Table 1a and 1b). Density of trees was calculated on a per hectare basis while that of herbs and shrubs were worked out per 100 square meter. After the preliminary survey, plant species of high economic importance were identified from a sample survey of retail medical outlets. The main criteria for choosing a particular drug was that a plant extract should be an essential ingredient in the drug and that the source plant should be recorded in the study area. Tribal markets, seasonal fairs, ayurvedic (Indian system of medicine) drug manufacturing units and retail medical outlets were surveyed to select the specific drugs chosen for the study (Table 2). The level of sustainable harvest was calculated from the density of occurrence estimated for the forest patch and their natural regeneration rates. Quantity of raw material reaching the drug manufacturer was computed using the above-mentioned rate of extraction, its dry weight and losses during storage and processing. Details on collection, transportation, and the forest–collector–agent–wholesaler–manufacturer channel in herbal marketing were gathered by visiting Chilpi, Bichia, Mawai and Amarkantak in the districts adjoining Jabalpur.

An ayurvedic drug production unit (Rudraksh Pharmaceuticals, Tilwaraghat) near the catchment area was the main source of data on pharmaceutical preparations, cost of production, pattern of acquisition of raw materials over years and cultivation practices. The agrotechniques for medicinal plants are only slowly being perfected due to lacunae in research and extension in medicinal plant cultivation aspects and difficulties in domestica-

Table 1a. Trees with recorded medicinal worth in the study area.

Scientific name	Density (No/ha)	Family	Parts used	Medicinal properties
Acacia catechu	7	Mimosaceae	Heart wood, bark	Sores, bronchitis
Aegle marmelos	29	Rutaceae	Root, stem, leaf, fruit	Diabetes, astringent
Anogeissus latifolia	119	Combretaceae	Leaf, root	Cholera
Bauhinia malabarica	11	Caesalpiniaceae	Bark	Dysentery, diarrhea
Bauhinia racemosa	29	Caesalpiniaceae	Bark, leaf	Dysentery, malaria
Bombax ceiba	7	Bombaceae	Root, heart wood	Cholera, urinary complaints
Boswellia serrata	3.6	Burseraceae	Bark, seed	Stomach pain, snake bite
Bridelia retusa	3.6	Euphorbiaceae	Bark	Rheumatism, contraceptive
Buchanania lanzan	14	Anacardiaceae	Root, seed, leaf, gum	Venereal diseases, asthma
Butea monosperma	131	Fabaceae	Whole tree	Blood pressure, astringent
Casearia tomentosa	7.1	Samydaceae	Bark, root, fruit	Sunstroke, diarrhea
Cassia fistula	112.8	Caesalpiniaceae	Root, leaf, bark, seed	Antihelmentic, diuretic
Embilica officinalis	82.1	Euphorbiaceae	Bark, leaf, fruit	Pimples, cholera, dysentery
Ficus racemosa	3.6	Moraceae	Root, leaf, bark	Dysentery, diabetes, piles
Gardenia gummifera	10	Rubiaceae	Stem, gum	Nervous disorders
Gardenia latifolia	10	Rubiaceae	Stem, fruit	Stomach pain
Lannea grandis	7.1	Anacardiaceae	Bark, leaf	Astringent, leprosy
Mitragyna parviflora	5	Rubiaceae	Bark, root	Muscular pain, fever
Nyctanthes arbortritis	17.8	Oleaceae	Root, leaf, fruit, seed	Atropy, menorrhagia
Pterocarpus marsupium	13.3	Fabaceae	Wood, bark, leaf	Diabetes, cholera
Randia spinosa	3.6	Rubiaceae	Bark, root, fruit, seed	Astringent, diarrhea
Stereospermum suaveolens	7.1	Bignoniaceae	Root, bark	Chest pain, brain fever
Syzigium cumini	3.6	Myrtaceae	Shoot leaf, bark, fruit	Diarrhea, diabetes
Tectona grandis	20.8	Verbenaceae	Wood, flower, seed	Eczema, urinary disorders
Terminalia alata	42.9	Combretaceae	Bark, gum	Dysentery, haematoria
Terminalia arjuna	3.6	Combretaceae	Bark, leaf, fruit	Mouth blisters, astringent
Terminalia chebula	10.7	Combretaceae	Bark, fruit	Cardiotonic, eczema
Wrightia tinctoria	17.8	Apocynaceae	Root, bark, leaf	Laxative, asthma

tion. Since the factory was only recently established, in order to avoid under valuation while calculating medicinal benefits from the demand side, price data of similar products by market leaders in the industry were also taken.

