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A Case Study in Four Temperate Villages of Garhwal Himalaya, India

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This case study explored forest resource-use patterns to understand villagers' dependency on forests in four temperate villages situated in two forested sites in Garhwal Himalaya: Mandal and Khalla in the Mandal area, Chamoli District, and Chaundiyar and Dikholi in the Chaurangikhal area, Uttarkashi District. Although the literacy rate in the villages was quite high, due to lack of employment opportunities people still invariably depend on forests for their livelihood. In all the study villages more than 75% of fodder and fuelwood were extracted from the forest. The pressure exerted by human and bovine populations, coupled with unsustainable management policies, has resulted in the destruction of forest cover and ecological degradation. Agriculture (which is 70% rainfed in the Mandal area and 90% rainfed in Chaurangikhal) and employment as laborers were the main occupations of people in the study areas; in addition, remittance income (8.6% in the Mandal area and 21.3% in Chaurangikhal) and dairy faming accounted for a major portion of total household income. The study revealed a positive relationship between income and livestock population (0.995), which reveals the strong role of animal husbandry in the rural economy. The equally positive relationship between income and fodder consumption (0.930) can be attributed to extraction of large quantities of fodder to sustain dairy farming for commercial purposes. The correlation between income and fuelwood consumption was found to be negative (−0.882), the likely reason being poor economic conditions, leading to dependency on the forest for fuelwood as a free source of energy.

Keywords: *Forest use; livestock; fuelwood; fodder trees; income sources; poverty; Gahrwal Himalaya; India.*

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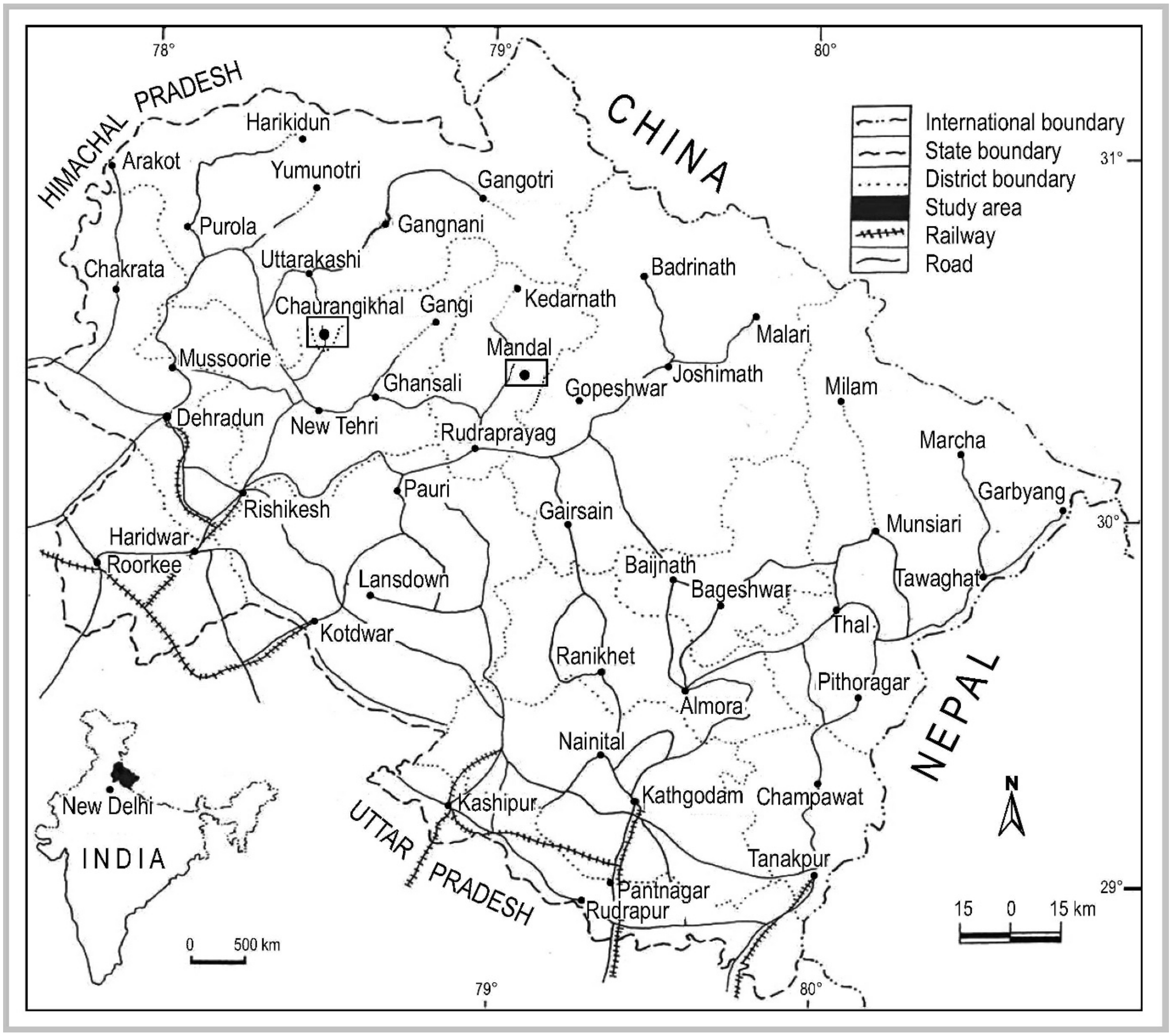
Introduction

