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Analysis and resolution of protected area–people conflicts in Nanda Devi Biosphere Reserve, India

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Summary

Conflicts between local people and protected area managers are a common problem in developing countries, but in many cases there has been little attempt to comprehensively characterize the underlying problems. Resource uses, management practices, economy and people's perceptions of problems and likely solutions were analysed in two villages near and two villages away from the core zone of Nanda Devi Biosphere Reserve in the Indian Himalaya. Agriculture, although practised on less than 1% of the area, was the primary occupation of local people. Six annual crops of a total of 22 and all four horticultural crops on private farms were damaged by wildlife, but Reserve management provided compensation only for livestock killing by wildlife and compensation amounted to only 4–10% of the total assessed monetary value of killed livestock. A variety of wild plant products were used locally but 27 were marketed by more than 50% of surveyed families; income from wild products was substantially lower than that from crops and livestock. A sociocultural change from a subsistence to a market economy, together with changes in traditional land/resource rights and institutions, has led to a number of changes in land-use and management practices. The livestock population has declined, agricultural area has remained the same and people have started cultivating medicinal species in the last 20 years. These changes seem complementary to the goal of conservation. However, changes such as abandonment of some traditional food crops and stress on cash crops lacking fodder value, requiring substantial manure inputs derived from forest litter and livestock excreta, and causing severe soil erosion, seem to counter the goal of environmental conservation. Some government-managed Reserve Forest sites were similar to the Community Forests in terms of species richness, basal area and soil physico-chemical properties. Two Reserve Forest sites showed basal areas of 160.5–191.5 m^2/ha, exceeding the highest values reported so far from the region. The formal institutional framework of resource management seems to be not as effective as the traditional informal system. The Reserve Management Plan lays more emphasis on legal protection than on the sustainable livelihood of local communities and has led to conflicts between local people and reserve managers. Plantation of fodder and medicinal species in degraded forest lands, suppression of economic exploitation of local people in the market, enhancement of local knowledge of the economic potential of biodiversity, incentives for cultivation of crops with comparative advantages and lesser risks of damage by wildlife, and rejuvenation of the traditional involvement of the whole village community in decison-making, could be the options for resolving conflicts between people and protected areas in this case.

Keywords: Himalaya, agriculture, forests, pastures, economy, conflict

Introduction

The Himalayas are a vast mountain system covering partly or fully eight countries of Asia including Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. Conservation of Himalayan ecosystems and biodiversity is important from local as well as national/global dimensions of sustainable development (Eckholm 1975; Ives & Messerli 1989; Ramakrishnan *et al*. 1996; Buch-Hansen 1997). India's recognition as one of the four 'megadiversity' countries of Asia and as one of the ten largest forested areas in the world derives partly from the Himalayas. The Himalayas, although covering only 18% of the geographical area of India, account for more than 50% of India's forest cover, and for 40% of the species endemic to the Indian subcontinent. The protected area network comprises 3 biosphere reserves, 18 national parks and 71 wildlife sanctuaries occupying 9.2% area of the Indian Himalayas. Enforcement of these protected areas has tended to disregard traditional agriculture, natural resource uses and sociocultural values of local communities leading to conflicts between local people and protected-area managers. These conflicts are major threats to conservation in developing countries as a whole

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(Hough 1988; McNeely 1988; Gadgil *et al.* 1993; Borrini-Feyerabend 1996; Ghimire & Pimbert 1997).

A few efforts have been made to analyse the impacts of selected national parks and wildlife sanctuaries on the livelihoods of local people in the Nepal (Hough & Sherpa 1989; Heinen 1993; Sharma & Shaw 1993; Nepal & Weber 1995) and Indian Himalayas (Kothari *et al.* 1989; Rawat & Uniyal 1993; Mishra 1997). However, a comprehensive analysis of the spatio-temporal dynamics of resource use and management practices, the different components of the rural economy and people's perceptions of problems attributable to protected areas and likely solutions, is lacking. In this study of the Nanda Devi Biosphere Reserve, we aimed to (1) describe changes in traditional agriculture, wild resource uses and management (2) compare the economy of villages near to and away from the core zone, and (3) assess reserve–people conflicts and options for conflict resolution.

Study area

Nanda Devi Biosphere Reserve (30°17′–30°41′N and 79°40′–80°5′E), located in the state of Uttar Pradesh, India, consists of a core zone (625 km^2 area) surrounded by a buffer zone (1612 km^2) (Fig. 1). The area experiences a monsoonal climate. At 2300 m altitude (village Reni), average annual rainfall (1994–96 data) is about 900 mm. Mean monthly minimum and maximum temperatures are 3–7° C and 14–24° C, respectively. The area is dominated by crystalline rocks and the soils are loam to sandy loam, and vary from well drained to excessively drained.

