ECOLOGY, ECONOMICS AND EQUITY OF THE PASTORAL SYSTEMS IN THE KHANGCHENDZONGA NATIONAL PARK, SIKKIM HIMALAYA, INDIA

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ABSTRACT

The Khangchendzonga National Park (KNP) is a part of the eastern Himalaya global biodiversity hotspot and is located in the Sikkim state of India. Increasing livestock populations coupled with the government policy to ban grazing and its selective implementation resulted in conflict. Hence we undertook this multi-disciplinary study involving consultations with traditional resource users, field surveys and remote sensing. We found that in the greater Himalayan part, over the past six decades sheep have been increasingly replaced by yaks (and their crossbreeds), who descend only up to the multi-layered temperate and sub-alpine forests during winter. These forests have been extensively manipulated by the yak herders to increase the fodder availability. In terms of economics and equity in benefit sharing we found that few yak herders earn high incomes by maintaining large herds while the sheep and pack animal herders earn subsistence level incomes from small herds. We propose a reduction in yak (and their female crossbreed) numbers with adequate alternative livelihood support for the herders.

KEYWORDS: *herding, grazing, sustainable, carrying capacity, yak, red panda, eastern Himalaya*

Mt Khangchendzonga - Third highest peak in the world

Khangchendzonga sacred landscape

INTRODUCTION

Sikkim the second smallest (7096 km^2) and least populous (0.54 million) state of India is located in the eastern Himalayan region (Census of India 2001). This region represents one of the 34 global biodiversity hotspots of the world (Myers et al. 2000, Mittermeier et al. 2004). The most significant locality set aside for the conservation of biodiversity in the state is the Khangchendzonga National Park (KNP; 1784 km^2) which was established in 1977 and covers nearly 25% of the total geographical area of the state. The park harbours both the greater Himalaya (86%) and the trans-Himalaya (14%). It has been carved out from existing reserve forests which were demarcated and freed from all previous rights in 1909. KNP also forms a part of the greater Khangchendzonga transboundary landscape providing biological connectivity with protected areas in Nepal (Kanchenjunga Conservation Area) and India (Barsey Sanctuary) (Fig. 1). KNP is well known for its high altitude landscape having nine peaks which rise above 7000 m including the third highest peak in the world - Mt. Khangchendzonga (8586 m). 90% of the park lies above 3000 m, 70% above 4000 m and 34% is under glaciers, ice-sheets or perpetual snow. The park also harbors more than 150 glaciers and 73 glacial lakes (CISMHE 2005). The monsoon climate is characterized by an extended, wet summer followed by a long, dry winter.

According to the classification by Champion and Seth (1968) there are 18 forest types in KNP. Maity and Maiti (2007) found 1580 species of vascular plants comprising of 106 pteridophytes, 11 gymnosperms and 1463 species of angiosperms in the park and the surrounding forests. Eight herbivores, ten carnivores and three pheasants have been reported from here (CEPF 2005, Chettri 2000). Four species of endangered mammals namely snow leopard (*Uncia uncia*), red panda (*Ailurus fulgens*), wild dog (*Cuon alpinus*) and particolored flying squirrel (*Hylopetes alboniger*) are found here (IUCN 2006). BNHS-Birdlife International have also declared the park as an "Important Bird Area" (Islam and Rahmani 2004).

This landscape is revered by the Hindus and Buddhists alike and is believed to have been blessed by Guru Padmasambhava, a revered sage of the 8th century A.D. But for one village comprising of ten households which is inside, the remaining 9500 households with a total population of nearly 30 000 live in 29 villages adjacent to but outside KNP (Census of India 2001). A number of indigenous communities viz., Lepcha, Limbu, Gurung, Mangar, Chettri, Bhutia, Sherpa, Lachenpa and Tibetan Dokpa have been residing in this landscape for at least the past several centuries. Large cardamom farming in the sub-tropical belt and livestock rearing in the temperate and alpine belt are the main livelihoods. Recently tourism in select villages has brought about local prosperity. The stunning variation in altitude of 7466 m (1220 m to 8586 m), the exceptionally high biodiversity and the existence of nine major ethnic communities on its fringes makes this park a global natural and cultural heritage site.

The cultural diversity of the local communities living adjacent to the KNP has given rise to a variety of livelihoods. Traditionally the *Gurungs* and *Mangers* were the shepherds, the *Bhutias* were the traders and yak herders, the *Lepchas* and the *Limbus* were the hunter-gatherers and shifting cultivators, the *Chettris* and *Bahuns* were the agro-pastoralists rearing cattle and the *Tibetan Dokpas* were the nomadic yak herders in the trans-Himalaya. During the beginning of the 20th century the forests of the state were demarcated with the "*protected* forests" set aside to meet the firewood and fodder needs of the villagers and the "reserve forests" for long term ecological security. The population of Sikkim increased almost 15 fold from an estimated 36 458 in 1891 to 540 891 in 2001, while the livestock (cattle, buffalo, yak, horse, sheep and goat) population stood at almost 300 000 in 2003 (Risley 1894, Census of India 2001, DAHLFVS 2003). Because of serious degradation, the government of Sikkim banned the practice of open grazing in the reserve forests in 1999. Selective enforcement of this ban in the greater Himalayan part of KNP resulted in the eviction of about 300 agro-pastoralists owning about 6000 cows from the reserve forests adjacent to KNP by 2002. However the yak population could not be reduced since the yak herders were influential and also they accessed remote alpine pastures whose ecology and nature of their impacts was not studied. This led to a three-way conflict between the agro-pastoralists who had been evicted, the yak herders and the forest department. The genesis of the present study lies in this conflict.

Pastoralism in the Himalaya and its coexistence with wildlife has been a topic of intense research, hot debate and limited "on ground" action. Our goals in this paper are threefold. First, we document the changing composition and numbers of livestock grazed at high altitudes. Second, we document the impact of grazing on native flora, by comparing heavily grazed areas with those that are less impacted. Third, we show that some of the major recent impacts in the temperate and subalpine forests are due to the presence of yak herds, which are owned by relatively few individuals.