The Indian Himalayan region occupies a special place in the mountain ecosystems of the world. This region is not only important from the standpoint of climate and as a provider of life, giving water to a large part of the Indian subcontinent; but it also harbors a rich variety of flora, fauna, human communities, and cultural diversity (Singh 2006). Dispersed small settlements and terraced agricultural fields carved out of the hill slopes for raising crops, with numerous multipurpose tree species growing, particularly on the boundaries of rainfed terraces, are typical features in the temperate area of Garhwal Himalaya. Average cultivated land per farmer in the central Himalaya is 0.5 hectares, but production is supplemented from the adjacent forest ecosystem (Tewari et al 2003). Singh et al (1984b) have reported that in Central Himalayan farming systems, each unit of agricultural crop energy produced entails an input of about seven units of energy from the adjacent forests in terms of fodder, fuelwood, and litter (for manure).

The link between forest management and the well-being of communities in forested areas has traditionally been defined by forest sector employment opportunities (Sharma and Gairola 2007). Forest areas in the proximity of population centers or villages are reported to be shrinking and degrading faster due to collection of fuelwood and cattle grazing, etc, compared to forests situated away from population centers and located in inaccessible areas (FSI 2000). Continuous heavy and unsustainable exploitation of forest resources has resulted in overall degradation of forests (Khanduri et al 2002). The dependency of the continually growing population on finite resources and lack of viable technologies to mitigate mountain specificities and enhance production to meet demand are depleting resources. Along with the increasing marginality of farmers, this ultimately causes poverty (Samal et al 2003). Depletion of forest cover, biodiversity and terrestrial carbon stocks, declining farm productivity, increasing hydrological imbalance, and soil erosion are interconnected problems and therefore root causes of the poor economic status of the hill people (Chipika and Kowero 2000).

Traditionally in this area, agricultural activities are concentrated at elevations between 1000 and 2000 meters

FIGURE 1 Map of the study areas. (Map by Dr. S.K. Ghildiyal)



above mean sea level, often called the agricultural or populated zone; pressure on forests is at a maximum in this range (Tewari et al 2003). Because of limited employment opportunities in the rural areas of Garhwal Himalaya, people either migrate to the plains in search of jobs or depend solely on forests and small-scale agriculture for their livelihood.

This article presents a case study from Garhwal Himalaya that deals with the links between the socioeconomic status of people and forest resource-use patterns. It explores the pattern of energy consumption, the relationship between income and forest use, and the causes of pressure on forests for various products. It concludes with suggestions regarding possible action to prevent further forest degradation.

Material and methods

The study areas lie in the temperate zone of Garhwal Himalaya in Uttarakhand State in India (Figure 1). The study was carried out in 4 villages, 2 in the Mandal area (Mandal and Khalla), which lies at latitude 30°27.560′N and longitude 79°15.234′E between 1500 m and 1550 m in the Chamoli district, and 2 in the Chaurangikhal area (Chaundiyar and Dikholi), which lies at latitude 30°27.906′N and longitude 79°15.303′E between 1600 m

TABLE 1 General climatic and agricultural details for the study areas.

Study area	Climate data (1998–2007)		
	Mean annual maximum temperature[a)]	Mean annual minimum temperature[a)]	Mean annual rainfall[a)]
Mandal	16.41 ± 3.60°C	6.14 ± 1.98°C	2044.47 ± 476.01 mm
Chaurangikhal	18.51 ± 3.70°C	5.71 ± 1.81°C	1825.39 ± 417.54 mm

Cropping pattern for both study areas		
***Ravi* (winter season crops)**	***Kharif* (rainy season crops)**	**Common leguminous crops**
Wheat (*Triticum aestivum*)	Paddy rice (*Oryza sativa*)	Black gram (*Vigna mungo*)
Mustard (*Brassica campestris*)	Finger millet (*Eleusine coracana*)	Kidney bean (*Phaseolus lunetus*)
Barley (*Hordeum vulgare*)	Soybean (*Glycine max*)	Pea (*Pisum sativum*)
Lentil (*Lens esculenta*)	Hog millet (*Panicum miliaceum*)	Horse gram (*Dolichos uniflorus*)
	Amaranth (*Amaranthus paniculatus*)	
	Japanese barnyard millet (*Echinocloa frumentacea*)	
Agroforesty tree species (planted on the bunds and boundaries of agricultural fields): *Q. leucotrichophora*, *Grewia oppositifolia*, *Celtis australis*, *Ficus roxburghii*, *F. glomerata*, *Bauhinia variegata*, *Toona ciliata*, etc.		

