Transhumance Herders' Perceptions Towards the Change in Temperature and Precipitation in Red Panda (*Ailurus fulgens* Cuvier 1825) Habitats in Jajarkot, Karnali Province, Nepal

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Abstract

The endangered red panda (Ailurus fulgens)is endemic to the Himalayas, including Jajarkot. Forest-dependent agro-pastoralists in Jajarkot rely on natural resources for their livelihoods in prime red panda habitats. This paper describes how agro-pastoralists perceive prevailing climate change threats and how they together with endangered red panda are sustaining in spite of these threats based on personal interviews, focus group discussions, key informant interviews, and observation methods. The results of the study revealed that the perceptions of the agro-pastoralists correspond with the increasing trend of temperature and the changing (both increasing and decreasing) trends of precipitation. Moreover, the agro-pastoralists have perceived the decrease in snowfall and reported the appearance of new forage and pasture species in the red panda habitat. The findings will be useful to understand the impact of climate change in the red panda range and devising adaptation strategies in these areas.

Keywords: *Biophysical indicators, climate change, interview,pasture, pastoralists*

Introduction

About 129.91 million (1.705% of the global total population) resideabove 2,500 masl up to 5000 masl (Tremblay & Ainslie, 2021)with a higher incidence of poverty than in the lowlands in the same regions (Hunzai et al., 2011).Transhumance pastoralism in high-altitude mountains is a unique age-old practice and adaptive strategy of the seasonal migration of livestock and humans between many agro-ecological zones and make their living through income from cattle-based products complemented by collection and trade of non-timber forest products (NTFPs) (Agrawal, 2010; Rota &Sperandini, 2010).Transhumant pastoralism supports the subsistence livelihoods and simultaneously increases pressure on forests and alpine meadows in Nepal (Khadka & James, 2016). Mountain pasture land ecosystems in Nepal extend about 12 percent of the country's land area comprising about

79 percent of these ecosystems in the High Mountains and High Himal areas and 17 percent in the Middle Mountains (GoN, 2014). Due to poor management, only 37 percent of the forage is accessible to livestock in Nepal (Ning et al., 2013).

Endemic to the Himalayas, the red panda (*Ailurus fulgens*) is listed as 'Endangered' by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species(Glatston et al., 2015), and the National Red List of Nepal (Jnawali et al., 2011).Due to variations in climate and topography across the entire range, the red panda shares different habitat rangesand vegetation compositions, including evergreen forests, evergreen, and deciduous mixed broadleaf forests, deciduous forests, deciduous and coniferous mixed forests, and coniferous forests with associated bamboo thicket understories (Yonzon et al., 1991a; Wei et al.,1999).In a pastoral system, livestock shelters are temporary and move across pastures and forests (Fox et al., 1996), which are considered potential habitats for the red panda (Bista et al., 2017). Livestock grazing is considered a major threat to the red panda in protected areas in Nepal, including in Langtang National Park, Dhorpatan Hunting Reserve, outside the protected area in Jajarkot (Yonzon &Hunter, 1991; Sharma &Belant, 2009, Baral, 2014), and elsewhere in Bhutan (Dorji et al., 2012).

Climate plays an important role in determining species distributions and evaluating the influence of climatic variables across a large geographic area (Morelle & Lejeune, 2015) to provide information about suitable habitats for a given species.Climatic variables are the dominant driving factors as opposed to distal variables such as elevation and topography, which are used frequently but have a low predictive performance (Bradie & Leung, 2017). Yonzon et al., (1997) built a potential habitat model incorporating annual precipitation; while Kandel et al., (2015)predicted the same based on temperature-associated in the vast Hindu Kush Himalaya region (Kandel et al., 2015). Climate change can cause substantial species range contractions and extinctions and lead to a disproportionate distribution of species along ecological zones (Wilson et al., 2007). Meteorological data showed warmer and drierclimates in the red panda habitat in recent decades and forecast this pattern to continue in the future(Wang et al., 2010).The mountains are highly sensitive and prone to climate change (Viviroli et al., 2011, IPCC, 2019) and its impacts are more pronounced in red panda habitats than in low-altitude regions. People adopting natural resources-based livelihood options are affected more and their perceptions might be different. These perceptions coupled with the modern climate model might be accurate and can be better applied tothe assessments of climate change (Alexander et al., 2011; Petheram et al., 2010; Sánchez-Cortés & Chavero, 2011) and indigenous people can better respond to climate change (Nyong, 2007; Turner & Clifton, 2009; Yeh et al., 2014). The indigenous knowledge is also acknowledged for its crucial role in further advancing the understanding of scientific knowledge of climate

change (Chaudhary & Bawa, 2011; Lead et al., 2005) and red panda conservation.With these understandings, building potential conservation interventions focusing coexistence of transhumance practice and red panda conservation could be biologically meaningful, the fact, however, has beeninadequately incorporated in previous studies.