Assumptions

To calculate sustainable level of harvest of plant parts, tree seedlings were assumed to have 0.1% survival rate, and 1% of that was assumed to reach maturity (Knight 1963).

The direct use value of forests is considered as constituted by two value components : timber and non-timber forest produce (NTFP). Fuelwood is included in both the above values. NTFP value in food, tannins, resins, dyes and gums are substituted by medicinal worth because (1) Most of the plants which yield any of the NTFP listed above are of therapeutic value; (2) Since we assume maximum sustainable rate of extraction of medicinal plants derived from forests, extraction of the same plant for other purposes if included will exaggerate their value.

So the mutually exclusive estimates of medicinal worth, use value in timber, option value (the amount that individuals would be willing to pay to conserve the forest for direct and indirect uses in the future, Pearce & Warford 1993), existence value (non-use value related to the willingness to pay for existence of environmental assets, Pearce & Warford 1993) and carbon credit (a credit for their role in averting global warming; in this case the benefit of avoided damage of not releasing the stored green house gases (mainly carbon) through deforestation Pearce *et al.* 1991) represent the economic worth of forests or *in-situ* preservation in totality.

Variables and notations

NPV of IP = (CAC + TBM + UOE) - (CCT + CCI)

NPV of EC = (TNBD + TBM) - (CCTE + CLT + MCE)

The notations are as follows : NPV : Net Present Value as in 1994; IP (*In-situ* preservation) : Represents the situation wherein dry deciduous forests in the area are preserved with sustainable rate of herbal extraction; EC (*Ex-situ* cultivation): Stands for the development activity wherein the forests are cleared, the flow of all use, option and existence values of wilderness cease after the construction of dam, and medicinal herbs required for the pharmaceutical sector are grown in *ex-situ* conditions; N : Time scale under study. Starting from 1971 when forests were cleared, it took 15

Table 1b. Herbs and shrubs of recorded medicinal worth in the study area.

Scientific name	Density ($No/100m^2$)	Family	Parts used	Medicinal uses
Atylosia scarabaeoides	5	Fabaceae	Leaf, root	Dysentery, diarrhea
Acrocephalus indicus	75	Lamiaceae	Whole plant	Expectorant
Asparagus racemosus	10	Liliaceae	Root	Urinary disorders
Adiantum philippense	40	Adiantaceae	Whole plant	Tonic, aphrodisiac
Acalypha indica	20	Euphorbiaceae	Whole plant	Bronchitis, pneumonia, rheumatism
Biophytum sensitivum	250	Oxalidaceae	Leaf	Headache, diabetes, asthma
Borreria stricta	10	Rubiaceae	Root	Conjunctivitis
Barleria cristata	15	Acanthaceae	Leaf, root	Coughs, inflammations
Borreria articularis	30	Rubiaceae	Leaf, root seed	Conjunctivitis, diarrhea
Cassia tora	2025	Caesalpiniaceae	Root, leaf, seed	Snake bite, fracture, vermicide, eczema
Cissampelos pareira	45	Menispermaceae	Root	Urinary troubles, epilepsy
Curculigo orchioides	170	Amarylliadaceae	Root	Leucorrhoea, epilepsy, piles
Curcuma pesudomontana	30	Zingiberaceae	Rhizome	Jaundice, body pain
Celastrus paniculatus	120	Celastraceae	Root, leaf, fruit	Headache, scbies, piles, rheumatic pain
Chlorophytum arundinaceum	125	Liliaceae	Root	Tonic
Cocculus hirsutus	5	Menispermaceae	Root, stem, leaf	Rheumatism, cardiotonic, eczema
Cassia mimosoides	60	Caesalpiniaceae	Root	Stomach spasms
Cassia absus	15	Caesalpiniaceae	Leaf, seed	Astringent
Cayratia trifolia	35	Vitaceae	Leaf, root seed	Ulcer, head-ache
Dioscorea bulbifera	205	Dioscoreaceae	Tuber	Ulcers, dysentery, piles
Desmodium trifolium	265	Fabaceae	Leaf	Galactagogue, dysentery
Ichnocarpus frutescens	155	Apocynaceae	Root, leaf, bark	Ulcer, night blindness
Elephantopus scaber	380	Asteraceae	Root, leaf	Pimples, amoebic dysentery
Embelia tsferiam-cottam	40	Myrsinanceae	Fruit, root	Taenifuge, antispasmodic
Emilia sonchifolia	5	Asteraceae	Root, leaf	Diarrhea, eye diseases
Euphorbia hirta	5	Euphorbiaceae	Whole plant	Asthma, kidney disorders
Evolvulus alsinoides	10	Convolvulaceae	Whole plant	Febrifuge, asthma, bronchitis
Gymnema sylvestre	15	Asclepiadaceae	Root, leaf	Diabetes, glycosuria
Gloriosa superba	10	Liliaceae	Root, leaf	Purgative, antihelmintic, leprosy
Glossocardia bosveallea	5	Asteraceae	Whole plant	Emmenagogue
Hemidesmus indicus	60	Asclepiadaceae	Root, leaf	Venereal diseases, skin diseases
Hedyotis corymbosa	320	Rubiaceae	Whole plant	Liver diseases
Lantana camara	135	Verbenaceae	Whole plant	Rheumatism, malaria
Phyllanthus urinaria	335	Euphorbiaceae	Root, leaf	Jaundice
Sida cordata	310	Malvaceae	Whole plant	Astringent, ulcers
Sida rhombifolia	10	Malvaceae	Root, leaf, stem	Rheumatism, asthma
Smilax macrophylla	25	Liliaceae	Root	Venereal diseases
Tridax procumbens	10	Asteraceae	Whole plant	Hemorrhage
Zornia gibbosa	315	Fabaceae	Root	Dysentery

