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Farmers' perceptions of grassland management in Magui Khola basin of Madi Chitwan, Nepal

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Abstract

Management of grassland is one of the important factors in traditional livestock farming systems. A survey was conducted in Madi of Chitwan Nepal to understand the perceptions of the farmers/graziers about grassland and feed management. For that, a well-prepared pretested set of questionnaires was used to collect information related to feeds and grassland ecological knowledge of the farmers. The questionnaire consisted of a set of questions about the household, factors affecting grassland productivity and alternative feeding resources. The survey revealed variations in household livestock ownerships, mostly for cattle (1–3) and buffalo (1–5), whilst goat ownership was similar across the survey sites. Grazing duration in months was similar in the study sites (about 7 months per year). Likewise, there was no conflict for grazing livestock, whereas it is believed that goat and buffalo have the same level of detrimental effect on grassland. A significantly higher number of respondents reported that flooding had a negative impact ($p = 0.032$) on grassland productivity. The *Imperata cylindrica* (L.) P. Beauv. locally known as *Siru* was a dominant forage species followed by the mosaics of *Saccharum spontaneum* L. locally known as *Kaans* in Nepali and *Jhaksi* in Tharu language, *Saccharum bengalense* Retz. locally known as *Baruwa* in Nepali and *Narkat* in the Tharu language. The respondents also pointed out that at least 2 to 3 years were needed for the recovery of grasslands when hampered by flooding and riverbank cut-off. Similar species dominated in the recovered grasslands over time of flooding. The seasonal fodder plantation was a major area of grassland improvement issue across the survey sites. There were high dependencies of the graziers on natural herbages and crop residues for feeding livestock in summer and winter, though the herbage species and preferences remained different. This study provides the primary background of the biophysical factors of grassland management for sustainable uses that require institutional support. The study further provides an insight into the need for implementation of the demand-based grassland technology interventions, possibly at a higher rate of adoption than the current local scale. However, the social-ecological consequences of grassland systems, i.e. the impact of climate change, herd dynamics and nutrient flow in vegetation and soil, have to be monitored in a long run.

Keywords: Biophysical factors, Seasonal feedstuffs, Animal husbandry, Crop by-products, Traditional knowledge

Introduction

Grasslands represent natural vegetation predominantly consisting of grasses, grass-like plants and forbs. They are found in the regions where the growth of trees is constrained by climatic and edaphic factors (CNP 2016). In some cases, these grasslands result from previous anthropogenic disturbance from cultivation and grazing of stock (Pokharel 1993; Thapa et al. 2021), but in

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others, the origin of the grasslands is unclear. Grasslands could be either tall or short. Grasslands are considered a primary source of the ecosystem cycle. Moreover, tall grassland has a crucial role in regulating soil water and nutrient cycle, thereby maintaining the biological stabilization mechanisms for soil surface (CNP 2016). Hence, it plays a vital role in mitigating climate change as an important carbon sequester. Besides, tall grasslands are considered an indicator of nutrient-rich soils. Similarly, tall grassland serves as a habitat for many important endangered animals, birds, reptiles, insects and plants (Thapa et al. 2021). Thus, grasslands are critical in enhancing biodiversity, maintaining a wide range of ecosystem services such as food, water, carbon storage and mitigation, pollination and cultural services (Bardgett et al. 2021). However, the widespread degradation of grasslands has been an important global concern (Kemp et al. 2013; CBD 2022; Bardgett et al. 2021).

Terai of Nepal is home to the tallest grasslands in the world. Mostly, the protected areas, and their surroundings, in the lowland Terai Nepal contain some of the few remaining tall grassland/forest mosaics and their fauna. Eight grassland associations have been known for Chitwan National Park (CNP) in Nepal (Lehmkuhl et al. 1988). These important grasslands support a wide range of biodiversity. Thus, these areas such as CNP are an important biodiversity hotspot (Dinerstein and Loucks 2002) and can play an important role in achieving Aichi Biodiversity Targets 14 and 15 with direct linkage with SDG#6 (MoFE 2018; CBD 2022). In addition, these grasslands are important resources for local people who rely largely on farming systems integrating livestock and forest (Lehmkuhl et al. 1988; Sætre 1993; Brown 1997; CNP 2016; MoFE 2018; Bardgett et al. 2021). The buffer zone around CNP also has numerous riverine grasslands. The productivity and traditional management information of such grasslands according to the perception of local farmers regarding both domestic and wild ungulates are less explored and documented. The usage history and productivity measurement activities have been poorly organized concerning the wild ungulates and domestic animals. The case is further worsened in the surrounding buffer zones where grazing pressure would be highly expected. In general, there are only shreds of evidence on grassland biodiversity, animal species-plant assemblages associations, the effect of cutting and burning, the spatial and temporal response of ungulates and the socioeconomics of livestock and grasslands. Under these circumstances, the conservation management of the remaining grasslands in Nepal remains a challenge (Peet et al. 1999), and there is a need for socio-ecological solutions (Bardgett et al. 2021) to balance the nature protection goals and livelihood needs of people. In this regard, understanding the local perceptions is an important aspect of grassland development planning, as it might help to increase the rate of adoption of new technologies by the farmers in the rural settings.

