

## **The Changing Face of Cattle Raising and Forest Grazing in the Bhutan Himalaya**

Authors: Wangchuk, Kesang, Wurzinger, Maria, Darabant, Andras, Gratzner, Georg, and Zollitsch, Werner

Source: Mountain Research and Development, 34(2) : 131-138

Published By: International Mountain Society

URL: <https://doi.org/10.1659/MRD-JOURNAL-D-13-00021.1>

---

BioOne Complete ([complete.BioOne.org](https://complete.BioOne.org)) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](https://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

# The Changing Face of Cattle Raising and Forest Grazing in the Bhutan Himalaya

Kesang Wangchuk<sup>1\*</sup>, Maria Wurzinger<sup>1</sup>, Andras Darabant<sup>2</sup>, Georg Gratzer<sup>2</sup>, and Werner Zollitsch<sup>1</sup>

\* Corresponding author: kesangwangchuk@rocketmail.com

<sup>1</sup> Division of Livestock Sciences, Department of Sustainable Agriculture System, University of Natural Resources and Life Sciences, Vienna, Austria

<sup>2</sup> Institute of Forestry Ecology, Department of Forest and Soil Sciences, University of Natural Resources and Life Sciences, Vienna, Austria

Open access article: please credit the authors and the full source.



Household surveys were conducted in 2 representative rural settlements in central and western Bhutan to evaluate differences in cattle raising practices and seasonal variation in the physical characteristics of cattle,

and to project future trends in herd management and forest grazing. Results indicated that cattle owners' perceptions, aptitudes, and attitudes are changing and that rural interventions need to take these changes into account. The proportion of households without cultivated pasture was greater in the central Bhutan study village. The settlements also differed in cattle owners' opinions on forest selection

and grazing pressure. The only outstanding similarity between settlements was the preference for crossbred cattle, revealing a strong orientation toward small but productive dairy herds and suggesting that a future reduction in forest grazing was likely. Although both settlements rely on forest grazing, there are considerable differences in cattle production practices and type of cattle reared, primarily driven by access to market, topography, and domestic forage resources. Our results suggest that management decisions should be based on site-specific information rather than generic guidelines.

**Keywords:** Crossbred cows; dairy cows; forest grazing; local breeds; socioeconomic development; Bhutan.

**Peer-reviewed:** December 2013 **Accepted:** January 2014

## Introduction

Livestock farming practices continue to evolve in response to rapid modernization and growing economic opportunities in the Bhutan Himalaya. The considerable changes over the last few decades have improved livelihoods and reduced rural drudgery. However, the pace of change differs between regions, determined primarily by topography, climate, tradition, and government regulations. In the Himalayan region, studies have shown farming differences between and within regions, with socioeconomic development as the main driving force behind changes in farming (Tulachan and Neupane 1999; Roder et al 2002; Tulachan et al 2002). A recent study by International Center for Integrated Mountain Development (ICIMOD) also highlighted region-specific factors determining mountain poverty (Hunzai et al 2011). Several authors (Mohammad 1989; Misri 1995; Pariyar 1995; Singh 1995; Roder et al 2002) have noted that the Himalayan environment and vegetation are highly variable with great sociocultural diversity, and have asserted (Rawat et al 1996; Tulachan 2001) the limited value of generalizations about the Himalayan region.

An overly general view of farming in Bhutan would mask variations between and within regions with regard to several important trends. For example, communities

near cities often have better access to modern facilities, and are able to modernize farming practices more quickly, than more remote communities; policies designed to promote rural prosperity must acknowledge such differences. Failures in pastoral development have been associated with failure to recognize pastoralists' indigenous knowledge (Admasu et al 2010), and policies incompatible with the interests of local inhabitants have had a negative impact on developmental programs (Wallner et al 2007). Thus, for rural livestock interventions to succeed, there is a vital need to understand regional differences in practices.

Forest grazing, although an important traditional farming practice in the Bhutan Himalaya, faces an uncertain future in the light of frequent criticism of its undesirable effects on forest health and regeneration (Roder et al 2001) and the government policy to promote intensive livestock management (Samdup et al 2010). However, there has been a lack of research comparing cattle production practices in different regions and their implications for the future. This study investigated the traditional cattle production practices of 2 rural settlements, 1 in central and 1 in western Bhutan, and one closer to a city than the other. The objectives of the study were to evaluate differences in cattle production practices between the 2 sites and project future trends in herd management and forest grazing.