Agriculture, forests, alpine meadows, wastelands (areas with extremely poor vegetation and soil) and permanent snow account for 0.7%, 22.2%, 4.5%, 6.6% and 66%, respectively, of the Reserve area (Sahai & Kimothi 1996). There are 17 settlements of the Bhotia tribe (total population: 2051 in 1996) in the buffer zone, a community which is socially differentiated into a privileged section with larger holdings and an underprivileged section with minute holdings. Crop and animal husbandry are the primary occupations of the local people. Livestock feed is derived from crop by-products, fodder lopped from forests, and grazing. A mixture of leaf litter and livestock excreta is used to manure crop fields. Non-timber forest products supplement the rural economy. About 600 plant species, 18 mammals and 200 bird species are reported from the Reserve (Rodgers & Panwar 1988; Mohan 1993).

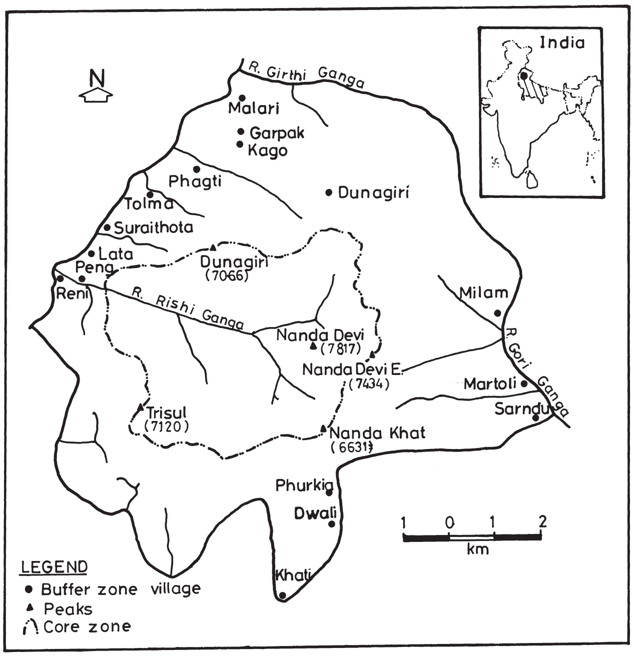

Figure 1 Location and sketch map of Nanda Devi Biosphere Reserve in India. Villages and important streams and mountain peaks (altitude in m given in parentheses) are shown.

There are two formal village-level people's institutions: (1) A Forest Council empowered to frame rules for subsistence uses of the Community Forests and realize fines limited to the equivalent of US$1.25 for each violation of rules, and (2) a Village Development Council, which implements government-funded development projects. Each council consists of 5–7 elected members. The government is represented by the Biosphere Reserve Directorate and sector departments dealing with land revenue, livestock, agriculture, health and education.

Methods

Archival records related to resource rights, management and rural development available at various institutions were studied. After a reconnaissance survey in 1995, two villages (Lata and Peng comprising 86 and 31 households, respectively, and located at 2250–2500 m altitude) near to and two villages (Phagti and Garpak comprising 18 and 24 households, respectively, and located at 2700–2900 m altitude) relatively away from the core zone were randomly selected. All households were surveyed to get information on land and livestock holdings, proportion of area under different crops, uses of wild products, traditional management practices and changes therein, and people's perceptions of development problems and possible solutions. Forty per cent of households in each village were randomly selected to analyse changes in crop diversity. Old family members were informed of the aggregate area of cereals, millets and pulses during the 1970–75 period available in revenue records and they were asked to recall the proportion of area under different crops during that period. Twenty per cent of randomly selected households in each village were visited once a month over a period of one year to estimate the harvest of wild products, quantities sold and the selling prices. Village agents and wholesalers in the marketing channel were questioned to determine the price spread.

Five households were selected at random in each village to estimate crop losses due to wildlife. Of the two plots (60–80 m^2 size) of each crop in a holding, one was fenced with thorny bushes and put under the supervision of a watchman for protection from wildlife. Similarly, 30 trees of each fruit species (10 trees each of small size, medium size and large size) were selected and 50% of the trees were protected. The difference between yields from protected and unprotected treatments was considered to be the loss due to wildlife.

Five Reserve Forest and five Community Forest stands were selected across an altitudinal gradient of 2150–2800 m. Average slope, aspect and altitude of sites were noted. In each stand, the density of mature trees and stumps was enumerated in 15 random 10 m × 10 m quadrats. Girth at breast height (GBH) of standing trees was measured. The density of shrubs and saplings (height > 20 cm and GBH < 31.5 cm) was observed in 5 m × 5 m quadrats and that of herbs and seedlings (height < 20 cm and GBH < 31.5 cm) in 1 m × 1 m quadrats, which were nested within quadrats laid for tree enumeration.

Results

Agrobiodiversity

In low-altitude villages near to the core zone, agricultural land was divided into two parts, namely the areas towards hill tops (*Mulla Sari*) and the areas down slope from these (*Malli Sari*). Each household had plots in both Saris. Though two crops, a summer crop (July–October) and a winter crop (October–April), could be harvested in a year, the tradition was to fallow a Sari during one winter season every two years. In high-altitude villages away from the core zone, only one crop was grown in a year and the Sari system did not exist. Scattered fruit trees were observed only in the low-altitude villages. In all villages, socially-privileged families unable to cultivate were culturally obliged to lease their land to underprivileged families.

