

Sustainability of Transhumance Grazing Systems under Socio-economic Threats in Langtang, Nepal

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Abstract: The decline or loss of traditional social-ecological systems may induce adverse effects to the societies and ecosystems. Transhumance, the recurring and seasonal movement of grazing livestock, is increasingly constrained by a numbers of factors including policy, land use and socio-economic changes in Nepal. To explore how these changes have affected the transhumance, this study investigated transhumance at the Langtang valley in central Nepal. The specific objectives of this study were to determine the herd size and composition, spatial-temporal patterns and to identify the major drivers of the system and the system changes. Data were collected from field study comprising semi-structured interviews with the herders, focus group discussions, key informants survey, and observations of rangeland and livestock management systems. The study revealed that the transhumance system in the Langtang is influenced by two types of drivers. In one hand, traditional practices are contributing to the sustainability of the system. On the other hand, the grazing patterns and adaptive responses are strongly influenced by changes in government policies, socio-economic and cultural transformation, livestock productivity, markets, rangeland conditions and climate change. The findings of this study help with the development and implementation of transhumance management policy for the sustainability.

Keywords: Chauri; Drivers; Langtang; Nepal; Transhumance

Introduction

Although the role of indigenous knowledge for sustainable utilization of resources has been realized in the recent past (MacDonald et al. 2000; Gemedo et al. 2006), such knowledge is rapidly disappearing from the world (Ostrom 2009). The ecological consequences from losses are unpredictable and the ways to recover them are also unknown (Rohde and Hoffman 2008). Indigenous knowledge provides the bottom-up approach and it integrates the nature, resources and livelihood (Rao et al. 2003). In grazing management, indigenous ecological knowledge is considered superior to modern ecology (Oba 2001). Indigenous knowledge is supposed to be more intact in remote and inaccessible areas such as in high altitude areas of the Himalayas (Rao et al. 2003).

Transhumance is a form of livestock production in which the livestock are moved between fixed points to utilize seasonal availability of grazing resources over a year (FAO 2001; Nyssen et al. 2009). Generally movement occurs between summer and winter pastures (Aitken 1945).

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Transhumance differs in its periodicity and regularity, and its fixity of sedentary base, from mere nomadism, the continuous casual vagrancy of whole pastoral peoples with no fixed residence (White 1926; Jones 2005). This is practiced by the inhabitants of settled communities to adjust certain set of environmental conditions combining livestock herding with arable agriculture (Jones 2005). This type of livestock herding is an historical and traditional strategy to the climatic variability, inaccessibility and low productivity. In addition to its socio-economic and cultural significance (Karki and McVeigh 1999; Moktan et al.; Chetri et al. 2011), transhumance may have an important role in maintaining cultural landscapes and ecosystem services (Rescia et al. 2008). These days the practice has been eliminated from many areas, as people have moved to other businesses such as tourism (Akis 2011; Hoffman and Rohde 2007; Özden et al. 2004) and overseas employment (Banerjee 2009). In addition, this system has also been constrained by new national land-use policies that promote intensive agriculture and settlement in grazing land (Bassett 2009; Herzog et al. 2005; Kamara et al. 2004). Furthermore, new conservation policies restricting traditional grazing inside national park and reserves have added to the constraint (Colchester 2004; Kala and Shrivastava 2004; Rao et al. 2003).

Transhumance, still common in the Himalaya (McVeigh 2004), is an adaptation of mountain people to cope with low temperatures and shortages of fodder (Moktan et al. 2008). This system is a herder's rational approach of livestock production to utilize seasonal production of pastures at different altitude (Chetri et al 2011). Karki and McVeigh (1999) argued that transhumance was one among a number of pasture management strategies including rotational and deferred grazing, adjustment of stocking rates and burning that could be used to promote desired herbaceous growth.

Transhumance practice in northern Nepal has been affected by many factors. Then there are the social and economic changes in some communities, such as those in the upper Langtang valley (>3000 m asl) in the Langtang National Park, resulting from contemporary constraints on transhumance, some of which are driven by globalization and others more directly by government policies and

local adaptations to land use regulations. Some of these factors threatening the system include restrictions on access to traditional grazing areas due to the conversion of low altitude forest into community forests and sealing the border with China (Devendra and Thomas 2002). Furthermore, there are increasing demands for conservation outcomes from rangelands of higher elevations through protected areas and the general perception that the rangelands under traditional practices have been overgrazed (HMG/N 1993) have led to an increase in the spread of bushes and other unpalatable species (Bauer 1990). There are some contrary arguments too. For example, some argue that the encroachment of bushes may be more likely due to avoidance of traditional land management practices such as burning (Shaoliang et al. 2007) than overgrazing.

