CONDITION AND POTENTIAL FOR IMPROVEMENT OF HIGH ALTITUDE RANGELANDS

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Introduction

This paper is an extract from the Ph.D. thesis of the author "Assessment of the Condition and Potential for Improvement of the High Altitude Rangelands of Bhutan". It deals with the factors influencing the degradation of rangelands in the high altitude areas of the northwest Bhutan, and proposes possible legal and technological measures to improve rangeland conditions.

Definition of Rangelands

Rangelands have been described as those areas of land, which by reason of physical limitations, low and erratic precipitation, rough topography, poor drainage or extreme temperatures, are unsuited for cultivation, and which are a source of forage for free ranging native and domestic animals as well as a source of wood products, water and wildlife (Stoddart et.al. 1975). In Bhutan, it is known as *ri* which literally means a range shed, when used in the context of a source of grazing, collection of firewood and non-edible products, medicinal or incense plants. Hence the term *rikha* means 'on the range' and *rikhaley* means 'from the range'. The term *tsamdrog* is nearly synonymous with rangelands, and it means grasslands.

Role of Rangelands

In addition to their roles as wildlife habitat, source of quality water, rich biodiversity and natural beauty, the high altitude areas of Bhutan's rangelands must continue to provide food, fibre, fuel, timber, water, and shelter for the local people, in addition to fulfilling increasing new demands for recreation

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and tourism. The ability of the rangelands to meet the traditional and new demands would much depend on the way it is managed for any one purpose as this will invariably influence the ability to meet other demands.

Criteria for Condition Assessment of Rangelands

According to American standards, prime rangeland is defined as the best rangeland because its soil, topography, vegetation, water, and related attributes make it better than other rangeland in its ability to produce forage for grazing animals without degradation of related values and environmental quality (USDA, 1978). Prime rangeland must have slopes less than 50%, produce annual DM yields of at least 750 kg per ha, have adequate water supply, and not contain high proportions of plants with toxic imbalance of minerals.

If the above criteria are strictly applied to the high altitude rangelands of Bhutan, than one would surely come to the conclusion that the rangelands are in poor condition as most of them would fall short of meeting the first two criteria. However, since the natural conditions as well as the purpose of rangelands and the methods of utilization are different from the standard use of rangelands in the West, criteria for judging must vary. Vegetation type, ground cover, fodder production and species diversity are most important parameters in the high altitude areas of Bhutan. Further, one must take into account that the criteria used by the herders and agronomist for assessing rangeland conditions do not always coverage with those used by conservationists, and therefore, the relative weightage given to an individual criterion will vary.

The following pictures clearly emerge from the preliminary assessment of the rangeland condition of Laya, Lunana and Lingzhi:

i) Most rangelands are located on steep slopes above 40%, and altitudes above 3500 m;

ii) The vegetation status is influenced by altitude, slope angle and direction, past and present management of grazing, fire and nutrients;
iii) The condition of rangeland deterioration varies considerably from very poor to good based on ground cover and biomass production; and
iv) The causes of rangeland deterioration are not easy to define, and vary from natural flash floods from glacial lakes to overgrazing.

Causes of Rangeland Deterioration

Natural Causes

Erosion includes all processes that result in the physical wearing down of the earth's surface. These processes are complex, consisting of natural (geological) and accelerated (man-induced) erosion. Natural erosion is characterized by different forms of mass wasting such as mass movement of fractured rocks, saprolite and other unconsolidated materials, rock failures, landslides, slumps, and riverbank cutting-including soil movement from slopes and gullies.

The rangelands of Lunana were severely damaged by past and recent flash floods from glacial lakes, particularly the winter grazing sites along the bottom of the valleys. In the Tarian valley which was subjected to flooding about 40 years ago (Gansser, 1983) by the rupture of the terminal moraine of one of the glacial lakes at the South-eastern base of the Tsendagang mountain, the present vegetation consist primarily of low lying shrubs of Hippophae and Myricaria species, which are of little use of grazing but provide adequate ground cover. The main Lunana valley from Thansa to Hedi was badly affected by the October 1994 flash flood, which not only washed away substantial area of land in its wake but also covered most of the flat areas by sand rendering them unsuitable for grazing. Gansser warned that these events must have happened frequently during the last 100 years, are still happening now, and will continue to happen in the near future.