Though farm area and cropping intensity had not changed over the last two decades, there had been prominent changes in agricultural biodiversity. Cultivation of six medicinal species (*Angelica glauca*, *Carum carvi*, *Dactylorhiza hatagirea*, *Megacarpaea polyandra*, *Pleurospermum angelicoides* and *Saussurea costus*) emerged during the 1980s in high-altitude villages away from the core zone. Cultivation of *Echinochloa frumentocea*, *Glycine max*, *Setaria italica* and *Pennisetum typhoides* at lower altitudes and *Hordeum vulgare* at higher altitudes had been abandoned. The area under *Solanum tuberosum* and *Phaseolus* spp. had increased in all villages. Monetary outputs from *Fagopyrum* spp., *S. tuberosum* (pure crop) and mixed crops of *S. tuberosum* and *P. vulgaris* were significantly ($p < 0.05$) higher in high-altitude villages away from the core zone when compared to low-altitude villages near to the core zone (Table 1).

Crop damage by wildlife

Six food crops and all four fruit crops were damaged by wild boar (*Sus scrofa*), bear (*Selenarctos thibetanus*), musk deer (*Moschus chrysogaster*), porcupine (*Hystrix indica*), monkey (*Presbytes entellus*) and partridge (*Alectoris chokor*). In low-altitude villages near to the core zone, mean annual loss per household was US$90.6 compared to US$27.9 in high-altitude villages away from the core zone. *Malus sylvestris* accounted for the highest loss in villages near to the core zone and *S. tuberosum* in villages away from the core zone (Table 2).

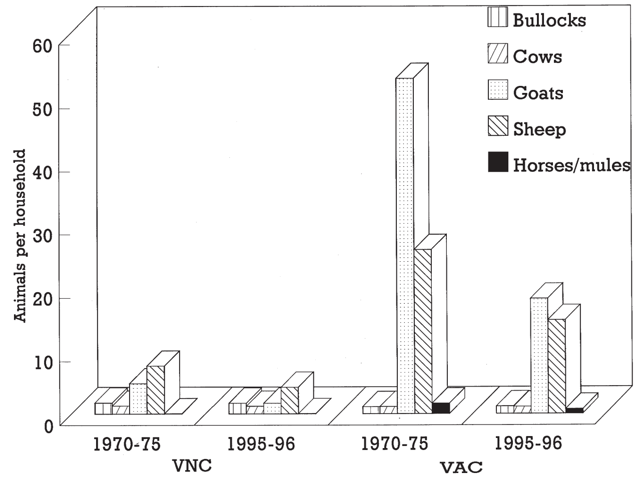

Figure 2 Average livestock holding during 1970–75 and 1995–96 in villages near to (VNC) and villages away from (VAC) the core zone.

Livestock holding and depredation by wildlife

High-altitude villages away from the core zone showed larger holdings. Horses/mules were absent from low-altitude villages near to the core zone. In both types of villages, sheep and goat populations had declined during the previous 20 years (Fig. 2). The killings by wildlife were endorsed by the Chairman of the Village Development Council and subsequently verified by veterinary experts and were considered by the Reserve Directorate for compensation. Only aggregate statistics for the whole Reserve for the 1992–95 period were available (Table 3). Of a large number of compensation claims, only a few were settled and compensation accounted for 4–10% of the total assessed value of killed livestock (Table 3).

Forests: structure, species richness and soil characteristics

Pinus wallichiana was the most dominant, or second most dominant tree in the Community Forest sites, but it was a minor species in the Reserve Forest sites. *Arundinaria* spp. and *Artemisia nilgarica* were the dominant shrubs in the Reserve Forest sites and *Prinsepia utilis* and *Berberis asiatica* in the Community Forest sites. The total number of vascular species ranged from 32 to 66 in the Reserve Forest sites and from 36 to 76 in the Community Forest sites. Community Forest sites were richer in terms of the number of economic herbs and shrubs. Of 173 locally valued plant species (details in Nautiyal [1998]), only 56 species were sampled (Table 4).

Standing tree density was 370–946 trees/ha, basal area of standing trees 11.6–191.5 m^2/ha and density of stumps (natural tree falls + cut trees) 40–126/ha in Reserve Forests compared to 520–1405 standing trees/ha, 16.6–64.1 m^2/ha

Table 1 Area cropped in 1995, change in area cropped between 1970–75 and 1995 (the data are means of mixed and pure cropping practices as people were unable to recall pure/mixed crops separately), and monetary value of the produce in plots protected from wildlife (mean ± SE), for different crops in villages near to and away from the core zone of the Nanda Devi Biosphere Reserve. Results of Mann-Whitney test comparing area, and of t-test comparing values, between villages near to and far from the core zone: values for any variable with different superscript letters are significantly different ($p < 0.05$) within rows.

