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Herbage Mass Productivity and Carrying Capacity Estimation of Some of the Selected Rangelands of Taplejung District

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Abstract

A study of the representing rangelands of Taplejung district was carried out during summer of 2009 to estimate the herbage mass yield of different slope categories, and to calculate the carrying capacity (CC) of the representing rangelands based on 60 days re-growth period so that optimum number of livestock unit (LU) per unit area would be possible to allow for grazing. The findings revealed that plain slope had higher herbage mass produced, but was comparatively over-grazed as revealed by higher stocking rate. Existing carrying capacity reasonably supports the grazers, but irrespective of the quality herbage. In deed there was a lower CC for higher slope area with higher CC for plain slope. Nevertheless, the CC values for different slope categories indicated that rangelands in Taplejung district has wider scope of improvement, both for herbage mass productivity, and grazing management through precise stocking rates to match with the prevailing carrying capacity. A major challenge, however, lies to convince herders about the benefits of reducing stocking rates and improving production efficiencies, with the increased income and less degradation of the present available rangelands. Detail study on herbage mass production based on total herbage mass harvest days of a year along with stocking rate for the respective period would be important to consider in generating concrete and site specific information.

Key words: herbage mass, carrying capacity, stocking rate, rangelands, herders, Taplejung district

Introduction

Rangelands in Nepal are often taken synonymously with pasturelands that are usually considered the piece of uncultivated open land with natural vegetation across the altitude, aspect and climate (Devkota & Kolachhapati 2008, 2009, Pariyar 1993). Most of the rangelands in Nepal are diversified, and are characterized as rocky substratum, low fertile soil with degradation due to overgrazing, and also due to the presence of often nutritionally poor and unpalatable species (Devkota & Kolachhapati 2009, Miller 1997). Nevertheless, high altitude districts in Nepal have a vast potential of developing rangelands for livestock rearing. Taplejung district in the eastern region of Nepal is among the districts, also renowned for Chauri rearing, besides other livestock species.

Taplejung is situated at the northernmost region of the Mechi Zone. It has Sikkim state of India towards the east, Sankhuwasabha district to the west, Tibet an autonomous state of China, towards the North, and Tehrathum and Panchthar districts towards the South. Having at least a dozen of mountains higher than 7000 m, it has areas ranging from 777 m (Kabeli river) to 8586 m (Kanchanjungha Mountain) above the sea level. It is situated between 27° 15' to 27° 56' northern latitude to 87° 32' to 88° 15' Eastern longitude (Devkota & Kolachhapati 2009).

Taplejung district has a total area of 365,220 ha and a total human population of 135,540 (CBS 2058 B.S.). About 83% of the total population is involved in

agriculture, whereas there are 77,450 cows, 44,045 buffaloes, 121,567 goats, 13,839 sheep and 2,836 Chauri (DLSO 2064/065 B.S. a,b) in the district. The main livestock products of the district comprises of milk, meat, eggs and wool which have a total share of 1.17, 1.28, 0.6 and 0.79 % respectively, to the gross national livestock production (DLSO 2064/065 B.S.a,b; ABPRSD 2007, Devkota & Kolachhapati 2009). The northern four village development committees (VDC), Olangchungola, Lelep, Tapthok, and Yamphuding occupy a greater portion of forest and rangeland as the total rangelands covered by these VDCs is 411.2 sq. km (DDC 2064/65 B.S, DFO 2064/2065B.S). This indicates that Taplejung district has huge potential of developing productive rangelands, yet people are not taking maximum benefit of this vast resource (Devkota & Kolachhapati 2009).