MATERIALS AND METHODS

Over the years different approaches have been used to evaluate the sustainability of pastoralism in the alpine rangelands. The commonly used tool is the carrying capacity which tries to balance forage production with consumption by livestock. These studies assume livestock production to be the sole objective of alpine landscape management. However in the Himalaya as elsewhere the landscape is a multiple use area, serving as a habitat for endangered flora and fauna, *in situ* germplasm of valuable medicinal plants, source of major perennial rivers and more recently a destination for nature tourism (Miller 1997). Hence despite much information on the impacts of pastoralism, only a few of them resulted in direct conservation action (Saberwal 1996, 1998, Fox *et al.* 2004, Mishra and Rawat 1998). Recent studies have attempted to correlate the health of livestock production systems with the health of the alpine rangelands including impact on the wild ungulates and conflict with carnivores (Mishra *et al*. 2001, Mishra 2001, Bagchi *et al*. 2004). Here we use a combination of techniques including consultations with traditional resource users, extensive field surveys and remote sensing to assess recent impacts of livestock grazing.

The study area was the alpine zone of KNP which broadly includes the areas between 4000 m and 5000 m elevation. Physiognomically it starts from where the *krummholz* thickets end and the alpine scrub begins and extends up to the subnival vegetation. About 22% of the park with an extent of 390 km^2 falls within this zone. The winter pastures of the yaks and their crossbreeds in the temperate subalpine forests adjacent to KNP in the 2500 m to 3500 m elevation range were also surveyed. The data were collected from 2004 to 2006 with field surveys during summer and village consultations in winter.

Moonset and Sunrise over Jonsang Peak, North Sikkim

Village consultations

Information from herders, ex-herders and other resource users was collected using participatory appraisal tools like historical time-line, participatory resource mapping and pair-wise ranking. Consultations were conducted in 17 villages over 49 days and one focal group herder interaction workshop was also organized. Each of these meetings had between 50 to 100 participants including ex-herders. We recorded information on pastoral systems related to historical and current population trends, ownership pattern, migration routes, ecological impacts and incomes using these participatory appraisal tools. Livestock composition and population data for the years 1950 and 1975 were collected in this manner village wise and then consolidated. We cross-checked this information using field censuses. The number of households benefiting from a particular pastoral system was used as a measure of its equity. This interpretation tries to capture how broad-based is the livelihood and the extent of society profiting or dependent on it. The per capita income of the state was based on the economic survey (Lama 2007).

Field surveys

We surveyed the study area in summer season in 14 field visits spanning 125 days from 2004 to 2006. We conducted a census of the herders and information relating to livestock holding, ownership pattern, migration and fodder preference was recorded. The field study on the impacts of pastoralism was carried out in the greater Himalayan part of the park since this was the location of conflict and maximum impacts. Location of areas impacted by herding and those relatively undisturbed was selected based on village consultations and herder interviews. The undisturbed areas were located far from the herder villages and also protected by steep passes. It was difficult to delineate the impacts of various pastoral systems in the alpine meadows (summer pastures) since the grazing areas are the same and the vegetation has evolved over several years of sheep grazing and recently growing yak numbers. So in the alpine meadows we studied the combined impacts of the various pastoral systems on the native flora. We laid a total of 129 square quadrats of $1m^2$ area each in the alpine landscape between 4000 m to 5000 m elevation range, 88 in disturbed and 41 in relatively undisturbed in 21 sampling sites with 5 replicates each. We recorded the plant species composition and abundance.

Prek chu valley with Mt Pandim in the backgroud

The winter pastures of the yaks and their crossbreeds are located largely outside KNP in the temperate and sub-alpine forests of Yambong and Barsey sanctuary. This is because these forests receive lesser snowfall and are accessible during winter unlike the ones within KNP that are blocked by heavily snowed alpine passes making it difficult for the herder to cross them to ascertain the wellbeing of his herd. Unlike the summer pastures, the winter pastures are used only by the yaks and their crossbreeds, since the sheep descend down to the farmer's fields in winter. Here we laid 60 (10m x 10m) quadrates, 39 in disturbed and 21 in relatively undisturbed in 16 sampling sites, at least 4 km apart with 5 replicates each. We recorded density and girth at breast height (GBH) of tree species for the top and middle layers and plant species and cover for the ground layer.

Most of the plants were identified closest to the genera and species in the field using the regional floras available namely Flowers of Himalaya (Polunin and Stainton 1987) and Flora of Bhutan (3 volumes which includes collections from Sikkim). Voucher specimens of unidentified plants were collected and later verified from other monographs and herbaria at Gangtok and Dehra Dun. Native uses of plants were noted from the local field guides.

Temporal change in vegetation

We compared NDVI (Normalized Density Vegetation Index) of the two LANDSAT images acquired almost 24 years apart, on 23rd January, 1977 (NASA Landsat Program 1977) and 26th December, 2000 (NASA Landsat Program 2000). ERDAS IMAGINE version 8.5 and ArcVIEW GIS 3.2 digital image processing software were used. NDVI helps compensate for changing illumination conditions, surface slope, aspect and other extraneous factors (Lillesand and Keifer 2000). Though seasonally the images are less than a month apart the 1977 image showed higher shadow intensity and snow cover, leading to a positive bias in NDVI values. Presumably this could reflect annual differences as much as the one month difference, hence we focused on only the negative changes. We highlighted the negative changes in the map with the change detection threshold set at more than 15% negative change in NDVI values

Data validation and analysis

Herd owners when interviewed were inclined towards under reporting their livestock holding and under estimating their incomes. By contrast, the herd caretakers who were employed by the herd owners on wages and the ex-herders who

Trans-himalayan landscape of Lhonak

had sold off their livestock recently were more forthcoming and reliable. Based on our independent field surveys we found that the most reliable information on livestock was collected from these herd caretakers and the ex-herders since they had lesser conflict of interest. Deductive approaches were used to evaluate the economic traits of the pastoralism enterprise based on total livestock products sold and costs incurred. The stocking levels of different types of livestock was combined into a common measure of livestock unit (LU) based on the grazing study of Singh (1999). One LU is equivalent to 1.1 yak, 0.8 female yak-cow yak crossbreed, 0.8 horse, 0.8 *dzo* and 3 sheep. The livestock impact unit (LIU) was calculated by multiplying the total livestock units (LU) with the total duration of stay of the livestock in the summer and winter pastures separately in days per unit hectare.