The present study addressed the following questions:

1. How do transhumance herders perceive the impact of changes in climatic variables on the mutual co-existence of the livestock herds and red pandas?
2. What are the observed changes in biophysical indicators in red panda habitats?

Materials and Methods

Study Area

The research was conducted in the Barekot Rural Municipality (RM), Kuse RM,and Nalagad Municipality of Jajarkot District, Karnali Province, Nepal (Figure 1). Barekot and Kuse RM and Nalagad Municipality are homes to a total population of 74,425 (CBS, 2022). The seven adjoining fringe settlements close to the red panda habitat namely: Archanni and Paink of Kuse RM, Nayakwada, Rokayagaun and Sakala of Barekot RM and Ragda and Bhagawati of Nalagad Municipality were selected for primary data collection.

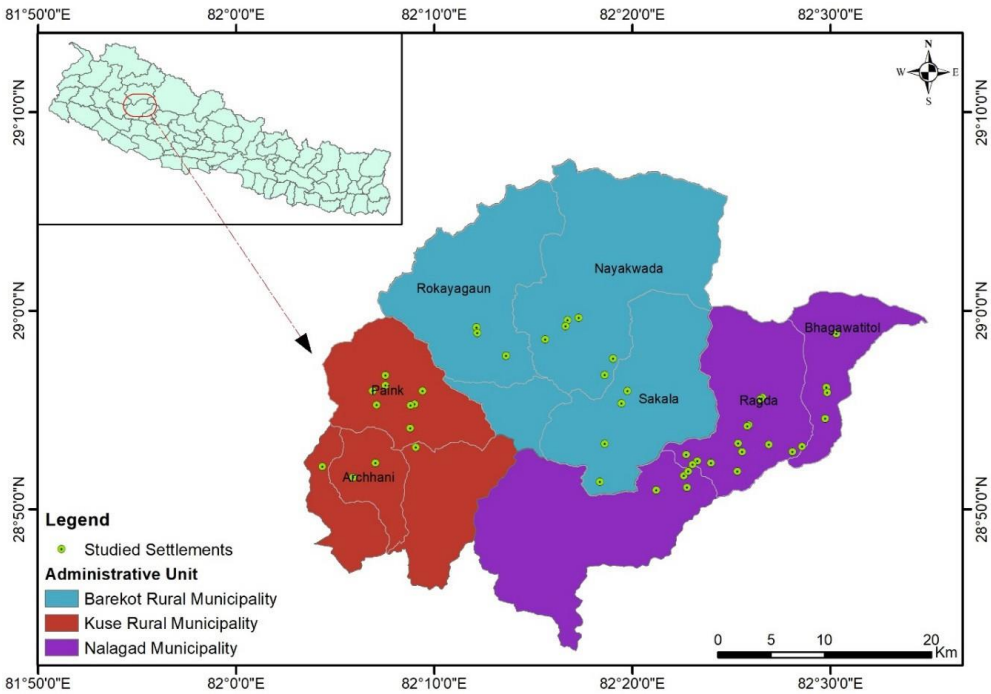


Figure 1. Map of the study area.

Human communities in the study area are mostly agro-pastoralists belonging to the Thakuri ethnic group. The traditional practice of transhumance, NTFPs collection (*Ophiocordyceps sinensis*, *Delphinium himalayai*, *Nardostachys jatamansi*, *Picrorhiza scrophulariiflora*, *Swertia chirayita*, *Paris polyphylla*, *Delphinium denudatum*, *Morchella esculenta*, *Ganoderma lucidum*, *Polygonatum cirrhifolium*, *Polygonatum verticillatum*, *Rheum australe*, *Valeriana jatamansii*, *Dactylorhiza hatagirea,etc.)* in red panda habitats contributes to the livelihoods of communities, relying mainly on subsistence agriculture with a strong linkage between farming, pasturelands, and forestry. Jajarkot is ranked as a district with a high ecological vulnerability index and a very high overall vulnerability to climate change (GoN, 2010). During the late spring and summer seasons livestock herders graze their livestock like *Bos Taurus, Bubalus bubalis,Equus ferus coballus, Equus asinus*, mules, *Capra aegagrus hircus*, and *Ovis aries* in the alpine pastures above their villages. Herders shift their herds among different pastures in the alpine region before bringing them down to the villages during winter. The study area beholds temperate,sub-alpine, alpine and nival types of vegetation and acts as a refuge for different mammal species such as *Ursus thibetanus, Ailurus fulgens, Semnopithecus schistaceus, Moschus spp., Muntiacus vaginalis, Hemitragus jemlahicus, Naemorhedus goral, Capricornis thar,* etc. (Baral, 2014; Baral et al., 2014).