A few efforts have been made in the past to document the grassland ecology and conservation practices in the Terai region of Nepal. However, these efforts are limited to describing the grasslands around the national parks and wildlife reserves of Nepal, where anthropic activities might have affected the species distribution and grassland productivity. The interactive effects of grazing and firing have significant impacts on biomass production and the energy content of herbs. Fire is an important concept worldwide, and this is still in haphazard usage in Nepal. Likewise, grazing influences the composition, quantity and quality of aboveground biomass (Lehmkuhl 1999). The regrowth potential and nutrient flow after the above-illustrated factors are unknown, whilst the river is the focus of landscape dynamics, erosion, deposition and channel meandering which has destroyed, created and modified the grasslands for a long time. Besides, these grasslands are threatened by illegal grass cutting, summer wildfire, uncontrolled grazing, natural succession of woody vegetation and human disturbances (CNP 2016). More importantly, the present state of important grasslands of the CNP and peripheral buffer zones can result in the decline of biodiversity as well as loss of livelihood means of locals, which will have serious implications on our common effort to achieve Sustainable Goals, specifically SDG#15 life on land, SDG#1 no poverty, and SDG#2 zero hunger (CNP 2016; MoFE 2018). Hence, this study aimed to assess farmers' perception of grassland management in the two human settlements in the grasslands of Magui Khola basin of Madi, Chitwan, Nepal.

Materials and methods

Study area

The Magui Khola basin was selected as a site for study purposes in Madi Chitwan, Nepal (Fig. 1). The river basin consists of grasslands with distinct features of anthropic usages, i.e. one is close to the Churia hills, the next one is close to the riverbanks and adjoining human settlements, and thirdly connecting to CNP in the north. Accordingly, based on the similar nature of vegetation distribution, the farmers were selected from the two villages, namely Bankatta and Khairahani; one of them was close to the Churia hills, whilst the other one to the riverbanks and human settlements, adjacent to CNP forest, respectively.