years to build the dam and power unit, which turned operational only in 1986. Anticipated fully useful life span of the dam is 50 years *i.e.* until 2036 AD. Thus n = 65 years (from 1971 to 2036 AD) *r*: Discount rate : 5% and 10%.

CAC : (Anticipated carbon credit of the submerged forests) - (Value of sequestered carbon in afforestation)

Carbon credit of the forests = C x A x P; where, C = Carbon release from the submerged forests/ha. This works out to be 115 t for tropical dry deciduous forests (Brown & Pearce 1992); A = Total forest area submerged; P = Shadow price of carbon = 20$/t (Fankhauser 1995); CAP = 115 t/ha x 8478 ha x 20$/T = 19.5 million $.

The afforestation target envisaged was three times the submerged forest area (3 x 8478 ha), but practically no afforestation occurred even after 23 years except for some surviving scattered avenue trees in the surrounding degraded areas. Hence sequestration in afforestation is negligible and so CAC is equal to CAP. CAC has been valued at $ 19.5 million. This has been incurred as a fixed cost in 1971 for the sake of benefits, which started flowing in 1994 and is supposed to continue till 2036.

TBM : TB_M represents the total annual benefits from medicinal plants in the lost forests. This is derived using the prevailing market price of the raw material price (TB_{MR}). Wherever possible, more than one drug from each of the five selected species are taken for calculations.

TBM = (TB_M x No. of medicinal plant species).

TB_M = Annual medicinal benefits per species = (TBm1 + TBm2 + TBm3 + TBm4 + TBm5)/5 m1 to m5 are the five medicinal plant species (Table 2) selected after the market survey and identification of plant species in the selected representative forest patches.

Total pharmaceutical value of the forest is supposed to be reflected by the total worth of herbal raw material (TB_m) calculated from the sustainably harvestable raw material from each of the species and their market prices. Selected plant species are used to arrive at an average value of raw material worth. To make this estimate of medicinal worth realistic, different kinds of plants, plant parts (herbs, climbers and trees yielding fruits, leaves, barks and tubers etc.), different therapeutic properties (tonic, anti hemorrhage, cardio-protective and anti diabetic) were chosen from those plants widely used in drug manufacture in India, especially by those firms located near the study area.

The assumption is that from 1971 to 2036 AD, benefits from medicinal plants are supposed to be realised whether the herbs are available from forests or not. The source of raw material first changes to other forested areas and then to *ex-situ* plots in the case of EC, where developing the area into a dam alters the environment and the herbs are grown outside natural habitats. While in the case of IP, the source remains as forests from where they are sustainably extracted. The raw material prices realised remain the same whether they are

Table 2. Value of medicinal herbs selected for computing total pharmaceutical benefits in a tropical deciduous forest in Jabalpur, Madhya Pradesh.

