HIGH ALTITUDE RANGELANDS INVASION BY NON-PALATABLE PLANT SPECIES IN THE PERCEPTION OF YAK HERDERS

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ABSTRACT

The biological and socio-ecological dimensions of alpine rangelands degradation by invasive species have been considered in a field survey conducted in two yaks (Bos grunniens) rearing areas i.e., Langtang National Park (LNP) and Kanchanjunga Conservation Area (KCA). Data were collected by herder's interview using the well-prepared and pretested set of questionnaires (60), followed by a focus group discussion (FGD) and key informants survey (KIS) each five at each site by following a set of checklists. There was a common perception about the invasive species among the herders in the study sites. The Rumex nepalensis was the most invasive species reported (75% of the respondents) at altitudes up to 3000 m in the KCA, while it was additionally with Eupatorium adenophorum (60%) in the LNP, while the Lyonia and Juniperus were the common invasive species in both sites. Altogether, twelve plant species were reported as invasive and non-palatable species from various botanical groups were indifferent to the changes made by invasive species in rangelands soil characteristics but gave well insight into the declining productivity of grasslands and herbage productivity and quality. Herders established bush clearance and slash and burn agriculture in rangelands as traditional adaptation measures to control the invasive species. Mapping of risk zones of invasive and alien species in the alpine rangelands is necessary across the alpine rangelands of Nepal and a long-term monitoring framework is desirable to confirm the herder's information on invasive alpine species of Nepalese Himalayas.

Keywords: Adaptation, himalaya, invasive species, rangelands, yak

INTRODUCTION

The ecosystem provides several other alternative services (Dong *et al.*, 2007). Grazing is a major land-use system in the Hindu Kush Himalayan (HKH) region (Joshi *et al.*, 2013), as being vulnerable to a couple of natural and human-induced factors (Gentle and Thwaites, 2016). The rangelands in Nepal, are vulnerable to numerous anthropic stresses, together with over-grazing and over-exploitation of medicinal plants (Dong *et al.*, 2007). In addition, the looming impacts of climatic change in the subalpine and alpine regions of the Himalayas are omnipresent (Sharma and Tsering 2009), in conjunction with several notable issues at the ecosystems level (Gilani *et al.*,2017).

The climatic change would adversely impact the ecosystems and their economic potential and ecological property (Aryal *et al.*, 2013). The grasslands are one of the

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open areas for the invasion of alien species (Siwakoti *et al*., 2016). The International Union of Conserve Nature IUCN has shown that there are over a hundred species that are probably to be shifted because of global climate change (Bellard *et al*., 2013). Invasive plant species have the potential to considerably alter the ecosystem composition and functioning, drive native fauna to extinction (Hobbs, 2001), and the invasive plant species appear more dependent and influenced by anthropic disturbances (Bhattarai *et al*.,2014).

The invasive plant species richness has been reported correlated with phylogenesis factors (Acharya and Baral, 2017). Climate amendment threatens to shift vegetation, disrupting ecosystems and damaging human well-being. However, there is a scarcity of native abstraction information on vulnerability that hinders the management of natural resources like alpine rangelands from characteristic priority areas for adaptation measures to invasion. Nepal is a country ranked among the most vulnerable countries to biological invasions and climate change in the world (Shrestha *et al*., 2019). The invasive plant species richness has been reported correlated with the anthropogenic factors (Acharya and Baral, 2017). There is a scarcity of native information on the management of natural resources like alpine rangelands in terms of invasion by non-preferable plant species. This study assumes the hypothesis that invasion is naturalized and coupled with livestock-induced vegetation shift due to high altitudes from the lower altitude over time in the Himalayan alpines.

METHODOLOGY

SITE SELECTION

Olang Chung Gola (Sherpa dominated) at the Kanchanjunga Conservation Area (KCA) of Taplejung district and the Gatlang (Tamang dominated) at Langtang National Park (LNP) of the Rasuwa of Nepal were purposively chosen for the study (Figure 1). The chosen sites have drawn the cultural diversities (Tamang communities in Gatlang (2500-3500 m) and Sherpas in the Kanchanjunga region(3000-4200) and variety in holding the domestic ungulates (i.e., yak, different yak & cattle hybrids, sheep and goats) rearing areas. The chosen sites were the model landscapes for different species of domestic animal holding and management systems i.e., transhumance where the livelihood of the herders is still predominant.