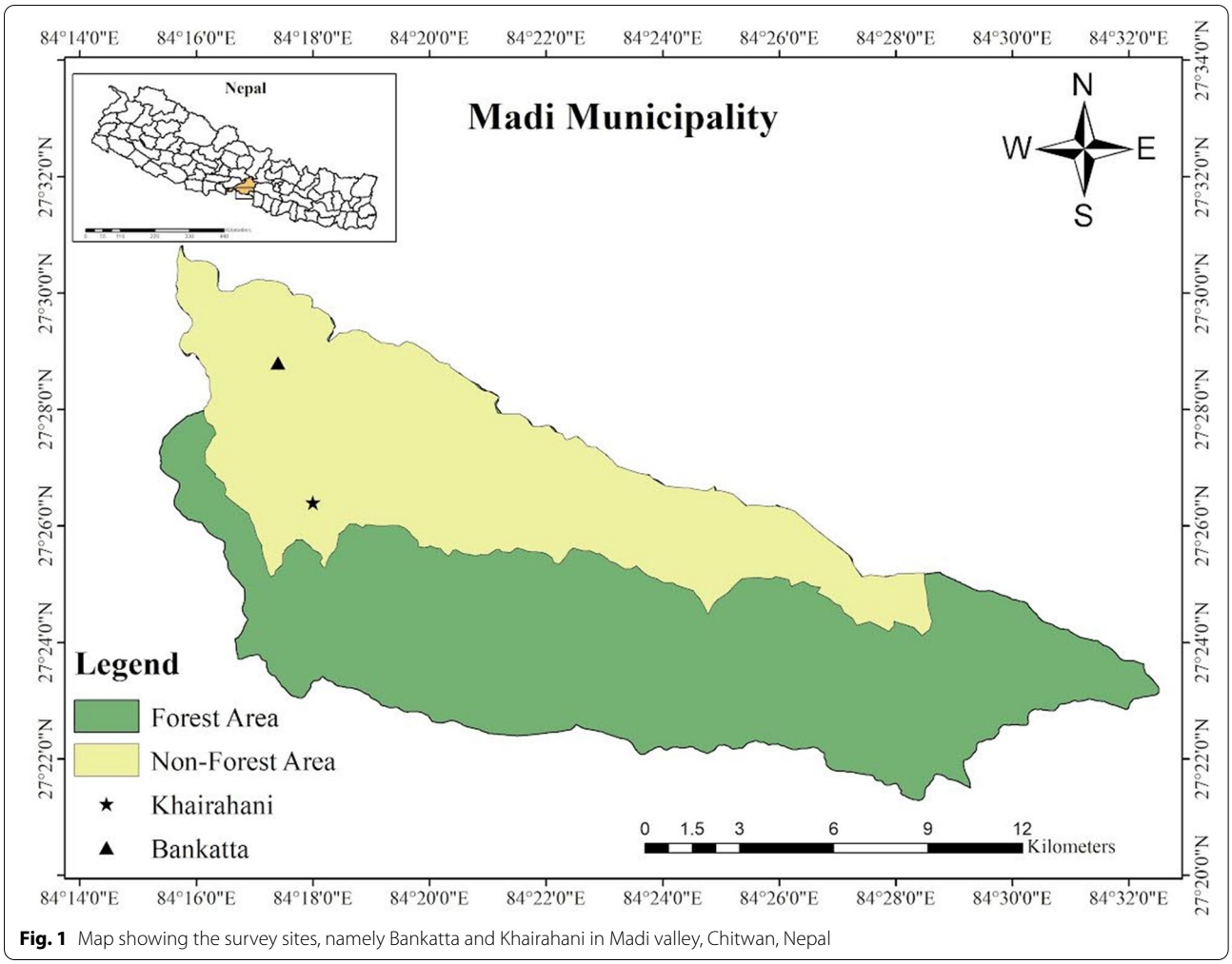

Fig. 1 Map showing the survey sites, namely Bankatta and Khairahani in Madi valley, Chitwan, Nepal

Local knowledge holders

The local Tharu community people (75%) speaking native Tharu language and Nepali and the hill migrants (25%) have a specific culture of integrating livestock in the farming system across the survey sites. The major domestic species were cattle, buffaloes, sheep and goats. The local traditional farming is based on crop cultivation integrated with animal husbandry (mainly buffalo farming followed by the goat, cattle and sheep). Cultivation of major staple food crops, supplemented with the production of garden vegetables and pulses, is also significant. The basic social unit is the family smallholding (Poudel et al. 2020) with a well-developed inter-familial cooperation system during grazing and other labour-intensive farm activities in both the selected sites for a survey.

Forests were partially taken by the state in 2016 (Chitwan National Park, CNP). The study area is surrounded by the CNP and the community forest; villagers are allowed to have access to the forest land (known as buffer zones to CNP) for grazing, collection of fodder collection, thatch and medicinal herbs and timber, etc. According to our estimates, the community members spend around the year outdoor on activities related to farming (grazing, fodder collection, forest use, cultivation), whereas medicinal and wild food plant gatherings are done on holidays, and that is more seasonal. About 70% of the transport is still done by wooden carts, whilst 95% of the food is self-produced. Hand mowing of herbages is mostly done by sickle, less often by machines and most rarely by tractors. Local people possess a deeper understanding of the ecological knowledge that is utilized in their traditional farming activities. They can recognize herbage species and have deep knowledge about their habitat preferences and usages (Dangol and Gurung 1991).

Data collection and analysis

As part of the long-term forage production analysis, the study was initiated in 2016 on folk's traditional social-ecological knowledge. Data were collected from 78 local farmers, 39 from each study site. Prior informed consent

was obtained before all the interviews, and ethical guidelines suggested by the International Society of Ethnobiology were followed. Data were collected by participatory methods, i.e. free listing, indoor and partly outdoor semi-structured pre-tested and designed set of questionnaire interviews (Newing et al. 2011). The interviews were conducted in the local Tharu and Nepalese languages, were recorded in a format and translated to Nepali language from Tharu by a Tharu translator for the native Tharu-speaking respondents. The summary of the questionnaire sets has been presented in Table 1.