There is lack of concrete and comprehensive scientific study of Nepalese rangelands due to several pertinent reasons, such as remoteness, low level of priority, and due to no or poor estimates of mountain livelihood systems (Miller 1997a, Devkota & Kolachhapati 2008, 2009). Estimation of pasture productivity and thereby understanding the situation of carrying capacity helps to manage the pastureland in a better way. Productivity is often estimated based on primary data on herbage mass whereas in Nepal herbage growth in the temperate and alpine rangelands restricts to the 6-8 months in a year due to snow covered for the rest of the period. Continued work to generate primary information of herbage productivity is thus important aspect of grazing management. A scientific study of the representing rangelands of Taplejung district was carried out during summer of 2009 to estimate the herbage mass yield and thereby to understand the range-based feed resource for ruminants. The other objective of the study was to estimate the carrying capacity of the representing rangelands based on total available herbage mass based on 60 days re-growth period so that optimum number of livestock unit (LU) per unit area would be possible to allow for grazing with higher degree of precision.

Methodology

Site selection

Three different categories of rangelands (gentle plain, middle steep, and steep slope) having altitude more than 7500 m above mean sea level were purposively selected for this study, based on the information available at DLSO, Taplejung district. The *Kharka/* rangeland, where the experiment was conducted, is situated at Phawakhola VDC ward 9. This rangeland is one of the communal land, and has ~ 4-7 ha area. All three categories of rangelands were available in the same Ballu danda/ Puwakhola site (Table 1).

Slope category was determined by using topographical map. Accordingly, slope was calculated by using the slope formula:

% slope = vertical distance/ horizontal distance ×100

Where vertical distance was measured as a difference in elevation between two points (Rise), and horizontal distance was the distance from one point to the other and was calculated by measuring distance with a rural and by applying the map scale of a topographical map. Besides, the slope categories were also verified by directly measuring the slope in the research site by using a inclinometer for slope angle measurement (RANGER 15TDCL,Made in Finland). Finally, slope % was adjusted to plain category (<4% slope), medium slope (5-10% slope) and steep slope (12-16% slope).

Table 1. Selected rangelands with their corresponding area, altitude and aspect inTaplejung district

Rangelands/Kharka	Slope category	Area (ha)	Altitude (ft)	Aspect
Ballu Danda/Puwakhola	Steep slope	4-7	9905	South-E
Ballu Danda/Puwakhola	Medium slope			South-E
Ballu Danda/Puwakhola	Plain			South-E

Source: Field study (2009)

Herbage biomass yield estimation

For each rangeland type (representing three slope categories, steep slope, medium/gentle slope and plain/ normal slope), herbage harvested were estimated using quadrat cut technique**.** Nine areas for quadrat cut were taken in each pastureland category with the total cut

of 27 quadrats. Nine quadrat cut area were determined using Z shaped transect. Thus the total available herbage mass was estimated based on herbage harvested (Devkota & Kolachhapati 2009). Quadrat with the size of 1× 1 m was used for this purpose. Area used for quadrat cut was identified, marked, and protected against grazing by keeping watch-man for one month period. This procedure was followed for each of the pastureland type (representing three slope categories).

Once the herbage harvested was done, weight of the green herbage mass per quadrat was determined using weighing balance. Dry weight was estimated based on sun-drying technique. Livestock population was converted into LU as per Sardar (1989) whereas adult cattle, buffalo, sheep, goat and horse were equivalent to 1.0, 1.5, 0.2, 0.3 and 1.3 LU, respectively. Yak and Chauri were considered to as LU equivalent to the cattle. Other secondary sources were used as far as available and practicable.

The total duration of the study was 60 days (2 Baisakh, 2066 (April 15, 2009) to 30 Jestha, 2066 (June 13, 2009) covering two times harvest of the herbage mass. The first time harvest covered about 30 days after the melting of snow to cover and estimation of initial pasture growth (31 Baisakh, 2066; May 14, 2009) whereas the second harvest covered 30 days of re-growth after the first time harvest (30 Jestha, 2066; June 13, 2009).

Carrying capacity estimation

Carrying capacity was determined on the basis of information of herbage harvested, collected from productivity estimation of the each site. Carrying capacity was calculated by using the following formula:

$$\text{CC (per ha) of a given period} = \frac{\text{Cumulated herbage (dried wt. in kg/ha) for 60 days}}{\text{Requirement of one livestock unit (LU) per day} \times \text{time}}$$

Where, requirement of one LU was set as 10 kg DM/ day, and Time indicates duration; which was 60 days in this study

The above calculation/expression is close to the concept of animal unit month (AUM) as in range management it is common to express the usable herbage in a given pasture/range as AUM per acre (Allen 1991), or hectare, mainly due to transhumance grazing system where animal grazes in a given range only for a certain period and moves to the other pasture/range.