High altitude areas in general and transhumance herding system in particular have been neglected by the policies and policy actors of Nepal (Banjade and Paudel 2009). Even though the system is under threat from a number of policy and socio-economic changes, it is unfortunate that there is little and poor understanding of the social dimensions and the sustainability of transhumance practices in northern Nepal (Dong et al. 2009). In this changing legislative and social context, this study aimed to explore the status of the transhumance system in the Langtang valley. Specifically, the objectives of the study were to (i) determine the herd size and composition, (ii) investigate the spatio-temporal pattern of seasonal migration, and (iii) analyze the major drivers of the system and the system changes.

1 Materials and Methods

1.1 Description of the study area

This study was done in Langtang valley. This valley lies in the Langtang National Park (LNP), Central Nepal (Figure 1). The valley is U-shaped in the upstream and V-shaped in the downstream areas of the Langtang River (Figure 2). The LNP was the first mountainous Park in Nepal, established in 1976 to preserve the diversity of plants and wildlife. The whole Langtang valley lies in the Langtang Village Development Committee

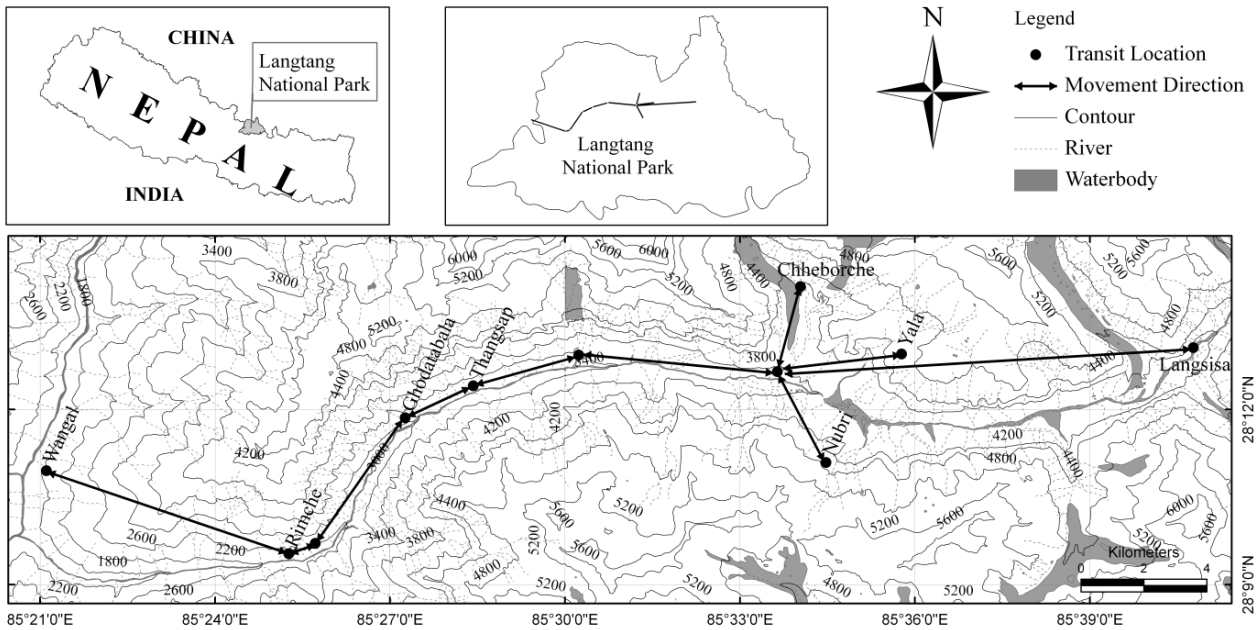


Figure 1 Location map of study area showing major stops used by herders.



Figure 2 Features of Langtang valley; U-shaped valley at upstream (Left), V-shaped valley at downstream (Middle), and Langtang village (Right).