Estimation of the number of respondents

The total population size in the given survey sites (villages) was obtained from the Madi municipality. Later, the minimum respondents' sample size from the population was determined using the sample determination formula with 95% confidence level by following Yamane (1964). The sample size was estimated as Eq. 1.

$$n = \frac{N}{1 + Ne^2} \quad (1)$$

where n is the number of the sample size of respondents, N is the size of population (census data collected from Madi Municipal Office, Nepal) and e is the expected allowable error which is 5% or 0.05.

Ranking of feeding resources

The seasonal ranking of feed resources was obtained from the equation modified from the Problem Confrontation Index (PCI) was computed as used by Hossain and Miah (2011) and Saha et al. (2022).

The PCI was computed by using the following formula:

$$PCI = Ph \times 3 + Pm \times 2 + Pl \times 1 + Pn \times 0 \quad (2)$$

where PCI is the Problem Confrontation Index, Ph is the no. of the respondents expressed "abundantly available", Pm is the no. of the respondents expressed impact as "less abundantly available", Pl is the no. of the respondents expressed impact as "available in low quantities" and Pn is the no. of the respondents expressed "not available".

Results

Household sojourn

The details of the household sojourn of the survey sites are presented in Table 2. The average age of the respondents was about 52 years, and the average family size was about 6. The average landholding was about 1 ha. However, there was variation in livestock ownerships. The cattle were significantly higher in Khairahani as compared to Bankatta, and it was higher for buffaloes in Madi 1 as compared to Kharahani. Whilst the number of goats owned (about 4 goats/household) was similar across the survey sites (Table 2), the number of grazing durations in months was the same (about 7 months/year) at both the survey sites.

Perception of respondents on grassland issues

The survey results showed that there was no conflict among the grassland users for grazing livestock in the survey sites. Upon a question about the most detrimental domestic species for grazing, the respondents referred ($p = 0.048$) to goats as compared to buffalo. Likewise, the respondents noted substantial changes in the herbage composition associated with grazing, as almost 65% of them responded to it positively

Table 1 Nature of questionnaires used to interview through semi-structured questionnaires survey in Madi, Chitwan, Nepal

Major groups	Subsets	Data acquisitioned	Category/unit
Household sojourn	Age	Numeric	years
	Family size	Numeric	Persons/family
	Total landholding	Numeric	ha
	Livestock holdings	Numeric	Number per species
	Duration of grazing	Numeric	months
Attitude of farmers	Social conflict	Categorical	1 = yes, 0 = no
Ranking of seasonal feedstuffs	Detrimental grazing animal species	Categorical	1 = buffalo, 2 = goat and 3 = others wild
	State of herbage composition		Open semi-structure
	Dominant herbage mixtures		Open semi-structure
	Time required for regeneration	Numeric	years
	Areas of grassland improvement	Categorical	1 = fodder cropping 2 = multipurpose fodder tree plantations 3 = river bank protection
	Ranking of the natural herbage and crop residues	Frequency data	Open semi-structured for summer and winter herbages and crop residues. Ranking from 1 to 5 indicating the level of preferences

Table 2 Household information on the survey sites

Parameters	Bankatta ($N=39$)	Khairahani ($N=39$)	SD	Test of significance
Age (years)	51.85	51.72	10.07	0.956
Family size (head)	5.72	6.05	2.13	0.492
Total land owned (hectare)	0.99	0.79	0.70	0.467
Livestock (number)				
Cattle	1.46	2.63	0.99	$p<0.01$
Buffalo	4.67	2.94	2.45	$p<0.01$
Goat	4.36	3.71	2.04	0.145
Duration of grazing (months)	7.07	7.07	0.27	1.00

p-value estimated by log transformation of data

N number of respondents, *SD* standard deviation

($p=0.032$). Among the dominating species in grasslands, *Imperata cylindrica-S. spontaneum* mixtures remained the most abundant mixtures ($p=0.003$) followed by *I. cylindrica-S. spontaneum-S. bengalenses* mixtures. The grasslands can be recovered in about 3 years after flooding or cutting. Later, the newly grown species remained like that of preceding cut-off and flood deposition ($p=0.011$). In the perception of locals, river belt protection (about 44%) was the most desirable area of grassland protection ($p=0.014$) and management followed by fodder cropping (41%), whilst tree plantation was the least preferred choice (about 15%). The details of the attitude of respondents to grassland management in Madi, Chitwan, are presented in Table 3.