DATA COLLECTION

Data were collected through each primary and secondary literature survey. Within the literature survey, an in-depth review of the relevant journals was done in connection to the subject. A brief set of semi-structured forms was developed and pretested within the Langtang region. The set of the form consisted of the ecological aspects of the invasion in a very semi-structured format (60 households). The checklists additionally consisted of the herder's ancient observed ecological knowledge on the native and invasive and non-palatable species and their rankings. The respondents were asked to produce a worth from 0-100 score from low to high rank. The checklists were separately developed for FGD (5 at each site) and the KIS (5 at each site) respectively.

Later in the FGD the 'sample display' methodology was followed. The locally available plant species (35) were shown to the normal herders and any incidents within the last 10 years within the goat and sheep, yaks, yak×cattle (*Urang Chauries*) and cattle×Yak (*Dimjo Chauries*) herds.

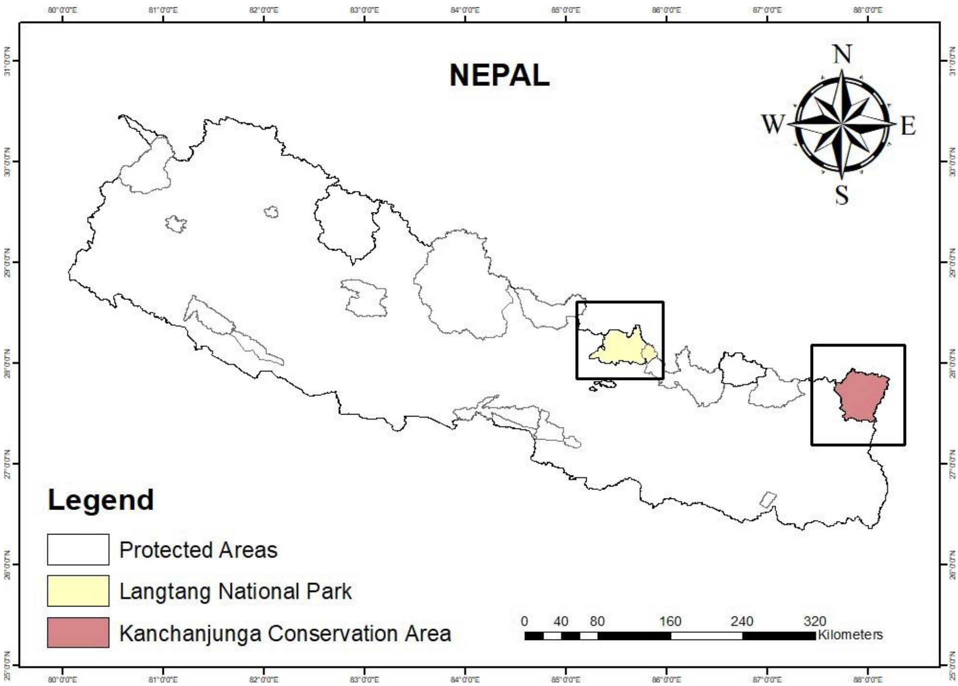

Figure 1. Map of Nepal showing two Protected Areas and the survey sites of the study namely Langtang National Park (LNP) and Kanchanjunga Conservation Area (KCA)

Later a transect walk was followed to grasp the sites of toxic plants, incidents while grazing etc. that range from 2500 m to 4800 m.asl. Later all information was verified through the key informant's interview at each site. A short questionnaires survey and checklists were used to collect the primary information that consisted of the information in three broad categories i.e., the pastoralism in the community, the herder's observations on alien species and their invasion potential of the native grasslands respectively.