(VDC) of the Rasuwa district and also lies completely within the park. The older settlements within the valley are Langtang (Figure 2), Sindum, and Mundu. However, in recent years, other new settlements are also developed in the valley to start tourism business. The terraces and fan of the Langtang valley were formed by deglaciation (Barnard et al. 2006) whereas soil scars in the valley side were formed due to yak and sheep grazing (Watanabe 1994). Average annual rainfall of the study area (Kyanjing station at 3920 m asl) is 674.64 mm with almost 75% of that in the monsoon period (June - September). However, there is a local variation in the amount and type of precipitation due to aspect and altitude. The average minimum temperature remains above 0°C for six months (May - October) and for the remaining six month (November - April), it is

below that (DHM 2011). The maximum and minimum temperatures for the hottest month (July) are 11.7°C and 7.3°C and coldest month (January) are 3.2°C and -6.6°C respectively (DHM 2011).

In Langtang valley, agricultural production is limited to few crops, such as barley, buckwheat and potato due to climatic, topographic, and soil constraints. The usual crops are barley, buckwheat and potatoes. Livestock rearing is an integral part of social, religious and agro-economic life (DUHE 1977; McVeigh 2004) in the area that has been practiced at least for 300 years (McVeigh 2004). The main livestock unit in this pastoral landscape is a *chauri* (common name for female hybrid between yak/nak and cow/bull) (McVeigh 2004). Herders follow a vertical transhumance from high to low elevation in a definite spatio-temporal pattern (Fox et al. 1996). This system is primarily

guided by traditional practices (Dong et al 2009). They establish *goth* (temporary shed made up of stones) at different elevations and graze their livestock in *kharkas* (grazing land) around them. Local organizations namely 'community committees' (elected bodies at community level) and 'civil associations' (self identified at group levels such as yak association, forest association) are active in herd and rangeland management (Dong et al. 2009).

The Nepalese Government originally sought to support transhumance in the Langtang valley through the establishment of cheese factories in 1953, leading to increased number of *chauries*, and a probable change in the grazing intensity in particular areas. Then, the declaration of Langtang National Park in 1976 excluded grazing from defined areas, which had a small spatial impact but was perhaps a sign of an emerging multi-functionality in the Himalayan landscapes. While multi-functionality is a concept more associated with the developed countries of Western Europe, the expectation of, and in some cases aid funding for, the development of conservation areas in production landscapes was exported to developing countries. In a related development, there was also increasing demand for recreational uses with a popular trekking route in the study area, and other regions of Nepal (MoCTCA 2008), creating other economic opportunities in addition to livestock herding. Globalization has also created other forms of competition for local labor, with extensive youth migration in search of work, including and especially overseas. Thus, transhumance practices in the study region are potentially being eroded by competition for land and labor.

1.2 Data collection and analysis

Data collection was undertaken in the field in June/July 2009. Semi structured interview with herders, participatory observation of rangelands, stopping points and livestock management, Focus Group Discussion (FGD), and key informants' interview were used for primary data collection during the field study. First of all two FGDs were organized; one in Langtang village (the main permanent settlement of the Langtang VDC) and another in the Choyana *kharka* near Kyanjing by inviting herders of the Langtang valley. Twenty

three herders participated and discussed transhumance and rangeland related issues. The topics of discussion were provided one after another. The main topics of discussion were the pattern of seasonal livestock grazing and drivers of and threats to, the transhumance system. They were asked to discuss the impact of cheese factory, National Park, tourism and climate change on the system. Herders prepared a list of rangelands where they graze livestock over a year and a list of stopover points where they established *goths* to graze their livestock.

After getting the list of rangelands and stopover points from the FGD, semi-structured interviews were held with individual herder in their houses or *goths*. Thirty herders from Langtang VDC were interviewed about the types and number of livestock they owned and purpose of each type of livestock. Because of lack of official register, interviewees were purposively selected through snowball sampling whereby one herder provided the name of another herder and so on. They were also asked to select stopover points from the list prepared during FGD.

Participatory observations of the rangelands and all the stopover points were done. Two to four herders were included in the group while observing selected high elevation rangelands and all the stopover points identified during FGD. Geographical Position Systems (GPS) of each stopover points were recorded and later used for mapping migration pattern. The participating herders were asked to show and identify (in local name) exotic, unpalatable and poisonous plants in the rangelands to determine the condition of the rangelands based on the distribution of unpalatable and exotic species in the rangelands. The scientific names of those species were obtained from Flowers of the Himalaya (Stainton 1984). The data/information collected from FGD and interview with herders were triangulated through a key informant survey, with the former chairman of Langtang VDC, hotel staff, an officer each from District Livestock Office (Rasuwa) and Agricultural Research station (Pasture) Rasuwa). The major drivers and challenges of the Langtang transhumance system were analyzed based on the information obtained through these processes.