Grazing and alternative feed resources

The survey data has clearly stated that the farmers were relying mostly on the natural grassland for feeding livestock. Based on the season of growing and available bulk, naturally available feedstuffs were the top priorities for both summer and winter seasons and that was rather

Table 3 Attitude of local respondent farmers on grassland management in Madi valley of Chitwan, Nepal

Attributes	Bankatta	Khairahani	LR	CC	Chi.sq	Significance
Social conflict						
Yes	25 (32.1)	21 (26.9)	0357	0.104	.848	$p=0.357$
No	14 (17.9)	18 (23.1)				
Detrimental animal species						
Buffalo	16 (20.5)	18 (23.1)	0.209	0.052	0.209	$p=0.048$
Goat	23 (29.5)	21 (26.9)				
Herbage composition change after flooding						
Yes	21 (26.9)	30 (38.5)	0.236	4.66	4.59	$p=0.032$
No	18 (23.1)	9 (11.5)				
Dominant mixtures mosaics						
Imperata-S. spontaneum	36 (46.2)	25 (32.1)	0.718	0.323	9.101	$p<.003$
Imperata-S. spontaneum-S. benghalense	3 (3.8)	14 (17.9)				
Herbage recovery period (years)*	2.69	2.62	-			$p=0.482$
Herbage similarities in newly formed pasture after flooding damage						
Yes	18 (23.1)	29 (37.2)	6.588	0.277	6.478,	$p=0.011$
No	21(26.9)	10 (12.8)				
Main areas of riverine grassland conservation and management						
Fodder cropping	11(14.1)	21(26.9)	0.118	0.315	8.576	$p<0.014$
Plantation trees	10 (12.8)	2 (2.6)				
River belt construction	18 (23.1)	16 (20.5)				

LR likelihood ratio, *CC* contingency coefficient, values in the parentheses indicated percentage respondents, *Chi-sq* Pearson chi-square coefficient

* Mean analysed by one-way ANOVA, standard deviation = 0.479

Table 4 Ranking of seasonally available feedstuffs based on biomass availability in the study areas

Season of availability	Feed resources	Observation		Overall ranking
		Frequency	Percentage	
Summer season				
Natural herbage	*Imperata cylindrica* (L.) P. Beauv. (Siru)	78	100.0	1
	Saccharum spontaneum L. (Kaans/Jhaksi)	71	91.0	2
	Cynodon dactylon (L.) Pers	20	26.0	3
	Saccharum benghalense Retz. (Baruwa/Narkat)	14	18.0	4
Crop residues	Rice and wheat straw	70	90.0	1
	Legume straw	57	73.0	2
	Maize stover	14	18.0	3
Standing forage		63	80.8	
Winter season				
Natural herbage	*Saccharum spontaneum L.* (Kaans/Jhaksi)	78	100.0	1
	Imperata cylindrica (L.) P. Beauv. (Siru)	68	87.2	2
	Cynodon dactylon (L.) Pers	51	65.4	3
Browse	*Morus alba* L. (Kimbu)	68	87.18	1
	[a]*Thysanolaena maxima* (Roxb.) (Amriso)	10	12.82	2
Crop residues	Rice straw	68	87.18	1
	Pea straw	9	11.54	2
	Lentil straw	2	2.56	3
Standing forage	[b]*Thysanolaena maxima* (Roxb.) (Amriso)	1	1.3	
	Zea mays L. (Fodder maize)	1	1.3	

[a] Collected from river banks and forests as an adaptive regenerated species

[b] Cultivated

dominated by *I. cylindrica* (L.) P. Beauv., *S. spontaneum* L. and *Cynodon dactylon* (L.) Pers., respectively (Table 4). The straw remained the common statement for most of the respondents in terms of crop residues in the winter lean season. The respondents further responded to the browse species, e.g. *Morus* and *Thysanolaena* as of their low priorities to feed livestock mostly in the winter/lean season. The standing forages were of interest to most of the respondents (80.8%) in the summer season only. The details of the list of the ranking of seasonally available feedstuffs are presented in Table 4.