Botanical composition of the pastureland was determined. Accordingly, for each pastureland type (representing three slope category of steep slope, medium/gentle slope and plain/normal slope) about 5 samples were randomly taken (with 0.5m quadrat size); they were mixed together; representative samples of about 200 g were taken and botanical composition was determined based on separation method. Legumes, grasses, weeds and dead material were separated, their green and dry weight were taken and proportions of each of them were determined as botanical composition. The other information collected included (Devkota & Kolachhapati 2008, 2009).

Social aspects

Group discussion with key informants and stakeholders was carried out both in the sites of productivity estimation research and also in the district head quarter. Several issues related with the livelihoods and changes in the livestock husbandry practices (if any) of the herders were discussed. Available literature were reviewed to collect relevant information on livestock production issues in the high hills and mountain. Information provided by key informants, experienced farmers/herders in the locality were duly considered to understand the existing livestock rearing and livelihood systems of the people.

All the data produced were subjected to the statistical analysis, using two ways ANOVA (á level set as 0.05). Three sites were considered as treatments, each with 9 replications. Means were compared using LSD and DMRT ($P<0.05$).

Results

Status of rangelands, herbage mass yield and its productivity

The detail of *kharkas* available in the Taplejung district with their approximate size, productive performance and other related characteristics have been reported by Devkota and Kolachhapati (2008). Accordingly it was reported that there are more than 100 of small and large pasture/range in the district covering all types

of slopes and aspects, whereas productivity of the pasture in the study sites could be varied as per differences in botanical composition, and also due to variation in natural growth and coverage. Natural variation provides guidelines for an optimum grazing plan and stocking rate over the given period.

Herders reported in the discussion that livestock are grazed in the rangelands –*Kharkas*, that occur within bioclimatic zones of temperate (2000-3000 m elevation), and sub alpine (3000- 4000 m elevation) of the area. Herders follow traditional system of grazing which does not consider rotational grazing system in the strict sense. This particularly depends to the knowledge of the herders. In deed traditional knowledge based systems provide strong guidelines of pasture management. Table 2 presents herbage mass yield for two dates of harvest covering three different slope categories.

Table 2. The mean green herbage yield (g/m^2) estimation, their dried weight (g/m^2), and respective cumulated value at Taplejung district, 2009

Rangeland Category	At first harvest		At second harvest		Cumulative green weight (g)/m^2	Cumulative dried weight (g)/m^2
	Green weight (g)/m^2	Dried weight (g)/m^2	Green weight (g)/m^2	Dried weight (g)/m^2		
Steep	74.44b	40.33	353.33b	123.18	423.89b	163.51ab
Medium	57.22b	30.56	238.11b	97.27	295.33b	127.83b
Plain/Normal	208.89a	69.97	551.67a	158.38	760.56a	228.35a
Probability	0.03*	0.08	0.00**	0.06	0.00**	0.01**
Cv%	104.7	77.71	44.68	40.03	47.24	38.33
Lsd $_{(P<0.05)}$	118.8	NS	170.1	NS	232.9	66.36

Note: * P<0.05, and ** P<0.01, respectively; NS, not significant at P<0.05

Table 2 provides information on herbage harvested and their respective dried weight also considering cumulative green and dried weight. Accordingly the highest green herbage per unit area (g/m^2) was harvested from plain site at first harvest, where the value (209 g) significantly differ (P<0.05) to the rest of the value from steep and medium slope categories. However, the fresh green mass value of steep and medium slope remained statistically similar (P>0.05).

The dried weight of herbage harvested at first date also followed the similar trend to that of green herbage harvested, but the values were statistically similar (P>0.05). Nevertheless, highest dry weight per unit area (g/m^2) was from plain slope, whereas the value of medium and steep slope categories remained statistically similar (P>0.05) (Table 2).

