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Medicinal Plant Cultivation and Sustainable Development

A Case Study in the Buffer Zone of the Nanda Devi Biosphere Reserve, Western Himalaya, India

The Nanda Devi Biosphere Reserve (NDBR) in the western Himalaya has a high level of biological and cultural diversity. The Bhotiya community, whose livelihood is highly dependent on local natural resources, inhabits the buffer zone of NDBR. Bhotiya practice seasonal and altitudinal migration and stay inside the buffer zone of NDBR for only 6 months (May–October). A survey was conducted in 1996 in 5 villages in Pithoragarh District of the buffer zone, where Bhotiya cultivate medicinal plants on their agriculture fields. The aim of the survey was to understand the socioeconomics of medicinal plant cultivation and evaluate the future prospects of this practice in promoting sustainable development among the local community. Of a total of 71 families, 90% cultivated medicinal plants on 78% of the total reported cultivated area (15.29 ha). At the time of the survey, a total of 12 species of medicinal plants were under cultivation, of which 6 were being marketed while the remaining 6 were still under nursery plantation for future propagation. On average, a family earns about Rs.2423 ± 376.95 per season from the sale of medicinal plants (Rs.38 = US$1 in 1996). Based on the average productivity (kg/ha/y), we estimated that an average family could earn between Rs.4362 and Rs.86,500 from the sale of medicinal herbs. Encouragement of medicinal plant cultivation at high altitudes in the Himalayas would help to generate better monetary returns as well as conserve these herbs in the wild and preserve traditional ethnomedicinal knowledge among local people.

Keywords: *Biosphere reserve; biodiversity; medicinal plants; indigenous knowledge; mountain rural economy; Nanda Devi; Himalaya; India.*

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Introduction

Since time immemorial, plants containing beneficial and medicinal properties have been known and used by human beings in some form or other (Jain and Saklani 1991). In developing countries, 80% of the population still use traditional folk medicines obtained from natural resources (Farnsworth et al 1985). In India, with more than 75% of the population residing in rural areas (Anonymous 1991) close to natural resources, rich traditions of utilizing medicinal plants have existed among indigenous peoples for ages. Particularly in the Himalayan region of the country, traditions of using medicinal plants and other biological resources in a variety of ways are directly linked to the cultural milieu. Moreover, the communities in the region have conserved these natural resources by using their indigenous skills (Panwar, unpublished data). The ethics and the mythology of the Himalayan region are linked to plants, animals, and the immediate environment. These components of the natural world have a place in the sociocultural and religious activities of Himalayan communities, who worship them in the form of various gods, goddesses, and minor deities. Thus, local attitudes have long helped the conservation of natural resources in this region.

Owing to the great diversity of their ecosystems, the Himalayas act as a storehouse for a whole range of medicinal plants. It is recorded that about 30% of the endemic species of the Indian subcontinent are found in the Himalayas, most of which are collected at high altitudes (Farooquee and Saxena 1996). The Nanda Devi Biosphere Reserve (NDBR) in the western Himalayas is one such diverse ecosystem, and it harbors a wide range of medicinal plants (Hajra and Balodi 1995; Samant et al 1996).