Plant specimens were selected based on the observation of the native herders as the key informants. The specimen was collected and identified later with the required literature from the Fodder and Pasture Division of Nepal Agriculture Research Council (NARC), Khumaltar Nepal. The traditional healers in the Tamang communities and Sherpas *Amchis* (Tibetan traditional medicine practice) local healers (that include priests locally known as *Lamas*[i]), plant traders, and experienced and old people (including herders) were selected as the respondents and two focus group discussion were conducted at each site. Permission for the interview was obtained verbally from every variety of respondents before the interview.

DATA ANALYSIS

The data were visualized thorough summary of the herders' responses and a chi-square test for the ecological aspects of invasion. The invasive non-palatable (un-grazed) species were shown in rank based on the herders' response to the grading (0-100) in the table.

RESULTS AND DISCUSSIONS

LIVESTOCK GRAZING SYSTEM

The herders within the survey sites managed the yaks and chauries (Urang and Dimjo chauries) and the majority of sheep within the transhumance followed by sedentary grazing (sheep and goat) and there have been nominal cases of the stall feeding (cattle) in the lower basins at each site. Later, it was found that both small and large ruminant domestic ungulates were the detrimental species for the native pasture species, whilst the invasive species were typically rumoured to be astringent for grazing species. Herders additionally responded to a declining trend of the native pasture species, and there have been hardly any animals grazing on the invasive forbs because of their astringent character (Table 1).

The invasive species were reported by the respondents as extremely prolific and propagated each by seed and also the vegetative propagules, such fact has been reported also by Cantero *et al* (2003) with lower palatability and smaller proportion of zoochory. Moreover, these species were adapted to dynamical ecological situations i.e., low and high light intensities. The native species were found responsive to a selected style of soil fertility however the invasive species were adapted to any soil fertility status. The grazing patches shaped throughout grazing were the first sites of invasion (Table 1).

The herders additionally responded to the high grazing pressure in the rangelands and grazing had induced the multiplication and site colonization might be attributed to the animal movement during transhumance along the altitudinal gradient. In the herders' experience, the native species' grasses and sedges were more accompanied by coarseness than the invasive species, whilst the invasive species were thorny (e.g., *Berberis*) as shown in table 1.

The invasive species had been distinguished with a higher potential to migrate to elevations in comparison to the native species in the rangelands (Table 1, 2). The species richness was low in invasive species dominant patches, while it was found lower in the native grassland patches. Further, the invasive species were found to encroach even the water bodies (lakes) within the study area (mainly in the Langtang region) by *Acorus calamus*. The invasive species were further pointed out with higher potentiality to adapt to the climate and weather changes being due to poisonous or toxic plants (Table 2,3).

The indigenous knowledge is considered a base of the current knowledge system of herding communities that have evolved over generations (Berkes *et al*., 2000), and maintains approaches to land use that are appropriate to the varied biophysical conditions, and ethnical diversity that characterizes Nepal's mountain livelihood. The indigenous knowledge has additionally been employed in the management of natural resources (Schmink *et al*., 1992). Sustainable management of rangeland ecosystems has direct implications for the conservation of biological diversity and the livelihoods of local communities in general (Bhattarai and Upadhyay, 2013). The mechanisms that regulate operations would contribute to our knowledge of complex coupled human-natural systems (Dong *et al*., 2012), and the utmost of such knowledge is developed from the peoples' indigenous knowledge.

The farmers and herders in the Nepalese Himalayan landscape were already aware of many varieties of noxious flora and the traditional knowledge made an important contribution to ethnomedicine, and there is diversity in the use of plants as ethnomedicine across the landscape by ethnic groups (Bhattarai *et al*., 2006) with different medicinal properties (Taylor *et al*., 1996; Pokharel *et al*., 2008). To the knowledge of the author, this is the first report that the invasion exists in the Himalayan alpines of Nepal that integrates the herder's indigenous observation. In the former studies, it's been mentioned that the invasive species has been expected to shift towards high alpines in the years to come. Still, in the present study, it had been found that the herders had the traditional ecological knowledge on the invasion of the rangelands and there were already some non-palatable plant species naturalized in the alpine areas.