	Near to the core zone and low altitude			*Away from the core zone and high altitude*		
Crops	*Cropped area in 1995 (% total) (n = 117)*	*Change in area (%) (n = 46)*	*Monetary value (US$/ha) (n = 10)*	*Cropped area in 1995 (% total) (n = 42)*	*Change in area (%) (n = 17)*	*Monetary value (US$/ha) (n = 10)*
Food crops						
Monocropping						
Amaranthus paniculatus	4.4	+36	289 ± 31	–	0	–
Brassica campestris	0.6^{a}	0	519 ± 37^{a}	3.1^{b}	–	494 ± 34^{a}
Echinochloa frumentocea	0	−100	–	0	0	–
Eleusine coracana	0.6	−10	311 ± 28	–	0	–
Fagopyrum esculentum	7.7^{a}	0	337 ± 21^{a}	16.3^{b}	−30	503 ± 27^{b}
Fagopyrum tataricum	8.2^{a}	−19^{a}	343 ± 30^{a}	2.3^{b}	−76^{b}	474 ± 28^{b}
Glycine max	0	−100	–	0	0	–
Hordeum himalayens	5.6^{a}	−41^{a}	235 ± 27^{a}	8.1^{a}	−60^{b}	239 ± 15^{b}
Hordeum vulgare	4.0	−28^{a}	247 ± 24	0	−100^{b}	–
Pennisetum typhoides	0	−100	–	0	0	–
Panicum miliaceum	0.6^{a}	−82^{a}	268 ± 27^{a}	2.5^{b}	−79^{a}	310 ± 27^{a}
Phaseolus lunetus	14.6^{a}	+43^{a}	549 ± 62^{a}	8.6^{b}	+68^{a}	626 ± 63^{a}
Phaseolus vulgaris	6.0^{a}	+40^{a}	906 ± 27^{a}	8.9^{a}	+143^{b}	969 ± 82^{a}
Pisum sativum (Var. 1)[1]	0.3	+25	485 ± 49	0	0	–
Pisum sativum (Var. 2)[1]	0.3^{a}	−28^{a}	547 ± 55^{a}	2.3^{b}	−50^{b}	647 ± 44^{a}
Solanum tuberosum	6.6^{a}	+97^{a}	805 ± 81^{a}	31.3^{b}	+650^{b}	1048 ± 28^{b}
Setaria italica	0	−100	–	0	0	–
Triticum aestivum	21.3	+13	265 ± 29	0	–	–
Mixed cropping						
A. paniculatus + P. vulgaris	3.4	–	842 ± 92	–	–	–
H. himalayens + Pisum sativum (Var. 2)	–	–	–	4.8	–	511 ± 27
S. tuberosum + P. vulgaris	10.1^{a}	–	1133 ± 115^{a}	7.1^{a}	–	1505 ± 68^{b}
S. tuberosum + P. vulgaris + A. paniculatus	4.0	–	1151 ± 75	–	–	–
Medicinal plants						
Allium humile	0.9^{a}	−7^{a}	846 ± 79^{a}	2.3^{b}	−7^{a}	945 ± 87^{a}
Allium stracheyi	0.9^{a}	−6^{a}	502 ± 48^{a}	1.2^{a}	−13^{a}	560 ± 87^{a}
Angelica glauca	–	–	–	0.3	+100	544 ± 57
Carum carvi	–	–	–	0.3	+100	971 ± 85
Dactylorhiza hatagirea	–	–	–	0.2	+100	786 ± 80
Megacarpaea polyandra	–	–	–	0.2	+100	272 ± 19
Pleurosperum angelicoides	–	–	–	0.2	+100	627 ± 60
Saussurea costus	–	–	–	0.3	+100	690 ± 68

[1] Var. 1 and Var. 2 are the local varieties of *Pisum sativum* locally called *Mitha Matar* and *Kong Matar*, respectively.

basal area and 66–206 stumps/ha in Community Forests. Reserve Forest sites 3 and 5 showed the lowest density of seedlings and saplings, respectively.

Rural economy

Wild products sold by more than 50% of families surveyed included eight species valued for vegetables, five for edible fruits, two for edible oil, one for handicrafts and 13 for healthcare. Per household harvest of *Allium humile*, *Megacarpaea polyandra* and *Paeonia emodi* was significantly ($p < 0.05$) higher, and that of temperate bamboo *Thamnocalamus spathiflorus* lower, in villages away from as compared to villages near to the core zone (Table 5). Mean annual household income did not differ much between villages near to and away from the core zone, but relative importance of different components varied (Fig. 3). Income from livestock was higher than that from food crops, more so in villages away from the core zone. Income from medicinal

Table 2 Crop damage due to wildlife (mean reduction in yield ± SE) for different crops in villages near to and those away from the core zone in the Nanda Devi Biosphere Reserve. Results of t-test comparing villages near the core zone with those away from it: values for either variable with different superscript letters are significantly different ($p < 0.05$) within rows.