## Methods

### Study sites

The study took place in 2011 at Tsaluna village in western Bhutan and Hurchi-Domkhar in central Bhutan. These areas well represent the mixed conifer forests of Bhutan (Sargent et al 1985), where forest grazing is a backbone of cattle production. Although both rely on forest grazing, one is closer to an urban market and the other is more subsistence oriented.

Tsaluna village (27°27'55.13"N, 89°31'23.70"E) is very close to Thimphu, the capital city. The topography is rugged. Hurchi-Domkhar village (27°29'36.43"N, 90°40'05.79"E) lies in central Bhutan about 245 km from Thimphu. More recent weather data are not available, as data collection from the weather stations has been discontinued.

### Household selection and field interviews

A total of 30 households in Hurchi-Domkhar and 25 in Tsaluna were selected to represent the herding communities using purposive sampling. All households surveyed relied on forest grazing. The survey was administered through questionnaires with open- and closed-ended questions that were pretested and amended prior to conducting field interviews.

The survey questionnaire had 2 main parts. The first part solicited information on the socioeconomics of the herding community, herd composition, and trends in livestock rearing. For trend analysis, we asked questions about the presence of different kinds of cattle 10 years ago and about expectations for 10 years in the future (a decade is the equivalent of two 5-year plans under Bhutan's development policy). A similar time frame has been used to study temporal changes in livestock population and composition in the Indian Himalaya (Directorate of Land Records 1992). Herders ranked the importance of milk production, manure, and draught power as outputs from cattle raising. We also collected information on the contribution of dairy farming to the total annual cash income of each household.

The second part of the questionnaire explored cattle production practices related to forest grazing using open-ended questions on the criteria used for selecting forests for grazing, number of grazing months, types of cattle sent to graze in the forest, and approximate forest area grazed daily. We asked about grazing pressure and mitigation measures to better understand the condition of grazed forests. Finally, we asked for opinions on the system of requiring a legal permit for forest grazing. This is an important research question because answers indicate the herders' concern for grazing sites and the need for regulated grazing, despite the fact that the government has not yet proposed to introduce legal permits for grazing in forests. Moreover, the 2007 Land Act abolished traditional user rights for forest grazing.

These were not linked to land tenure and foresaw the conversion of user rights into long-term lease. This provision of the law has not been implemented because of resistance from herders and technical difficulties. The government is seeking to identify alternative solutions to the problem. Finally, the questionnaire was supplemented by informal and personal discussions when additional information was needed.

### Measurements and estimates

An important distinction in Bhutanese livestock raising is made between cattle from breeds that developed locally and those that are the result of cross-breeding between local and exotic breeds such as Jersey and Brown Swiss. Study participants revealed in informal interviews that they mainly grazed local cattle in the forest, and these were the cattle whose physical characteristics we measured.

We used the body condition score (BCS), which has a scale of 1 to 5, with 1 representing the most emaciated animal and 5 the fattest (Rodenburg 2004). Weight was estimated using Schaeffer's formula (Sastry et al 1983):  $W = (L \times G^2)/300$ , where  $W$  is the estimated live weight in pounds,  $L$  is the length from point of shoulder to pinbone (measured in inches), and  $G$  is the chest girth in inches. This estimated weight was converted to kilograms. Field measurements were carried out in July 2011, the peak summer month, and again in February 2012, the peak winter month. We estimated the annual stocking rate for both study sites from the number of cattle and the available area of forest grazing land.

### Data analysis

Differences in body weight and cattle population trends between the 2 study sites were tested using analysis of variance. A nonparametric Mann-Whitney  $U$ -test was used to test the difference in BCS between the study sites. We performed a chi-square test to determine the association of different opinions with likely future trends in forest grazing. The dataset was analyzed using SPSS 19 (Landau and Everitt 2004).

## Results and discussion

The study used socioeconomic information to explore the rationales behind differing cattle production practices.

### Socioeconomic aspects of cattle production

In Bhutan, income generation is often mentioned as a motive for engaging in milk production. Our results show that this may be true for farming communities near urban settlements, but not for those with little or no access to markets. Although milk production was given the highest priority in both study sites (Table 1), it was reported as the major cash-generating activity in Tsaluna village but not in Hurchi-Domkhar. In Tsaluna, dairying contributed

**TABLE 1** Cattle owners' ranking of cattle products.

	Percentage of respondents choosing answer					
	Tsaluna			Hurchi-Domkhar <sup>a)</sup>		
	Milk	Manure	Draught power	Milk	Manure	Draught power
<b>Importance</b>						
Rank 1	58.5	17.3	24.2	66.7	33.3	0.0
Rank 2	22.2	38.9	38.9	26.9	73.1	0.0
Rank 3	7.6	53.9	38.5	0.0	0.0	100.0
<b>Contribution to cash income</b>						
<25%	15	—	—	70	—	—
25–50%	12	—	—	23	—	—
>50%	73	—	—	7	—	—