Table1. Summary of the herder's response to the native and invasive species and their habit in the rangelands of the Kanchanjunga (Olangchung Gola) and the Langtang region (Gatlang) of Nepal (data obtained by FGD and KIS).

Subsets	Grazable native species	Invasive species
Invasive vs native species	Naturalized and local	Species shifted from a lower altitude, naturalized shrubs,
Detrimental grazing animal species	Yaks and chauries, sheep	Animals do not graze on invasives
Changes in herbage composition	slow	rapid
Dominant species	native species are lost many	Increasing trend
Regeneration	Low and slow regeneration in native species	Highly prolific
Sensitivity to light stress	Adapted to a specific altitude and especially	Adapted to both low and high light intensities
Response to soil fertility	1 adapted to a particular kind of soil fertility	Adapted to any kind of soil even to the water bodies
Colonization	Natural distribution	Colonized within a few couples of years.
Grazing effect	Resistant to grazing, poor biomass	Grazing induced the propagation and seed
Growth and development	Fibrous stems (grasses), short stature with more	Glossy and watery stems in many herbs (forbs), thorny
Compatibility with native species	compatible but less aggressive	Compatible highly aggressive to dung
Odour and flavour	odour adapted by animals	The astringent flavours is not adapted by animals at
Soil properties	indifferent	indifferent

Source: Field survey, 2020.

Table 2. Invasion potential of the alien and invasive species in the high-altitude rangelands of the KCA and LNP (summary information gathered from FGD and KIS).

Assumptions	KCA	LNP
High altitude shift	Potential	Highly potential
Species composition	decreasing	Increasing and colonized
Animal poisoning	Adapted or tolerant/ resisted by domestic and wild	Sometimes lethal to domestic animals.
Invasion to special niche	Land invasion mostly	Invasion of land and water
Adaptation potential	Grazing intensity and species driven	Potential for high adaptation and naturalization

Source: Field survey, 2020.

It is an assumption that the cases of plant poisoning are much in the grassland-based systems presently where overstocking is predominant, and Nepal is already facing the problem of overstocking as seed dispersal could be expected more due to overstocking.In the present study, the majority of the respondents were confident about the positive effect of grazing on the invasion of grazing lands. The grazing animals act as the transporting agents (Belsky and Gelbard, 2000) to seeds of alien species by both endo- and epi-zoochory, trampling, and feeding and, the survival of invasive species is favoured by grazing avoidance (Vavra *et al*., 2007). The changes in vegetation distribution that are altered by grazing may be a major reason for invasive species encroachment.

The patchiness in the rangelands can be considered as an example altered by the grazing. The habitat patchiness provides the space for the expansion of the invasive alien species (e.g., Harrison *et al*., 2001). Temperate humid grasslands are known to be notably vulnerable to invasion by invasive plant species once when grazed by the domestic livestock (Hayes and Holl, 2003) Furthermore, Nepal's alpine rangelands are reported to be already overgrazed (Banjade and Paudel, 2008)) and facing socio-economic crises (Gentle and Thwaites, 2016; (Bhusal, *et al*., 2018).

The herders positively responded to the effect of grazing pressure increased the invasion of alien and non-preferable species in the alpine rangelands. As grazing pressure increases, perennial grasses declines, while the relative proportion of forbs and annual grasses increases (McIntyre and Lavorel, 2001). In a continuously grazed and degraded pasture such vegetation trend has also been reported (Barsila, 2019). It is found that grazing promoted exotic plant invasions, and was confidently responded to by the herders in the present study, which might have elicited the functional heterogeneity of vegetation at the landscape scale (Chaneton *et al*., 2002).