The climatic data of Langtang station (Kyanjing) was collected from the Department of

Hydrology and Meteorology (DHM), Babarmahal, Kathmandu for the years between 1987 and 2011. The trends of rainfall and temperature were analyzed and tallied with herders perceptions in the climatic variables. Since there were no climatic stations to get data of monthly temperature for all the stopover points used during transhumance, the lapse rate of 0.6°C /100 m (Pepin et. al. 1999) was used to adjust temperatures at different elevations from the difference in elevation from Kyanjing station. Data for tourists visiting Langtang each year was obtained from the Nepal Tourism Board and data for cheese production from Kyanjing Cheese Factory was obtained from Dairy Development Corporation (DDC), Kathmandu and Kyanjing Cheese Factory Langtang. These data were analyzed and presented in subsequent sections.

2 Results and Discussions

2.1 Herd size and composition

Herd composition in the Langtang was dominated by *chauri*. Hybrids of yak/nak and cow/ox constitutes above 75 percent of total livestock in Langtang which was almost tripled in 15 years (Table 1). The average herd size consists of 17 livestock with 13 such hybrids (both male and female), 2 yaks/naks and remaining animals consisting of horses, cows/bulls, sheep and goats. *Chauri* are managed primarily for milk production, *jokpyo* (common name for male hybrid between cow/ox and yak/nak) for transportation, plowing and meat, and horses solely for transportation. Herders reared sheep and goat for wool that could be exported easily. However, no such enterprises

were observed or reported.

Local herders mentioned that the number of transhumant herders had decreased drastically because many people are increasingly attracted to alternate business i.e tourism. Furthermore, the average herd size has declined from 25.73 livestock unit per household (HH) to 16.9/HH over a decade (from 1997/98 to 2009). All other livestock types except hybrids experienced decrease in their number over same period of time (Table 1). The number of yak/nak declined from about 6/HH to 2/HH and the number of sheep declined from about 4/HH to 1/HH. The number of goat reduced severely and it was completely eliminated from the study areas in the same decade.

Although, average numbers of *chauri* which is reared for milk has increased, cheese production in the nearby cheese factory which is the only place to sell milk by herders has sharply decreased after 1994/1995 suggesting decreasing productivity.

2.2 Spatial and temporal pattern of migration

The herders of Langtang move in a definite spatio-temporal pattern throughout the year to graze their livestock (Table 2 and Figure 1). Their movement starts from the main permanent settlement (Langtang village) where they stay for about one month (mid-April to mid-May while going up in the summer and mid-October to the end of October while going down). They spent about four months (June 1st to September 30) in the rangelands above Langtang village and about seven months (mid-October to mid-May) in the grazing areas below the village. Herders reach to the lowest point (Wangal) at about 1635 m asl in mid-November where they spend about two and half months during the peak winter season. They move upward with the onset of spring season and reach to the high elevation rangelands (Nubri, Langsisa, Yala and Chheborche) at about 4300 m asl in mid-June where they stay till mid-September.

After mid-September (with the onset of winter

Table 1 Change in the herd composition in the study area (/HH = per household)

Livestock type	1997/1998 (by NARC)		2009 (by field survey)	
	Number/HH	Percentage	Number/HH	Percentage
Yak/Nak	5.82	22.62	2.00	11.83
Cow/Bulls	3.53	13.72	0.31	1.83
Hybrid (<i>chauri/jokpyo</i>)	7.14	27.75	12.74	75.38
Horse	1.25	4.86	0.81	4.79
Sheep	3.92	15.24	1.04	6.15
Goat	4.07	15.82	0.00	0.00
Total	25.73	100	16.9	100