Discussion

Respondents' perception of grasslands management

The main purpose of this study was to examine the perception of local farmers within the context of local settings and assessment of local knowledge on livestock grazing and feed resources management. The study used household surveys, focal persons interviews and group discussions to elucidate the current state of livestock grazing on natural grasslands and seasonal feed resources available for round the year feeding.

It is known that the traditional knowledge as noted by the respondents in their perceptions in the present study is intrinsic and adaptive to some scales and could be passed through generations (Berkes et al. 2000) and can be applied well in ecological processes (Alcorn 1989), sustainable use of natural resources (Schmink et al. 1992; Berkes 1999) and rangeland assessments (Angassa & Beyene 2003).

The observation of socio-economic data in the present study implies the need for strategic planning of grassland management in the Madi, Chitwan, where natural disasters such as flooding and inundation govern the herbage species coverage and the aboveground biomass available for livestock grazing. Flooding is one of the driving factors of grassland diversity and productivity (Henry et al., 1996: Van Eck et al., 2006), which has been supported by the respondents' positive response (see Table 2). The time required for colonization, and the observation of similarities on herbage species at the floodplains to that of the pasture at the origin at higher elevations are some of the key determinants of grassland diversity and productivity as well.

The available scientific evidence suggests that Terai grassland is dominated by tall grasses in the subtropical Terai (Thapa et al. 2021) and especially in and around the CNP (Lehmkuhl et al. 1988; Ghimire et al. 2019), and this is well represented in the farmers' indigenous knowledge in the present survey. There might be competition

between the species as it appears from the respondents' response that *Saccharum spontaneum* L. dominated in national park areas whilst *Imperata cylindrica* (L.) P. Beauv. dominated in the nearby forest areas and riverbanks widely. This also implies further study needed on the differentiation in the ecological processes of the available herbage species in the survey sites, in response to different anthropic factors, for example, colonization and adaptation in the floodplains concerning grazing. There is increasing evidence that biotic and abiotic disturbances are important natural factors affecting community composition and structure (Sousa 1984). The biotic factors were not perceived much by the local communities; instead, goats are more detrimental grazers, but flooding was taken as the disturbance factor of grassland species in the present study.

Anthropic factors and grassland

Human interventions have typical effects on grassland productivity and species distribution. Such phenomena in the present study could not be illustrated in detail, although grazing is free and was responded to as a continuous activity around the year in the study sites, although the grazable pastures were available for only about seven months.

Flooding occurs due to excess rainfall, and these kinds of lands exposed to flooding could be useful better for grazing than cultivation (Henzell and L. 'tMannetjie 1980). Farmers well perceived this thought in the present study sites. Furthermore, the forage may be available for a longer time in these areas as it happened also in the present survey that *Saccharum spontaneum* L. (Kaans/Jhaksi) and *Imperata cylindrica* (L.) P. Beauv. were harvested year-round in variable quantities (see Table 4) most probably due to available residual soil moisture. Scientific evidence had shown that the flooding drastically reduces oxygen diffusion into the soil causing hypoxia which is the main limitation that reduces root aerobic respiration (Burdick & Mendelssohn 1990) and absorption of minerals and water (Baruch 1994) and that damages the general metabolism (Crawford 1982), which, however, may reduce the herbage cover.

This might be the reason that the inundated flood plains in the survey sites have similar species mostly dominated by three taxa associations (see Table 2) that might have also morphological adaptations in addition to the biochemical (Jackson & Drew 1984). Though much information is lacking in this respect in the present survey, but it can well be hypothesized that plants adapted and regenerated in the floodplains could be tolerant and could have wider land coverage over time with biomass that could be available for grazing. The deposition of soil nutrients towards the inundated plain areas might have further additive effects on the dominance of such herbage species, whilst grasses are known to respond quickly and competitively to the soil fertility gradient. However, the data set are not enough to link to the effect of climate change. The present survey result might open the questions for the physiological mechanism of adaptation to flooding and the inundation of pasture species.

Grazing and the ecological consequences

The mixed mosaic of short and tall grasses and herbs at the riverbanks and forest openings are the principal food sources for domestic ruminants (Lehmkuhl et al. 1988; Ghimire et al. 2019; Sharma and Shaw 1993), with variable nutrient concentrations (Thakur et al. 2014; Thapa et al. 2021). When the grass is too short and dry in the winter, the farmers were forced to feed crop by-products, whilst the cultivated fodder production remained as a newly introduced practice, in a technology adoption process. However, the present survey results lack information on the dynamics of nutrient flow in the herbages across the pasture growing period.