[a)] Source: Uttarakhand Forest Department.

and 1750 m in the Uttarkashi district. Details of the climate and cropping patterns in these study areas are shown in Table 1.

The climate in the study areas can be divided into three distinct seasons, namely summer (April–June), rainy (July–September), and winter (November–February). The rainfall pattern in the region is largely governed by the monsoon rains (July–September), which account for about 60–80% of the total annual rainfall. The vegetation in the study areas is both natural and man-made. Khalla and Mandal villages are situated at the base of natural temperate mixed broad-leaved forests, whereas Chaundiyar and Dikholi are situated between pure pine forests. The mixed broad-leaved forests at both sites have more or less similar species composition (Table 2).

Structured and pretested questionnaires were used to interview approximately 30% of the total households in each village (a total of 108 in 4 villages; Table 1). These questionnaires were based on the requirements of the study and on information extracted from general discussions with villagers to gather information from each social caste, economic level, gender, and age. We also used different ways of collecting precise, quantitative data on income and income sources: questionnaires, personal observation, and discussions with *gram pradhans* (heads of village legislative councils). The head of each sample household was interviewed. The data collected for the study included general information about each household, such as literacy level, family size, landholding, number of animals per family, sources of income, occupation, sources of energy, extraction of non-timber forest products, and so on.

To estimate the amount of fuelwood and fodder consumption per day per household, 10% of the households per village (a total of 34) were surveyed in the 4 villages, and their consumption amounts were noted for 7 consecutive days in 3 different seasons: summer, rainy, and winter. The families surveyed were chosen to include equal representation from all economic classes and family sizes. To understand pressure on individual forest tree species, we asked about villagers' preferences for various purposes such as fuelwood, fodder, agricultural implements, household articles, and other uses; a maximum of 10 points was given for each use. This information was further verified by personal observations. All points were combined to give a final ranking for each tree species. The order of preference for all trees was subsequently ranked in descending order.

Results and discussion

Socioeconomic observations

The average family size varied between 5.3 persons per household in Chaundiyar and 5.8 persons per household in Khalla (Table 3). The sex ratio (females/thousand males) ranged between 862 in Chaundiyar and 1136 in

TABLE 2 Vegetation pattern and types of human activities at different altitudes and distances from the study villages. (Table continued on next page.)[a)]

Altitude (masl)	Distance from villages	Tree species found at various altitudes (species in bold are dominant species)		Types of resource use (anthropogenic disturbances)	
		Mandal Forest	Chaurangikhal Forest	Mandal	Chaurangikhal
2700–2900	7–8 km	***Abies pindrow***, *Lyonia ovalifolia*, ***Quercus semecarpifolia***, *Rhododendron arboretum*, *Sorbus cuspidata*	***A. pindrow***, ***Q. semecarpifolia***, *Symplocos paniculata*	LTL, LG	LSC, LTL, LG, ENTFP
2500–2700	6–7 km	***A. pindrow***, ***Acer acuminatum***, ***Aesculus indica***, *Diospyros montana*, *L. ovalifolia*, *Neolitsea pallans*, *Persea duthiei*, ***Quercus floribunda,*** *R. arboreum*	***A. pindrow***, *Buxus wallichiana*, *L. ovalifolia*, ***Q. semecarpifolia***, *R. arboreum*, *Taxus baccata*, *P. duethei*, *S. paniculata*, *A. acuminatum*, *Abies spectabelis*, *Carpinus viminea*, *Q. floribunda*	LG, LTL	LSC, LTL, LG, ENTFP
2300–2500	5–6 km	*A. acuminatum*, *A. indica*, *A. pindrow*, ***B. alnoides***, *Corylus jacquemontii*, *L. ovalifolia*, *P. duthiei*, ***Q. floribunda***, ***R. arboreum***, *T. baccata*	***A. pindrow***, *C. viminea*, *L. ovalifolia*, *P. duethei*, *Pyrus pashia*, ***Q. floribunda***, ***Quercus leucotrichophora***, *Q. semecarpifolia*, *R. arboreum*	LG, LTL	HSC, HTL, LG, ENTFP
2100–2300	4–5 km	*A. indica*, *A. pindrow*, *A. spectabilis*, ***B. alnoides***, *B. wallichiana*, *C. viminea*, *D. montana*, *Daphniphyllum himalense*, *Doedcademia grandiflora*, *Euonymus tingens*, *Fraxinus micrantha*, *Juglans regia*, *L. ovalifolia*, *N. pallans*, *P. duthiei*, ***Q. floribunda***, ***Q. leucotrichophora***, *R. arboreum*	*A. nepalensis*, *B. alnoides*, *L. ovalifolia*, *Myrica esculenta*, *P. pashia*, ***P. roxburghii***, *Q. floribunda*, ***Q. leucotrichophora***, *R. arboreum*	LSC, LTL, LG	HSC, HTL, LG
1900–2100	2.5–4 km	***A. nepalensis***, *B. alnoides*, *C. viminea*, *D. himalense*, *D. montana*, *Ilex dipyrena*, *L. ovalifolia*, *N. pallans*, *P. duthiei*, *P. pashia*, ***Q. leucotrichophora***, *R. arboreum*, *S. paniculata*, *Ulmus wallichiana*	*A. nepalensis*, *B. alnoides*, *L. ovalifolia*, *M. esculenta*, *P. pashia*, ***P. roxburghii***, *Q. floribunda*, *Q. leucotrichophora*, *R. arboreum*	LSC, LTL, HG, RT	HSC, HTL, HG, ENTFP, RT, CF
1700–1900	1.5–2.5 km	*A. nepalensis*, *B. alnoides*, *C. viminea*, *Cupressus torulosa*, *D. himalense*, *D. montana*, *F. micrantha*, *L. ovalifolia*, *P. odoratissima*, *P. roxburghii*, *Pyrus pashia*, ***Q. leucotrichophora***, *R. arboreum*, *U. wallichana*	*A. nepalensis*, *L. ovalifolia*, *P. pashia*, ***P. roxburghii***, *R. arboreum*	LSC, HTL, HG	HG, HSC, HTL, RT, CF