RESULTS

Evolution of pastoral system

The livestock composition and population in the KNP have been rapidly changing over the last six decades (Table 1). Current livestock composition includes sheep, cow, yak, yak-cow crossbreed and horse (Plate 1). Historical records (Hooker 1853, Risley 1894, Smith and Cave 1911) indicate that while sheep and trans-Himalayan yaks (Tibetan breed) were traditionally grazed in the alpine landscape of KNP, cows, buffaloes, yaks (Nepalese breed), female yak-cow crossbreeds (*urang or dzomo*) and horses in the greater Himalaya have arrived only over the last 60 years. The total livestock population in KNP reduced significantly from about 11,010 in 1,950 to 3,710 in 2004, while the total livestock biomass increased from about 6,08,000 to 7,64,000 kg during this period. This is because sheep have been mostly replaced by larger sized livestock.

Impacts on the alpine meadows in summer

The impacts of pastoralism on the species richness and fodder cover in various vegetation types of the alpine landscape is shown in Figures 2, 3 and Plate 2. In the Juniper and Rhododendron scrub habitats species richness increases substantially with disturbance. This vegetation in an undisturbed state is largely unpalatable, but with disturbance mostly in the form of burning and grazing, the fodder cover increases significantly due to the presence of palatable species like *Kobresia nepalensis, Calamogrostis filiformis* and *Festuca valesiaca* ($p=0.02$, 95% CI). The yak herders clear this shrub habitat to increase the fodder availability. In the marsh and sedge meadows also the disturbed plots show higher species richness. In terms of fodder availability the sedge and marsh meadows are the only habitats with substantial forage in their natural state. The important fodder plants are *Kobresia nepalensis* (sun buki), *Festuca valesiaca* (rani buki), *Kobresia duthiei* (bhalu buki), *Kobresia capillifolia* (kesari buki), *Kobresia* sp. (ghode buki), *Juncus* sp. (suire buki), *Allium prattii (dandu), Heracleum* sp. (ganer), *Selinum tenuifolium* (cheeru), *Rheum acuminatum* (khokim), *Carex nivalis* (dharkhare), *Carex nigra* (harkat), *Phleum alpinum* (doodhe jhar), *Kobresia pygmaea and Elymus nutans* (Plate 3). However during winter due to heavy snowfall the alpine vegetation are not available to livestock. In an undisturbed state these meadows have a high fodder cover but with grazing due to the spread of unpalatable plants like *Potentilla peduncularis, Ranunculus hirtellus, Anaphalis* sp, *Geranium donianum* etc the fodder availability reduces. Plants sensitive to grazing found in relatively undisturbed pastures are *Heracleum* sp. (ganer), *Allium pratti* (dandu), *Pleurospermum* sp. (seto cheeru), *Rheum nobile* (kenjo) and *Saussurea uniflora* (thulo dudhe jhaar) are shown in Plate 4. Most of these plants are annual or biannual, tall, palatable and as informed by the herders nutrient rich. The important medicinal plants which occur in abundance only in ungrazed meadows are shown in Plate 5.

Impacts on the temperate and subalpine forests in winter

The winter pastures of the yak and their crossbreeds (urang) are the multi-layered evergreen oak and silver fir forests with a dense middle storey of dwarf bamboo and *Rhododendron* with a moss-dominated ground cover. *Yushania maling* (malingo) and *Thamnocalamus spathiflorus* (raat nigalo) are the main bamboo species that grow upto seven meters with a 7 to 10 cm girth and are densely packed with an average of 325 stems per 10 meter square plot. The herders open up

kharkas or forest openings around their cattle sheds (*goths*) where the top canopy is lopped, and the middle storey cleared to increase the ground fodder availability. South and east facing sunny aspects with moderate slope and perennial water availability are the preferred sites. Between 1975 and 2004 the livestock impact units (LIU) of the yak and *urang* in the oak and fir forests (between 2500 m to 3500 m) during winter, increased from 2 to 17 LU days ha^{-1} (192 to 1531 LU). Change detection study in the 1977 to 2000 time series indicates that 25% of these forests, having an extent of 48 km^2 show more than 15% reduction in NDVI value (Fig. 4). Contemporary geospatial studies in the Barsey Sanctuary by Kushwaha *et al.* (2005) showed that out of the total area of 120 km^2, 63 km^2 had been disturbed. Areas impacted by cattle sheds (*goth*) have been converted to degraded forests and scrub showing relatively high disturbance.

Opening of canopy of oak forests to create winter pastures by the herders

Vegetation sampling showed that in these forest openings the number of trees reduced from 3.7±2.2 to 0.6±1.6 in a 10 m square plot, while the basal area reduced from 103±83 $m^2 ha^{-1}$ to 21±51 $m^2 ha^{-1}$ compared to the undisturbed sites. Maximum difference was noticeable in the middle storey of bamboo (*Yushania maling* and *Thamnocalamus spathiflorus*) whose stem density reduced from 324±139 to 0.7±2. In the openings heavily used by livestock, *Arthraxon microphyllus* (bonchu) is the dominant ground cover along with some *Carex* sp. (harkat) and moss. The herders also plant an exotic fodder grass - *Pennisetum clandestinum* (ghode dubo) in these openings. The ground fodder availability in these openings with *Arthraxon microphyllus* (bonchu) and supplemented with *Pennisetum clandestinum* increased substantially from 1.8±1.4 % to 75.7±20.8 %. With the opening of the forest canopy and clearing of the bamboo and *Rhododendron* middle storey, thickets of secondary, unpalatable shrubs like *Viburnum erubescens*, *Berberis* sp. and *Rhododendron* middle storey, thickets of secondary, unpalatable shrubs like *Viburnum erubescens*, *Berberis sp.* and *Rosa sericea* have increased substantially. The surveys also showed that fodder trees of the *Moraceae*, *Lauraceae* and *Araliaceae* families are preferentially lopped in winter. *Ficus foveolata* (dudhe lahara), *Ficus neriifolia* (dudhilo), *Schefflera impressa* (bhalu chinde), *Symplocos racemosa* (badam), *Ilex* sp. (lisse) and *Machilus* sp. (rani kaula) are the preferred fodder trees.