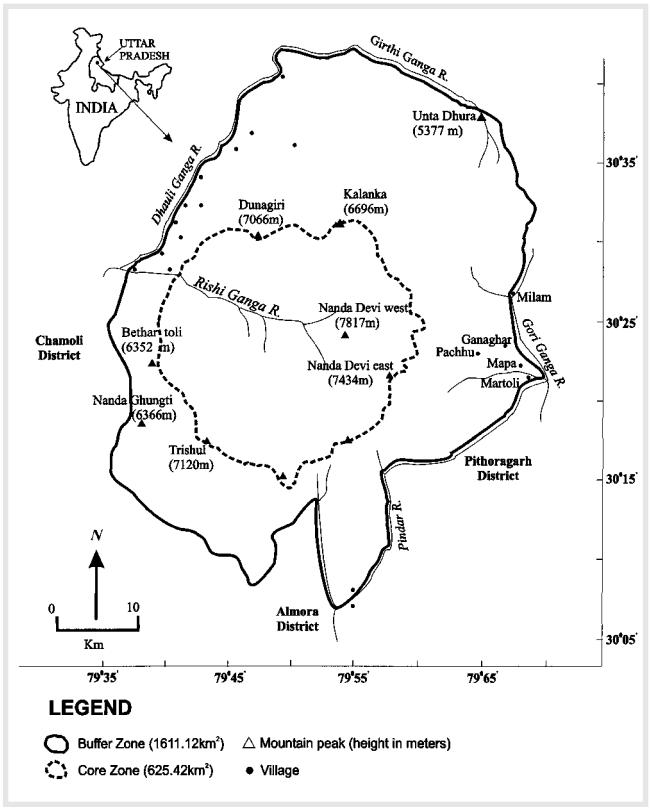
The present paper attempts to explore the potential of the much advocated community-based approach to resource conservation (McNeely et al 1990; Gadgil 1991; UNCED 1993) practiced by the *Bhotiya* tribe in NDBR. This is based on the belief that indigenous communities have evolved traditional wisdom about resource conservation over the centuries (Gadgil 1992). This paper focuses on the cultivation of medicinal plants as practiced by the *Bhotiya* and on the economics of this practice in the 5 villages of the Pithoragarh District in the buffer zone of NDBR. It also attempts to explore the prospects of medicinal plant cultivation as a potential economic venture in the region and a way of ensuring the long-term conservation of these herbs in the wild.

Study area

Geographical location and climate

The Nanda Devi Biosphere Reserve was officially designated in 1988 to conserve valuable Himalayan flora and fauna. Geographically, NDBR is situated between 79°40' and 80°5'E longitude and 30°17' and 30°41'N latitude (Figure 1). It spreads over an area of 2236.74 km^2 across three districts—Chamoli, Almora, and Pithoragarh—in the state of Uttar Pradesh in northwestern India. The reserve has 2 distinct zones: an inner core zone of 625.42 km^2 and, encircling this, an outer buffer zone of 1611.12 km^2. The Indian government already designated the core zone of NDBR as Nanda Devi

FIGURE 1 Nanda Devi Biosphere Reserve (NDBR, Government of India Notification no. 1/6/80-ND under UNESCO's Man and Biosphere Programme) in the western Himalaya, India, showing the locations of the 5 villages surveyed in the Pithoragarh District in the buffer zone. Nanda Devi National Park was created by the Government of India through its Notification no. 3912/14-3-35-80 of 6 September 1982, which included a ban on tourism activities. NDBR was created in 1988.



National Park in 1982. The core zone is surrounded by a series of high mountain peaks. The reserve was named after the Nanda Devi west peak (7817 m), located within the core zone.

The entire area is characterized by distinctive microclimates. The annual approximate variation in precipitation ranges from 750 to 2000 mm, while the temperature varies from below 0°C (December–January) to 35°C (June–July) (Silori and Badola 1999). The rainfall gradient decreases from south to north; therefore, the northern valleys of the Dhauli Ganga and Girthi Ganga rivers are comparatively dry, characterized by a trans-Himalayan climate with stunted and sparse scrub vegetation. The upper portion of the reserve (at elevations above 4500 m) remains snow covered throughout the year. Thus, about 81% of the core zone and 60% of the buffer zone remain snow covered throughout the year (Sahai and Kimothi 1996).