Species	Major therapeutic use	Extractable Quantity* (tons)	Raw material Price ($/kg of dry wt.)	Value (million)	Mean value of allopathic drugs which a kg of dry raw material can produce ($)
Chlorophytum arundinaceum Baker	Tonic	339.12	20.0	6.78 (TBm1)	1133
Phyllanthus emblica L. (Syn: *Emblica officinalis* Gaertn)	Haemorrhages	5220.00	0.30	1.5 (TBm2)	140
Asparagus racemosus Willd.	Anti stress and immuno-stimulant	105.97	4.0	0.42 (TBm3)	157
Terminalia arjuna (Roxb.ex.DC.). Wt. & Arn	Cardio protective	274.69	0.67	0.18 (TBm4)	430
Gymnema sylvestre (Retz.) R.Br. ex Schultes	Diabetes	6782.40	2.0	13.56 (TBm5)	83

*(Density of occurrence/ha x Submerged forest area x Harvested dry weight of useful part/plant/annum)

from the forests or from cultivated fields. However, there can be a difference in the active ingredient principle between naturally occurring and cultivated herbs which is taken care of by another variable (MCE). The respective costs are dealt with elsewhere (CCT, CCI, CCTE and CLT). Hence the estimates of the pharmaceutical value of species wealth (TBM) will be the same in both I.P. and E.C.

UOE : This variable stands for : (a) Values other than those contained in the estimate of TB_M namely the use value in timber, (b) Option, and (c) Existence value for the tropical dry deciduous forests. In the absence of any secondary data on these variables for the particular patch of forests, the estimates for the variables for similar type of forests were adopted from a previous study (Chopra *et al.* 1993) and converted to US dollar terms. Non timber use values from their estimate has not been used. The present value of timber, option value and the average of minimum and maximum existence value (for timber and non-timber products) are added together to calculate UOE. Their present worth per unit area of the lost forests was calculated as (a) $ 692.6 (b) $ 110.83 and (c) $ 2928.02 totaling to $3731.45 ha and hence for the 8478 ha of forest cleared in the case study, the UOE comes to $ 31.63 m.

CCT : This variable stands for the cost of collection of plant parts from the wild and transporting them to the drug manufacturer. In the case of a self-supporting *in-situ* preservation, this cost is inevitable. Average cost of collection and transport/medicinal species/year was calculated as $ 0.326 million year.

CCI : Cost of conservation to be incurred in I.P. is the expenditure involved in protecting a dry deciduous tropical forest from fire, encroachment and unsustainable harvest. Statements of expenditures for the past one decade were taken from the working plans for the forest tracts concerned, as also ex-

Table 3. Valuation of cost and benefit variables used for computing net present worth of a tropical deciduous forest in Jabalpur, Madhya Pradesh

Variables	Calculation	Estimated value (in US$) for the study period (1971-2036) as in 1994	
		r = 5%	r = 10%
CAC : Carbon credit of the submerged forest area	(Anticipated carbon credit of the submerged forests) - (Value of sequestered carbon in afforestation)	66.11 m	211.19 m
TBM : Total annual medicinal worth of the lost forests	(Mean annual medicinal benefit per species) *(No. of medicinal plant species)	18.02 b	27.36 b
UOE : Use values (other than medicinal) option and existence values	Value of timber harvested annually + Option value + Existence value	33.21 m	34.79 m
CCT : Cost of collection and transport from forests	Average annual cost of collection and transport of medicinal plant parts	1304.78 m	1981.12 m
CCTE : Cost of collection and transport of plant parts when neither the original source nor the *ex situ* cultivation can meet the demand for raw material.	Mean annual cost of collection and transport of medicinal plant parts from an alternate source in the lag period between forest clearance and establishing cultivated plots	358.72 m	957.58 m
CCI : Cost of conservation to be incurred in IP.	Annual expenditure in protecting forests from fire, encroachment and unsustainable harvest	0.0976	0.130
CLT : Cost of cultivation of medicinal plants when they are grown *ex-situ*	Mean annual cost of cultivating medicinal plants *ex-situ*.	1586.25 m	1929.60m
MCE : Marginal cost in using raw material raised *ex-situ*.	10% of CLT 25% of CLT	158.63 m 396.56 m	192.96 m 482.4 m
TNBC : Total net benefit of development	Direct benefits - Direct costs (from the hydroelectric project)	872.07 m	376.05 m

*million US $, **billion US $

penditure incurred in the present submerged area, before submergence. For each of them, cost of conservation per hectare was calculated under constant prices and the mean value used in calculating CCI. Mean cost of conservation/ha comes to $ 0.174.