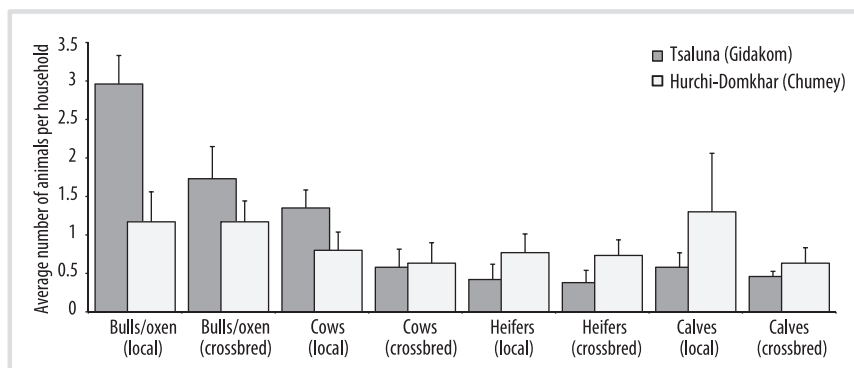
<sup>a)</sup>Note: There are no draught animals in Hurchi-Domkhar village.

more than half of the total cash income for almost three-quarters of the respondents (Table 1). This is closely linked to the greater number of lactating cows in Tsaluna (Figure 1) and the generally greater emphasis on dairying to meet the demand of the capital city (Department of Livestock 2008). In contrast, dairy contributed less than a quarter of total cash income for almost three-quarters of households in Hurchi-Domkhar village (Table 1), indicating that off-farm activities and crop production contribute more to household incomes. The differences observed for the 2 study sites clearly illustrate the need to tailor livelihood-promoting efforts to the specific circumstances of different rural farming communities.

Tsaluna village had more local bulls (Figure 1) with heavier body weight (see section below), and the majority of respondents there ranked cattle manure and draught power as equally important after milk, which explains why cattle owners also maintain nonlactating animals. In rural

Bhutan, unproductive animals are retained in the herd mainly for manure production and as a symbol of the family's wealth. Because the unproductive cattle graze in the forest, they are efficient carriers of nutrients from the forest to cultivated fields (Roder et al 2003). The importance of draught power in Tsaluna village may be primarily due to the rugged terrain that limits mechanization. In contrast, in Hurchi-Domkhar, the flat terrain is highly suitable for mechanization, which would explain the smaller numbers of local bulls and oxen and the lesser importance of draught power. The case of Tsaluna suggests that, if there is assured access and a stable market for milk, cattle owners are willing to take up commercial dairying even on difficult terrain. Maintaining and eventually enhancing the specific and differentiated functions that livestock provide to mountain farmers (in this case draught power, fertilizer, food, and income) will be essential for sustainable development.

**FIGURE 1** Types of cattle kept by households. The thin lines extending up from the bars represent the ± standard error (se) of means.



**TABLE 2** Respondents' criteria for selecting forest grazing, and measures suggested by them to minimize grazing pressure.

Questions	Attributes	Percentage of respondents choosing answer	
		Hurchi-Domkhar (Chumey)	Tsaluna (Gidakom)
What measures do you follow to minimize grazing pressure on forests?	Pasture cultivation	76	44
	Root crop cultivation	24	22
	Oat cultivation	0	19
	Rotational grazing	0	15
What is your motivation for forest grazing?	High forage availability	75	55
	Less investment	25	30
What are the characteristics of "good forests"?	Abundant forage	67	71
	Short distance	33	29
What are the characteristics of "bad forests"?	Less forage	36	64
	More predators	53	3
	Long distance	11	33
What criteria do you use for selecting forests?	Forage availability	60	55
	Location	40	45

Cattle production in both villages is largely based on forest grazing. Because forage supply is an important factor limiting the production potential of cattle (Roder 1998), the following discussion addresses the relevance of forest grazing practices and how grazing resources are managed.

#### Forest selection and measures to minimize grazing pressure

Availability of abundant forage and lower demand for inputs (labor and financial investments) were stated as the main reasons for letting cattle graze in the forest (Table 2). This may explain why forest grazing is invariably the preferred practice. On the one hand, it fits very well into traditional livestock production systems. On the other hand, the current and potential shortcomings of this practice need to be thoroughly considered when developing systems for sustainable farming in mountain areas. Our findings are similar to those of Roder (2004), who found low input demand and ease of production to be the main factors in mountain farmers' higher adoption of improved forage production practices.