Research Methods

The temperature and precipitation dataof the nearest meteorological stations were collected from the Department of Hydrology and Meteorology for trend analysis. Meteorological stations in Nagma, Musikot, Dipalgau, Jajarkot, Guthichaur and Dunai lies very close to those respective red panda habitats in Jajarkot. Therefore, the rainfall data during the last 37 years (1981-2017) and the temperature data during the last 27 years (1990-2016) in those stations were analyzed. The trends of the temperature and rainfall were calculated following the least square linear regression model (Wilks, 2011). Let x_1, x_2, x_3, ……x_n represent data points where represents the data point at time j. Then the linear equation of the data series is represented as:

$y = mx + c$ .....(i)

where x represents the data series x_i for time i=1 to n and m gives magnitude of slope of the trend line. The positive value of m shows the increasing trend while the negative value gives the decreasing trend. The annual trends of temperature and rainfall were obtained using the data of all months (Shrestha &Aryal, 2011).

We adopted a qualitative research approach with in-depth face-to-face interviews (Babbie, 2007) to collect possible qualitative information about the impact of change in temperature and precipitation among agro-pastoralists in red panda habitats and its

associated impacts on red panda. A total of 175 agro-pastoralists were purposively sampled and interviewed between September and December 2017. Seven focus group discussions (FGDs) containing a group of 5-8 agro-pastoralists per FGD were conducted in each study rural municipality and municipality. The likely impacts of climate change on the transhumance and red panda habitat were also discussed during the FGDs. The participants of in-depth and semi-directive interviews and FGDs were purposely selected to represent all geographical locations in the village and all categories of ethnicity, caste, class, and gender (Table 1). Participant observation was conducted in the research area by spending a total of forty days following daily herding activities and the potential risk of those activities on red pandas. The observations were noted in a diary, and important events were captured in photographs. The data collected through interviewees and FGDs were recorded using a voice recorder; they were then transcribed, translated, and analyzed using R (version4.1.2) and the Chi-Square test was performed to analyze the perception of herders on variables of climate change.

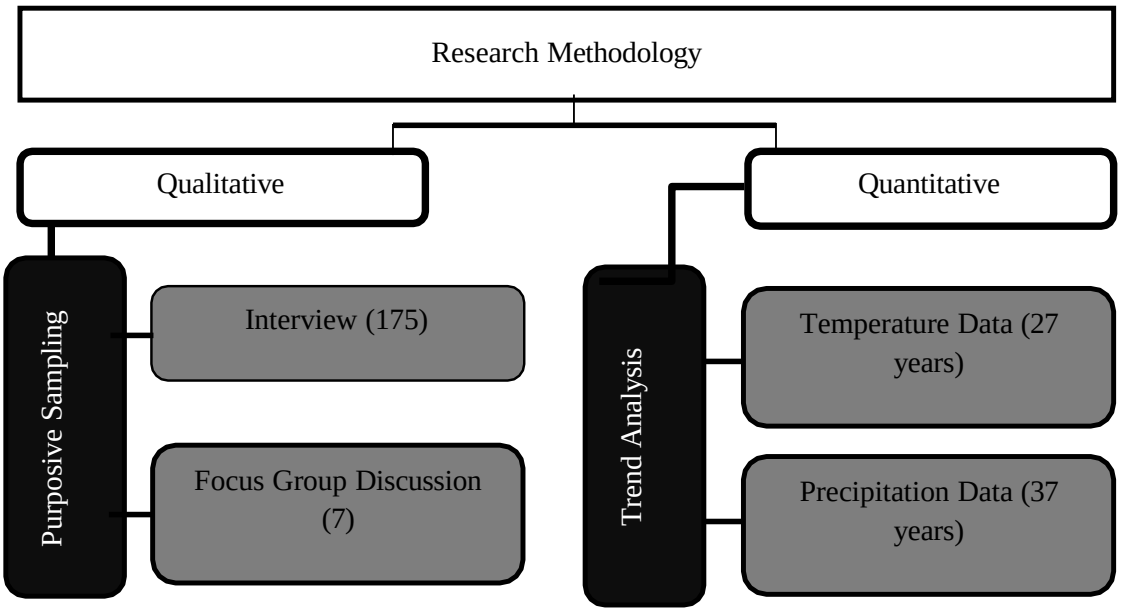


Figure 2: Methodological flow chart

Results and Discussion

Precipitation and Temperature change pattern analysis

The detailed analysis over a period of 37 years (1981-2017) reports that average annual precipitation is decreasing (Figure 3). The trend analysis showed a decrease in the

average annual precipitation significantly over 37 years period with 6.2392 mm.