The grasslands in the study sites were uncontrollably grazed by domestic animals almost for more than half a year and we found almost no management practices adopted. Grazing is the principal cause of the spatial heterogeneity of vegetation, which modifies the ecosystem processes and biodiversity (Adler et al. 2001) and modifies the plant diversity itself (Milchunas & Lauenroth 1993). The intensity of heterogeneity could be expected much in the survey sites, where both the domestic and wild ungulates and other small animals (wild hares and wild pigs), many kinds of deer, rhinos and elephants graze on the same piece of grassland. Thus, changes that occurred in spatial heterogeneity caused changes in habitat diversity and thus influence the grazing habit of other animals (Dennis et al. 1998). Whilst grazing reduces the quantity of available forage, in many systems, it increases forage quality, typically measured as nitrogen or crude protein content (McNaughton 1984; Jefferies et al. 1994), although other essential minerals such as sodium may be unchanged (McNaughton et al. 1997). The possible mechanisms for the increases in nutrient concentrations following grazing may include a reduction in senescent material, maintenance of leaves in an early phenological state (Hobbs et al. 1994), or increases in belowground available nitrogen (Holland & Detling 1990) and that might allow graziers to graze continuously up to 7 months as has been perceived from the response of local respondents in the survey. However, the respondents' statements about the most detrimental species being goats might be due to the different vegetation preferences by browsing habits and much of the disturbance habit (Animut and Goetsch 2008; Garcia

et al. 2012). Several studies have shown that changes in management intensity could affect the sward structure, plant species diversity, productivity and the nutritive value of the forage (Hofmann et al. 2001; Marriott et al. 2005; Pavlů et al. 2006), which however could not be well illustrated from the farmers' responses except for the comparison of grazing behaviour of goats and buffaloes in the present survey. Buffalo is a grazier type animal whilst goat is an intermediate browser (NRC 2007). The grazers can well adapt to the short stature and low biomass forage whilst goats tend to select tall and brouse species in general (Soest 1994), being agile and competitive for browse selection (Sanon et al. 2007) and can neutralize the plant secondary compounds such as tannins which play a defines mechanism in plants (Robbins 1995). Such grazing habits of goats would render treading, tethering and urinary damage to vegetation and might thus be expected as the detrimental species as compared to buffalo.

Ecological consequences on the composition and nutritive values of feedstuffs

The domination of tall grasses as abundant fodder species has been perceived by farmers and that has been well documented in the other studies. Most of the farmers could identify the severity of grassland dynamics and colonization of the species in the inundated areas. The indicators of the farmers' perception in this regard could be supported by other studies of south Asia where flooding is a determining factor (Adhakari 2013; Mirza 2011) of the grassland systems (Van Eck et al. 2006). However, the other sources of grassland deterioration due to wildlife is not addressed in the present survey and for the changes in the composition of nutritive value of the pasture species thorough out the grazing season. The problem of flooding would be expected, mainly derived from the higher rainfall in summer and inundation at the lower elevations banks that promotes the translocation of the same vegetation towards the lower elevations.

Scientific investigations have further proved that grazing alters plant diversity in permanent grasslands through the stocking rates (e.g. Diaz et al. 2001, 2007), the seasonality (e.g. Sternberg et al. 2000) and the livestock species grazed (e.g. Huntly 1991). Thus, the severity of grazing pressure, including the wild and domestic animals and their interaction, would be expected in the present study. These results suggest the necessity to consider not only taxonomic indices but also plant functional ecology to evaluate the effects of farming practices such as domestic animals grazing and interaction of wildlife and domestic animals in further studies.

Nitrogen (N) in open grasslands has a detrimental effect on grassland diversity (Jacquemyn et al. 2003). The alluvial deposition of fertilizer nitrogen and phosphorous (P) due to flooding might have reduced the appearance of many species instead of the *S. spontaneum*, *S. Bengalese* and *I. cylindrica* in the grasslands and might have hindered the colonization of other species. Though not mentioned in the present survey, such phenomena in the grasslands need to be further verified through pasture ecological research in the future.