Table 2 Elevation and temperature of each stops used during transhumance

S. N	Name of stop	Altitude (m asl)	Time spent by herder in the stop	T ₁ *	T ₂ *
1	Wangal	1635	Nov 15- Jan 30	2.2	15.9
2	Rimche	2489	Feb 1 - Mar 1; Nov 1 - Nov 15	3.1	11.7
3	Lama hotel	2781	Mar 1 - Apr 15; Nov 1 - Nov 15	7.5	14.3
4	Ghodatabala	3009	Apr 15 - May 15; Oct 15 - Oct 30	11.5	17.0
5	Thangsap	3104	Apr 15 - May 15; Oct 15 - Oct 30	11.5	16.4
6	Langtang (main village)	3410	May 15 - May 30; Oct 1 - Oct 15	14.1	17.2
7	Kyanjing	3794	Jun 1 - June 15; Sept 15 - Sept 30	14.1	14.9
8	Chheborche	4197	Jun 15 - Sept 15	15.2	13.5
9	Yala	4160	Jun 15 - Sept15	15.2	13.8
10	Langsisa	4150	Jun 15 - Sept 15	15.2	13.8
11	Nubri	4340	Jun 15 - Sept 15	15.2	12.7

Notes: T₁ = Temperature at Kyanjing (°C); T₂ = Temperature of the stop (°C); * Mean monthly temperature when herders reach each stop.

season), herders gradually move to low altitude areas resting for a few days in stops at different elevations before they reach to the lowest point in mid November. Herders use the same route (either side of Langtang River) from Wangal (number 1 in Figure 1 and Table 2) to Kyanjing (number 7 in Figure 1 and Table 2) from where they separate into four groups, where they have fixed usage rights at the high altitudes kharkas (number 8, 9, 10 and 11 in Figure 1 and Table 2). All the grazing areas in between two extremes i.e lowest and highest altitudes are grazed twice in a year; while moving up and down. On average, each herder use six stops (*goth*) ranging from five to seven over a year. Herders with small herd sizes do not reach to the lowest point; instead graze their livestock near Ghodatabala and Lama Hotel (Figure 1). Yak/nak cannot go below Rimche (2500 m asl) because they cannot tolerate higher temperature; they graze freely above this point when herders go to the lower stop with other livestock in the winter.

Herd mobility is a tool for managing environmental variability in the pastoral systems. However, their daily decisions are often made in response to their social, economic, or personal situations (Baker and Hoffman 2006). Livestock

movement patterns in Langtang are also related to temperature at different elevations so that the average monthly temperatures of all the stops range from 11.7°C to 17°C (Table 2) where herders graze livestock at that particular elevation. There is also a considerable variation in the vegetation at different altitude in Langtang. The complex topography, geology and climatic patterns have enabled a wide range of plant communities to establish themselves. Vegetation of LNP ranges from sub-tropical and temperate forests, to alpine meadows and scrubs to the nivale zone of dry, scree vegetation (Malla et al. 1976; DUHE 1977). In the downstream areas of the Langtang valley where herders graze their livestock in the

winter season consist of forest whereas in the upstream areas there are meadows and scrubs.

There was a lack of previous data on the number of stopover points where they established *goth*. The herders concluded from the focus group that there has been no major change in the number of such stops except that all herders do not reach to the lowest and highest *kharkas*. The system continues from previous generations to fix the ownership of pastures and number of grazing days at stops of different altitude. Though the system is not documented well and there is no government owned enforcement mechanism, each herder has been practicing de-facto rights over routes for livestock movement and *kharkas* to graze livestock. After the declaration of National Park, some areas were identified as potential habitat of red panda (*Ailurus fulgens*), an endangered species of Nepal. Livestock grazing was prohibited in such areas. This affected the livestock grazing pattern inside the Park. In case of this study area, though the livestock grazing was excluded in the forest areas just below Ghodatabala (Figure 1), access was given to go down and up through the area because there was no alternative route available as it was deep river valley (gorge) with steep slopes in either side.

It did not affect the movement pattern since there were no *goths* in the restricted area, but it increased livestock pressure in the pasture around Ghodatabala and just above it.