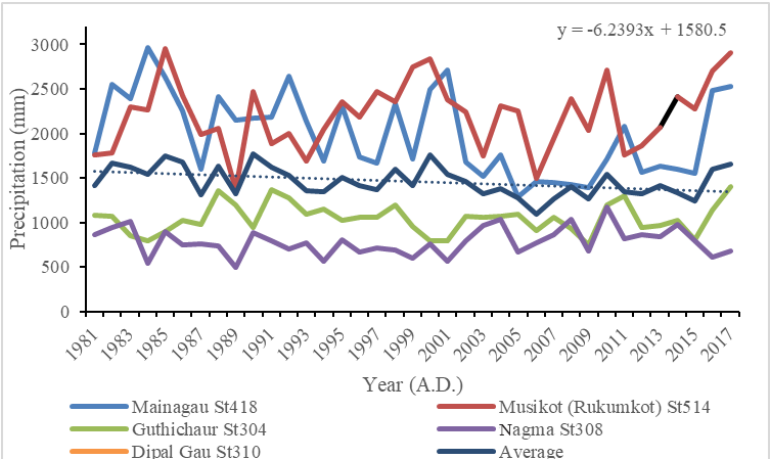


Figure 3: Precipitation trend analysis for five nearest stations to the study area from 1981-2017

The detailed analysis over a period of 27 years (1990-2016) reports that maximum and mean temperatures are decreasing. The trend analysis showed a decrease in the minimum, average and maximum temperature over 27 years period with 0.0332^0C, 0.0545^0C, and 0.0147^0C respectively.

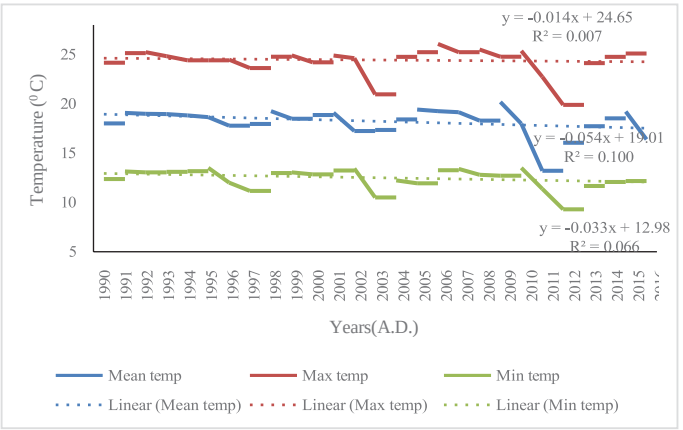


Figure 4: Temperature trend analysis for nearest station to the study area from 1990-2017

Perceived impacts of climate change

The impact of climate change on transhumant pastoralism and red panda habitat was reported by interviewees in different ways. The chi-squared test showed that there is no significant difference in the perception of transhumant herders on climate change based on gender (Table 1). According to 76.44% of respondents (57.47% Male and 18.97% Female), summer temperature is increasing and others 23.56% responded as no change. Whereas, according to 55.17% (42.53% Male and 12.64% Female), winter temperature is decreasing and remaining 28.16% responded as no change and few 5.75% as increasing. The total amount of annual rainfall, winter rainfall and monsoon rainfall are decreasing according to 60.92%, 76.44%and 62.07%respondents respectively. The total number of snowing days and the total amount of annual snowfall is also decreasing according to 97.7% and 87.35% of respondents respectively (Figure 5). This showed both male and