	Villages near core zone		*Villages away from core zone*	
Crops	*kg/household*	*US$/household*	*kg/household*	*US$/household*
Annual food crops (n = 10)				
Amaranthus paniculatus	24.7 ± 5.4	6.3 ± 1.4	–	–
Fagopyrum esculentum	32.7 ± 5.8[a]	8.4 ± 1.5[a]	32.0 ± 6.2[a]	8.2 ± 1.6[a]
Phaseolus lunetus	26.1 ± 8.7[a]	14.8 ± 4.9[a]	8.6 ± 3.5[b]	4.9 ± 2.0[b]
Phaseolus vulgaris	29.6 ± 7.6[a]	12.2 ± 3.1[a]	10.6 ± 4.5[b]	4.4 ± 1.9[b]
Solanum tuberosum	61.0 ± 6.7[a]	6.3 ± 0.7[a]	101.4 ± 15.4[b]	10.4 ± 1.6[b]
Triticum aestivum	65.5 ± 15.2	6.7 ± 1.6	–	–
Fruit trees (n = 15)				
Juglans regia	1.9 ± 0.6	1.5 ± 0.5	–	–
Malus sylvestris	119.5 ± 24.2	21.5 ± 4.4	–	–
Prunus armenica	48.1 ± 12.2	12.3 ± 3.1	–	–
Prunus persica	2.2 ± 0.8	0.6 ± 0.2	–	–

Table 3 Livestock killing by wildlife, and compensation provided by the Nanda Devi Biosphere Reserve Authority during 1992–95.

	Years			
	1992	*1993*	*1994*	*1995*
Number of households affected	110	95	79	82
Number of animals killed (market value in parenthesis)				
Cattle	32 (423)	19 (244)	23 (295)	24 (308)
Goats	55 (1551)	45 (1269)	38 (1072)	27 (762)
Sheep	48 (1231)	41 (1051)	39 (1000)	48 (1231)
Horses/mules	2 (1036)	1 (518)	1 (518)	3 (1554)
Poultry	3 (7)	4 (8)	6 (12)	3 (6)
Dogs	–	–	2 (23)	3 (35)
Total	140 (4248)	110 (3090)	109 (2920)	108 (3896)
Number of cases settled by the Reserve Authority	23	1	5	8
Compensation provided by the Reserve Authority (US$)	422	9	122	160

plant products collected from the wild was twice that from cultivation. The selling prices of village-level agents were about 55% (mean of all products) higher than that of villagers, and of wholesalers about 37% higher than that of village agents (Fig. 3).

Forest and pasture use and management

Forest and pasture use, and management practices, have changed with time. Important aspects of traditional practices and changes therein are summarized as follows.

Village traditional alpine pasture and forest territories were taken over by the government in 1865. Subsequently, these lands were classified into Civil and Community Forests, which were freely accessible to the local people, and Reserve Forests, where access was restricted. Community Forests were not as great in area as the traditional village territories. The core zone was a Reserve Forest and was notified as a wildlife sanctuary in 1939. This followed severe restrictions on grazing and a ban on wildlife hunting within the Sanctuary. In 1982, the Sanctuary was given the status of a national park and absolute exclusion of local people and tourism was enforced. In the traditional system, people were free to collect deadwood, leaf litter and wild edible species at any time. Fodder and medicinal plants were harvested in groups during fixed periods as decided by consensus of the village community. In the present system, resource rights are granted to individuals. The decison-making power is vested in a few individuals. However, the tradition of temperate bamboo utilization has not yet changed. Bamboo handicraft objects are made by all families for self use but are marketed by socially underprivileged families. All traditional pastures

Table 4 Vegetation and soil attributes of Government Reserve Forests and Community Forests in the Nanda Devi Biosphere Reserve.

	Reserve Forest sites					*Community Forest sites*				
	Site 1	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Site 1*	*Site 2*	*Site 3*	*Site 4*	*Site 5*
Altitude (m)	2150	2400	2400	2800	2800	2300	2300	2600	2600	2600
Slope (°)	30–40	60–65	60–70	75–80	70–80	65–70	65–70	55–60	65–70	60–70
Aspect	northern	northern	northern	northern	northern	southern	southern	northern	northern	northern
Dominant trees	*Triostaum hirsutum, Populus ciliata*	*Aesculus indica, Eunymous lacerus*	*Abies pindrow, T. hirsutum*	*Betula utilis, Acer caessium*	*A. pindrow, A. caessium*	*Pinus wallichiana, Cupressus torulosa*	*P. wallichiana, C. torulosa*	*Cedrus deodara, P. wallichiana*	*P. wallichiana, A. pindrow*	*C. torulosa, P. wallichiana*
Dominant shrubs	*Indigoflora haterantha, Artemesia nilgarica*	*Arundinaria* spp., *I. heterantha*	*Arundinaria* spp., *Desmodium elegans*	*A. nilgarica* – –	*Arundinaria* spp., *A. nilgarica*	*I. heterantha, Prinsepia utilis*	*P. utilis, D. elegans*	*Ribes himalayensis, Colquhounia coccinia*	*R. himalayensis, P. utilis*	*R. himalayensis, Berberis aristata*
Dominant herbs	*Galium rotundifolium, Potentilla* spp.	*Goldfusia dalhosiana, Viola canescense*	*Geranium nepalense, V. canescense*	*Centella asiatica, G. dalhosiana*	*Ainsliaea aptera, G. dalhosiana*	*A. aptera, V. canescense*	*Origanum vulgare, Oxalis corniculata*	*G. rotundifolium, Myractis nepalense*	*G. rotundifolium, O. vulgare*	*G. rotundifolium, V. canescense*
Density standing trees/ha	946	411	495	370	418	857	1050	692	520	1405
Density stumps/ha	126	78	56	40	55	66	70	206	147	202
Basal area of standing trees (m^2/ha)	11.6	92.2	160.5	54.5	191.5	53.9	36.0	64.1	62.1	16.6
Number of saplings/ha	1039	46	185	530	40	241	1330	790	499	326
Number of seedlings/ha	532	952	218	380	566	616	1343	3006	1506	512
Number of tree species	2	8	15	3	5	3	3	2	8	4
Number of shrub species (all species)	15	14	14	8	15	16	18	11	21	7
Number of economic shrub species	5	10	12	2	12	12	15	10	18	7
Number of herbs (all species)	31	27	37	21	22	41	27	25	47	37
Number of economic herb species	8	4	12	6	12	17	15	7	13	5