Forage availability also stood out as the most important criterion for forest selection. Asked to describe what made forests appropriate for grazing, participants indicated that cattle owners continue to base their selection on indigenous and intuitive knowledge. Location was the second most important criterion; grazing sites closer to the homestead were preferred. As long as there was abundant forage, steepness of terrain was of the least concern. In Hurchi-Domkhar, 53% of cattle owners viewed forest as less appropriate for grazing

if it was inhabited by a larger number of predators. As much as cattle owners want to maximize benefits from the forest, they are equally concerned about the risk of losing cattle to predators.

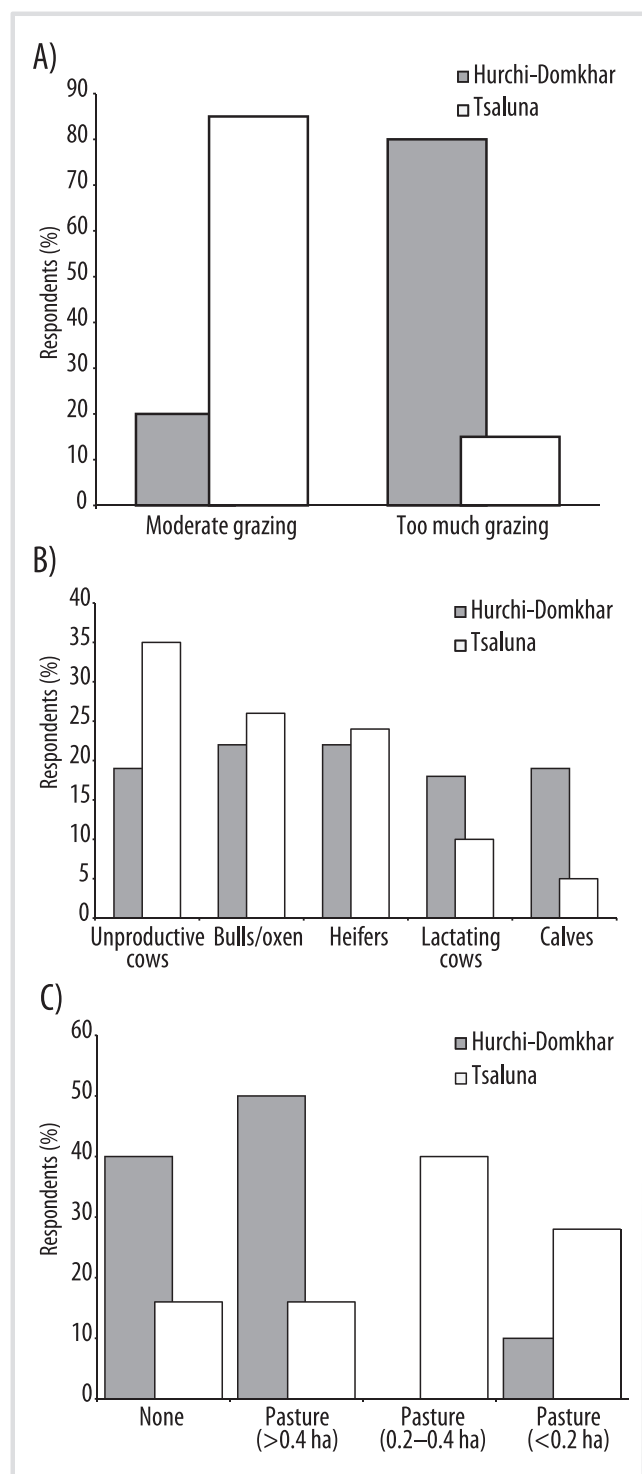
Among measures to minimize grazing pressure, the cultivation of pasture near homesteads was named as the most important on both sites, followed by cultivation of root crops as winter feed (Table 2). However, the importance of pasture was greater in Hurchi-Domkhar. This apparently reflects cattle owners' consciousness of the need to increase the forage supply to feed the growing number of lactating cows that can be expected from the comparably high number of heifers in that village (Figure 1). It could also be explained by the presence of terrain that is suitable for mechanized farming. Hence, the scope for cattle production from cultivated pastures is relatively greater in Hurchi-Domkhar.