Herders responded to a high prolific behaviour of the invasive species in the present study, although, the trait-specific characteristics were difficult to identify in alarger scale in the survey. The scientific evidence suggests the traits specific biotic interactions became the foremost vital drivers of success or failure of the growth and development (Kempel *et al.*, 2013), and generally, the alien species can propagate even in neglected and abandoned lands (Csontos *et al.*, 2009) that has been well ascertained by the herders over time in the present study sites. The prolific amount of growth and reproduction in invasive plants as perceived by the herders is also achieved by greater net photosynthesis and/or resource-use efficiency (McDowell, 2002 & Ordonez and Olff, 2013), even at a higher level of disturbance (Pattison *et al.*, 1998). The disturbance in the study sites has been created due to overgrazing or grazing elicited soil loss or erosion. In woody species, there is a tendency to adapt to the low light irradiance (Sanford, *et al.*, 2003), such tendency is foreseen for the woody species such as *Eupatorium, Juniperus, Rhododendron, Berberis* etc. that were pointed out by the herders in the present study.

The astringency and thorns attributed by the invasive species might be a natural strategy for survival or grazing avoidance in the native species-dominated areas. These characteristics of such species have been perceived over time by the herders in the present study. An experiment in Hawaii conjointly proves that the greater odour emission capacity could confer protection against multiple stresses and may partly account for the success of the invasive species, will but invasive species additional competitive in response to new global change-driven combined stresses (Llusià *et al.*, 2010). The different odour and flavour reported by respondents in the invasive species might be the grazing avoidance mechanism. Furthermore, the alien species had a higher efficiency in water transport (i.e., higher minimum leaf water potential and lower wood density values) and faster resource acquisition and use (higher specific leaf area values) than the native species (Zeballos *et al.*, 2014) as compared to native species. There is a strong tendency for invasive species to possess larger stomata conductance than native species (Cavaleri and Sack, 2010). However, all the scientific mechanisms related to ecological invasion could not be dealt with poorly educated herders but could be dealt with in a better way in future biological studies.

ECOLOGICAL ASPECTS OF INVASION

In herders view, the *Rumex nepalensis* and the *Eupatorium adenophorum*, followed by the *Lyonia* and *Juniperus* respectively were the most invasive species in the rangelands.We did not find the problem of invasion of water bodies in KCA while it was reported threatened by *Acorus* in the Gatlang area of the LNP.

The livestock death rates were about 2-5% across the study sites and *Urang* and *Dimjo chauries* were more in the KCA and sheep in the LNP respectively. The distinction in invasive species was additionally imperative to the altitude in the survey sites because it was up to higher altitudes in Kanchanjunga 3000-4000 m) than the Langtang region (2500- 3000 m) on an average. The herders were indifferent to the changes created by invasive species within the grazing land's soil properties.

In question to climatic change, the shift of native vegetation to higher altitudes was also responded well by the herders. The high-altitude shift of *Berberis* and *Rhododendron* in the Kanchenjunga and the *Juniperus* and Rhododendron *sp.* in Langtang was reported as the key species of indicator of climate change. The bush clearance and slash and burn agriculture practices were the predominant measures of bush management in the survey sites (Table 4 &5).

Table 3. Summary of the herder’s response about the most detrimental invasive species in the high-altitude shift in the Kanchanjunga and the Langtang area of Nepal.

Attrubutes	KCA	LNP	Total	x^2 test			
	N=30	N=30	N=30	CC	Pearson x^2	LR	p-value
Rumex nepalensis	25(83.3)	20(66.7)	45 (75)	1.42	2.22	2.56	0.136
Eupatorium adenophorum	14(46.7)	26(86.7)	40 (66.7)	9.08	10.80	11.37	<0.01
Lyonia ovalifolium	21		21				
L. ovalifolium+ Juniperus recurva		21	21				
Livestock death	1.89(0.39)	5.3(0.89)	3.63 (1.78)				<0.001

*Values in parentheses indicated percentage. For livestock death rate values in parentheses indicate the standard deviation, CC represents Contingency Coefficient, LR represented the Likelihood Ratio. (*Source: Field Survey, 2020).

The common sensitive domestic ungulates due to climate change was responded to yaks and chauries, mountain goats and sheep respectively. The household holding of yak and chauries was bout 30-45 within the surveyed households. The goats (average 10 holdings) at low altitudes were recorded across the survey sites and sheep were mostly recorded in Langtang (27 holdings per household) as compared to KCA (5 holdings) respectively (Table 4).