TABLE 2 Continued.

Altitude (masl)	Distance from villages	Tree species found at various altitudes (species in bold are dominant species)		Types of resource use (anthropogenic disturbances)	
		Mandal Forest	Chaurangikhal Forest	Mandal	Chaurangikhal
1500–1700	0–1.5 km	***A. nepalensis***, *Cinnamomum tamala*, *D. himalense*, *F. roxburghii*, *Ficus subincisa*, *Fraxinus xanthoxyloides*, *L. ovalifolia*, *M. esculenta*, *P. odoratissima*, *P. pashia*, *P. roxburghii*, *Quercus glauca*, ***Q. leucotrichophora***, *R. arboreum*, *Toona ciliate*, *U. wallichana*	*A. nepalensis*, *P. pashia*, ***P. roxburghii***	HG, CF, HTL, LSC, RT	HG, HSC, HTL, ENTFP, RT, CF
Species richness		38	18		

[a] HSC, heavy stem cutting; LSC, low stem cutting; HTL, heavy tree lopping; LTL, low tree lopping; HG, heavy grazing; LG, low grazing; ENTFP, extraction of non-timber forest products; CF, controlled fire; RT, resin tapping.

Mandal village. This difference can be attributed to lack of employment, which has led to migration of the male population from Mandal area to other areas in search of jobs. The literacy rate was above 80% in all 4 villages; most of the people were educated between grades 5 and 10 in Chaundiyar village area and above grade 10 in the Khalla, Mandal, and Dikholi villages. Few people were uneducated, and most of those were older. Although the literacy rate was very high, most people were unemployed because of a lack of employment opportunities. The villagers therefore still relied for their sustenance on rainfed agricultural land and forests.

The average cultivated land at both sites was less than 0.5 ha (Table 3); therefore, production was supplemented from the adjacent forest ecosystem. A positive relationship (0.784) between income and landholdings (Table 4) points to the major role of agricultural land in the economy of hill people. More than 90% of the agricultural fields in the Chaurangikhal area and about 70% in the Mandal area were rainfed. Approximately half of the houses in all the villages were made of cement, and the rest were a traditional type made of slate (*pathals*), wood, and straw. Mainly traditional stoves (*chullhas*) with smoldering fuelwood were used for cooking. Because of the smoke produced by fuelwood and lack of proper ventilation in the houses, women generally face problems of suffocation and suffer from swollen eyes, loss of vision, bronchitis, and tuberculosis.

Mean monthly income and sources of income

The mean annual income in Indian national rupees ranged between Rs 17,895 (US$ 376) per household in Dikholi village and Rs 49,727 (US$ 1044) per household in Khalla village (Table 3), which is higher than the Below Poverty Line limit defined by the government of India for rural areas (Rs 12,000; US$ 252). The main occupation in all 4 villages was agriculture, which was practiced at a small scale on terraced farms and was not sufficient to feed an entire family for the year. Few vegetables and fruits from agricultural land were sold on the open market to earn cash income. Employment as a laborer was the second-largest source of income for the villagers. People worked in Gramin Rozgar Yojna and other welfare schemes run by the government, and they sometimes worked as laborers in the private construction sector. Dairy production was the third-largest source of employment in Mandal valley. Remittance income sent by people who had migrated to other places also accounted for a large portion of income in the Chaurangikhal area (21.3%), whereas in the Mandal area it was just 8.6% (Figure 2). This is because most of the men in the Chaurangikhal area are nomadic shepherds and migrate to higher altitudes during the summer and rainy season. They earn most of their income while residing outside their traditional villages.