Cultivation of oats and rotational grazing were also undertaken in Tsaluna to minimize grazing pressure. The diverse measures carried out in Tsaluna reflect cattle owners' strategy to minimize risks in the rugged terrain. The farmers' consciousness of the need to improve forage supply and to proactively respond to potential risks, while at the same time avoiding increased grazing pressure on the forests, is beneficial for sustainable forest grazing.

#### Forest grazing and homestead pastures

In Hurchi-Domkhar, the majority of the respondents acknowledged the existence of high grazing pressure on the forest (Figure 2A). This likely results from all categories of animals grazing small areas in the forest. The

**FIGURE 2** (A) Grazing intensity in the forest; (B) types of cattle sent to graze in the forest; (C) size of cultivated pasture owned by households.



estimated stocking rate for Hurchi-Domkhar was over 3 livestock units per hectare, but the forest pastures have low productivity, with 1.6 hectares needed to support a single adult head of cattle (Roder et al 2001). Thus, the

estimated stocking rate is higher than the land can support, which validates farmers' perception of high grazing pressure. In Tsaluna, on the other hand, 85% of respondents said grazing pressure was moderate, most likely because of the larger grazing area. The estimated annual stocking rate for Tsaluna was less than 1 livestock unit per hectare.

In Tsaluna, the majority of forest grazers were unproductive and nonlactating cows (Figure 2B), which may be interpreted as a strategy to minimize pressure on fodder resources near the homestead. Most productive cows were tethered near the homestead and were fed high-quality feeds. That reflects the care given to this category of cattle and appears compatible with government crossbreeding policies aimed at intensifying livestock management (Samdup et al 2010) while also considering sustainability of resource use. Our results, together with the findings of Roder et al (2002) on the subject, suggest that forest grazing might exist in the future mainly for nonlactating and unproductive cattle.

In Hurchi-Domkhar, as shown in Figure 2C, pasture holdings ranged from over 0.4 hectare of sown pasture (about 50% of the respondents) to no cultivated pasture at all (about 40% of respondents). Households without cultivated pasture relied solely on forests for forage. This lack of pastures near homesteads could lead to increased grazing pressure on forests. Insufficient land is probably the primary reason for not cultivating more improved pasture (Roder 1998; Phanchung et al 2002), and is thus a major constraint to dairy production (Ministry of Agriculture 2001).

Despite the rugged terrain, sown pastures were owned by a greater proportion of households (84%) and were more uniformly distributed in Tsaluna than in Hurchi-Domkhar. This indicates that, as long as the economic returns are high, difficult topography does not necessarily limit dairy farming. This might also be interpreted as the willingness of households to take greater financial risk (by forgoing crop diversification) if economic benefits are greater (Roder 2004). Phanchung et al (2002) also reported the willingness of dairy farmers to convert arable land to pasture when marketing opportunities exist. Attention needs to be paid to these different factors influencing resource management and farming choices in future development of farming systems.

#### Characterization of grazing cattle

Table 3 shows the seasonal weight and BCS of local cattle according to sex and age class. The estimated average weights were close to the live weight of a standard Bhutanese livestock unit, 300 kg (Samdup et al 2010), except for the male cattle in Tsaluna, whose average body weight was over 400 kg. Phanchung and Roden (1996) estimated the body weight of adult Siri cows at 212–307 kg and that of bulls at 260–360 kg. At both sites, weight declined in winter by 4% to over 10%.

**TABLE 3** Estimated seasonal weight and physical condition of cattle in different age categories. Female cattle older than 7 years of age are listed because of their importance for milk production. Difference in seasonal body weights is reported in percentages and difference in body condition scores is reported in points.

	Weight (kg)			Body condition score		
	Male 3–6 years	Female 3–6 years	Female ≥7 years	Male 3–6 years	Female 3–6 years	Female ≥7 years
<b>Hurchi-Domkhar</b>						
Summer	293.6	301.6	289.2	2.5	2.5	2.3
Winter	266.6	276.9	260.0	2.3	2.4	2.2
Difference	9.2	9.9	10.1	0.2	0.1	0.1
Significance	none	none	none	none	none	none
<b>Tsaluna</b>						
Summer	457.2	282.4	322.8	3.4	2.6	2.6
Winter	435.6	261.2	288.2	3.1	2.4	2.6
Difference	4.7	7.5	10.7	0.3	0.2	0.0
Significance	none	none	$P \leq 0.05$	none	none	none

Except for the male cattle in Tsaluna, the average BCS was less than 3 (the middle of the BCS scale) for both study sites. Rodenburg (2004) described the cattle as generally thin. Because BCS reflects the adequacy of dietary energy and nutrient intake (Edmondson et al 1989; Syafnir et al 2010), poor body condition would indicate an inadequate supply of nutrients from forest pastures.