The mean green weight value of herbage harvested at second date (after 30 days of re-growth) was quite high compared to the values of first harvest for all categories. The increment from first to second harvest was as high as five folds, especially for steep and medium slope whereas in the case of plain site it was more than double (Table 2). Similar trend of producing higher green mass at plain site continued in this date of harvest as well, whereas the figures from plain site was significantly different (P<0.01) to the rest of the categories. On the other hand, the respective dried weight value for second harvest remained statistically similar (P>0.05) for all three slope category, although higher dried weight was for plain slope compared to the other slopes (Table 2).

The value of cumulated green herbage (g/m^2) was also statistically different (P<0.05) among the slope categories, with the highest yield for plain type of slope, followed by for steep slope and least for medium category of slope. This trend of differences in cumulative green herbage value continued in the case of cumulative dried weight (g/m^2) as well. Accordingly, plain type of slope had highest value (228) followed by the steep slope category (163), whereas this value remained statistically similar to the cumulative dried weight value for medium slope category (Table 2).

Carrying capacity

Table 3 presents the situation of carrying capacity of selected representative sites in Taplejung district.

Table 3. Stocking density and carrying capacity (CC) of the three Kharkas, Taplejung district, 2009

Name of the *Kharka*/rangelands	DM (kg/ha)	Stocking rate (LU)	Carrying capacity (LU)	Stocking density over the CC
Ballu Danda/ Puwakhola(Steep)	1635.1	7	2.72	2.57
Ballu Danda/Puwakhola(Medium)	1278.3	6	2.13	2.82
Ballu Danda/Puwakhola(Plain)	2283.5	9	3.80	2.37

Source: Field study (2009)

Carrying capacity of all three representing rangelands of Taplejung district varied least, whereas the value of carrying capacity resembled quite standard to match with the requirements. Accordingly, maximum carrying capacity was for plain site as supported by the highest dried yield whereas the carrying capacity of other two sites was also at par with that of plain site. Likewise, the values for stocking density over the carrying capacity for all three sites looks close to the standard, ranging 2.3 to 2.8 (Table 3).

Botanical composition

Table 4 presents status of botanical composition across the three representing rangelands sites in Taplejung district. Accordingly the presence of legumes was >15% in plains and steep sites, whereas it was virtually nil in medium slope site.

Table 4. Composition of grasses, legumes and weeds (based on 100 g sampling) at three categories of rangelands, Taplejung, 2009

Slope/site	Dried weight of each component (g)				
	Legumes	Grasses	Weeds	Dead materials	Total
Ballu Danda/ Puwakhola(Steep)	6(14)	25(58)	7(16)	5(12)	43 (100)
Ballu Danda/Puwakhola(Medium)	0	30(73)	8(20)	3(7)	41 (100)
Ballu Danda/Puwakhola(Plain)	8(18)	27(60)	7(16)	3(6)	45 (100)

Source: Field study (2009)
Note: Figure in the parentheses indicate percentage distribution of each component

Likewise, proportion of grass was >60% in general, with the highest value for medium slope site. The proportion of weeds was about 16% in all representing sites. Likewise small proportion of dead matter was found in all slope categories (Table 4).

Discussion

This study was conducted for a period of 60 days. During this period two times harvesting of the biomass was done; the first in 31 Baisakh, 2066 (14 May, 2009) by observing that snow melting was some how over in 2 Baisakh, 2066, and thus first harvest was done after 30 days of snow melting. The second harvest was done in 30 Jestha, 2066 (13 June, 2009), after 30 days re-growth period of first harvest.

If we compare the report of Devkota & Kolachhapati (2008), herbage mass estimation and carrying capacity (CC) values were quite different to that of the present study report. There could be many reasons behind these variations, but one thing is clear, study in the summer of 2009 was accomplished two weeks earlier than the study of 2008, whereas the latest study also covered herbage mass of initial slow growth period which added comparatively less herbage biomass. On the other hand the study done in the year 2008 was confined for single time harvest covering a period of 30 days only, whereas the present study was for 60 days. Yet, herbage biomass and respective CC values reduced a lot for the study carried out during the summer of 2009 (Devkota & Kolachhapati 2008; 2009).