Table 5 Harvest (mean ± SE) of important wild products in villages near to and away from the core zone of the Nanda Devi Biosphere Reserve. Results of t-test comparisons of harvests from near the core zone with those away from it: values with different superscript letters are significantly different ($p < 0.05$) within rows.

Botanical name	*Local name*	*Harvest (kg household^{-1} year^{-1})*	
		Near to core zone (n = 23)	*Away from core zone (n = 9)*
Aconitum heterophyllum Wall Ex. Royle	Atis	0.08 ± 0.03^a	0.18 ± 0.12^a
Allium humile Kunth	Sedum	10.50 ± 0.97^a	13.58 ± 0.75^b
Angelica glauca Edgew.	Chippi	1.16 ± 0.45^a	1.28 ± 0.20^a
Bergenia ligulata Wall	Shilphori	0.24 ± 0.12^a	0.15 ± 0.10^a
Betula utilis D.Don	Bhojpatra	0.30 ± 0.10^a	0.42 ± 0.12^a
Cedrus deodara Royle Ex.	Deodar	1.10 ± 0.25^a	1.25 ± 0.24^a
Dactylorhiza hatagirea D.Don	Hathazari	0.05 ± 0.01^a	0.05 ± 0.02^a
Fagopyrum dibotrys D.Don	Ban-oggal	1.96 ± 0.89^a	2.64 ± 0.95^a
Hippophae rhamnoides Serv. Subsp.	Amesh	0.30 ± 0.12^a	0.75 ± 0.35^a
Juglans regia L.	Jungli-Akhroot	2.52 ± 0.24^a	3.65 ± 1.75^a
Megacarpaea polyandra Benth.	Barmao	14.24 ± 1.56^a	19.35 ± 0.98^b
Morchella esculenta L.	Gucchi	0.97 ± 0.35^a	0.84 ± 0.12^a
Nardostachys grandiflora DC.	Mashi	0.05 ± 0.01^a	0.06 ± 0.02^a
Paeonia emodi Wall	Chandra	6.27 ± 0.56^a	8.85 ± 1.22^b
Picrorhiza kurrooa Royle	Katuki	0.14 ± 0.10^a	0.18 ± 0.34^a
Pleurospermum angelicoides DC.	Choru	1.60 ± 0.72^a	1.72 ± 0.52^a
Prinsepia utilis Royle	Bhainkal	0.92 ± 0.84^a	0.54 ± 0.40^a
Prunus persica L.	Kirol	1.20 ± 0.25^a	0.85 ± 0.32^a
Rheum australe L.	Dholu	0.04 ± 0.02^a	0.06 ± 0.03^a
Ribes himalayense Ex Royle	Darbag	0.62 ± 0.35^a	0.52 ± 0.35^a
Rosa webbiana Wall Ex Royle	Sedum	0.29 ± 0.10^a	0.32 ± 0.18^a
Rumex hastatus D.Don	Chalmore	1.22 ± 0.92^a	1.94 ± 0.95^a
Saussurea costus (Falc.) Lipsch.	Kut	0.65 ± 0.30^a	0.92 ± 0.21^a
Smilacina purpurea Wall	Puyanu	12.52 ± 1.25^a	11.59 ± 1.52^a
Thamnocalamus spathiflorus, Trin	Ringal	110.50 ± 15.87^a	77.84 ± 5.23^b
Taxus baccata L	Thuner	4.96 ± 0.65^a	3.92 ± 1.21^a
Viburnum cotonifolium D.Don	Ghenu	2.95 ± 0.78^a	1.96 ± 0.95^a

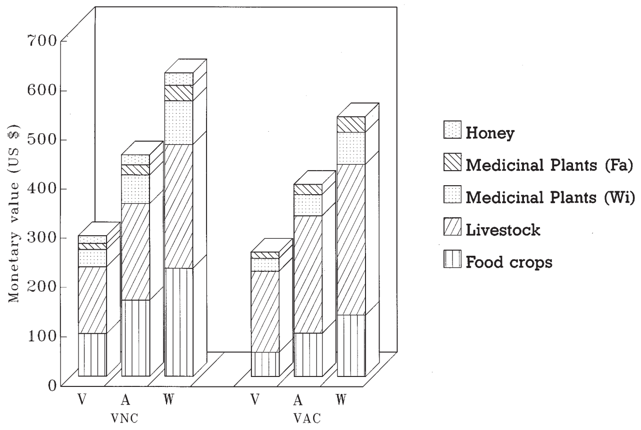

Figure 3 Monetary value of products at different levels in the marketing channel. V = money received by villagers; A = money received by village agents; W = money received by wholesalers; medicinal plants (Fa) = products from medicinal species cultivated in private farms; medicinal plants (Wi) = medicinal plant products collected from the wild.