Habitat manipulation by converting temperate multi-layered forests to artificial grasslands by the herders

Economics of pastoral enterprises

The incomes from pastoral systems depend on the herd size, livestock management system and the breeding strategy. The fixed costs include the expenses of hiring a caretaker, his living expenses, maintaining cattle-sheds and a stud bull, while the running costs (which vary with herd size) include the feed and salt requirements of the livestock. While sheep and yak give incomes from sale of calves, wool and milk products, the incomes from *urang* are only from the latter. Table 2 shows the key economic traits of these milch livestock. The *dzos* and horses are hired as pack animals in the trekking tourism sector. The major risks involved are early snowfall, falling off cliffs, feeding on poisonous plants, depredation by carnivores and diseases.

Figure 5 shows that the annual profit earned is highest for the yak and then the *urang* owner since the corresponding herd size owned by them is also much larger. The annual returns on investment which was calculated as a ratio of the total annual profit of the herder to the total market value of his herd is highest at 60% for the pack animal enterprise and varies between 30% to 37% for the other livestock production systems. So while the total profits are the highest for the yak herder, the pack animals give highest annual returns on investment.

Equity and benefit sharing of pastoral systems

After studying the ecological and economic dimensions, the aspects relating to equity in benefit sharing were explored. In terms of livestock biomass ownership nine yak herders own 19 500$\pm$8700 kg (71.7 LU) each, 18 *urang* herders own 9100$\pm$3200 kg (31.3 LU) each, 63 pack animal herders own 1900$\pm$1000 kg (6.0 LU) each and 33 sheep herders own 1000$\pm$700 kg (11.4 LU) each (Fig. 5). The annual per capita income of the state which was Rs 27,000 in 2005 was used as the baseline (Lama 2007). Relative to this the yak herder earns 6.3 times (Rs 1,69,000), the *urang* herder 2.6 times (Rs 69,000), the pack animal owner 1.1 times (Rs 30,000) and the sheep herder 0.8 times (Rs 20,500). Thus it was found that few yak herders maintain large herds and earn high incomes. On the other hand a substantial number of sheep and pack animal herders earn subsistence incomes from small herds. *Urang* rearing falls in between subsistence level sheep and pack animal rearing and commercial yak ranching.

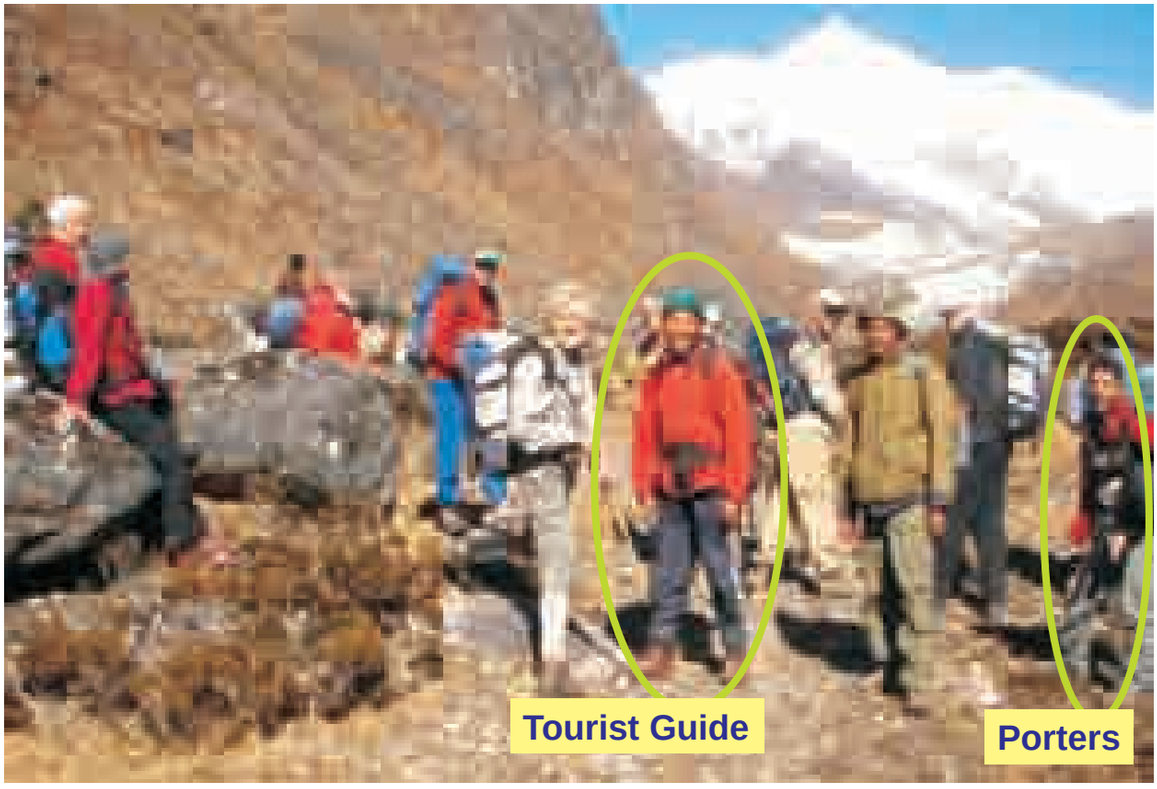
DISCUSSIONS

Interviews with local villagers and historical records show that traditionally in the greater Himalayan part of the KNP, *Banpaala* breed of sheep were the dominant livestock that used to graze in the alpine meadows during summer and then descend down to the fallow farmer's fields in winter. The farmers provided the shepherds with shelter and rations, while the sheep manured his fields. This unique symbiosis between the semi-nomadic sheep herders and the sedentary farmer existed till the advent of large cardamom agro-forestry and intensive farming systems. With reduced access to winter pastures, the shepherds were forced to reduce the herd size and shift to a sedentary livelihood of mixed farming. From the mid 20th century, trans-border *Bhutia* yak herders from eastern Nepal started migrating and settled in the border villages of West Sikkim adjacent to KNP. In 1975 with the merger of Sikkim with India, rapid development created new opportunities and markets. In order to meet the growing demand for dairy products, the herd size of the yak (Nepalese breed) and the female yak cow crossbreeds *(urang)* started increasing. In summer they accessed the moist alpine meadows till the winter snowfall forced them down to the temperate and sub alpine forests.