Biological diversity

Great altitudinal variation (1800–7817 m) and the varied topography of the area support a vast range of biological diversity in the entire biosphere reserve. Due to rich biological and cultural diversity, NDBR was also declared a UNESCO World Heritage Site in 1988. According to a remote sensing study by Sahai and Kimothi (1996), 66% of the total area of the NDBR is snow bound or covered by glaciers throughout the year. The vegetative cover of the reserve spreads over 22.2% of its total area; 6.6% is wasteland and 4.5% is grasslands or alpine pastures, known locally as *bugyal*. Only 0.7% of the NDBR is developed or under agriculture. Of the total forest cover, about 47% is dense forests (>40% crown cover), 35% open (10–40% crown cover), and 18% miscellaneous and degraded forests (<10% crown cover). So far, a total of 793 plant species have been recorded in the entire biosphere reserve (Hajra and Balodi 1995). The major forest types at the lower altitudes (between 1800 and 3000 m) are Himalayan moist/dry temperate forest with oak (*Quercus semecarpifolia*), deodar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), and other coniferous species. Above 3000 m, along the altitudinal gradient, the tree vegetation comprised of subalpine and alpine forest types is dominated by firs (*Abies pindrow*) and junipers (*Juniperus communis*), while birch (*Betula utilis*) in association with rhododendron (*Rhododendron campanulatum*) forms the timber line around 3600–3800 m (Champion and Seth 1968). The shrub species *Prinsepia utilis*, *Berberis aristata*, *Rosa macrophylla*, and *Rosa webbiana* dominate the understorey vegetation. In alpine meadows above the timberline (Figure 2), which remain snow free for about 4–5 months of the year (June–October), varieties of flowering plants of species such as *Primula, Potentilla, Anemone, Geranium, Pedicularis,* and *Saussarea* abound.

The entire reserve is a storehouse for several ethnobotanical species, including medicinal plants. Silori and Badola (1999) have listed a total of 101 species of plants found in the entire buffer zone of NDBR that are used by the villagers for various purposes. These include fibers used as a source of food or medicine, agricultural implements, timber, firewood, and herbs that have religious significance. Of these, the local people use 27 species as medicinal herbs.

Sociocultural milieu

There is a high level of ethnic diversity throughout the Nanda Devi region. Human habitation is limited in the 19 villages in the buffer zone (Figure 1). The *Bhotiya,* a tribal community, dominate the human population. Traditionally, the cross-border trade with Tibet was the main source of income for the *Bhotiya* before it was banned in 1962 after the Indo-Chinese war. Adventure tourism to Nanda Devi peak emerged as a popular alternative source of income for the villagers, especially those residing in the part of Chamoli District in the buffer zone. But in view of the potential loss of biodiversity due to lack of control over this form of tourism, it was banned by governmental decision in 1982. The consecutive loss of major sources of income forced the *Bhotiya* to look for alternatives.

FIGURE 2 Alpine meadows above the timberline contain a great variety of flowering plants, including medicinal herbs. (Photo by C. S. Silori)

Recently, rearing sheep and goats, practicing agriculture on marginal lands, and the production and sale of woolen articles have been major occupations among the *Bhotiya*.

Methods

The questionnaire survey method was employed to collect information on the cultivation and economics of medicinal plants. Extensive surveys at the household level were conducted in 5 villages in Pithoragarh District, that is, Martoli, Mapa, Pachhu, Ganaghar, and Milam (Figure 1). All the households in the villages surveyed were interviewed to collect information on various aspects of medicinal plant cultivation, harvest season, yield, and marketing options. Interviewing the head of each family, we also collected data on the average annual income per family from other sources, such as agriculture, dealings in woolen articles, and rearing of sheep and goats. Since the *Bhotiya* stay for 6 months in these villages (May–October), the information was collected during this period in 1996. We also recorded the perception of the villagers regarding the constraints they face in the cultivation and marketing of medicinal plants and possible measures to make the venture more viable in both economic and ecological terms.

Results

Socioeconomic features of the villages surveyed

All 5 villages are located in remote valleys at altitudes above 3000 m (Table 1). The villages are inhabited by the *Johari,* a subgroup of the *Bhotiya* community; therefore, the entire valley of the Gori Ganga River is also known as the Johar Valley. All the villages are accessible after a tough hilly trek of at least 35 km and up to a maximum of 55 km, from motorable roads across and along the contours at high altitudes.