CCTE : This is the value in 1994 prices of average cost of collection and transport of medicinal plant parts from a distant forest *i.e.,* for five years since forest clearance, the drug factories were assumed to be in the process of establishing herbal gardens and mastering agro-techniques for pharmaceutical plants. During this period they are assumed to acquire the needed raw material from a distant forest situated in Mandla district which is the next nearest source. Mean value of CCTE was found to be $ 0.378 million species/year.

CLT : Represents the costs of cultivation of the medicinal plants *ex-situ*, per year. The area to be cultivated was derived from the land needed to plant the species in the recommended spacing and the total population of that particular species in the forests lost. CLT is calculated for five different species and average value used for all. *Ex-situ* cultivation is supposed to be undertaken after five years of forest clearance. CLT/species computed was $ 0.512 million year.

MCE : MCE stands for the additional cost of cultivation to be incurred by the pharmaceutical industry because of an anticipated difference in active ingredient content between the wild and domesticated plants. It has been observed that the stimuli in natural habitats from herbivores and microclimatic variation are absent in *ex-situ* plots (Ehrlich & Gretchen 1993). Since we have only isolated evidences of such variation (Sarin 1982), three situations were foreseen.

(1) The *in-situ* preserved plant and *ex-situ* cultivated plant do not differ much in the content of active ingredient principle (MCE = 0).

(2) Active ingredient content is 10% higher in the case of *in-situ* preservation, i.e. an increase of 10% in the requirement of raw material to manufacture a drug which makes it necessary to have an additional 10% in the cultivated area of *ex-situ* plot and correspondingly a 10% rise in cost of cultivation. (MCE = CLT X 10/100 = $ 3.48 million).

(3) Active ingredient content is 25% higher in the case of *in-situ* preservation *i.e.,* an increase of 25% in the requirement of raw material to manufacture a drug which makes it necessary to have an additional 25% in the area cultivated *ex-situ* plot and correspondingly a 25% rise in cost of cultivation. (MCE = CLT x 25/100 = $ 8.71 million).

TNBD : The case of development in this study being a hydel project, benefits and costs are listed in Tables 4a and 4b.

Results and discussion

The NPV of *in-situ* preservation was found to

Table 4a. Realized annual benefits and operational costs of the Rani Avanti Bai Sagar Pariyojana Project, Bargi, Madhya Pradesh.

Benefits	Quantity	Million $/year
Power generation	90 MW	26.67
Drinking water	54 million m^3	0.113
Additional agricultural production	0.198 million tons	23.10
Fish yield	325 tons	0.20
Total benefits		50.083
Operation costs		
Maintenance		0.833
Salaries		5.67
Total operation cost		6.503

*Source : Govt. of Madhya Pradesh (1994)

Table 4b. Present value of capital costs incurred at two discount rates of the Rani Avanti Bai Sagar Pariyojana Project, Bargi, Madhya Pradesh.

Capital costs	Million $	Present values	
		r = 5%	r = 10%
Dam, canals and power generation	120.25	169.55	234.33
Rehabilitation of project affected people	4.00	7.92	15.2
Forest land acquisition	5.33	21.96	84.53
Other land and property acquisition	5.54	17.84	54.51
Afforestation programmes	5.33	10.55	20.20
Erosion control in the catchment	33.99	67.33	128.82
Prevention of water logging in the command area	5.33	8.26	12.58
Total	179.77	303.38	550.17

*Source : Govt of Madhya Pradesh (1994).

be greater than NPV or *ex-situ* cultivation with development, when 10% discount rate was used. If there is no difference in the marginal cost of extraction of the active ingredient (attributable to a lower content of the active principle in a plant cultivated *ex-situ*), then at a 5% discount rate, NPV of *ex-situ* cultivation and development exceeds that of choosing conservation (Table 5). To avoid accusations of 'conservationist bias' the premium in environmental benefits has been neglected though it is well acknowledged that the benefits of preservation may be increasing indefinitely and development benefits decline over time, even within their projected life span (Pearce & Warford 1993). Both preservation and developmental benefits have been computed to the time commensurate with full capacity development benefits.