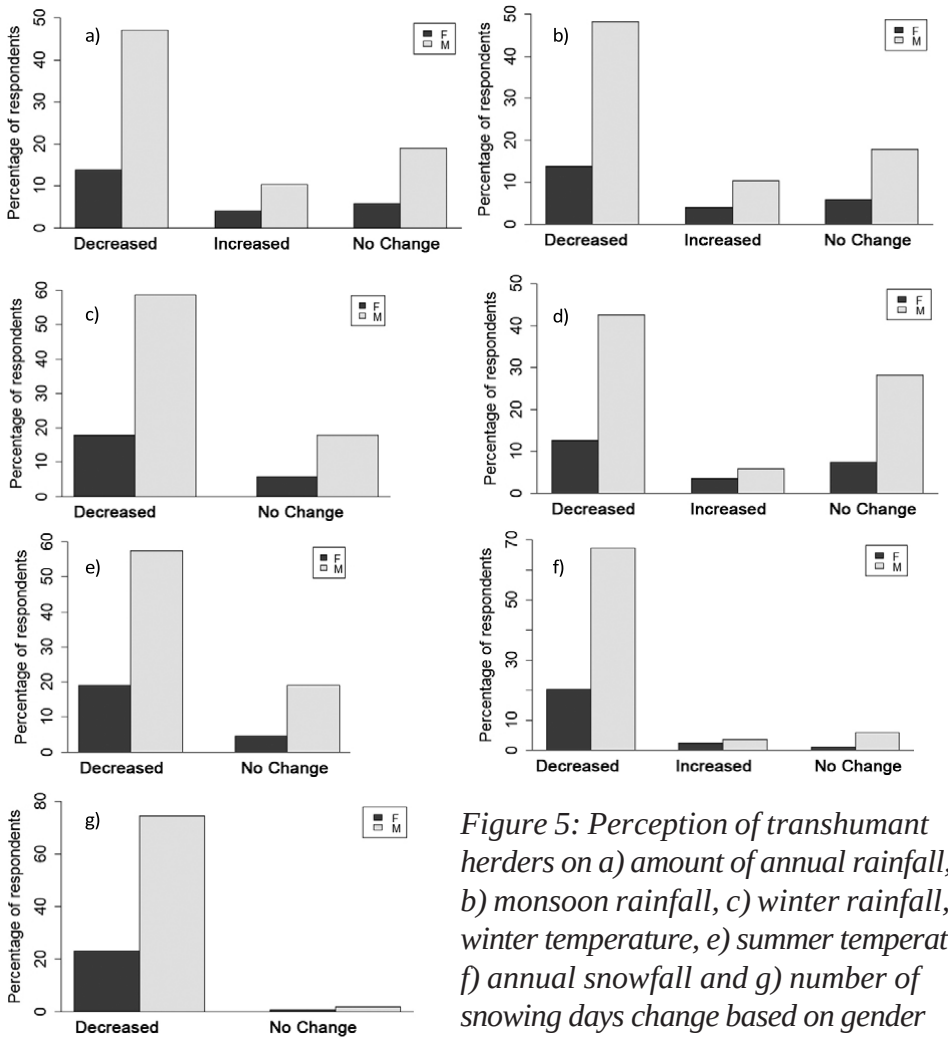
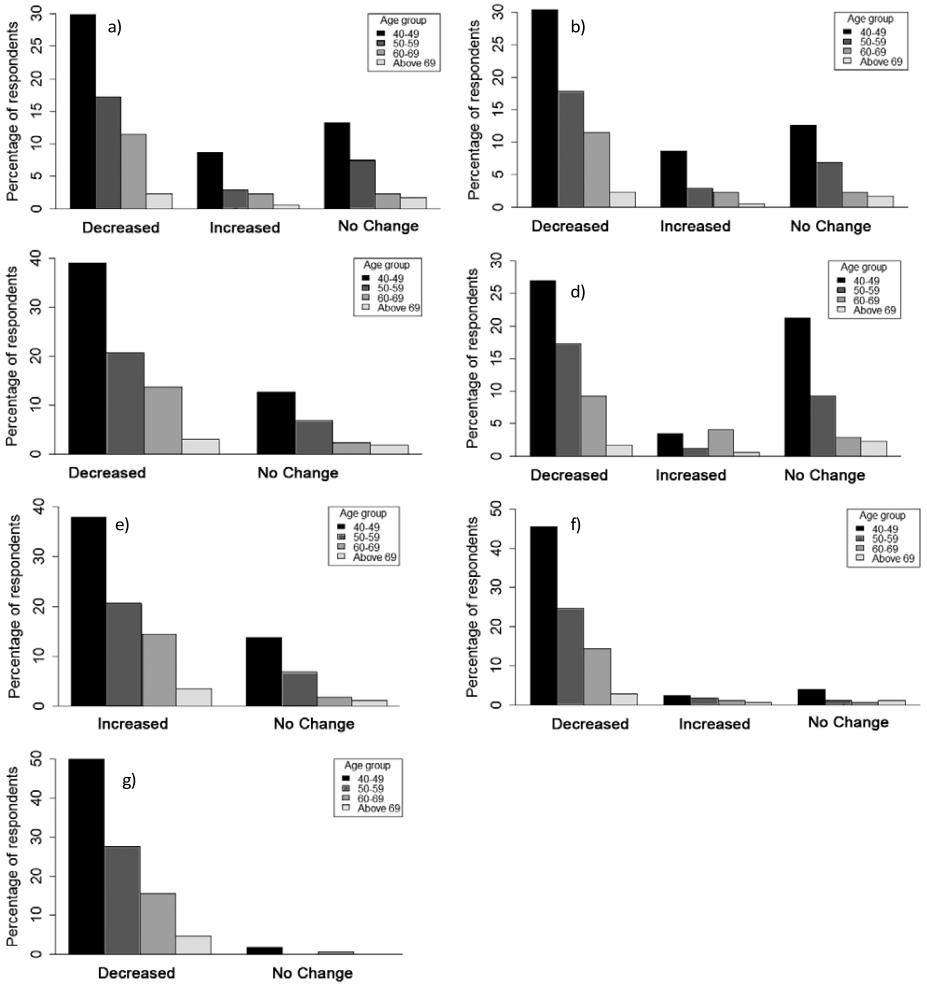