2.3 Drivers of the system

2.3.1 Drivers of traditional system

Transhumance system in the Langtang valley is primarily guided by traditional practices. Similar to other mountainous areas, transhumance in Langtang was developed to harness low productivity of marginal areas and to deal with harsh conditions. This system became a major activity because the cultivation was not favored by climatic, edaphic and topographical factors. Langtang communities recognize de-facto rights in rangeland on the basis of which indigenous rangeland management system operate (Karki and Mcveigh 1999; Dong et al. 2009). Rights to highland pastures were effectively hereditary. The number of stops, duration of stay in each stop and migrating routes are little changed. These days, they have formed a herder committee which can adjust the date of migration from one stop to another. They have defined user groups and access rights to minimize conflict and developed pastoral management strategies such as burning, rearing mixed herds and rotational grazing. The existence of such indigenous system is considered the best for Langtang grazing as this system has evolved over a long time to suit varying climatic, biophysical and ethnic diversity (Dong et al. 2007). However, the herders acknowledged that this system was not sufficient to resolve all the problems. Herders noticed that there are no proper veterinary and health facilities in the traditional system. There is no record of livestock number and types. The record is essential for the demand and supply evaluation of rangeland and to harmonize grazing with the carrying capacity.

2.3.2 Drivers of system change

2.3.2.1 Government policies

In one hand, there are traditional practices that are guiding transhumance system in the Langtang valley for its continuity, but in the other hand there are different factors affecting or

changing its existence. One of the important factors driving the Langtang transhumance system was change to government policies. The first of these interventions in 1953 was to support herders. Realizing that animal husbandry is a major economic activity in the high altitude areas of Langtang, the Government of Nepal established two cheese factories under the Dairy Development Corporation (DDC) in the Park area at Kyanjing (3840 m asl) and Sing Gumpa (3254 m asl). These cheese factories were a source of cash for the herders. They sold milk in the factory and maintained large herd sizes (Yonzon and Hunter 1991). After the establishment of the factories, herders increased number of *chauri* in the herd that led to increased fodder shortages in winter and heavy grazing near stops and routes used in transhumance.

In 1976, the government declared the area as a National Park to protect flora and fauna. Some areas were recognized as habitat of endangered species and the livestock grazing was excluded from these areas. Lopping fodder and the collection of green fuel wood was also banned. Armed posts were established in different areas of the Park to protect endangered species and their habitat. This created conflict between biodiversity conservation and fulfilling human needs such as livestock grazing and collection of fuel-wood (Fox et al. 1996). Sheep and goat predation increased in the area whereas snow leopard and dogs kept in the armed posts were the predators. Herders mentioned that depredation harassed sheep and goat rearing and those livestock were eliminated from the Langtang. Neither the interview with herders revealed presence of goat in the area nor did we find goat in the Langtang valley during our field visit.

We could not trace the exact date when foreigners made the first visit to the Langtang area but the increased flow of tourist in the areas almost corresponds with the Park establishment. With the opening of Langtang-Helambu trekking route, the tourist flow in the area has increased. The overall visitor trend is up with a downturn during political unrest during peak Maoist insurgency from 2000 to 2007 (Figure 3). Some herders left livestock rearing for tourism related business and some started to run hotels and lodges along the trekking route. Others, who could not afford to run hotels

and lodges, started working as porters. The economic gap between people following traditional professions and those in tourism widened as tourism-related income increased more quickly. The tourism led to socio-economic and cultural transformation in the area and also discouraged herders in their profession to some extent.

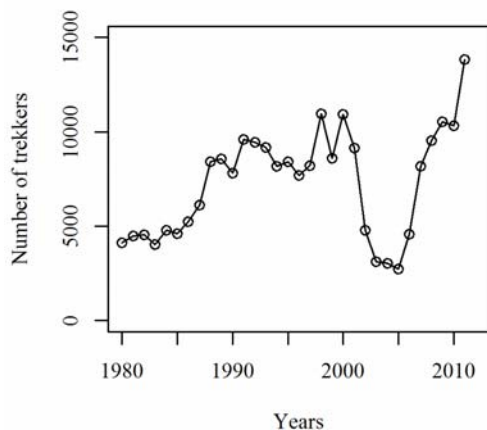


Figure 3 Number of trekkers (foreigner) visiting Langtang (MoCTCA 2011).

Recently, government of Nepal has formulated rangeland policy (Rangeland policy 2012). It has clearly identified the problems faced by the transhumant herders in the Nepal Himalayas; however, it is very difficult to get desirable outcomes as mentioned in the policy because there are several cross-cutting policies, acts and rules that may predominate to its implementation. For instance, National Park and Wildlife Conservation Act (1973), Forest Act (1993), Buffer Zone Management Rules (1996) etc. among others are in contradiction with the rangeland policy.