Table 5. Net present worth (NPV) and Benefit Cost (BC) ratios of preservation and Development with *ex-situ* cultivation in a tropical deciduous forest, Jabalpur, Madhya Pradesh.

NPVEC = (TNBD + TBM) - (CCTE + CLT + MCE) in billion $	r = 5%	r = 10%
MCE = 0	16.94 (9.71)	24.84 (9.62)
MCE = 10% of CLT	16.78 (8.98)	24.65 (9.01)
MCE = 25% of CLT	16.54 (8.07)	24.36 (8.24)
NPVIP = (CAC + TBM + UOE) - (CCT + CCI) in billion $	16.81 (13.88)	25.62 (13.93)

*Figures in parentheses represent BC ratio

NPVIP : Net present worth of *in situ* preservation.

NPVEC : Net present worth of development with *ex situ* cultivation.

TNBD : Total net benefit of development.

TBM : Total annual medicinal worth of the lost forests.

CCTE : Cost of collection and transport of plant parts when neither the original source nor the *ex-situ* cultivation can meet the demand for raw material.

CLT : Cost of cultivation of medicinal plants when they are grown *ex-situ*.

MCE : Marginal cost in using raw material raised *ex-situ*.

CAC : Carbon credit of the submerged forest area.

UOE : Use values (other than medicinal), option and existence values.

CCT : Cost of collection and transport from forests.

CCI : Cost of conservation to be incurred in *in-situ* preservation.

While the value of benefits of development with *ex-situ* cultivation are higher than benefits of *in situ* preservation, the corresponding costs incurred in development with *ex-situ* cultivation are high enough to neutralize the ensuing benefits, despite the fact that cultivation may rank as the cheapest *ex-situ* method of propagation. Costs for *in-situ* preservation are negligibly small owing to the economies of scale involved. *Ex-situ* costs include cultivation expenditures separately for the 68 recorded species, huge capital investment in constructing the dam, social and ecological rehabilitation costs etc. In all the estimates at both the discount rates, BC ratios (Table 5) indicate the relative advantage of *in-situ* preservation. Compared to the NPV values, B:C values turn out to be in favour of conservation at both the discount rates and irrespective of whether the raw material is inferior in quality when cultivated *ex-situ*. Given the comparatively high economic benefits from development combined with *ex-situ* cultivation, it is possible that if the costs were lowered then development with *ex-situ* cultivation may emerge as the optimum alternate strategy. The economic costs would be reduced if the total submerged area was not extensive or not of much direct economic significance; and when the anticipated targets in irrigation potential and area targeted under compensatory afforestation were actually realized.

If the net benefits of development and environmental costs arising from development are to be compared on a per unit area basis, then the choice can be more explicit. At both the discount rates, environmental cost per hectare of irrigation potential created was much higher than net benefits of the dam. Consequently, NPV of opting for the dam was found to be much lower than the NPV of not clearing the forests (Table 6). It is apparent

Table 6. NPV of *in-situ* preservation per unit area (in million US $) of a tropical deciduous forest in Jabalpur, Madhya Pradesh.

	r = 5%	r = 10%
Net benefit of the Dam per hectare of irrigation potential	0.05	0.02
Environmental costs per hectare of irrigation potential	1.01	1.54
NPV of *in-situ* preservation per unit area of forest cleared	1.98	3.02

that development benefits can economically justify the investment so far incurred in the hydel project only if the irrigation potential crated was at least four times that of what has been achieved so far. Achievement has been only 8.19% of what was targeted initially at the time of launching the project and whatever be the achievement the fixed costs remain the same, diminishing the net economic worth. Modifying the equation suggested for computing environmental cost (Chopra *et al*. 1993) in the current context, environmental cost per unit area benefited has been calculated as follows :

Envt Cost = [(FL/IRP)* (VFL/FL)] + (WLA*AC)

where, Envt Cost = Environmental cost per hectare of irrigation potential created; FL = Forests lost (in hectare); IRP = Irrigation potential created. (in hectare); VFL = Value of forests lost (Carbon credit + Medicinal worth + Timber use, option and existence value) in million $; WLA = Waterlogged area as a percentage of IRP (0.20%); AC = Per hectare cost of technology for abatement of water logging and salinity ($ 0.001 m).