Figure 5: Perception of transhumant herders on a) amount of annual rainfall, b) monsoon rainfall, c) winter rainfall, d) winter temperature, e) summer temperature, f) annual snowfall and g) number of snowing days change based on gender

female perceive summer temperature is increasing whereas winter temperature, annual rainfall, winter rainfall, monsoon rainfall, number of snowing days and annual snowfall are decreasing in red panda habitat.

There is also no significant difference in the perception of transhumant herders on climate change variables based on age group (Table 1). According to 37.93%, 20.69%, 14.37% and 3.45% respondents of age group 40-49, 50-59, 60-69 and above 69 respectively, summer temperature is increasing. Maximum respondents of age group 40-49 (27.01%) and only fewer respondents of age group above 69 (1.72%) responded decrease in winter temperature. Maximum percentage of the respondents of age group 40-49 perceived total annual rainfall, winter rainfall and monsoon rainfall are decreasing. The total number of snowing days and the total amount of annual snowfall is also decreasing according to all age groups (Figure 6).



The chi-squared test showed that the perception of transhumant herders on the total amount of annual rainfall change and the total amount of monsoon rainfall change is significantly different with ($\chi^2 = 20.22$, $p < 0.01$) and ($\chi^2 = 20.33$, $p < 0.01$) respectively based on education. All the respondents having bachelor level of education responded increase in the total amount of annual rainfall and the total amount of monsoon rainfall but the maximum respondent perceived decrease in it. Perception on all other variables of climate change is not significantly different based on education level. Maximum percentage of respondent 76.43% perceived increase in summer temperature (Bachelor: 2.87%, Illiterate: 22.41%, Literate: 17.82%, Primary: 20.11% and Secondary: 13.22%) and 56.16% (Bachelor: 0.57%, Illiterate: 16.09%, Literate: 15.52%, Primary: 12.64% and Secondary: 10.34%) perceived decrease in winter temperature based on education level. Total number of snowing days and total amount of annual snowfall is also decreasing according to 97.7% (Bachelor:2.87%, Illiterate: 28.16%, Literate: 21.84%, Primary: 25.86% and Secondary: 18.97%) and 87.35% (Bachelor: 2.87%, Illiterate: 25.29%, Literate: 20.11%, Primary: 22.41% and Secondary: 16.67%) of the respondents respectively (Figure 7).