The overall livestock composition and population trend shows that smaller sized sheep have reduced drastically while heavier animals mostly yaks, their crossbreeds and horses are on the rise. The sheep traditionally migrate long distance between the alpine meadows (5000 m) in summer to the subtropical villages (1800 m) in winter. This long distance migration of the sheep has been replaced by an altitudinal one of the yaks and their crossbreeds that do not descend down to the permanent human habitations during winter. The result of this switch from sheep to yaks is the much higher winter impacts on the temperate and subalpine forests.

Scarcity of natural fodder during the long winter season from November to March is the biggest hurdle in sustainable livestock production in KNP. The yak and *urang* pastoral systems have substantially impacted the oak and fir forests with *Rhododendron* and bamboo middle storey in the 2500 m to 3500 m elevation range of Yambong valley and Barsey sanctuary. Satellite images too confirm that at least 25% of these forests show greater than 15% decrease in NDVI values between 1977 and 2000. Field study shows that these vegetation types have limited natural fodder cover and the yak herders use ingenious methods such burning, cutting and lopping of the woody vegetation to create forest openings and then supplement these with exotic fodder grasses. The carrying capacity of these man-made pastures for livestock is substantially higher than the natural carrying capacity. These forests are a unique habitat whose flagship species is the endangered red panda (Pradhan *et al.* 2001). Recent studies in the Langtang national park of Nepal indicate that the red panda has been severely impacted due to disturbance from yak crossbreeds, herders and their dogs (Yonzon and Hunter 1991). Comparatively the sheep which descend down to the agricultural fields during winter and pack animals that are free ranging without an attendant herder have lesser impacts. Yak herding livelihood showed the highest inequity in benefit sharing with high incomes concentrated amongst 10 households, followed by *urang* herding. Relatively the sheep and pack animal herding were found to be more equitable and provided benefits to a larger section of society. Lower impacts and greater equity in benefit sharing made the sheep and pack animal herding relatively more sustainable.

Under national wildlife laws, livestock grazing is not permitted in a national park, but lack of people's support and political will have resulted in a weak or sporadic enforcement of the stringent national forest and wildlife laws (Chhatre and Saberwal 2005). Consequently grazing is pervasive in most of the protected areas in the country (Kothari *et al*. 1989). However in Sikkim a determined political leadership with strong support from the local people is acting on the findings of this study to reduce the yak and *urang* numbers in the greater Himalayan part of KNP while also providing alternative livelihood support to the herders. The Yambong Singalila ecotourism package (www.yambong.com) was launched jointly with The Mountain Institute NGO (www.mountain.org) and a total of 314 overseas and 13 domestic tourists visited this new destination in 2006. The local ecotourism service providers who served as porters, assistant guides and *dzo* operators earned Rs 16 lakh. About half of this income was earned by the yak herders. Consequently by 2008 the number of yaks in the greater Himalayan part of KNP had reduced from 779 to 465 and yak crossbreed (*urang*) from 469 to 15 (Table 1). With the benefits from tourism livelihoods and participatory law enforcement the number of yaks and their crossbreeds (*urangs*) has been steadily reducing since then.



From herders to trekking guides and porters - Yambong tourism

Trend in population of livestock and blue sheep in Dzongri area of KNP in West Sikkim

	2004	2007	2008
Yak population	779	505	465
Blue sheep population at Lamune (indicator species)	38	55	75

Source: Interview with local villagers

From herders to pack animal operators - Yambong tourism

As a result of this substantial decrease in livestock numbers, the population of wildlife, blue sheep and blood pheasant (state bird) in particular are showing a significant increase. These species are the indicator species of the health of the alpine zone. As per the winter baseline survey of 2004 the blue sheep population in Lamune in Khangchendzonga National Park (KNP) was 38 including 6 yearlings. With the continued reduction in livestock, the numbers reported here in 2008 are 75. This increase can be attributed to the reduced competition for fodder from livestock and less disturbance from the herders and the guard dogs. The distribution of blue sheep is also expanding and they can be now sighted even in Dzongri.

With reduction in grazing - the blue sheep population is now growing

The strong direction from the political level, active support from the local community and alternative livelihood support from trekking tourism, all of which was lacking previously was instrumental in this reduction. Multi-disciplinary ecological and socio-economic research is needed to distinguish between need and greed based livelihoods and their ecological impacts. Such studies will provide a basis for shaping political will and mobilizing people's power, which in a democratic framework is vital for bringing about change.

Table 1. Dynamics of livestock population and biomass in KNP from 1950 to 2004 (baseline year of the study) **to 2007** (after implementation of the findings of study is underway)

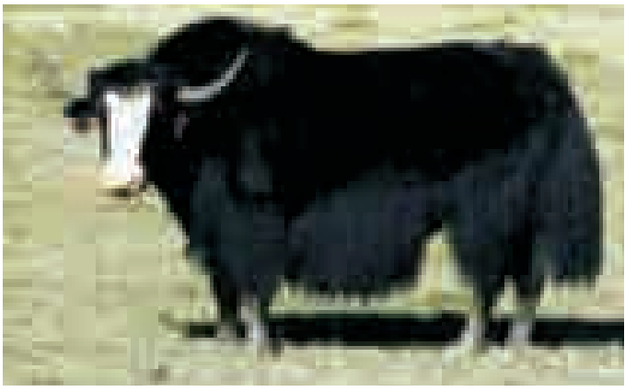
Livestock Type	Population				Biomass (in '000 kg)			
	1950	1975	2004	2007	1950	1975	2004	2007
Greater Himalaya								
Sheep (*Banpaala* breed)	8800	5200	1141	912	264	156	34	27
Cow	100	600	150	145	30	180	45	44
Buffalo	0	200	5	0	0	60	2	0
Yak (Nepalese breed)	50	200	779	505	13	50	195	126
Female yak-cow crossbreed (*Urang* or *Dzomo)*	0	0	469	15	0	0	164	5
Pack animal (horse and *dzo*)	60	60	316	434	21	21	111	152
Trans Himalaya								
Sheep (Tibetan breed)	1000	1000	0	0	30	30	0	0
Yak (Tibetan breed)	1000	630	850	944	250	158	213	236
Total livestock	**11 010**	**7890**	**3710**	**2955**	**608**	**655**	**764**	**590**