The raw material price per unit dry weight of plant parts as a proportion of the value of allopathic drugs it can give rise to ranges from 0.16% to 2.41% in the selected cases. Table 2 shows the divergence between the price the herbal collector receives and the potential worth in the market of what he collects from the forests. Once the demand for these pharmaceutical preparations now extending to allopathic order is stabilized, the difference encountered here can be expected to minimise, if accompanied by necessary policy measures in drug pricing, quality control and marketing.

Summary and outlook

The methodology outlined here ratifies policy changes towards long term forest management based on traditional local use of the forest. While many other valuation efforts (e.g.: Ruitenbeek 1994 b) quantify and emphasize the non extractive conservation methods, or recommend either protected areas with tourism as a major component or options of alternative land uses along with compensatory afforestation; the case study alerts developing countries against blindly aping these well known packages of conservation and development. There can be potential indigenous uses for conservation in the tropics with economic, cultural and ecological distinctions. Hence the multiple benefits of extractive *in-situ* preservation cannot be neglected and the costs of irreversible alternative land uses should be juxtaposed upon before embarking on any investment (Grimes *et al*. 1994).

At the prevailing time preference rate, failure in achieving the targets of compensatory afforestation nullifies developmental benefits substantially. The aspect of actually realizing projected benefits is a much-needed emphasis in impact assessments or feasibility studies of river valley projects. Even when the targets in afforestation are achieved, the flow of use values, in the form of non timber forest products will not be the same as that from natural habitats. While the paper relies on the economic significance of a minor forest produce like medicinal plants, it should be noted that we have overlooked other positive externalities of extractive conservation like possible employment generation with an ideal social and gender impact. A larger proportion of employment generated by NTFP accrues to women. Annual employment generation is estimated at over 5 million (Tewari 1993). The opportunity cost of irreversible alteration of ecological environment for development will be high if preserving that habitat involves the portfolio of participatory management, which can capture considerable market benefits. Evolution of a suitable management strategy, allowing extraction of minor forest products with minimal disturbance to the structure and function of forests is the need of the hour in India, as has been done in Brazil, Indonesia, Cameroon and West Africa (Amadi 1993; Nepstad & Shwartzman 1992; Richards 1993).

It has been argued that the low contribution of non timber products to household income is low and it is mainly due to low collector's margin and lack of competitive local market (Kant & Mehta 1993). The traditionally popular local utilization of forests needs to be streamlined to realise the benefits of contemporary market. The under lying implication is that, there is urgent need for assessing sustainable levels of non timber raw material extraction, taking into account the natural regeneration status, seasonal growth characteristics and biotic pressures. This also involves harnessing those use values most relevant in the socio-ecological conditions. Finding and implementing policy measures to ensure adherence to such rates of extraction, equity in the marketing channel, value addition at the local level, and institutional reforms to re-establish usufruct rights (extractive reserves for instance), would be a natural corollary to the adoption of conservation option.

References

Amadi, R.M. 1993. *Harmony and Conflicts between Non Timber Forest Product Use and Conservation in Korup National Park*. Net work paper 15c. Rural Development Forestry Network. Overseas Development Institute, U.K. 21-28.

Ashton, P.S. 1981. Forest conditions in the tropics of Asia and the Far East. *Studies on the Third World* **13**: 169-179.

Barrow, C.J. 1991. *Land Degradation : Development and Breakdown of Terrestrial Environments*. CUP. U.K.

Blum, E. 1993. Making biodiversity conservation profitable. *Environment* **35**: 16-20, 38-45.

Brown, K. & D.W. Pearce. 1992. The economic value of non market benefits of tropical forests. *In*: J. Weiss (ed.) *The Economics of Project Appraisal and the Environment*. Edward Elgar, London.

Champion, H.G. & S.K. Seth. 1968. *Forest Types of India*. Controller of Publications, Govt. of India.

Chopra, K., G.K. Kadekodi & N. Mongia. 1993. *Environmental Impacts of Projects : Planning and Policy Issues*. Institute of Economic Growth working paper. IEG, Delhi, 95-110.