Table 4. Herders' response to climate change sensitivity in livestock production and indigenous management of invasive species.

Attributes	KCA(N=30)	LNP(N=30)
Most sensitive livestock category		
Yaks and chauries	×	×
Goats	×	×
Sheep	× (10)	× (27)
Cattle	× (5)	× (7)
Most sensitive pasture sites	3000-4000 m	2500-3000 m
Management of invasive species		
Low altitude (<2000 m)	Bush clearance, slash and burn agriculture.	Partial firing
High altitude (2000-5000m)	Partial bush clearance	Partial bush clearance

× *indicated 99% positive response.*
Source: Field Survey, 2020.

HERDERS RANKING OF INVASIVE AND NON-PREFERABLE SPECIES

The ranking of the invasive and non-preferable species for grazing has been shown in Table 5, the species pointed out by the residents were site and altitude specific per the herder's ancient ecological knowledge. The species that were reported to be ubiquitous at both sites were *Rumex nepalensis*, *Lyonia ovalifolia*, *Rhododendron sp.* and *Ageratum sp.* respectively (Table 5).

Table 5. Ranking of major invasive species and their botanical groups in the survey sites and their availability at different elevations

Rank	species	Botanical groups	propagation	site	Altitude (m)
1	*Rumex nepalensis*	herb	seed	Both	2000-4000
2	*Eupatorium adenophorum*	herb	seed	LNP	2000-3000
3	*Lyonia ovalifolia*	shrub	seed	Both	2000-3500
4	*Juniperus sp.*	shrub	stolon	Both	3000-4000
5	*Berberis sp.*	shrub	seed	KCA	2500-3500
6	*Aconitum spicatum*	herb	stolon	Langtang	3000-4500
7	*Rhododendron sp.*	shrub	seed	Both	2000-4000

Rank	species	Botanical groups	propagation	site	Altitude (m)
8	*Ranunculus sp.*	herb	seed	KCA	2000-4000
9	*Alnus nepalensis*	tree	seed	KCA	1500-3000
10	*Acorus calamus*	herb	stolon	LNP	2000-3000
11	*Ageratum sp.*	herb	seed	Both	1500-2500
12	*Pterydium sp.*	fern	Seed, stolon	KCA	1500-2500

Source: Field survey, 2020.

The herders' response to vegetation change can be appreciated as indigenous knowledge well linked to scientific knowledge in the present study. There is a change in vegetation composition than the species richness in some areas (Vilà and Gimeno, 2007). In an exceedingly grazed rangelands in KCA, forbs were in the highest proportion followed by grasses and sedges (Barshila and Devkota, 2013). The changes in species composition are probable due to an increase in soil nitrogen (N) favoured by the invasive species (Vilà *et al.*, 2011). However, the amount of dung deposition was unknown in this regard.

Alien non-preferable and invasive plants are capable of modifying ecosystem functions (Gioria *et al.*, 2014), and this has been well reflected by the herders' response in the present survey. However, it is always not much justifiable to generalize the herder's response and literature findings, because impacts often appear to be both species- and site-specific (Scharfy *et al.*, 2009), or sometimes the impacts are heterogeneous and not unidirectional ((Vilà *et al.*, 2011). For example, the *Impatiens balfourii* in Europe brought from the Himalayas is believed to adapt to the high light intensities (Schmitz and Dericks, 2010) than in the Himalayas. Though not much clear in the present study it could be speculated that changes in soil properties are one of the strategies of invasive and alien species for adaption in addition to the herder's common perceptions. The invasive species alter the soil properties and affect ecosystem structure and biogeochemical cycles (Raizada *et al.*, 2008). There is a decrease in pH and increase of soil N in the invaded soil (Dassonville *et al.*, 2008) and a negative correlation exists between soil Ca-Mg content (Cantero *et al.*, 2003). Thus, the density of the invasive species (Truscott *et al.*, 2008) may decrease the dominance of native annual species and might induce the risks of fire (Brooks, 2003) possible due to higher above-ground biomass as compared to naturalized species. Such ecological information in the herders has been realized developed and undergone over generations as expected. However, the herders' educational status might have played the role in the perception of soil-related parameters. The luxurious growth of invasive species and species colonization under shade and dark soil in the invaded area has been well noted as responded by the respondents.

