Assessment of natural resources use patterns: a case study along a trekking corridor of Sikkim Himalaya, India

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In the Himalayas, subsistence largely depends upon resources derived from natural forests due to the free and easy access to these and simplicity in their use. Sikkim has 43% of its total geographical area under forest cover, of which 34% is under dense forests. The burgeoning human population and family fragmentations are exerting a tremendous pressure on the natural resources to meet the requirements of food, fuel, fodder, timber, and other human needs. In recent years, tourism has increased manifolds in Sikkim, which has been one of the major factors behind destruction of forests. Irrational use of natural resources has resulted in the lowering of forest quality and shortage of resources. As a result, people have started using less-valued species as firewood and fodder. This study deals with bioresources use pattern by the community and tourism enterprises along a trekking corridor in the Sikkim Himalaya, with special reference to firewood, fodder, and timber.

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Introduction

The Himalayan forest resources have been widely used to provide food, fuel, and feed for livestock, construction material, medicines, etc. by mountain communities since time immemorial. This is because these resources are free and easy to access (Bajracharya [1983]; Eckholm, Foley, Banard, et al. [1984]; Fox [1984]; Blakie [1985]; Mahat, Griffin, and Shepard [1987]; Sundriyal, Sharma, Rai, et al. [1994]; Sundriyal and Sharma [1996]; Chettri, Sharma, Deb, et al. [2002]). In the Himalayas, commercial resources are beyond reach of the local communities due to difficulty in access, and the high prices and limited supply (Sharma, Sundriyal, Rai, et al. [1992]; FAO, [1994]). Most tropical forests were lost during the past century due to unsustainable levels and ways of exploitation by the local communities, government agencies, and traders (Brown and Lugo [1982]; Brown, Gillerpie, and Lugo [1991]; WRI and IIEED [1987]; Thapa and Weber [1990]). The burgeoning human and livestock population in the rural areas is exerting an immense pressure on bioresources. In the process, overexploitation and improper use of these resources have resulted in the disappearance of forests, erosion of soil, and deterioration of fragile ecosystems (Thapa and Weber 1990; Sundriyal, Sharma, Rai, et al. 1994; Sundriyal and Sharma 1996; Chettri, Sharma, Deb, et al. 2002). Thus, human disturbances have been noted as the single-largest cause for loss of biodiversity, and the remaining forests are vulnerable to deterioration and degradation due to their indiscriminate use (Hannah, Carr, and Lakerani 1995; Chettri, Sharma, Deb, et al. 2002).

A total of 43% of Sikkim's geographical area is under forest cover, of which 34% is under dense forests (Government of Sikkim, RRSSC, and ISRO 1994). A majority of people in Sikkim depend upon forests for firewood, fodder, and timber, a substantial portion of which comes from natural forests. Firewood is used by the local community for different purposes, such as cooking, preparing animal feed, house and water heating, local wine and beer preparation, and for festivals. About five tonnes/hectare of woody biomass is removed for firewood annually from forests (Sharma, Sundriyal, Rai, et al. 1992). A large number of households also depend upon livestock for which they, in turn, depend upon forests for fodder. Likewise, most houses are constructed from timber collected from surrounding forests. Fragmentation of families leads to construction of many new houses each year, entailing a substantial consumption of woody biomass from the forest (Sundriyal, Sharma, Rai, et al. 1994). The change in land use pattern, resource exploitation, and weak conservation measures have evoked a concern for sustainability of such resources due to the growth in population and fragmentation of farm families (Rai, Sharma, and Sundriyal 1994).

Tourism, a fast-growing industry in the state, is putting an additional pressure on resources (Rai and Sundriyal 1997; Maharan, Rai, and Sharma 2000; Chettri, Sharma, Deb, et al. 2002). An increased demand of resources for consumptive use of the rural communities and increasing tourism activities in mountains are believed to have a considerable impact on the forest vegetation and wild life (Bhowness 1980; Byers 1986; Singh and Singh 1992; Byers and Bansko 1993; Bansko and Sharma 1994; Chettri, Sharma, Deb 2001; Chettri, Sharma, Deb, et al. 2002). Therefore, a careful study of the resource extraction pattern is important for understanding the status of resources and their effective management.

This paper (1) identifies the species preferred as firewood, fodder, and timber, and (2) delineates the extraction pressure, in terms of annual firewood, fodder, and timber demands in the trekking corridor from Yuksam to Dzongri of the Sikkim Himalaya.
firewood, fodder, and timber species. Preference ranking scores (higher the preference, higher the scores) for fodder, firewood, and timber species were recorded. This information was cross-checked with the other local persons who were not present at the time of the PRA.