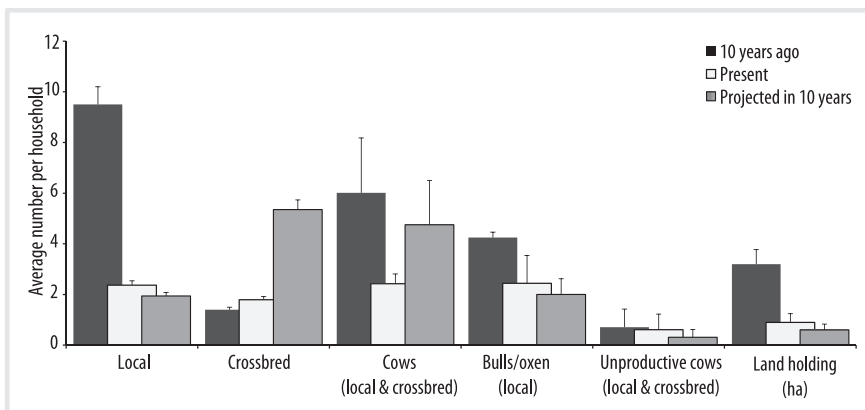
The average BCS of cattle was lower in Hurchi-Domkhar than in Tsaluna, which is probably because of the higher stocking rate. Syafnir et al (2010) reported similar results on the BCS of cattle receiving insufficient forage.

#### Perceptions on the future development of cattle herds

Figure 3 summarizes the results of the trend analysis, based on farmers' opinions and not on empirical data.

Analysis suggested a likely decline in the number of cattle per household and an increase in the number of lactating cows for both study areas, in agreement with the findings of the Ministry of Agriculture (2001). However, the anticipated increase in crossbred cattle and decline in local cattle indicated that crossbred cattle will comprise the majority of lactating animals in the future. Our results, when compared with those of Phanchung et al (2002), suggest that farmers' perceptions of dairying have probably changed during the last decade. In 2002, dairy farmers wanted to increase milk production by increasing herd size (Phanchung et al 2002), whereas our study showed that cattle owners aimed at increasing production by maintaining fewer but more productive cows. This is a positive trend that can accelerate cattle improvement programs and contribute to sustainable development in

**FIGURE 3** Past, current, and projected cattle populations in both villages (Hurchi–Domkhar and Tsaluna). The thin lines extending up from the bars represent the  $\pm$  standard error of means.



**TABLE 4** Cattle owners' opinions on the future of forest grazing and the advisability of a grazing permit system.

Questions	Percentage of respondents choosing answer					
	Tsaluna			Hurchi-Domkhar		
	Yes	No	$\chi^2$	Yes	No	$\chi^2$
Will cattle grazing in forests decline in the future?	83.0	17.0	$P < 0.001$	93.0	7.0	$P < 0.01$
Will forest grazing decline due to increased adoption of crossbred cattle?	73.0	27.0	$P < 0.01$	83.0	17.0	$P < 0.001$
Will forest grazing increase due to increases in local cattle populations?	27.0	73.0	$P < 0.001$	17.0	83.0	$P < 0.001$
Would you support the government introducing official permits for forest grazing?	88.0	12.0	$P < 0.001$	69.0	31.0	$P < 0.001$

the region, including a more efficient use of resources (Roder et al 2001).

The cattle owners predicted that the number of cattle per household would decrease. Our results revealed 2 important reasons for the anticipated decline in herd size: a preference for rearing a smaller number of more productive crossbred cattle and maintaining only a few local bulls and old cows, and an anticipated shortage of farm laborers due to the rising tendency of young and literate people to migrate to urban areas seeking better economic opportunities. When asked about mitigation measures, they pointed to reduction in herd size as the most likely measure. Shortage of labor is a challenge for farming in Bhutan (Tamang and Perkins 2005; Tenzin 2012) and a cause of decrease in the livestock population in the Indian state of Uttarakand (Makino 2011).

### The future of forest grazing

In both study areas, the majority of respondents expected forest grazing to decrease in future (Table 4) as a result of introduction and increased adoption of crossbred cattle, which are used for commercial dairying and require more intensive management instead of extensive forest grazing. Many predicted a decline in local cattle populations and stated that local cattle would likely not contribute to any future increase in forest grazing. It is possible that, given the limited availability of feed resources and farm labor, the big herds that were considered a symbol of prosperity in rural society (Ura 2002) may be viewed as a burden in the future.