2.3.2.2 Socio-economic and cultural transformations

Before the opening of trekking route in the area, all the villagers were dependent on animal rearing. With the increase in tourism there was a change in the identification of the social prestige among villagers. In the past, people with the highest number of livestock were seen as rich and reputed in the village, but those operating hotels and lodge are now more esteemed and seen as wealthier. Traditionally, men were largely involved as herders in the Langtang area but recently they are more interested in alternate businesses and overseas work. With the increased interaction with tourists (outsiders), local people became more

aware of education, health and sanitation. School enrolment has now increased, with more and more children going to Dhunche (district headquarter) and even to Kathmandu for study.

In recent years, youth migration to overseas in search of work is increasing to an extent that Nepal is one of the five countries where the contribution of remittance to the total GDP of the country is the highest, currently contributing over 23% (MoLE 2012). Youth-out migration was more than 0.37 million people in a one year period (December 09/January 10 to December 10/January 11), with migration of more than 1000 per day (NIDS 2010). This resulted in a lack of people involved in livestock rearing. Herders in the Langtang have identified the shortage of labor as one of the major challenges of the system and they are not sure whether traditional practices of livestock grazing could continue into the next generation. The shortage of labor has reduced more labor-intensive goat and sheep rearing and thereby increasing the proportionate number of *chauri* in the herd.

2.3.2.3 Rangeland condition

Change in the resources availability in the rangeland was also one of the major drivers of the system change. The rangelands, particularly near settlements are degraded. Nitrophilous species that tolerate disturbance such as *Corydalis juncea*, *Cynoglossum* sp., *Euphorbia stracheyi*, *Iris goniocarpa*, *Plantago* sp., *Ranunculus pulchellus* and *Rumex nepalensis* were abundant in the rangeland near settlement and near *goth*. Aryal (2010) indicated that there was more grazing in grass dominated patches as compared to shrub and stone dominated patches in the rangelands of Langtang. The unpalatable herbs were more frequently distributed in such patches. Green and Tchinelé (2004) argued that resource uses are largely consolidated to a central corridor. The herd composition determines the grazing patterns and feeding requirements and hence influences grazing impact in the rangelands. The changes in the herd composition have degraded the rangeland near settlements and trekking routes. The rangeland areas that were used by sheep and goat in the past were not accessible to *chauri* while the areas accessible to *chauri* are now overgrazed.

The study also revealed a new but growing issue, between hotel owners and herders, related to

fodder shortage. They were blaming each other for overgrazing near settlements and shortage of fodders in the pastures. Herders were saying that hotel owners were increasing the number of horses as means of transport and packing animals which consume more grass/fodder than *chauri*, degrading the pastures near settlements. They further claimed that there was a problem due to scattered plastic and glass in the grazing land leading to increased injuries in livestock. Hotel owners agreed that they have more horses as compared to the past but they argued that they gave up other livestock rearing and hence few horses as compared to large number of *chauri* are nothing. They suggested that the shortage of fodder/grass may be due to change in herd composition. From these contrasting arguments between hotel owner and herders, it can be said that the quality of grazing land near the settlements is degraded and there is a shortage of fodder/grass.

2.3.2.4 Livestock production and markets

Herders concluded that the milk productivity was heavily declined as compared to the past. They mentioned that the size of the *chauri* as well as milk production per *chauri* has declined considerably. The literature suggests that the inbreeding is also one of the major reasons for declining productivity. In Langtang, restriction of free movement of livestock in China after late 1970s led to inbreeding. In the past, the import of yak bulls from China reduced the chances of inbreeding and the Langtang was also the source of yak bulls and *chauri* for other areas such as Timure of Rasuwa, Sailung and Thodung of Ramechhap and Helambu of Sindhupalchok district (Pande 2004). However, this practice is also very rare now. Herders recognize that too-frequent inbreeding has weakened the herd and the fresh genetic material is necessary to overcome this situation (Zi 2003).

Langtang herders are not only suffering from the declining productivity, but also from the monopoly of the Langtang Cheese Factory at Kyanjing in fixing the price of the milk which was the only place to sell milk. Herders were unsatisfied with the price of milk provided by the cheese factory. To illustrate this, herders illustrated the case that one liter of mineral water costs 200 Nepalese Rupees (2.25 US dollars as per 10th July,

2012 conversion rate) in the nearby hotel whereas the cost of the same amount of milk provided by the Cheese Factory was one tenth of that (20 Nepalese Rupees or 0.22 US dollars as per 10th July, 2012 conversion rate). This has created economic disparities between people involved in the livestock rearing and those involved in tourism.