Policy implications

The present study suggested some research and grassland development strategies in the survey sites. In the survey sites, most of the community development activities in the past were attempted towards nature and wildlife protection, which however lacked sufficient strategies to address the livelihood opportunities. It is repeatedly reported that the dependencies of local people on natural grasslands and forest is higher for livelihoods in the villages around the Chitwan National Park (Stræde and Treue 2006; Dangol 2015), and livestock grazing is one of them. There is a lack of scientific investigation on the assessment of changes in vegetation dynamics and the feed resources situation in Nepal in general and in the study area particularly, due to the priority of CNP as the protectionist rather than the productionists' role.

In the perception of the local farmers in the present survey sites, the grassland degradation and feed resources usages confirm the need for participation of the stakeholders with a possibly higher rate of adoption. The data also further shows broader areas of potential interventions, i.e. grassland management, promotion of alternative feed resources and livestock ownerships.

There is a need to address the local farmers' livelihood priorities where the dependencies are higher on natural resources grazing and feed management in the winter. Farmers' awareness of the problem of resources to feed livestock is derived from the farming system adopted, economic, social and ecological uses of livestock in the study sites, which, however, will be considered in detail in future studies. The severity of grassland degradation in the grazing season is not demonstrated well in the present study because the livestock grazing sites were in close vicinity of the CNP and surrounding buffer zones are always open for the wild and domestic animals. Moreover, farmers nevertheless used various grazing management practices although the common method has been well pointed out as a long-term solution to protect the grasslands, e.g. fodder production and riverbank protection. Later, the benefits of multispecies grazing have been postulated (Walker 1997), which, however, could be well-applied to species having similar grazing behaviour, only that was stated as detrimental for being different habits

of buffaloes and goats grazing in the same grasslands in the present study.

All these factors suggest the need to undertake a scientific investigation to determine the processes and the demand of farmers in addition to the survey on local knowledge (Celio et al. 2014; Assefa & Hans-Rudolf 2016). The use of local knowledge could prove to be an important aspect of technology dissemination (Kelly et al. 2015) and their chance of higher rate of adoption (Füsun Tatlıdil et al. 2009) by the farmers.

Conclusions

This study provides collective evidence of biotic and abiotic factors for grassland management for sustainable uses in sub-tropical Terai Nepal. The resources identified for improvement could use the farmers' perceptions derived possibly from traditional farming. The locals were aware of vegetation changes in the grasslands, and the need of supply and management of the alternative forage resources respectively. Whilst the resources that need to be considered are the pasture ecology (soils and herbage nutrient dynamics as result of flooding) herbage biomass production and regrowth, animal species grazing and interactions and intensity of the natural disasters, as most of these risks are prevalent in the commonly available resources. Therefore, the management of these available grasslands and alternative feed resources necessarily depends on effective social institutions (stakeholders) which require careful attention to maintaining the quality of these resources and the forms for sustainable livestock grazing. A detailed study is needed to further explore grazing systems and other social-ecological functions of grasslands in Magui *Khola* basin.

The result from this study can further be used to select herbage species for the regeneration of flooded and inundated lands to improve the land cover and to advise farmers on the importance of herd composition during grazing. Most of the farmers, however, have a some knowledge in identifying the severity of grassland degradation as flooding was stated as the main response factor. In addition, farmers were also aware of the seriousness of multispecies grazing and herbage utilization which affect the raising of livestock as buffalo and goats have different grazing behaviour patterns. It is anticipated that the decisions of farmers on the use and management of the grassland depends on their perception of its deterioration, whilst the technology disseminated by the stakeholders for improving grassland and feed resource usages would have a higher rate of adoption among the farmers.

Abbreviations

ANOVA: Analysis of variance; CC: Contingency coefficient; CNP: Chitwan National Park; Chi.sq.: Pearson chi-square coefficient; LR: Likelihood ratio; *P*: Probability; PCI: Problem Confrontation Index; SD: Standard deviation.

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Authors' contributions

SRB and DRC designed the field survey and data analysis. NPJ and NRD helped to design the questionnaires and their pretesting, whilst TNP and BD carried out the household survey. All the authors were involved in the revision of the manuscript. The author(s) read and approved the final manuscript.

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Availability of data and materials

All data generated or analysed during this study are included in this manuscript.

Declarations

Ethics approval and consent to participate

We affirm that the study does not involve the use of any animal or human data or tissue. Informed verbal consent was acquired from each respondent at the time of the household survey.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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