Dairy products were sold to private agencies that collect them and sell in cities. Other sources of income were poultry, goat rearing, government jobs, government pensions, and extraction of minor forest products (Figure 2). A negative relationship between income and literacy level (−0.946) was recorded (Table 4), which is very rare and can be directly attributed to a lack of employment among the educated people in the area. This increases people's dependency on agriculture and forest resources for income from which they earn substantial money, although agricultural work does not necessarily require educated people.

TABLE 3 Socioeconomic status of the people in the study areas.

Study area and village	Mandal area		Chaurangikhal area	
Variable	**Mandal**	**Khalla**	**Chaundiyar**	**Dikholi**
Total number of households	100	85	69	81
Number of households sampled	30	28	23	27
Total population	556	493	365	457
Average family size (persons per household)	5.6	5.8	5.3	5.6
Number of males	260	238	196	243
Number of females	296	255	169	214
Sex ratio (females per thousand males)	1136	1070	862	880
Landholding per family (ha)	0.33	0.35	0.26	0.31
Annual income per family (Indian Rupees)	36,421	49,727	22,241	17,895
Literacy level				
Uneducated	13.2%	16.1%	12.8%	11.7%
< 5th grade	26.5%	17.3%	14.0%	17.2%
5th–10th grade	29.8%	30.9%	40.0%	34.2%
> 10th grade	30.6%	35.8%	33.4%	37.0%
Livestock				
Total livestock population	521	519	258	283
Average number of animals/household	5.2	6.1	3.7	3.5
Livestock-owning families	89%	91%	100%	98%
Average fodder consumed/household/day (kg)	40.0	40.5	31.6	27.2
Fodder extracted from the forest	84.9%	88.8%	79.7%	83.3%
Distance traveled for fodder collection (km)	3	0.5–2	5–6	7–8
Energy consumption				
Average fuelwood consumed/household/day (kg)	11.6	13.1	21.0	24.6
Fuelwood extracted from forest	85.9%	97.2%	75.9%	75.5%
Distance traveled for fuel wood collection (km)	4	3	5–6	7–8
Average LPG consumed/household/year (L)	56.8	68.4	31.2	44.0
Average kerosene consumed/household/month (L)	6.4	3.3	4.4	5.8

Livestock and fodder consumption

Almost everywhere in the mountains, agriculture is by and large based on livestock. Mountain communities are fully dependent on natural resources, livestock, and traditional agriculture; mountain agriculture is a socioeconomic symbiosis of crop, livestock, production, and manpower. In this type of system, besides human activities, livestock play a crucial role in strengthening the economy. Livestock are considered a capital asset. In addition, livestock provide gainful employment to a large section of the population throughout the year.

Common livestock domesticated by people in the study region are cattle, buffalo, sheep, goat, horses, ponies, and poultry. Among Hindus, only the meat of goats and chickens is eaten, and these animals are often sold to earn income, whereas large animals are rarely sold

TABLE 4 Pearson's correlation coefficients between different parameters.

Correlation / Parameter	1	2	3	4	5	6	7	8	9	10
1. Fodder consumed/ household	1.000									
2. Income/ family	0.930*	1.000								
3. Number of animals/ household	0.948*	0.995**	1.000							
4. Fuelwood consumed/ household	−0.991**	−0.882*	−0.913*	1.000						
5. LPG consumed/ household	0.771	0.888*	0.909*	−0.751	1.000					
6. Kerosene consumed/ household	−0.240	−0.487	−0.395	0.108	−0.230	1.000				
7. Average family size	0.393	0.625	0.638	−0.363	0.888*	−0.212	1.000			
8. Sex ratio (females/ 1000 males)	0.923*	0.829	0.881*	−0.954**	0.840	0.082	0.531	1.000		
9. Literacy level	−0.780	−0.946*	−0.910*	0.695	−0.801	0.734	−0.624	−0.605	1.000	
10. Landholding/ family	0.638	0.784	0.811	−0.624	0.981**	−0.151	0.952*	0.763	−0.706	1.000

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.

and hence are kept as a source of wealth. The major fodder resources are crop residues, leaves from trees, ground flora in forested areas, and dried grasses, which are stored on treetops in heaps and used as feed during lean periods when little fodder is available. The forest is the major source of leaf fodder and bedding material for livestock in the area.

Most of the families in the study areas owned livestock. Fodder consumed per household per day was 40.0, 40.5, 31.6 and 27.2 kg in Mandal, Khalla, Chaundiyar, and Dikholi villages, respectively (Table 3). This difference in fodder consumption per household between the Mandal and Chaurangikhal areas is due to the higher number of livestock in the Mandal area. Women in the study area spent about 1.5 to 3.5 hours daily to collect fodder from forested areas, which was the major portion of their everyday activity. In the Mandal valley, approximately 86% of the total fodder was being extracted from the forest, and the figure was 81% for the Chaurangikhal area.