Table 2: Key economic traits of milch livestock in KNP in 2005

Economic Traits	Units	Yak	Urang	Sheep
Adult weight	kg / livestock	250	350	30
Age of first calving	years	3 – 4	3 – 4	2 - 3
Gestation period*	months	9^N / 10^C	9^N / 10^C	6
Daily milking yield	liters / day	1	2.5	0.35
Lactation length	months	8 – 10	6 – 8	6
Milking period	months	3 - 4	6	3
Calving interval	months	17 – 18	15 – 16	1
Hair / Wool yield	kgs / year	0.5	0	1
Life span	years	18 – 22	18 – 20	10 -12
Total calving	no of calves	8 – 10	14 – 16	7 - 8
Sale value of calf*	Rs / calf	$1,400^N$ / $4,600^C$	0	1,850
Sale value when adult	Rs / livestock	6,050	7,000	1,850
Sale value when old	Rs / livestock	3,700 – 4,200	2,350 – 3,275	1,850

** N = Normal calf, C = Crossbreed calf*

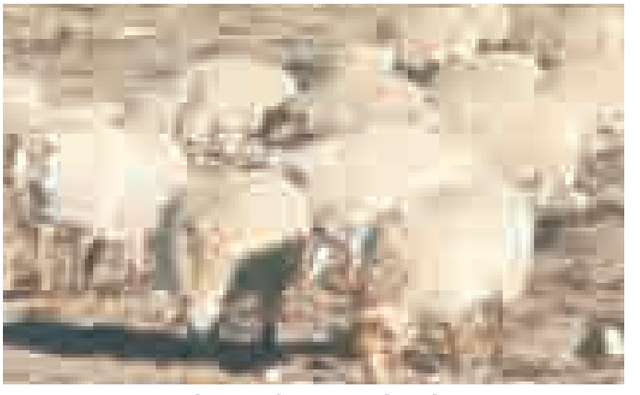
Plate 1: Pastoral systems in KNP (GH = Greater Himalaya, TH = Trans Himalaya)