Chopra, K. 1994. Evaluation and pricing of non timber forest products : A study for Raipur district of Madhya Pradesh (India). Paper presented at the Third Conference of the International Society of Ecological Economics, Costa Rica.

D'souza, R., P. Mukhopadhyay & A. Kothari. 1998. Re-evaluating multi purpose river valley projects - A case study of Hirakud, Ukain and IGNP. *Economic and Political Weekly* **33**: 297-302.

Ehrlich, P.R. & C.D. Gretchen. 1993. Population extinction and saving biodiversity. *Ambio* **22**: 64-68.

Fankhauser, S. 1995. *Valuing Climate Change*. Earthscan, London.

Govt. of M.P. 1994. *Rani Avanti Bai Sagar Pariyojana*, Jabalpur. Narmada Ghat Development Pradhikaran, Bhopal.

Grimes, A., S. Loomis & P. Jahnige. 1994. Valuing the rain forest : the economic value of non-timber forest products in Ecuador. *Ambio* **23**: 405-410.

Kant, S. & N.G. Mehta. 1993. A forest based tribal economy : a case study of Motisingloti village. *Forests-Trees-and-People News Letter* Italy **20**: 34-39.

Knight, D.H. 1963. A distance method for constructing forest profile diagrams and obtaining structural data. *Tropical Ecology* **4**: 89-94.

Krutilla, J.V. & A.C. Fisher. 1975. *The Economics of Natural Environments*. John Hopkins Press. Baltimore.

Mishra, P.K. 1994. Role of tribals in conservation, production, collection, processing, storage and trasportation of medicinal plants. *In* : *Souvenir on National Seminar on Conservation of Medicinal Plants and Their Trade Potential for Rural Development*. M.P. Rajya Van Vikas Nigam Limited and M.P. Rajya Laghu Vanopaj (Trade & Development) Sahkari Sangh Limited. Bhopal.

Montgomery, C.A., G.M. Brown & D.M. Adams. 1994. The marginal cost of species preservation. The northern spotted owl. *Journal of Environmental Economics and Management* **26**: 111-128.

Nath, K. 1994. Speech in the first meeting of the parties to the convention of biodiversity. Nassan, Bahamas. Ministry of Environment and Forests, Govt. of India.

Nepstad, D.C. & S. Shwartzman (eds.). 1992. *Non Timber Products from Tropical Forests: Evaluation of a Conservation and Development Strategy*. Woods Hole Research Centre, Massachusetts, U.S.A.

Pearce, D.W., E. Barbier, A. Markandya, S. Barrett, K. Turner & T. Swanson. 1991. *Blue print* **2**: *Greening the World Economy*. Earth Scan Publication. London.

Pearce, D.W. & J. Warford. 1993. *Environment and Economic Development*. OUP.

Poffenberger, M., H.Mc. Green, N.H. Ravindran & M. Gadgil. 1992. *Field Methods Manual*. Vol. I Diagnostic tools for supporting joint forest management systems. SPWD Publications Delhi.

Richards, E.M. 1993. *Commercialisation of non timber forest products in Amazonia*. NRI socio-economic series. U.K. 26.

Ruitenbeek, H.J. 1994a. Modelling economy - ecology linkages in mangroves : Economic evidence for promoting conservation in Bintuni Bay, Indonesia. *Ecological Economics* **10**: 233-247.

Ruitenbeek, H.J. 1994b. The rainforest supply price: a tool for evaluating rain forest conservation expenditures. *Ecological Economics* **6**:57-78.

Sarin, Y.K. 1982. *Costus speciosus* Rhizome as commercial source of Diosgenin pp. 107-120. *In* : C.K. Atal & B.M. Kapur (eds.). *Cultivation and Utilization of Medicinal Plants*. RRL. CSIR. Jammu.

Silvy & M. Patidar. 1998. Madhya Pradesh : Villagers oppose Maheshwar Power Project. *Economic and Political Weekly* **33**: 324-326.

Templet, P.H. & F. Stephen. 1994. The complementarity between environmental and economic risk : an empirical analysis. *Ecological Economics* **9**: 153-165.

Tewari, D.N. 1993. Non timber forest produce in poverty alleviation. *Indian Forester* **119**: 959-969.