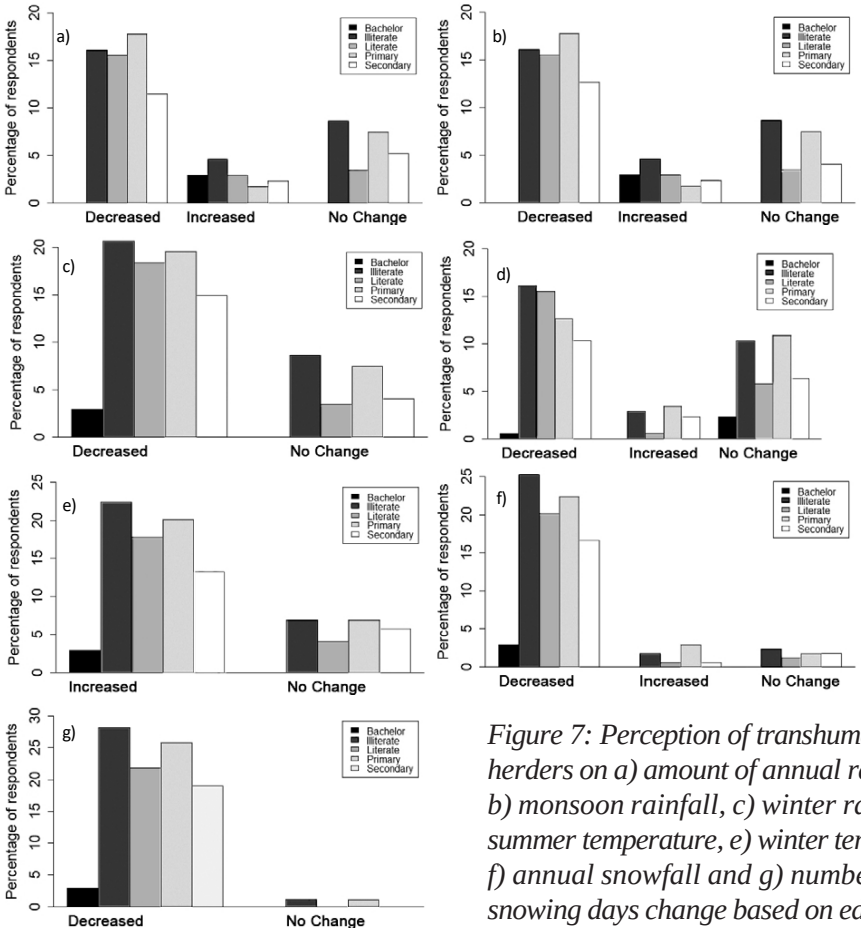


Figure 7: Perception of transhumant herders on a) amount of annual rainfall, b) monsoon rainfall, c) winter rainfall, d) summer temperature, e) winter temperature, f) annual snowfall and g) number of snowing days change based on education

The Chi-square test showed that there is a significant difference in the perception of transhumant herders on change in winter temperature based on duration of time spend in corrals with (χ^2 = 13.07, p = 0.01) (Table 1). The 55.18% of the respondents who spend (1-4 years: 10.92%, 4-8: 28.74%, above 8: 15.52%) perceived a decrease in winter temperature while the other 9.19% perceived an increase, and 35.64% perceived no change. Perception on all other variables of climate change is not significantly different (Table 1).

Table 1:Chi-squared test on the perception of transhumant herders on variables of climate change (Significant values are shown in bold).

Perception of transhumant herders on climate change	**Based on gender (df = 1 and 2)**		**Based on age group (df = 3 and 6)**		**Based on education (df = 4 and 8)**		**Based on duration spend in corrals (df = 2 and 4)**	
Change in	χ^2	**p-value**	χ^2	**p-value**	χ^2	**p-value**	χ^2	**p-value**
Summer temperature	0.06	0.80	1.79	0.62	1.74	0.78	4.39	0.11
Winter temperature	1.14	0.57	8.34	0.21	6.16	0.63	**13.07**	**0.01**
Total amount of annual rainfall	0.19	0.91	2.07	0.91	**20.22**	**< 0.01**	9.15	0.05
Total amount of winter rainfall	0.00	1	1.32	0.72	2.49	0.65	1.97	0.37
Total amount of monsoon rainfall	0.23	0.89	1.96	0.92	**20.33**	**< 0.01**	6.84	0.14
Total number of snowing days	0.00	1	1.12	0.77	1.83	0.77	3.65	0.16
Total amount of annual snowfall	1.06	0.59	3.73	0.71	2.54	0.96	3.70	0.45

All herder interviewees reported that in recent years the snowfall pattern had been erratic. The amount of snow was decreasing, and the accumulated snow was melting earlier than in the past with its repercussion effect of drying of streams earlier. The herders observed the decrease in the thickness of snow in many Kharkas (pasturelands), scarcity of water in traditional water sources such as streams and ponds along the livestock migration routes within red panda habitats.

As described by one of the leading herders in the Barekot region:

In the past red pandas' habitats used to be less disturbed because we used to graze our livestock many days in a single Kharka, now we have to move to many Kharkas and our herds reach every good habitat of the red panda to find nutritious grasses. Due to the scarcity of water, we have to change our travel route and locations of overnight camps these days, so does red panda change and its activity concentrate close to these limited water resources.

One of the respondents in the Kuse region reported that the forests and pasture invasion by non-palatable invasive weed as a climate-driven effect related to increasing temperature and the suppression of regeneration of undergrowth vegetation in the forests and pasture lands induced by erratic rainfall pattern with an impact on livestock grazing. As reported by herder respondents:

All the farmlands, forests and pasture lands are now covered by Banmara *(Eupatorium sp., a non-palatable invasive weed),* Nilo gandhejhar *(Ageratum sp., an invasive weed).* These non-palatable invasive weeds suppress the regeneration of undergrowth vegetation in the forests and pasture lands causing a decline in other palatable grasses from Kharkas. So, we don't have enough grasses now.

Another interviewee from the Nalagad region described the increase in livestock diseases and the use of medicines against livestock diseases in recent years in their view to the changing climate. As reported by a herder interviewee:

These days our cattle started suffering from Namle (foot-and-mouth disease) which has become quite common, a disease we had never experienced before. Now we have experienced many livestock deaths in our Kharkas due to this disease. In the winter many goats and sheep are dying due to pneumonia. We mostly live far from the service centers and don't get any veterinary support in these Kharkas.

The transhumance system is a means of livelihood, adaptive strategy as well as a matter of indigenous practice and cultural significance.However, due to the impacts of socioeconomic and environmental changes, the practice is gradually declining towards extinction in the mountains of Nepal (Gentle &Thwaites, 2016). A similar trend has been reported from the study area.