of the villages of Lata and Peng became a part of the National Park. The unaffected villages permitted the livestock of affected villages to graze in their territories but on payment of US$0.6/horse and cattle and US$0.1/sheep and goat. Such linkages between resource rich and poor villages did exist in the past but without charging any fee. Timber utilization was limited to essential needs in the traditional system. The government sanctioned commercial timber extraction during 1960–70 but strong opposition from the people led to a ban on the felling of green trees in 1976. The Reserve Authority can sell dead/diseased trees in Reserve Forests of the buffer zone. To derive monetary benefits from dead/diseased trees of Community Forests, Forest Councils are required to submit formal proposals. If the Reserve Authority assesses the market value of proposed removals to be US$125 or less and discerns no adverse ecological impacts, the Council can be allowed to auction wood. If the assessed value is more than US$125, the Forest Department carries out the auction. In the latter case, 10% of the income goes to the Forest Department as institutional charges, 36% for management of the Community Forest jointly with the Council, 18% to the District Development Board for district development, and 36% to the Revenue Department for local development. Proposals submitted two years ago are still pending. Until 1960, local people used to go to Tibet during the summers and foot hills during winters. Livestock were the means of transport. The foot hill community allowed penning of livestock for manure. The closure of Indo-Tibetan trade in 1962, forest management practices favouring timber species over fodder species, large-scale conversion of grazing land to agricultural land-use and replacement of organic manure by fertilizers in the foot hills during 1950–70, led to the abandonment of the migratory tradition and thereby more intensive uses near native areas.

The first Biosphere Management Plan was formulated in 1993. Of the annual plan budget of US$190 000, 58% was allocated for salaries and facilities to reserve staff compared to 21% for ecodevelopment and 11.8% for research and education (Mohan 1993).

Perceptions of the local community

Rights to derive income from dead/diseased trees in the Community Forests, the opening up of the core zone for tourism, and government support in marketing, were the development options identified by more than 90% respondents (Table 6). A ban on tourism was felt as an enforcement to live in isolation from the outside world apart from loss of monetary benefits.

Discussion

Changes such as a reduction in livestock holding, absence of extensification of agricultural land-use and cultivation of medicinal plants on private farms in recent years seem to have fallen in line with the goal of conservation envisaged for the Nanda Devi Biosphere Reserve. There are a few other reports on positive changes in and around protected areas in the Himalaya. Restrictions on access to resources in the Royal Chitwan National Park (Nepal Himalaya) could slow down the livestock population growth rate (Sharma & Shaw 1993). Nepalese farmers in some locations have switched over from grazing to stall feeding and have introduced fodder trees on private farms in response to fodder scarcity (Gilmour & Nurse 1991; Fox 1993). Exclusion of people from protected areas seems scarcely justifiable when one realizes the positive role of local communities in maintaining and enhancing biodiversity and their age-old dependence on resources within protected areas (McNeely 1988; Shengji 1991; Gomez-Pompa & Kaus 1992; Gadgil *et al.* 1993).

Yet, changes such as an increasing emphasis on cash crops by abandonment of some traditional crops mean a significant loss of agricultural biodiversity that remains 'lesser known' or 'unknown' to the scientific and wider communities (Maikhuri *et al.* 1996). Expansion of cash crops such as potato, by-products of which do not have any fodder and manure value, imply lesser production of fodder from private farms and thereby more use pressure on forests. Soil erosion rates from potato fields could be 6–8 times higher than that from traditional staple food crops despite 2–4 times the organic manure input in the former than the latter (Sen *et al.* 1997). Larger quantities of manure input imply more removal of leaf litter from forests. Though local food production is sufficient to meet the basic local needs (Nautiyal *et al.* 1998), improvement in energy and nutrient use efficiency of the existing farming system is required. Agricultural biodiversity is a neglected component of protected area management because of the poor understanding of its ecological and economic func-

Table 6 People's perceptions of development options.

Development options	*% of total responses*	
	Villages near to core zone	*Villages away from core zone*
Increase in crop yields:		
by expanding farm holdings	2	2
by using chemical fertilizers	14	12
Improvement in livestock productivity:		
by increasing fodder productivity of degraded forest lands around settlements	94	82
by replacing traditional breeds with high-yielding breeds	8	8
Income from timber of dead trees in community forests	96	92
Improvement in margin of profits from local products:		
by local cooperative societies	18	12
by value addition locally	18	12
by protective government policies	98	98
Opening of core zone for tourism	98	96
Plantation of coniferous trees by Reserve Authority	24	12
Replacement of traditional bee hives by ones provided by Reserve Authority	4	8
Replacement of traditional looms by ones supplied by Reserve Authority	6	4

tions (Singh *et al*. 1984; Hrabovzsky & Miyan 1987) amongst the foresters who are at the helm of protected area decision-making.