Yak (Tibetan) in Lhonak TH

Yak (Nepalese) in GH

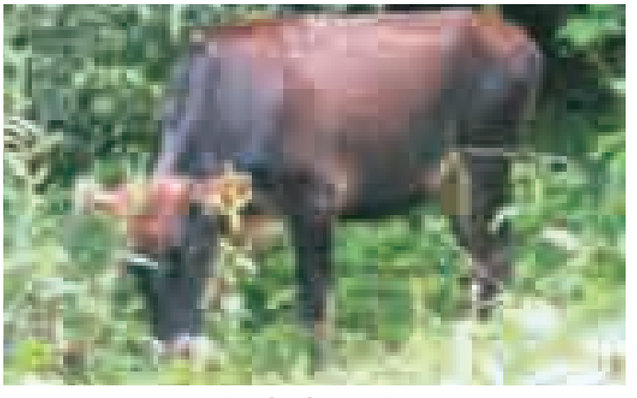
Sheep (*banpaala*) in GH



Sheep (Tibetan) in Lhonak

Cattle yak crossbreed (*urang*) in GH

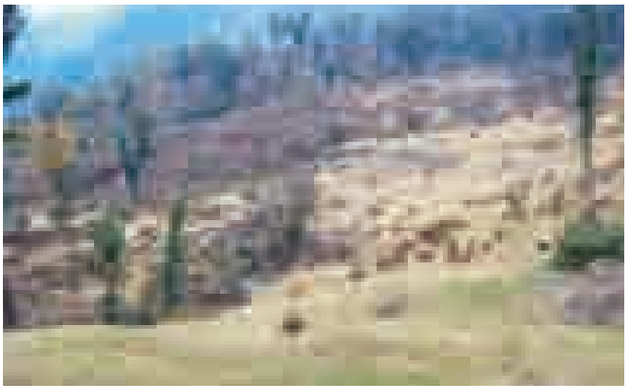
Pack animal (*dzo*) in GH



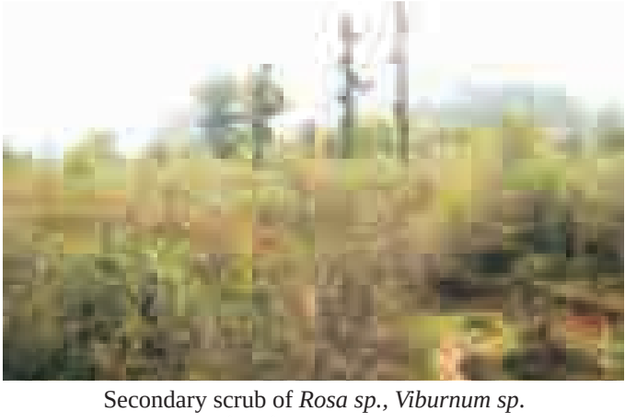
Cow herding in GH

Plate 2: Threats and impacts of pastoralism

Yak and *urang* descend to temperate and sub-alpine forests in winter

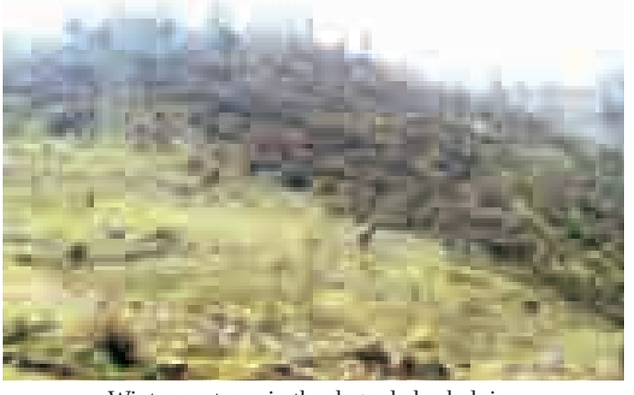


Winter pastures in the degraded temperate oak forests of Naya-patal



Secondary scrub of *Rosa sp.*, *Viburnum sp*. in winter pastures

Winter pastures in the degraded subalpine forests of Thulo dhaap



Winter pastures in the degraded subalpine forests of Kalijhaar

Trap laid for Himalayan musk deer

Trap laid for blue sheep

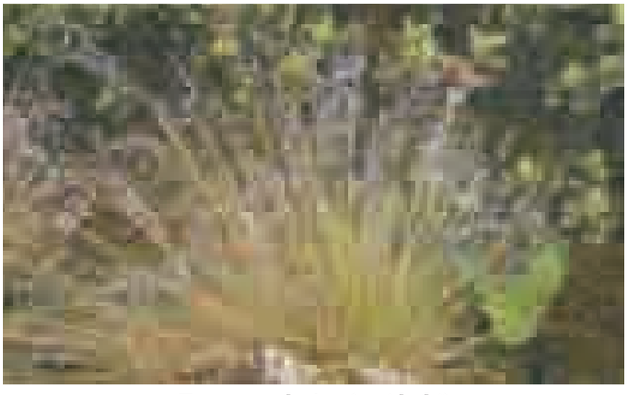
Poisoned Himalayan griffon vulture

Plate 3: Some important subalpine and alpine fodder plants

Kobresia nepalensis (sun buki)

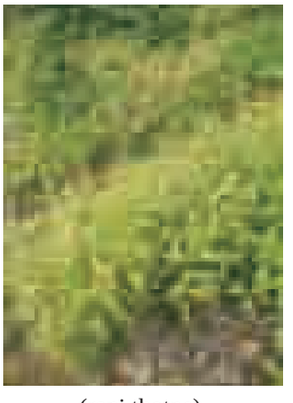
Kobresia duthiei (bhalu buki)

Ilex intricata (kurkure)



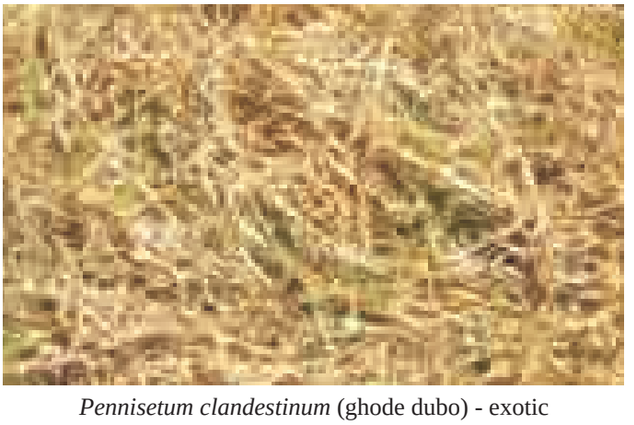
Festuca valesica (rani buki)

Heracleum sp. (ganer)
Polygonum sp.



(rani thotne)

Rubus paniculata (kanre lahara)



Pennisetum clandestinum (ghode dubo) - exotic

Schefflera impressa (bhalu chinde)

Plate 4: Some alpine plants sensitive to yak grazing

Heracleum sp.

Pleurospermum sp.

Saussurea uniflora

Pleurospermum sp.

Saussurea obvallata

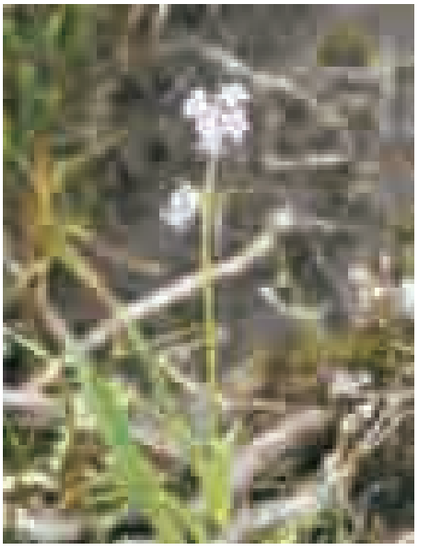
Rheum nobile

Plate 5: Some important medicinal plants of the alpine zone

Podophyllum hexandrum

Ephedra gerardiana

Picrorhiza scrophulariiflora (kurki)



Nardostachys grandiflora (jatamanshi)

Aconitum ferox (bikh)

Gymnadenia orchidis (panch-amle)

Figure 1. Location of summer and winter pastures of livestock in KNP and adjacent forests

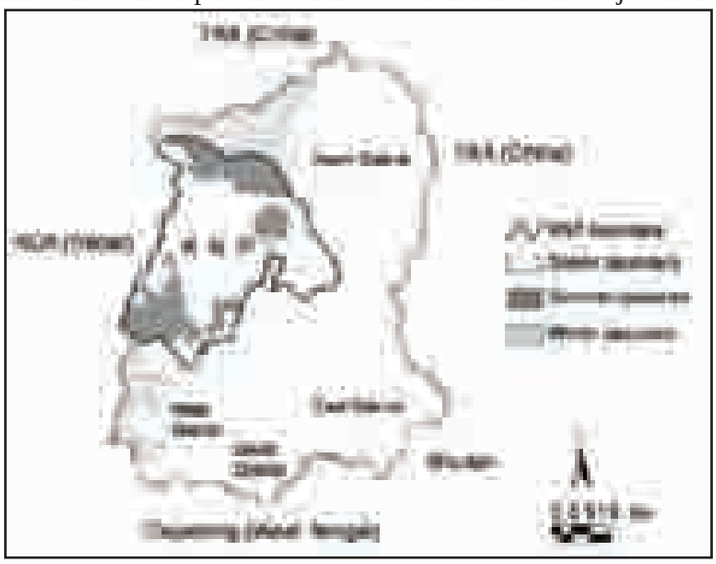


Figure 2. Mean (± SD as error bars) impacts of pastoralism (burning and grazing) on plant species richness in the various vegetation types in the alpine landscape of KNP