The only milk products from Langtang factory were cheese and butter, and perhaps with new technology, some greater value-adding might help redress the relatively low prices of milk. Technologies to convert milk into other products such as ice-cream, chocolates, etc. which are consumable by tourists could benefit local herders and may even help to minimize conflict between hotel owners and herders.

2.3.2.5 Climate change

Herders identified unusual and unpredictable weather has also affected their grazing system. They have already noticed rising temperatures and increase in total annual rainfall. Furthermore, they suggested that there is increasingly heavy rainfall at the end of monsoon seasons (late August and early September) which had previously occurred between mid July and mid August. These perceptions of herders were in line with the temperature and rainfall trends for Langtang (Table 3) and also with the observed temperature and precipitation trend and predictions for Nepal (IPCC 2007; Marahatta et al. 2009; MoEnv 2010). Warming is more pronounced in the high altitude regions as compared to the low lands in the Himalayas (Chaudhary and Bawa 2011; MoEnv 2010; Shrestha et al. 1999). Climate change is a major concern in the Himalaya because of its potential impacts on the economy, ecology, and environment of the Himalaya and areas downstream (Liu and Rasal 2007).

Table 3 Trends of rainfall (mm/yr) and temperatures (°C/yr) in Kyanjing station (data from 1987 to 2011)

Variables	Trends		
	Annual	Winter	Summer
Rainfall	5.342	-0.652	3.433
Max. temp.	0.060	0.123	0.981
Min. temp.	0.063	0.0121	0.107

Herders also noticed that the amount of snowfall and duration of snow cover in the

rangelands have decreased. Water availability in the rangeland has been affected in the Langtang which has induced water shortage in the rangelands during dry season. IPCC (2007) predicted that in the high elevation areas where snowfall is the current norm, there will be increasing precipitation in the form of a rain. If the increase in temperature is more pronounced, it is likely to affect the seasonal grazing pattern by changing temperature range of different elevations where herders graze livestock in different seasons. However, the rise in temperature might lead grass to grow further up in the rangelands that could be beneficial for livestock. Studies from other regions has shown that herders' traditional response to both natural and socio-economic change is dependent on a flexibility in herding practice (Thornton et al. 2007; Tyler et al. 2007; Dong et al. 2011) but such flexibility is being eroded by several non-climatic factors (Tyler et al. 2007; Dong et al. 2011). The climate change is considered an additional burden to the poor people such as transhumant herders in the mountainous region of Nepal (Gentle and Maraseni 2012).

3 Conclusions

Transhumance system in the high altitude Langtang valley is herder's rational approach developed through the century's old trial and error for the utilization of grazing resources distributed in different ecological zones along the elevation gradient. The movements also capture the seasonal temperature variation at different altitudes. The study revealed that there was an overall decline in the number of transhumant herders and the herd size. Herd composition was also changed as compared to the past where numbers of *chauri* has increased and other livestock types have decreased.

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There were no major changes in the spatio-temporal patterns of livestock movement as herders follow same routes, timing and pastures for livestock movement and grazing.

Two types of drivers operating inversely were identified for the existing status of the Langtang transhumance system. In one hand, traditional practices are contributing to the sustainability of the system whereas in the other hand, changes in government policies, socio-economic and cultural transformations, rangeland condition and climate change among others are contributing to the system change. Traditional practices were playing an important role to fix the ownership over pastures, migration routes, movement date and timing. These factors have contributed to the sustenance of transhumance system. However, traditional practices only are not sufficient enough to counter the effect that arose due to the multiple drivers of the system change operating at different scales. This led to the decrease in total number of herders as well as herd size and changed herd composition.

While the cessation of grazing may have some ecological benefits, it is also possible that a transhumance system, or at least some optimum variation of it, could contribute to biodiversity and the control of invasive species. It might also be reasonably presumed that globalization bringing tourists and job opportunities elsewhere will lead to increase in regional incomes, but there might also be other social changes that bring additional problems. Rather than just let transhumance become an historical curiosity, a comprehensive study considering ecological, economic, social and cultural aspects of transhumance will reveal if there might be value in providing incentives to maintain this practice in some form and perhaps even support it.

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