The frequency and quantity of resource extraction were monitored from the trailhead of forests. All head loads carried by communities along the trail were recorded. The sex and age of communities carrying loads and the quantity was estimated with structures, including estimation of annual or one-time requirements.

Results

Firewood, fodder, and timber: species preference

Baseline information gathered using the PRA tools showed that communities living at Yuksam and Tshoka use a wide variety of plant species for firewood, fodder, and timber (Tables 1 and 2). Due to their knowledge of the virtues of different species and their ability to recognize these species, communities living in these areas collect the preferred species and compensate with the other species if the preferred ones are not available. Results of the preference pair-wise ranking on firewood, fodder, and timber are given in Tables 1 and 2.

Eleven woody tree species are listed as widely used firewood from the pair-wise preference ranking at Yuksam. Quercus lamellose ranks the highest followed by Schima wallichii, Eurya acuminata, Castanopsis hystricis, Belischmeda stinkimensis, and Prunus cerasoides. Three forest species have a high ranking as fodder plants. Acer laevigatum, A. oblongum, and Magnolia sp. are among the most-preferred species. Litsea elongata, Arundanaria sp., and Dedrocalamus sp. have a high ranking as fodder plants. Acer laevigatum, A. oblongum, and Magnolia sp. are among the least-preferred species. Sambucus nigra, Alnus nepalensis, and Prunus cerasoides have a high ranking as timber species.
Firewood, increasing the manpower. Moreover, the area remain closed. Hence, students free during vacation, join their parents for collection of this season due to the availability of people to move around. The highest frequency of Magnolia campbellii followed by Acer oblongum and Quercus of its availability.

Table 2 Pair-wise ranking scores of preferred species used as firewood, fodder, and timber at Tshoka, West Sikkim

<table>
<thead>
<tr>
<th>Species (local name)</th>
<th>Firewood</th>
<th>Fodder</th>
<th>Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies densa (Gobre salla)</td>
<td>4</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Acer oblongum (Phiriphere)</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Acer papillo (Kapase)</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Arundanaria sp. (Parang)</td>
<td>8</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Betula alnoides (Saur)</td>
<td>8</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cyperus sp. (Bukki)</td>
<td>-</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Dendrocalamus sp. (Bans)</td>
<td>1</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Lisae elongata (Pahanli)</td>
<td>2</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Magnolia campbellii (Ghoge chap)</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Magnolia sp. (Phuree chap)</td>
<td>6</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Prunus rufa (Lekh panyn)</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Quercus lamellosa (Bajrant)</td>
<td>10</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Quercus lineata (Phalant)</td>
<td>11</td>
<td>-</td>
<td>8</td>
</tr>
<tr>
<td>Rhododendron arboarem (Lali guras)</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rhododendron barbatum (Cirling)</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rhododendron falconeri (Cirling)</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sorbus sp. (Pans)</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Symplocos ramosisima (Kharane)</td>
<td>1</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

Juglans regia and Q. lamellosa by the Yuksam community and Abies densa as the highest followed by Acer oblongum and Quercus spicata by the Tshoka community (Tables 1 and 2). Alnus nepalensis, although being the least-preferred species, is widely used because of its availability. Betula alnoides and Magnolia campbellii are among the least-preferred species as other good-quality species by the Tshoka community are widely available.

Firewood, fodder, and timber—collection and utilization

Firewood is collected from forests largely during the winter season due to the availability of manpower. During winter all schools in the study area remain closed. Hence, students free during vacation, join their parents for collection of firewood, increasing the manpower. Moreover, this season is comparatively dry and it is easy for people to move around. The highest frequency of collection was recorded in January and the lowest in September (Figure 2). Data from the field revealed that frequency of trees chopped for use as firewood was the highest for medium-sized trees followed by small and large trees (Figure 3). The total demand for firewood for the community as well as other tourism enterprises was estimated to be 2434 tonnes/year. About 93% of the total demand is used for community needs and only 7% is used for tourism (Table 3). Domestic cooking accounts for about 84% of the total consumption of firewood followed by water heating (11%) and other purposes (5%). Consumption ranges from 2264 tonnes/year by the community to 0.98 tonne/year by pack animal operators. On an average, hotels and lodges consume about 40–50 kg of firewood per day. A large quantity of firewood is used by the HMI during training courses for cooking, water heating, and other purposes (Table 3).