The *Bhotiya* practice seasonal migration, moving to the lower altitudes outside the buffer zone during the severe winter months (November–April), while they spend the summer months (May–October) inside the buffer zone. However, over the decades, migration has undergone major transformation. The number of migrating families has declined every year ever since the ban on cross-border trade was imposed (Prasad 1989). Migrants are generally the older people in the families; the younger members stay back to continue their schooling or jobs in the lower plains. As a result, the average size of the migrant family recorded was approximately 2 people. Historically, Milam village, with more than 600 families, used to be the largest center in the cross-border trade. But during the survey, we

Variables	Villages				
	Martoli	Mapa	Ganaghar	Pachhu	Milam
Altitude (m)	3440	3345	3410	3410	3440
Distance from motorable road (km)	35	35	40	45	55
Total geographical area (ha)[a]	121.76	184.13	142.29	197.30	138.88
Total agricultural area (ha)[a]	22.15	58.32	24.96	3.68	14.76
Total cultivated land (ha)[b]	1.51	1.63	0.68	4.79	6.68
Number of families	13	10	5	25	18
Proportion (%) of landowning families	92	100	100	92	100
Total human population[c]	25	21	9	34	41
Total livestock population	749	189	311	304	967
Proportion (%) of sheep and goats	95	93	96	84	98
Average livestock holdings per family	57	19	62	12	54

TABLE 1 Socioeconomic features of villages surveyed in the buffer zone of NDBR.

[a]Source: District Statistical Office, Pithoragarh.
[b]Data recorded during household survey (1996).
[c]The figures are particularly low because only older members of families migrate to their summer abodes.

enumerated only 18 families from this village. The lack of alternative employment opportunities following the ban forced the people to migrate to the lower plains, a common phenomenon throughout the Himalayan region (Farooquee 1994; Hoon 1996).

Of the 71 families surveyed in the villages, 69% owned a livestock population totaling 2520 head (Table 1). Of this, 66% were sheep, 27% goats, and 4% cattle, while the remaining 3% were mules used for carrying loads during seasonal migration. On average, each family owned between 12 and 62 head of livestock. Ninety-seven percent of the families were landowners. Of these, 81% were marginal farmers with 1 ha of land, 18% were small farmers with 2 ha of land, and the remaining 1% were small- to medium-scale farmers with 2–4 ha of agricultural land. Of the total agricultural area, according to government records (123.87 ha), only 12% was recorded under cultivation during the household survey. This is due to the declining number of migrating families, which results in most of the area remaining uncultivated. Besides medicinal herbs, traditional crops (some introduced in the early 19th century) such as *oagal* (*Fagopyrum esculentum*) and *phaphar* (*Fagopyrum tartaricum*)—two species of buckwheat—*uwa* or barley (*Hordeum vulgare*), amaranth (*Amaranthus frumentaceous*), *rajma,* or kidney beans (*Phaseolus* spp), and potato (*Solanum tuberosum*) are also grown.

The study showed that the following areas were the major sources of overall income: agricultural produce (3–21%), medicinal herbs (5–10%), woolen products (24–53%), and the sale of sheep and goats (35–60%) (Table 2). The overall income from sheep and goats ranged between 72 and 89%, indicating the role of these animals in the economy of the villages surveyed.

Cultivation practices to produce medicinal plants

The cultivation of medicinal plants is in fact not a new practice in the villages studied. The *Bhotiya* have been known to cultivate *Jambu* and *Pharan* since these plants have been traded throughout the Himalayan region for

Sources of income	Average annual income per family (Rs) in:				
	Martoli	Mapa	Ganaghar	Pachhu	Milam
Agricultural produce	2963 (6)	357 (3)	1420 (4)	4992 (16)	8170 (21)
Medicinal herbs	2736 (5)	1063 (9)	3350 (10)	2450 (8)	2613 (7)
Woolen produce	14,850 (29)	6510 (53)	10,460 (33)	7371 (24)	12,763(32)
Sale of sheep and goats	30,600 (60)	4233 (35)	17,000 (53)	16,333 (52)	15,900 (40)
Total	51,149	12,163	32,230	31,146	39,446

TABLE 2 Average annual income per family (in Rupees) from various sources in the villages in the buffer zone of NDBR surveyed in 1996. Values in parentheses refer to the percentage of total income.