Although a decrease in the number of local and unproductive cattle may be desirable, it may also reduce the amount of cattle manure, which sustains traditional farming (Roder et al 2002). This challenge needs to be addressed by stakeholders and policy-makers.

The idea of legal grazing permits was supported by 88% of respondents in Tsaluna and 69% in Hurchi-Domkhar. This reflects a growing awareness of the

condition of grazing sites in the forests and the need to promote regulated grazing. The difference in support between the 2 sites may be due to the difference in the proportions of households without pasture fields (Figure 2C). In Hurchi-Domkhar, a greater proportion of households were fully dependent on forest grazing and thus less likely to support a permit requirement.

### Conclusions

The 2 sites of this study differed considerably in forest grazing practices, primarily because of the difference in their access to economic opportunities and market information. This illustrates the importance of management decisions being based on site-specific information rather than generic guidelines. Access to economic opportunities is redefining the perceptions and attitudes of cattle owners. Participants from both sites displayed a common trend toward smaller and more efficient herds. Future smaller herds are likely to comprise mostly crossbred cattle, which could make conditions favorable for intensification of dairy farming.

Smaller herds are also likely to lead to a reduction in forest grazing in the future, when forest grazers will probably comprise mainly nonlactating cattle, including bulls and bullocks. The cattle owners' preference for crossbred animals will strongly influence cattle development programs in the future. Thus, the change in farmers' attitudes and aptitudes is an important point for consideration in future interventions.

In the Bhutan Himalaya, forests will likely continue to be a major grazing resource and a way of reaffirming cattle owners' ties to tradition. Our findings are relevant for programs and policies aiming at sustainable development in mountain regions where livestock farming is largely dependent on forest resources. They are transferrable to other mountain regions with similar environmental conditions.



## ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support of the Government of Austria with funds routed through the Österreichischer Austauschdienst (OeAD). We also thank Mr. Samten Nidup and Mr. Harilal Nirola for their valuable assistance during the fieldwork.