One of the important reasons for such results is poor growth of pasture mass in the summer of 2009 due to prolonged dry period, coupled with lack of initiation of peak herbage mass growth in the early phase of summer season. Likewise, present study has covered

60 days period of herbage mass accumulation and thereby the CC calculation is also done for 60 days period and per hectare basis (Devkota & Kolachhapati 2009). This is important to note that herbage accumulation in the re-growth pasture keeps on increasing until October in the rangelands of Nepal, thus to understand the total picture of herbage growth, at least total herbage mass estimation of the whole year period is necessary to calculate the CC. Nevertheless, research approach followed in the summer of 2009 was more close to the reality, and was better in terms of estimating CC. The concept of considering duration for calculation based on grazing period shows rather realistic in the sense that grazing in the rangelands is migratory in nature due to following of a transhumance system. Therefore estimating CC for a period animal keeps on grazing in that particular location gives better pictures of CC to guide for a better grazing management by adjusting the stocking rate as well. Likewise, stocking rate as reported by Devkota and Kolachhapati (2008) was also very high compared to the findings of present study. Such variation is possible to occur due to many reasons; some are even difficult to analyze (Devkota & Kolachhapati 2009).

Animals move from lower belt to the high mountain for summer grazing in Nepal. They are underfed during winter hard at the lower belt. When the spring ends and summer starts, flocks and herds move to the high altitude pasture with high stocking rate, which is quite natural. However, failing to manage high stock rate for the ranges with lower herbage mass would result serious impact on the re-growth of the herbage due to heavy grazing pressure and hard grazing. Lesson thus must be learnt to tally grazing practice as per available herbage mass (Devkota & Kolachhapati 2008, 2009).

It was clear from the study findings that cumulative green herbage (over the period of 60 days) was significantly different ($P<0.01$) across the slope category, the highest mean was for plain site whereas the lowest value was for medium and steep slope. The value of steep slope, however, did not differ ($P>0.05$) with the value of medium slope (Table 2). This well presented the fact that plain site had significantly higher green herbage mass accumulation. Likewise, the cumulative dried weight value over the same study period also remained statistically different ($P<0.05$) across the slope category and ranged. The important message from this study is that since the green and dried weight value across the slope remained different, there is a need to differentiate pasture/rangelands for any management practices with respect to the slope category. Thus the findings provided the fact that management aspect would be varied as per the slope categories.

The findings of this study well reflecte that rangelands in high hills and mountain are relatively over-grazed in plain slope, whereas existing carrying capacity reasonably supports the grazers irrespective of quality herbage. Miller (1997 a) suggested that estimated carrying capacity and productivity of Alpine pasture is higher than the steppe, sub-tropical and temperate pasture land, thus it is important to consider this fact while addressing productivity issue as desirable CC would be close to one in order to address the capacity of rangelands to adjust the stock grazers in terms of DM requirements. Miller (1996,1997a, b), and Rajbhandari and Shah (1981) also reported that CC of the alpine range in Nepal could be 1.42 in general, compared to 0.19 for steppe rangelands (Pariyar 1993), whereas stocking density (SD) of alpine and steppe rangelands was estimated as 0.64 and 0.19 (Pariyar 1993), respectively. The findings of this study also revealed the lower CC for higher slope area with higher value for medium and plain slope, but the figures reported by Miller (1997), Rajbhandari and Shah (1981) and Pariyar (1993) are comparatively far lower than the figures reported in this study. Such variation in the CC could be partly due to the method followed in the estimation and coverage of the research sites. Nevertheless, the CC values for different slope categories, at least provided the indication that rangelands in Taplejung district has wider scope of improvement, both for herbage mass productivity, and grazing management through precise stocking rates to match with the prevailing carrying capacity. A major challenge, however, lies ahead to convince pastoral people about the benefits of reducing stocking rates and improving production efficiencies, with the increased income and less degradation of the present available rangelands.

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