There were visible changes in firewood consumption pattern among stakeholders during different seasons (Table 4). A higher firewood consumption was recorded during the winter season. The estimated value revealed that the local community alone used three times more firewood in winter as compared to summer (Table 4). The amount of firewood consumption was highest in winter (29 ± 10.1 kg/day/family) and lowest in summer (18 ± 6.9 kg/day/family). Mean daily consumption of firewood was found to be 25.5 kg/day/family for an average household size of 6.28 individuals, with a per capita of 3.45 kg at lower elevation and 4.17 kg at higher elevation.
Four sources of firewood supply areas were identified from the questioners, viz: (1) homestead surroundings, (2) privately owned wooded (agroforestry) area, (3) community-used forest (khasmai) and (4) reserve forest and biosphere reserve. Both, privately owned forest and government forests meet most demands of firewood (Figure 4). About 76% of firewood comes from government forests, including the biosphere reserve, and only 19% comes as support from private forests. Homestead surroundings provide Jhikra (3%) that includes portions of old wooded fences, dried bamboo pieces as it ignites fast, and agricultural residues, such as maize and millet stacks, especially for livestock feed preparation.

From the household surveys it was revealed that about 79% of the total demand depends upon firewood for cooking and other purposes, followed by 14% of the households on kerosene oil, 4% on electricity, and 3% on LPG (liquefied petroleum gas).

On the basis of standard values for livestock, total demand of fodder was estimated at 1209 tonnes/year for the entire livestock present in the study area (Table 5). During 1996–98, a net increase of 63% fodder demand was estimated. Fodder demand for cattle was the highest (41%).

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Table 5: Livestock number, increase during 1996-98, and fodder consumption estimation from Yuksam and Yuksam-Dzongri trekking corridor.

<table>
<thead>
<tr>
<th>Livestock</th>
<th>Years</th>
<th>1996</th>
<th>1998</th>
<th>Fodder consumption (tones/year)</th>
<th>Increase in fodder %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dzo</td>
<td>96</td>
<td>122</td>
<td>156</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Yak</td>
<td>83</td>
<td>78</td>
<td>100</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Horse</td>
<td>31</td>
<td>22</td>
<td>20</td>
<td>-29</td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>245</td>
<td>454</td>
<td>497</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>361</td>
<td>311</td>
<td>170</td>
<td>-14</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>441</td>
<td>461</td>
<td>252</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Pig</td>
<td>273</td>
<td>260</td>
<td>14</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1530</td>
<td>1708</td>
<td>1209</td>
<td>83</td>
<td></td>
</tr>
</tbody>
</table>

Table 6: Timber use pattern for private construction by community of Yuksam and Tshoka.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-size poles</td>
<td>15-25</td>
</tr>
<tr>
<td>Tree number</td>
<td>2-5</td>
</tr>
<tr>
<td>Average (DBH) size (cm)</td>
<td>40-70</td>
</tr>
<tr>
<td>Wood volume required (m³)</td>
<td>2.35-4.77</td>
</tr>
<tr>
<td>Medium-size poles</td>
<td>5-7</td>
</tr>
<tr>
<td>Tree number</td>
<td>10-15</td>
</tr>
<tr>
<td>Average (DBH) size (cm)</td>
<td>20-40</td>
</tr>
<tr>
<td>Wood volume required (m³)</td>
<td>2.16-7.1</td>
</tr>
<tr>
<td>Small-size poles (mainly bamboo)</td>
<td>3-5</td>
</tr>
<tr>
<td>Number of poles required</td>
<td>80-120</td>
</tr>
<tr>
<td>Average (DBH) size (cm)</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Wood volume required (m³)</td>
<td>8.16-15.1</td>
</tr>
</tbody>
</table>

The preference of resources by local communities is an age-old trend in the Himalayas but scientific studies of the same are few (Purohit and Nautiyal 1986; Purohit and Sammant 1995; Rai, Chettri, and Sharma 2002). These studies reveal that ideal firewood species are high calorie of heat during combustion, high density of wood, low ash content, and low moisture content as reported by Rai, Chettri, and Sharma (2002). The preference and usage pattern of different species depends upon the quality of firewood, season of collection, and time required for drying it before use. The people of Yuksam depend upon the natural forest for certain species of their choice for firewood, fodder, and timber. Extraction of high-quality species for firewood, fodder, and timber has resulted in a decline in the number of such trees along the corridor. On the other hand, the Tshoka community is completely dependent on resources of KBR for all forest-based resource requirements.