## REFERENCES

- Admasu T, Abule E, Tessema Z.** 2010. Livestock-rangeland management practices and community perceptions towards rangeland degradation in South Omo zone of Southern Ethiopia. *Livestock Research for Rural Development* 22(1): article 5. [www.lrrd.org/lrrd22/1/tere22005.htm](http://www.lrrd.org/lrrd22/1/tere22005.htm); accessed on 25 August 2011.
- Department of Livestock.** 2008. *Livestock Statistics 2008*. Thimphu, Bhutan: Ministry of Agriculture.
- Directorate of Land Records.** 1992. *Livestock Census*. Shimla, India: Government of Himachal Pradesh.
- Edmondson AJ, Lean IJ, Weaver LD, Farver T, Webster G.** 1989. A body condition scoring chart for Holstein dairy cows. *Journal of Dairy Science* 72:68–78.
- Hunzai K, Gerlitz JY, Hoermann B.** 2011. *Understanding Mountain Poverty in the Hindu Kush–Himalayas: Regional Report for Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan*. Kathmandu, Nepal: International Centre for Integrated Mountain Development.
- Landau S, Everitt BS.** 2004. *A Handbook of Statistical Analyses Using SPSS*. Boca Raton, FL: Chapman & Hall/CRC.
- Makino Y.** 2011. Lopping of oaks in central Himalaya, India. *Mountain Research and Development* 31:35–44.
- Ministry of Agriculture.** 2001. Constraints and opportunities in dairy production and marketing. In: *Sustainable Development of Smallholder Dairy Farming in Bhutan*. Kathmandu, Nepal: International Centre for Integrated Mountain Development, pp 48–52.
- Misri B.** 1995. Range and forest grazing in the Himalaya. In: Singh P, editor. *Proceedings of the Temperate Asia Pasture and Fodder Sun-Regional Working Group, Kathmandu, Nepal*. New Delhi, India: Publications & Information Directorate, pp 28–33.
- Mohammad N.** 1989. *Rangeland Management in Pakistan*. ICIMOD Senior Fellowship Series No. 1. Kathmandu, Nepal: International Center for Integrated Mountain Development.
- Pariyar D.** 1995. Forage Resources of Nepalese Hills and Strategies for Improvement. In: Singh P, editor. *Proceedings of the Temperate Asia Pasture and Fodder Sun-Regional Working Group, Kathmandu, Nepal*. New Delhi, India: Publications & Information Directorate, pp 18–21.
- Phanchung, Dorji P, Sonam T, Pelden K.** 2002. Smallholder dairy farming in Bhutan: Characteristics, constraints, and development opportunities. In: Tulachan PM, Jabbar MA, Saleem MAM, editors. *Smallholder Dairy in Mixed Farming Systems of the HKH*. Kathmandu, Nepal: International Centre for Integrated Mountain Development, pp 19–34.
- Phanchung, Roden JA.** 1996. Characterisation of the Siri breed and the Mithun cross Siri in Bhutan. *AGRI* 20:27–34.
- Rawat DS, Joshi M, Sharma S, Rikhari HC, Palin LMS.** 1996. Landuse planning for sustainable development—a case from the Haigad watershed in the Central Himalaya. In: Kumar K, Dhyani PP, Palin LMS, editors. *Land Utilization in the Central Himalaya—Problems and Management Options*. New Delhi, India: Indus Publishing Company, pp 229–244.
- Rodenburg J.** 2004. *Body condition scoring of dairy cattle*. OMAFRA Factsheets 109. <http://www.omafra.gov.on.ca/english/livestock/dairy/facts/00-109.htm>; accessed 24 November 2011.
- Roder W.** 1998. Fodder sources/fodder development/farmers management—preliminary data from a national survey. In: *Proceedings of the Third Annual National Livestock Research Workshop, Bathpalthang, Bumthang, Jakar, Bhutan*: Renewable Natural Resources Research Center, pp 72–79.
- Roder W.** 2004. Are mountain farmers slow to adopt new technologies? Factors influencing acceptance in Bhutan. *Mountain Research and Development* 24:114–118.
- Roder W, Dorji K, Gratzler G.** 2003. Nutrient flow from the forest—source of life for traditional Bhutanese agriculture. *Austrian Journal of Forest Science* 1:65–72.
- Roder W, Gratzler G, Wangdi K.** 2002. Cattle grazing in the conifer forests of Bhutan. *Mountain Research and Development* 22:1–7.
- Roder W, Wangdi K, Gyamtsho P, Dorji K.** 2001. *Feeding the Herds—Improving Fodder Resources in Bhutan*. Kathmandu, Nepal: International Centre for Integrated Mountain Development.
- Samdup T, Udo HMJ, Eilers CHAM, Ibrahim MNM, Van der Zijpp AJ.** 2010. Crossbreeding and intensification of smallholder crop-cattle farming systems in Bhutan. *Livestock Science* 132:126–134.
- Sargent C, Sargent O, Parsell R.** 1985. The forests of Bhutan: A vital resource of the Himalayas? *Journal of Tropical Ecology* 1:265–286.
- Sastry NSR, Thomas CK, Sing RA.** 1983. *Shaeffer's Formula for Body Weight of Cattle Described in Farm Animal Management and Poultry Production*. 5th edition. New Delhi, India: Vikas Publishing House.
- Singh P.** 1995. Forage resources of temperate Himalaya and strategies for improvement. In: Singh P, editor. *Proceedings of the Temperate Asia Pasture and Fodder Sun-Regional Working Group, Kathmandu, Nepal*. New Delhi, India: Publications & Information Directorate, pp 12–17.
- Syafnir, Hashida NH, Noraida I, Normala T, Hassan Z, Fuad M.** 2010. Effects of farming system and body condition score on fertility performances in synchronized cattle. *Indian Journal of Animal Research* 44:28–31.
- Tamang NB, Perkins JM.** 2005. Cattle management systems in humid subtropical areas of western Bhutan. *Journal of Bhutan Studies* 13:105–118.
- Tenzin P.** 2012. Remote Kangpar challenged by shortage of farm labour. *Bhutan Observer*, 7 August 2012, p 7.
- Tulachan PM.** 2001. Mountain agriculture in the Hindu Kush–Himalaya—a regional comparative analysis. *Mountain Research and Development* 21:260–267.
- Tulachan PM, Jabbar MA, Saleem MAM.** 2002. *Smallholder Dairy in Mixed Farming Systems of the HKH: Issues and Prospects for Development*. Kathmandu, Nepal: International Centre for Integrated Mountain Development.
- Tulachan PM, Neupane A.** 1999. *Livestock in Mixed Farming Systems of the Hindu Kush–Himalayas: Trends and Sustainability*. Kathmandu, Nepal: International Centre for Integrated Mountain Development.
- Ura K.** 2002. The herdsman's dilemma. *Journal of Bhutan Studies* 7:1–43.
- Wallner A, Bauer N, Hunziker M.** 2007. Perceptions and evaluations of biosphere reserves by local residents in Switzerland and Ukraine. *Landscape and Urban Planning* 83:104–114.