FIGURE 3 Cultivation of Pharan (*Allium carolinianum*) on an agricultural field. (Photo by C. P. Kala)

centuries (Atkinson 1882). They are propagated through bulbs and their leaves are harvested twice a year, during June–July and September–October. However, the commercial cultivation of medicinal herbs in the villages studied is a relatively recent development that began about 5 years ago.

Of the 71 families surveyed in the villages, 90% cultivate medicinal plants on their agricultural fields, on fallow land, and in kitchen gardens (Figure 3). In some of the villages, we found that the area surrounding abandoned houses was also used for cultivation of medicinal plants. Of the total reported cultivated area

TABLE 3 Cultivated medicinal plants, showing harvest season and uses by the *Bhotiya* community in the villages surveyed in the buffer zone of NDBR.

Scientific name	Local name	Harvest season	Part used	Uses
***Aconitum heterophyllum* Stapf.**	Atis	September	Root	Stomach and intestinal disorder
***Allium carolinianum* Kunth**	Pharan	August-October	Leaves	Condiments and spices
***Allium wallichii* Baker**	Jambu	August-October	Leaves	Condiments and spices
***Angelica glauca* Edgew.**	Gandrayan	October	Root	Whooping cough
***Carum carvi* Linn**	Kala jeera	August	Seed	Condiments and oil
***Dactylorhiza hatagirea* (D.Don) Soo**	Hathajari	October	Root	Urinary disorders
***Nardostachys grandiflora* DC.**	Mansi	September	Root	Incense
***Picrorhiza kurrooa* Royle ex Benth.**	Katuki	October	Root	Influenza and diarrhea
***Pleurospermum angelicoides* (DC.) Cl.**	Choru	October	Root	Fever and headaches
***Podophyllum hexendrum* Wall. ex Royle**	Ban kakari	September	Fruit	Skin diseases
***Rheum australe* D.Don**	Dolu	August	Root	Wounds and cuts
***Saussurea costus* (Fale.) Lipsch**	Koot	August	Root	Gastric pains and disorder

TABLE 4 Average productivity and projected earnings from the sale of medicinal herbs in the buffer zone of NDBR (Rs.38 = US$ 1 in 1996).

Scientific name	Area (ha) under cultivation	Average productivity (kg/ha ± SE)	Market rate (Rs/kg)	Projected cost (Rs/ha)
***Aconitum heterophyllum* Stapf.**[a]	0.57	—	250	—
***Allium carolinianum* Kunth**[b]	1.82	79.3 ± 41.4	55	4362
***Allium wallichii* Baker**[b]	2.31	102.8 ± 36.5	55	5654
***Angelica glauca* Edgew**[b]	1.78	593.3 ± 122.3	80	47,464
***Carum carvi* Linn**[b]	2.14	266.2 ± 61.3	200	53,240
***Dactylorhiza hatagirea* (D.Don) Soo**[b]	0.37	144.3 ± 51.7	600	86,580
***Nardostachys grandiflora* DC.**[a]	0.15	—	30	—
***Picrorhiza kurrooa* Royle ex Benth.**[a]	0.64	—	250	—
***Pleurospermum angelicoides* (DC.) Cl.**[a]	0.12	—	30	—
***Podophyllum hexendrum* Wall. ex Royle**[a]	0.10	—	40	—
***Rheum australe* D.Don**[a]	0.62	—	30	—
***Saussurea costus* (Fale.) Lipsch**[b]	1.31	190.8 ± 19.82	30	5724