All the animals graze in forestland, even up to an elevation of 2900 m, which harms the ground flora and impedes regeneration of dominant tree species in the area. In the Himalayan region, the prevailing opinion is that grazing is detrimental to forests. Forest grazing is frequently blamed for slow regeneration, poor forest conditions, and, in extreme cases, causing potential ecological disasters (Roder et al 2002). Negative effects on forest ecosystems attributed to forest grazing include loss of species diversity due to selective browsing, soil erosion, depletion of nutrients, soil acidification due to removal of biomass, compaction of topsoil and formation of hydromorphic humus, and damage to tree roots that facilitates root rot (Glatzel 1999). Uncontrolled grazing and overstocking of livestock prevent regeneration of the tree cover to some extent (Kumar and Shahabuddin 2005), but Ives (2006) has stated that its negative impact on land use in the Himalayas may be overstated.

The number of animals varied according to economic and social conditions in the villages. As dairy farming was one of the major occupations in the Mandal area, it accounted for a higher number of animals per households (5.6 in Mandal and 5.8 in Khalla) compared with the Chaurangikhal (3.7 in Chaundiyar and 3.5 in Dikholi) area (Table 3). A significantly positive (0.995) relationship was recorded between the number of livestock and the

FIGURE 2 Share of different sources of income in total household income in the study areas.

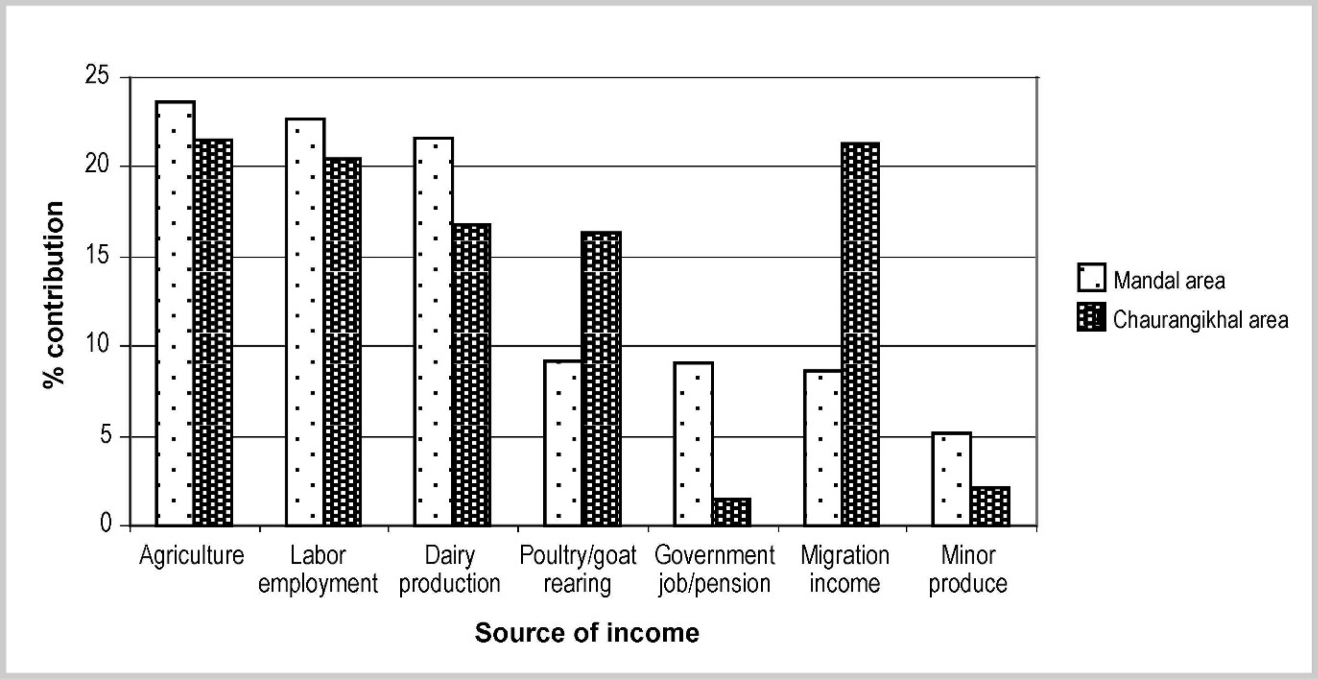


FIGURE 3 Heaps of fuelwood stacked for the winter season. (Photo by Sumeet Gairola)

income per household, implying the strong role of animal husbandry in the rural economy of the study area.

Pattern of energy consumption

Fuelwood is the most common and primary energy source among rural populations in developing countries (Allen et al 1988), and is used for cooking and also to heat rooms and water during the winter season. Other forms of commercial energy are beyond the reach of ordinary people because of poor socioeconomic conditions, lack of communication, high prices, and limited supply in inaccessible mountain areas (Chettri et al 2002). It has been reported that 54% of the total global wood harvest is for fuel (Nautiyal and Kaechele 2008). Hence, fuelwood plays a major role in the progression of forest degradation.