The majority of the transhumant herders have observed the early onset of the summer season, rapid melting of snow, early induce in greenery, and early flowering/maturing of vegetation and appearance of new plant species in the red panda habitat. Species Distribution Modelillustrated that the red pandahad a strong responseto precipitation-associated bioclimatic variables in the Himalayas, particularly annual precipitation, precipitation in the coldest quarter, precipitation seasonality, and precipitation in the driest month (Thapa et al., 2018). But in this study erratic snowfall, a decrease in the amount of snow, and early melting of accumulated snow than in the past have been reported hence could influence red panda distribution in the future.

The temperature and precipitation largely predict habitat suitability at a landscape level and are key components in shaping the vegetation composition of the red panda habitat (Thapa et al., 2018). Most of the herders in this study perceived summer temperature

is increasing whereas winter temperature, annual rainfall, winter rainfall, monsoon rainfall, the number of snowing days, and annual snowfall are decreasing in red panda habitat. Climate-associated variables provide basic information on suitable habitat for the species and are considered the most important determinant of species occurrence (Pearson & Dawson, 2003). High precipitation implies increased cloud cover, leading to a significant reduction in soil temperature, reduced radiation input and high cloud albedo (Takahashi et al., 2005) resulting in delayed soil warming in spring, reduced tree growth, and slow understory regeneration. Temperature and precipitation have a great influence over the growth rates of bamboo understories (Rao et al., 1991), a dietary staple for red pandas (Zhang et al., 2009; Pradhan et al., 2001; Wei et al., 1999; and Yonzon,1989). Hence, the changes in climatic variables like temperature and precipitation in rangelands could haveadverse effects like alteration of competition between plants and their growth habits, plant-animal interaction, productivity (IPCC, 2014). The drying of water resources can lead to the abandonment of rangelands which in turn can lead to grazing pressure in other rangelands (Aryal, 2015) and similar observations have been made in this study too.

As they directly depend upon nature and natural resources,the transhumance herders across the mountainsare disproportionately more vulnerable due to climate change (Aryal et al., 2014; Dong, 2011) and the situation could be even more severe when the flexibility of herders is restricted (Fu et al., 2012), so do thosefrom Jajarkot. The drying of water resources, increase in drought, and appearance of new livestock diseases were also perceived by transhumant herders. These observations are in line with the findings of previous scholars (Shrestha et al., 2012; Lama &Devkota, 2009; Xu et al., 2009; Aryal et al., 2014; Gentle&Thwaites, 2016) who have reported advancing growing season and change in the phenology of the vegetation in the Himalayas. Aryal (2015) indicated drying of water resources in the rangeland and the results of the Kuse also correspond to them. There were a very less proportion of herders who agreed that grassland zones are shifting. This particular observation of herders is not in line with another study (Gaire et al., 2014) that report a shift of range for many plant species, tree line and vegetation belt. A slow and gradual process of vegetation shift may be responsible for the differential response of herders.

Loss of native species in the pasture-induced gradual degradation in vegetation has been reported which is in line with Parajuli et al., (2013). There was a large proportion of respondents who agreed that non-native and unpalatable invasive alien species have appeared in the red panda habitats. The appearances of those species indicate the poor quality of rangelands and ultimately affect livestock production in the study area. Invasive alien species disrupt the ecology of the natural ecosystem, displace the native plant and animal species as well as degrade the landscapes unique and diverse biological

resources (Tiwari et al., 2005). The increase of such unwanted species can be related to an increase in temperature and associated range shift (Gaire et al., 2014) or an increase in drought, cessation of fire and range abandonment (Brandt et al., 2013). In the study site, it has been reported that livestock are more susceptible to increasing incidences of diseases like foot and mouth diseases and pneumonia. This increase in the incidence of diseases causing vectors may be related to change in climatic variables which largely determine their population dynamics and distribution range (Gage et al., 2008; Aryal, 2015).

Conclusion

Observations of transhumance herders' perceptions on climatic variables in red panda habitats of Jajarkot can complement modern conservation sciences, offer some clues about climate change, and associated livelihoods to reduce vulnerability to its impact by building adaptive capacity and resilience; and facilitate the integration of climate change and coherently, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.Concomitantly, the herding, a relatively secured livelihoods strategy of people residing nearby red panda habitats, hasbeen threatened with several socio-cultural, economic and ecological consequences. Hence, these sorts of research avenues can act as an important filter to inform government and other relevant actors to offer appropriate policy and programmatic support, strategic decisions for three core interwoven components: biodiversity conservation, sustainable landscapes and livelihood policies.

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