The annual demand of firewood, fodder, and timber is much more than any in other studies in the state made by Sandriyali, Sharma, Rai, et al. (1994) and Sandriyali and Sharma (1996). Local conservation initiatives and interventions from an ecotourism project have had a visible impact on firewood use by the community and on tourism enterprises. Although alarming, the rate of woody biomass extraction was nonetheless lower than the annual productivity rate in the study area (Chettri, Sharma, Deb, et al. 2002). Firewood collection and stocking for the rainy season by villagers have been a common practice in the area. Firewood is collected either from felled trees or from chopped branches. Firewood and fodder are collected in head-loads, either by putting these into a doko (bamboo basket) or by tying the load with a rope or bark of Argeli (Edgeworthia gardeneri). Men, women, children, and even donkeys and horses are engaged in carrying firewood loads from the forest to villages. The pressure on natural resources on the trail forest is comparatively higher than in the surrounding forests. Pressure from tourism, in terms of firewood use, is also significant. Such pressure at a high altitude area might result in severe degradation in future, bringing about a considerable impact on forests and wildlife (Bjonnaess [1980]; Byers [1986]; Banskota and Sharma [1994]; Chettri, Sharma, and Deb [2001]; Chettri, Sharma, Deb, et al. [2002]).

A remarkable increase in the number of cattle and dzo was seen during 1996 and 1998 in the study area. This was mainly due to promotion of tourism where the use of milk and its products increased tremendously during this period. The increase in the number of dzo is also directly related to tourism as more pack animals are in demand due to an increase in tourism. Interestingly, the economy of keeping dzo is found more beneficial than cattle or yak since it fetches more money from dzo than other economic options from these animals (Tambe 2000). An increase in pack animals and fodder demand are the real concern for conservation along the trekking trail (Chettri 2000).

Field observations revealed that forests remained undisturbed at steeper slopes. Forest degradation showed an increase in forests where human interference was more pronounced. This indicates that resources were generally used from forests situated in gentle slopes. This could mainly be due to the easy access to these sites as reported in the study by Brown, Gillette, and Lugo (1991). Chopping of trees and lopping off branches whose numbers were higher in the disturbed areas, have significantly disrupted the canopy structure, leading to open conditions (Chettri, Sharma, Deb, et al. 2002).

Conclusion

Forest-based resources are an integral part of people’s livelihood in the study area. The local community depends upon forests for firewood, fodder, timber, and many other non-timber forest products. Extraction of firewood, fodder, and timber for community and tourism purposes is observed all along the trekking corridor.

Pressure is more pronounced near major settlements of Yuksam. Tourism-related pressure on the forest is distinctly noticeable at Tshoka, the first camping site along the trail. Good-quality species are declining at an alarming rate and the area is dominated by secondary species. The forest species composition and structure are changing rapidly due to selective removal of preferred species. Thus, the Yuksam-Dzongri trekking corridor of KBR in Sikkim is facing an immense human pressure on its natural resources. This is mainly due to the rapid increase in tourist numbers and livestock.

Disturbances are pronounced in forests near settlements and campsites due to an immense human as well as grazing pressure. Management and regulation of tourism is weak and inadequate. Management of the trekking-corridor forests should be oriented in a way that pressure on the preferred canopy species is minimized. Natural regeneration should be promoted in the area and simultaneously, the persistent continued pressure on forest resources should be discouraged. Entrepreneurs and the community should be made aware of the legal status of KBR. Use of alternative sources of energy should be encouraged for improvement of forest conditions to make the area more attractive and valuable, in terms of biodiversity. During 1996–2000, participatory management of natural resources and compliance with the code of conduct for conservation by tourists, enterprises, and communities, especially on the use of alternatives to firewood, were promoted through the Sikkim Biodiversity and Ecotourism Project. However, these activities should be followed with a strict regulatory mechanism and restoration process to conserve this fragile and biodiversity-rich area.

Acknowledgements

The authors are thankful to the Director, G B Pant Institute of Himalayan Environment and Development, and The Mountain Institute, USA, for facilitating this study. This research was conducted under the Sikkim Biodiversity...
and Ecotourism Project, which received a grant from the Biodiversity Conservation Network funded by US Agency for International Development. IDRC (International Development Research Centre, Canada, also provided financial support to Mr. Nakul Chetri towards the study. The facility and support provided by ICIMOD (International Centre for Integrated Mountain Development), Kathmandu, is highly appreciated.

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Sustainable energy use for smallholder agriculture: a multi-objective programming approach

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Resources, Energy, and Development 3(1): 35–54

Smallholder agriculture has made an increasing use of subsidized mechanization and energy inputs to reduce short-term risks in semi-arid conditions in north-west India. However, geographic patterns of production and scale of mechanization are straining resources and increasing the risk of serious degradation of natural resources.

In this paper, the possibility of maximizing the revenue and energy returns in the agricultural sector at village level to fulfil the food, fuel, and feed requirements of the village has been attempted. This paper describes the energy flows through four subsystems of smallholder agricultural village: crop system; non-crop land uses; livestock systems; and households in a semi-arid region in India. By employing a multi-objective programming model, changes in agricultural activities required to optimize energy use are estimated so that economic conditions and local energy utilization of the village can be improved and energy import kept to a minimum.

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