In all the study villages, 100% of the families use wood as the chief source of fuel for cooking and heating. As all the villages are situated in the temperate zone, where it is usually cold, villagers extract wood for heating and cooking throughout the year. Collection of fuelwood from forests and private lands requires at least 2 to 4 hours of work every day in the study areas. The villagers travel 2 km in the Mandal area to 6–7 km in the Chaurangikhal area every day to collect fuelwood from the forest. In the Mandal valley, approximately 91% of fuelwood is collected from the forest, and the rest is collected from private lands; for the Chaurangikhal area, 75% of the fuelwood is collected from the forest (Table 3). Reasons for less forest wood collection in Chaurangikhal area could be linked to the greater distance of the forest from the village.

Average fuelwood consumption per household per day was recorded as 11.6, 13.1, 21.0, and 24.6 kg for Mandal, Khalla, Chaundiyar, and Dikholi villages, respectively. Stacks of fuelwood were collected during summer and stored for the winter season, when snowfall is high and accessibility to the forests at higher altitudes is minimal (Figure 3). Average liquefied petroleum gas (LPG) consumed per household per year was 56.8, 68.4, 31.2, and 44.0 kg in Mandal, Khalla, Chaundiyar, and Dikholi villages, respectively. In the study villages, LPG is occasionally used for cooking and mainly for preparing tea or quick food. Other sources of energy used in the area include kerosene oil, which is used mainly for lamps.

Other fuel types, such as crop residues and dung cakes, were not used in any of the villages studied. Dung cakes were not used as fuel for 2 reasons: (1) fertilizers are very rarely used in the agricultural fields, and because dung is the main source of manure, it is therefore required in large quantities; and (2) fuelwood is easily available at no cost and is simple to use compared with dung cakes. Whereas crop residues are either used as fodder or bedding material for livestock, a sod and dung combination constitutes the compost manure for agricultural fields.

A significant negative relationship (−0.882) between fuelwood consumption and income has been recorded in these villages, which shows that poor people are more dependent on forests for fuelwood as a source of energy (Table 4). A negative relationship (−0.751) was recorded between LPG and fuelwood consumption. A study by Nautiyal and Kaechele (2008) also showed a dramatic change in per capita fuelwood consumption in the villages where people are using LPG. A significantly positive relationship (0.888) between LPG consumption and income was recorded (Table 4), which suggests that greater purchasing capacity will reduce pressure on forests from fuelwood extraction and help people to adopt alternative sources of energy, such as LPG, kerosene, and solar energy. It is evident from Table 3 that the consumption of fuelwood per household in the Mandal valley was lower compared with the Chaurangikhal area, and consumption of other sources of energy, such as kerosene and LPG, was higher. This was mainly because economic conditions in the Mandal valley are better than in the Chaurangikhal area. Therefore, the villagers in Mandal area have more capacity to purchase LPG or kerosene and the supply of LPG and kerosene is regular. Also, the Mandal forest is part of the reserved forest; therefore, laws are strictly enforced and extraction of wood is difficult.

Pressure on forests

The Mandal forest is very dense and diverse compared with the Chaurangikhal forest (Table 2). We recorded 38 tree species in the Mandal forest and 18 tree species in the Chaurangikhal forest. Villagers in both study areas use wild and agroforestry tree species to fulfill their various needs. In the Mandal area, the villagers preferred 24 tree species (14 tree species in Chaurangikhal) for a variety of purposes. As these species were easily accessible, pressure on them was enormous (Tables 2 and 5).

Quercus leucotrichophora, *Q. floribunda*, *Q. semecarpifolia*, *Abies pindrow*, *Alnus nepalensis*, *Pinus roxburghii*, *Rhododendrum arboreum*, *Betula alnoides*, and *Lyonia ovalifolia* are the fuelwood species the villagers prefer because they have high calorific values and are easily available and accessible (Table 5). As shown in Table 2, pressure on forests growing in the vicinity of the villages (within a 5-km range and between 1500 m and 2300 m) is high. In *P. roxburghii* forest, resin tapping and regular forest fires are the major causes of destruction, whereas in *Quercus* forests, tree lopping, grazing, and stem cutting are the major forms of disturbance. Easily accessible *Quercus* spp, which also have high calorific and utility values, were the most affected species due to overexploitation (Table 5). Trees were indiscriminately lopped for fodder and cut down for fuelwood extraction. The climax communities of the Western Himalaya are characterized by the dominance of one or the other species of *Quercus* spp (Awasthi et al 2003). These forests are not only intricately associated with the hydrological balance but also form the life support system for the local inhabitants (Singh and

TABLE 5 Ranking of forest tree species on the basis of preference for various uses by the villagers and their utility values in the study area. (Table continued on next page.)[a)]