Most protected areas in the high Himalaya have been thinly populated since the distant past. People had access to vast forests and meadows. Local people first experienced scarcity when their access was restricted to the Civil and Community Forests. They started annual surface fires as a tool to improve grass fodder productivity in *P. wallichiana* forests around settlements. Higher fodder productivity in the present situation is often a short-term benefit at the cost of depletion of soil fertility and biodiversity (Semwal & Mehta 1996). A socio-cultural change from a subsistence-barter economy to monetary-market economy has occurred rapidly in the last few decades throughout the region (Nusser & Clemens 1996; Singh *et al*. 1997). The inner urge for economic development rather than mere survival is the force driving opposition from local people to the conservation policies which deny local resource-based economic benefits (Bandopadhyay 1992; Price & Thompson 1997). Dualism in policy, e.g. allowing tourism in some national parks (e.g. Corbett National Park) but not in the core zone of the Nanda Devi Biosphere Reserve, empowerment of the Reserve Authority to auction dead/diseased trees from Reserve Forests but not of the Forest Councils for the same practice in Community Forests, and huge expenditures on facilities to protected-area staff rather than on benefits to the local community, are the causes behind people–conservation conflicts in the present instance.

Differences between villages near to and away from the core zone seem to be related to altitude apart from proximity to the core zone. Villages away from the core zone located at higher altitudes have the comparative advantages of a more suitable climate for growing cash crops (potato and beans) and a wider range of medicinal species, abundance of alpine pastures near dwellings, and fewer risks of crop damage due to wildlife, but the disadvantages of climatic constraint on cropping intensity, scarcity of woody resources near dwellings and a higher degree of inaccessibility as compared to villages near to the core zone located at lower altitudes.

Biosphere reserves are intended to fulfil three complementary functions, namely conservation, development, and logistic support for research and education (UNESCO 1996). In most protected areas, emphasis is more on achieving conservation goals by legal protection than through development and logistic support functions. In the absence of systematic monitoring of ecosystem changes and education, false and uncertain impressions are likely. Complete elimination of grazing might result in a decline in species richness in alpine meadows (Kotiluoto 1998), although this trend may not be generalizable too far in the Himalaya (Rawat & Uniyal 1993; Saberwal 1996). People argue that the loss of crop yields and livestock is due to an increase in wildlife population following the closure of the core zone, but there are no data to support or contradict this perception. The observed rarity of many medicinal species has mostly been attributed to over-exploitation (Nayar & Sastry 1979), though rarity could also be due to the requirement of specialized habitats for growth and reproduction of medicinal species (Dobriyal *et al*. 1997). In the absence of monitoring, it remains uncertain whether exclusion of people is serving the goal of biodiversity conservation.

Traditions of utilization of wild resources in groups over fixed periods of time, allowing poorer families to cultivate the land of richer families, favouring derivation of economic benefits from bamboo handicrafts by poorer families, timber extraction limited to essential survival needs and permission to use forests and pastures given by resource-rich villages to resource-poor villages, seem to be appropriate from the standpoint of equity and sustainable utilization of resources. Strict adherence to traditions derived from participation of the whole community in setting norms or deciding penalties for violation of norms (Messerschmidt 1990; Pandey & Yadama 1990; Rao & Saxena 1996). The traditional system of a single forum for all village matters seems to be more effective than the present poorly-linked multiple institutions. Powers of Forest Councils are not commensurate with the potential profits from illicit extractions. Village institutions have no powers to penalize illicit extractions in the Reserve Forests, while Reserve Management is deprived of adequate staff and commitment for protection. Stump density data indicated small-scale illicit extractions from both Community and Reserve Forests. Reserve Forest sites 1 and 5, dominated by *Abies pindrow*, showed basal areas (160.5–191.5 m^2/ha) which were greater than the highest value of 105.6 m^2/ha reported so far from the region (Singh *et al*. 1996). Although during the last 10 years no case of illicit grazing or medicinal plant extraction by local people has been established, a positive attitude should not be taken for granted. Local dissent, if not controlled, may culminate in actions detrimental to the well-being of the local communities as well as the wider global goal of conservation. Establishment of plantations of fodder and medicinal species in degraded lands around settlements could help compensate for resources denied in the core zone. This is also likely to ensure the viability of natural populations of rare and threatened medicinal species (Rao *et al*. 1999). Other ways identified in this study of reinforcing conservation and development simultaneously are: (1) suppression of economic exploitation of hill farmers by middlemen in the marketing channel, (2) enhancing local knowledge of market dynamics and current discoveries, e.g. local people use *Taxus baccata* for medicinal use but are not aware of its value as a source of an anti-carcinogenic drug. Indigenous knowledge is a significant starting point for bioprospecting and local communities must realize the economic benefits from it (Posey 1990), and (3) providing policy incentives for cultivation of crops with fewer risks of damage by wildlife.

The vast variability in ecological, socio-cultural and economic attributes and in the history of different protected areas within the Himalaya demands more studies to develop strategies for reinforcing conservation to the benefit of local people as well as that of the wider global community.

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