Nepal is currently under threat of temperature change owing to its ununiformed ecological and climatic transitions (Bhattacharjee *et al.*, 2017). Climate change is a driving factor when human interference in creating an area appropriate for the easy establishment of invasive species (Thapa and Maharjan, 2014). Invasive and alien species (IAPS) become the second-worst trouble to biological diversity (Baral *et al.*, 2014). Due to changing climate, some species have been projected to shift towards 4000 m within 2070 AD in Nepal (Thapa *et al.*, 2018). However, the invasive species reported in the present survey by herders were already acclimatized in the Himalayan alpines.The invasive alien plants in the lower basins are likely to be moved to higher elevations and are likely to invade fresh areas (Shrestha *et al.*, 2018). Some alien species can acclimatize to the increasing temperatures (Song, 2017).In Nepal, because of ecological diversity, such calculations have to be done in future studies. The long-term studies are desirable to see the correlation between the livestock losses and the occurrence of alien and non-preferable herbage species in the common grazing resources.

Examples of such economic losses due to the invasion of alien plant species embrace the loss of biodiversity; lowering of population densities for a good kind of taxa; disruption of ecosystem functions, together with nutrient cycling and succession; modification in community organization; and alteration in the physical characteristics of each terrestrial and aquatic habitats (Fleischner, 1994). Globalization facilitates the unfolding of invasive alien plant species (IAS) as international commerce develops new trade routes, markets and products merchandise (Meyerson and Mooney, 2007). The study sites are the well-known trade routes with the Chinese Tibet and the cross-border migration of invasive species at high altitudes could also be expected, but lacks such a measurement in the present study.

It has been reported in kinds of literature that the alien species cause major environmental harm in the US. These species are the cause of losses and altogether with control costs in livestock and human about 120 billion US dollars and posed risks to endangered species (Pimentel *et al.*, 2005). In Africa, current annual economic losses are from US$ 0.9 to 1.1 billion; near future losses are US$ 1.0 to 1.2 billion (Pratt*et al.*, 2017). The total annual loss caused by non-preferable and invasive species to agriculture and human health in Southeast Asia was estimated to be US$ 33.5 billion (Nghiem *et al.*,2013).

The long-term studies are desirable to see the correlation between the livestock losses and the occurrence of alien and non-preferable herbage species in the common grazing resources.

CONCLUSIONS

Using herder's indigenous knowledge on the invasion it had been found that the present management of alpine rangelands is largely neglected by the herding communities and lacks the institutional capacity for supporting the herding communities. The findings can be used well for future planning purposes. As a result, the livelihoods of the transhumance pastoralists can be promoted to cope with the climate and other social-ecological vulnerabilities. The study findings would be a key to selecting the sites of best rangelands renovation, as revealed from the herder's indigenous knowledge that the site and altitude would be the valuable basis for assessing invasion in the Nepalese Himalaya where the pastoral livelihood is still predominant. The site and the altitude have to be considered in the monitoring tool. The ecological prices of this nearly omnipresent variety of land use will be dramatic and will prevail in several units of the ecosystem. The uncontrolled mass grazing often facilitates the invasions; thus, the reseeding and rotational deferred grazing as management tools can be urged to prevent the invasive species in the Himalayan alpines. It would further be helpful to support the emerging policies and management practices in the alpine rangelands to support the grazing rights of transhumance pastoralists. It could additionally be recommended to incorporate the management of invasive alien species as a standpoint in reviewing current protected areas management policies that the pasture has an impact on livestock grazing. Likewise, the priority of areas of the parklands and conservation areas got to be shifted from an environmentalist role to ecosystem management to prevent the encroachment of the invasive alien plants in the future.

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