Botanical name	Local name	Family	Utility values	Calorific value (kJ g^{-1} dry weight)	Ranking[b)]	
					Mandal	Chaurangikhal
Quercus leucotrichophora	*Banj*	Fagaceae	FW, F, HA, AI, BL	24.0[c)]	1	1
Quercus floribunda	*Moru*	Fagaceae	FW, F, HA, AI, BL	22.92[d)]	2	2
Carpinus viminea	*Chamkharik*	Corylaceae	FW, F, HA, BL	20.51[c)]	3	–
Quercus semecarpifolia	*Kharsu*	Fagaceae	FW, F, HA, AI	23.82[e)]	4	3
Abies pindrow	*Raga*	Pinaceae	FW, T, HA	19.17[e)]	5	4
Betula alnoides	*Saud*	Betulaceae	FW	19.65[f)]	6	7
Ulmus wallichiana	*Emrohi, chamar*	Ulmaceae	FW, F	–	7	–
Neolitsea pallens	*Pinna*	Lauraceae	FW, F	–	8	11
Alnus nepalensis	*Utees*	Betulaceae	FW	15.29[g)]	9	6
Fraxinus micrantha	*Angu*	Oleraceae	FW, F, HA, T	21.45[d)]	10	3
Lyonia ovalifolia	*Anyar*	Ericaceae	FW	18.05[f)]	11	8
***Persea* spp**	*Kaul*	Lauraceae	FW, F, HA	19.64[d)]	12	9
Aesculus indica	*Pangar*	Hippocas-tanaceae	FW	18.60[f)]	13	–
Taxus baccata	*Thuner*	Taxaceae	F, M, AI	17.36[e)]	14	6
Pinus roxburghii	*Chir/ Kulain*	Pinaceae	FW, T, HA, AI, BL	23.17[h)]	15	5
Pyrus pashia	*Melu*	Rosaceae	FW, F, Fr	19.50[f)]	16	12
Daphniphyllum himalense	*Ratnalu*	Daphniph-yllaceae	FW, HA	18.66[h)]	17	–
Rhododendron arboreum	*Burans*	Ericaceae	FW, Fl	21.54[e)]	18	10
Juglans regia	*Akhroot*	Jugland-aceae	FW, AI, HA, Fr	22.51[c)]	19	–
Fraxinus xanthoxyloides	*Thelka*	Oleraceae	FW, F	–	20	–
Quercus glauca	*Haring*	Fagaceae	FW, F, HA, AI, BL	23.50[e)]	21	–
Ilex dipyrena	*Kanel*	Aquifo-liaceae	FW, HA	–	22	–

TABLE 5 Continued.

Botanical name	Local name	Family	Utility values	Calorific value (kJ g^{-1} dry weight)	Ranking[b)]	
					Mandal	Chaurangikhal
Symplocos paniculata	*Lodh*	Symplo-caceae	FW, F	21.16[g)]	23	–
Myrica esculenta	*Kafal*	Myricaceae	FW, Fr	18.31[f)]	24	–

[a)] F, fodder; FW, fuelwood; AI, agricultural implements; HA, household articles; M, manure; T, timber; BL, bedding material for livestock; Fr, fruit; M, medicine; Fl, flower.
[b)] Ranking is based on the combined points given for availability and various uses of the trees, ie fuelwood, fodder, agricultural implements, household articles, and miscellaneous.
[c)] Jain (1993).
[d)] Jain (1998).
[e)] Krishna and Ramaswamy (1932).
[f)] Jain and Singh (1999).
[g)] Kataki and Konwer (2002).
[h)] Jain (1992).

Singh 1992). The sustainability of these forests depends greatly on their productivity, resilience and human activities (Awasthi et al 2003). Scientific studies suggest that the plant community structure is greatly influenced by disturbances in the forests (Yadav and Gupta 2006). Disturbances ultimately cause canopy gaps and reduce leaf fall; hence, they negatively affect the return of nitrogen to the soil and increase dryness in the forest (Singh et al 1984a) and consequently lead to poor regeneration of the forest trees.

Conclusion

Lack of employment opportunities and low income are the major causes for rural people's dependency on forests for their livelihood. This dependency is causing degradation of forests and is forcing people to migrate to cities in search of jobs. As agricultural and livestock productivity is sustained by inputs derived from forests, continued depletion of forest reserves in the long run will result in poor returns from agriculture and dairy farming. In hilly areas, to date the domestic sector is the major energy-consuming sector, which is largely dependent on fuelwood. In the study areas, 81–86% of fodder is also extracted from nearby forests. Increased resource dependency on surrounding conventional forests has affected the status of most of the preferred species.

Fodder and fuelwood plantations should be established on terraced land under an agro-silvicultural system and on community land. An effective method of eco-restoration incorporating involvement by local people is needed so that pressure on the forests can be reduced. Design of technology jointly by biological, physical, and social science researchers will resolve this issue. A proper understanding of the socioeconomic necessities of the population is essential. Attempts should be made to establish a local framework for generating a sustainable forest economy.

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