[a]The productivity of these herbs could not be assessed since they were still under nursery plantation and were not yet ready for harvest.
[b]Medicinal herbs marketed at the time of the survey.

in all 5 villages (15.29 ha), 78% was under medicinal plant farming, while the remaining area was under traditional crops. During the household survey and field observations, it was recorded that villagers cultivated a total of 12 species of medicinal plants (Table 3). Of these, one was rare (*Allium wallichii*) and one endangered (*Saussurea costus*), while two others (*Nardostachys grandiflora* and *Picrorhiza kurrooa*) are listed as vulnerable in the Red Data Book of Indian Plants (Nair and Sastry 1990). The roots of 8 species are used for medicinal purposes; therefore, the fresh roots of these species are dug up at the end of every season (October) while the old roots are left for propagation. The maximum productivity per unit area was recorded for *Gandrayan* or *Angelica glauca* (593/kg/ha/y), while the minimum was recorded for *Pharan* or *Allium carolinianum* (79/kg/ha/y) (Table 4).

Marketing of medicinal plants

At the time of the study, of the 12 cultivated species, 6 were being marketed by the villages surveyed while the remaining 6 were still under nursery plantation to prepare seeds, rhizomes, or bulbs for propagation. Of the total cultivated area under medicinal herbs (11.93 ha), *Jambu* (*Allium wallichii*) and *Pharan* (*Allium carolinianum*) together occupied about 35%, while *Kala Jeera* (*Carum carvi,* 18%), *Gandrayan* (*Angelica glauca,* 15%), and *Koot* (*Saussurea costus,* 11%) were other important species (Table 4). The *Bhotiya* sell these herbs or exchange them for grains and other spices at the lower altitudes in the foothills of the Himalayas.

The marketing of medicinal herbs by the villagers is generally done through middlemen, who visit these villages at harvest time (September–October). The prices of medicinal herbs fluctuated between Rs.30 and Rs.600 per kg during the study period (1996). It was calculated that, on average, a family earns about Rs.2423 ± 376.95 per season from the sale of medicinal herbs. The range of total earnings per family varied from Rs.200 to Rs.23,000 during 1996. The great variation in earnings from the sale of medicinal herbs is mainly due to variation in the area under cultivation and also to the type of species grown. Based on the average productivity of medicinal herbs in the study villages and on their prices, we estimated that one family could earn between Rs.4362 and Rs86,500 from 1 ha of agricultural land per season, depending on the choice of the medicinal herb to be cultivated (Table 4). Compared with traditional cash crops, such as potato, *rajma* (beans), and amaranth, the income from medicinal plants is quite high. The selling price of these traditional cash crops at the time of the survey in the villages studied was recorded as Rs.4, Rs18, and Rs.11 per kg, respectively, for potato, *rajma,* and *amaranth,* which is much lower than the lowest selling price of medicinal plants.

Discussion

The designation of Nanda Devi National Park (the core zone of NDBR) in 1982 and the creation of the biosphere reserve in 1988 imposed a ban on the collection of medicinal plants from the region. Therefore, to meet their own need for medicinal herbs in the absence of medical facilities in remote villages and to fulfill the growing demand for these herbs on the open market, the villagers began to cultivate them on their agricultur-

al fields. In addition, the lack of alternate employment opportunities, especially after the ban on cross-border trade in the early 1960s, and the changing concept of protected area management focusing on people's participation encouraged the *Bhotiya* to expand their activities. The net result of all these developments was a shift in the cropping pattern toward cultivation of medicinal herbs, largely due to the greater economic returns they brought by comparison with traditional cash crops such as potato, *rajma,* and amaranth.