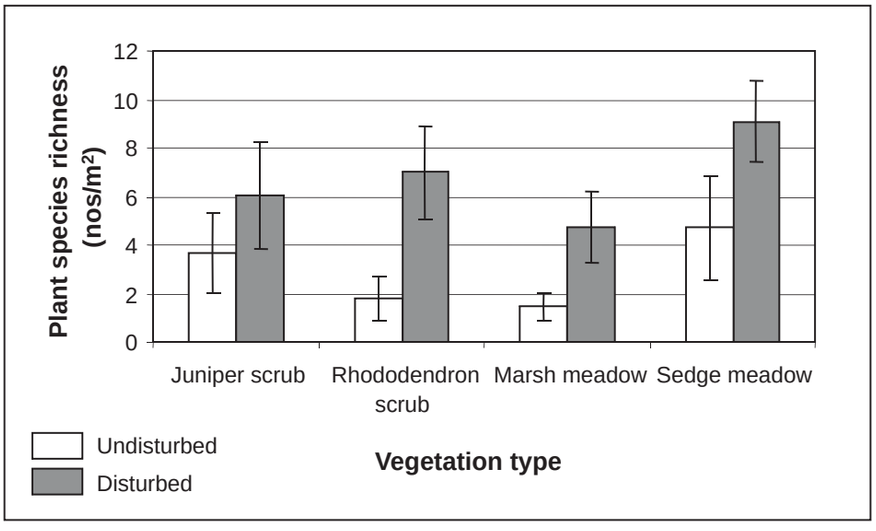


Figure 3. Mean (± SD as error bars) impacts of pastoralism (burning and grazing) on fodder cover in the various vegetation types in the alpine landscape of KNP

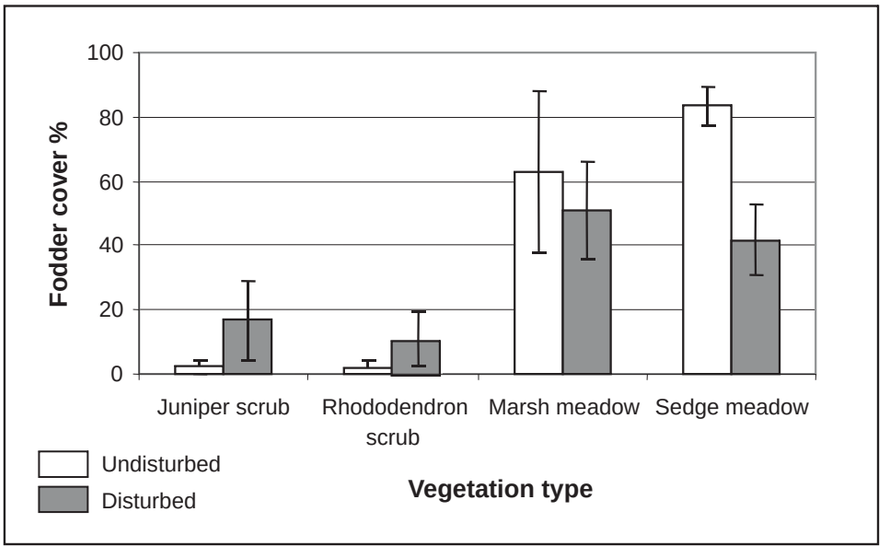


Figure 4. Map showing areas with more than 15% decrease in NDVI between 1977 and 2000 in the pastures of KNP and adjacent Reserve Forests

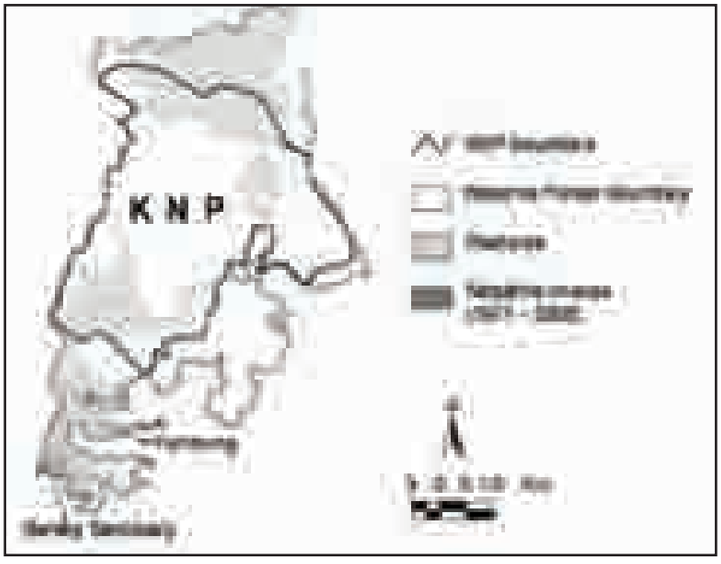
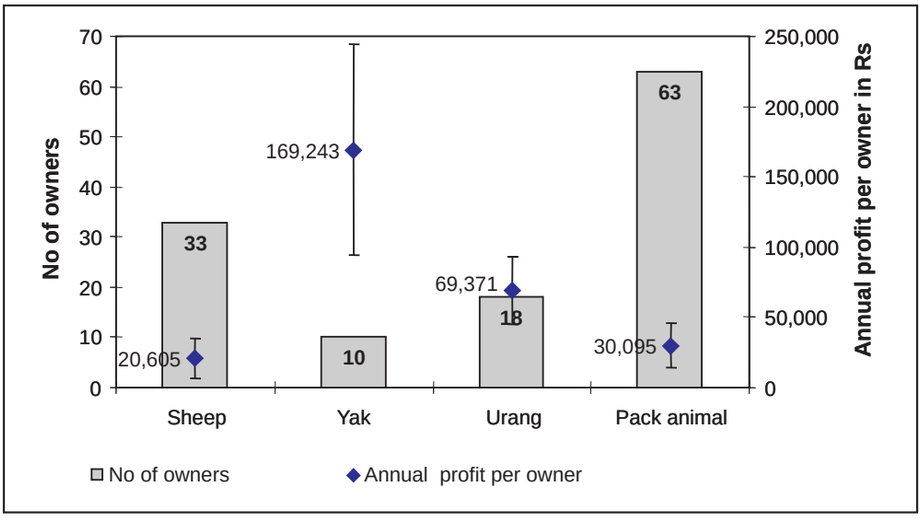


Figure 5. Mean annual profits (± SD as error bars) and benefit sharing from the pastoral systems in KNP relative to the per capita income of the state



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