These developments in the villages surveyed may be considered positive, both from an ecological and a socioeconomic point of view. As mentioned above, it has been established that the sale of medicinal herbs fetches more money than the sale of traditional cash crops. At the same time, medicinal plant cultivation has also helped to conserve indigenous knowledge about medicinal herbs among the *Bhotiya,* an important aspect of community-based resource conservation (Battisse 1982; Gadgil 1991; McNeely 1997; Dhar et al 1999; Dobhal 1999). Ecologically, cultivation of medicinal herbs is an incentive to reduce human pressure on the high-altitude forests, providing enough time for these forests to regenerate after severe degradation due to anthropogenic impacts in the recent past (Babu et al 1984; Moench 1989; Zhou 1993; Rao and Saxena 1994; Farooquee and Saxena 1996; Kala et al 1997; Maikhuri et al 1998a,b). Nevertheless, in view of the increasing demand for medicinal herbs in the near future, it will be necessary to organize current cultivation practices and improve them by using more technical and scientific inputs. The local villagers also felt that the absence of proper marketing strategies was an obstacle to obtaining the right price for their produce.

Maikhuri et al (1998a) have projected that the productivity of medicinal herbs could be substantially increased by more advanced techniques and proper management. The authors projected the productivity of *Angelica glauca* at 985 kg/ha/y in the western part of NDBR, compared with our findings of 593 kg/ha/y. Similarly, the productivity of *Dactylorhiza hatagirea* was projected at 450 kg/ha/y, as against 144 kg/ha/y recorded in our study. The projected productivity figures by Maikhuri et al (1998a) further elucidate the potential for greater economic returns from the cultivation of medicinal herbs in the study region under proper management.

There are enormous variations in the selling price of medicinal plants throughout the Himalayan region. For example, the roots of *Dactylorhiza hatagirea* are sold for prices from Rs.200 to Rs.1200 per kg, while the price of *Aconitum heterophyllum* can vary from Rs.160 to Rs.1000 per kg (Gupta et al 1998). These variations may be attributed to the absence of a proper marketing system and the increased role of middlemen in the business (Farooquee 1994; Gupta et al 1998). As far as economic returns are concerned, Nautiyal (1996) estimated an average annual income of Rs.7150 to Rs.55,000/ha/y, Maikhuri et al (1998a) projected earnings between Rs.12,750 and Rs.40,000/ha/y, while Rao and Saxena (1994) recorded earnings of Rs.12,000/ha/y in a mixed cropping system to produce medicinal herbs. From these studies, it can be concluded that potential average income from cultivating medicinal herbs is greater than from cultivating traditional crops. The findings of our study regarding income from the sale of medicinal plants support this conclusion.

Although domestication of medicinal herbs constitutes a potential component of sustainable rural development in the villages surveyed, it is highly likely that the increased involvement of middlemen and contractors in this trade will exclude the *Bhotiya* from the main trade. The trade therefore needs to be organized properly. Perhaps a highly cooperative culture, in which local people have an adequate stake, can be developed to provide the necessary benefits to the medicinal herb growers. Recommendations along these lines that could be feasibly implemented have already been advanced (Kala 1998), and the success story of the world-famous Chipko Movement—with one initiative launched by the inhabitants (mainly women) of the village of Reni in NDBR—shows how a participatory approach can work. However, more field work and research are needed on these aspects in the area.

Thus, in the wake of growing commercialization, which has brought substantial changes in the traditional subsistence economy, preservation of natural resources—particularly of medicinal herbs throughout the Himalayas—remains a challenge. The growing commercialization of natural resources could have negative impacts on fragile ecosystems such as the Himalayas if it is not planned in a proper way. A blend of modern agricultural technology suitable to high altitudes and the indigenous knowledge of the *Bhotiya* would help to make commercialization a promising venture for sustainable use of natural resources and economic development in local communities. But such a strategy requires further research before implementation is possible. Nurseries as well as gene banks in the form of seeds, seedlings, roots, rhizomes, bulbs, and tubers should be encouraged throughout the region; a few experimental studies (eg, Gupta et al 1998) have already been conducted in the Himalayas and show how the use of modern technology can also contribute to promoting conservation.

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