The other cause of natural deterioration is from scree erosion due to the easily erodible rock types (shale). The high intensity of rainfall during the monsoon season is another major cause of erosion over which man has little direct control.

Grazing by Herbivores

Grazing of both wild and domestic animals exert an influence upon the productive rangeland systems by their defoliation of plants through eating and physical damage, by their digestive processes, and by their movements (Heady and Child, 1994).

The estimates of grazing pressure from yaks alone on the rangelands of Lingshi (Gopula and Jarila) and Laya (Lungo, Omtsa, Rodophu) at less than 2 ha per yak adult equivalent (YAE) per year with estimated standing biomass yields of less than 400 kg DM ha^{-1} are reasons enough to be alarmed. In addition, there is a high density of blue sheep and marmots found in these rangelands. There is no question that overgrazing by a combination of wild and domestic animals is a serious problem. The evidence of overstocking is also abundant from the dense network of vertical and horizontal treks seen in all these rangelands near villages such as Gopula and Zumeri in Lingshi, Lungothang and Omtsa in Laya and Pangtegang in Lunana. This probably led to substantial surface soil erosion. The alignment of the cattle tracks in grasslands have a major influence on the amount of soil erosion as a result of paths formed for running water when rainfall rates exceed infiltration rates.

An interesting preliminary finding from this assessment, which warrants further investigation, was the inverse relationship between severity of grazing and the number of species. While this may be partly due to the difference in timing of assessment, and the precision of the visual estimation, there is enough evidence to indicate that species richness or biodiversity is not improved by grazing exclusion as seen in the case of the lightly grazed rangelands of Lunana (Ganglakachu and Nyisharling). As Heady and Child (1994) suggested, moderate intensities of grazing may be stimulatory and beneficial to the continued well-being of rangeland ecosystems.

While adequate information to enable quantification of the extent of competition between yak and blue sheep are not available as yet, there is little doubt that they have a high degree of overlap in their habitats and diet selection (Wangchuk, 1994). Two flocks of blue sheep between 150 and 200 in numbers continually move up and down the slope of Laya village, which is also continually grazed by yaks. Similarly, a large flock of blue sheep was seen in Jarila and Gopula, grazing on the same ranges.

The destructive impacts of marmot burrowing and browsing are particularly evident in the rangelands of Tsherijathang and Jarila as well as in many other rangelands not included in the survey. In Tsherijathang, entrances of marmots burrow (old and new) are encountered within a radius of 30 m in the stony meadows between 4000 and 4500 m and in Lungothang at every 40 metre's radius. These entrances are used by yaks to sharpen their horns and further expansion of the soil serve as resting pits for yaks. Eventually, they become large blotches of open scars on the alpine landscape and set off the soil erosion processes.

The above evidences clearly show that grazing animals influence the condition of the rangelands and that, in the severely affected areas, immediate steps need to be taken to limit further deterioration to eventual desertification of the rangelands through appropriate policies, research and development strategies for grazing control and re-vegetation.

Poor Nutrient Cycling

The analysis of soil samples from the rangelands show that the soils become increasingly acidic from east to west orientation, and vary from moderately acidic in Lunana and Laya to highly acidic in Lingshi (ph<5.5). Acidic soils in Bumthang have been considered as one of the limiting factors for the lack of response to pasture improvement treatments through reseeding with legumes and fertilization. This raises serious questions to the possibility of restoring vegetation through improvement measures such as protection from grazing, re-seeding or manuring in the highly deteriorated rangelands in Lingshi.

Generally, the soils also indicate very low levels of available P(<6 ppm). This will be one of the major limiting factor for improvement of rangelands since N deficiency which is also observed in most of the areas is expected to be overcome once local legume respond to P supply. There are two reasons behind the very low levels of soil fertility. Firstly, there is no practice of manuring the pastures by herders. Instead, yak dungs are removed from the pasture for use as fuel in Lingshi and as manure in Laya and Lunana.

The study clearly identified the sources of inputs, the flow through the components and the avenues of loss of nutrients from the rangeland ecosystem. The removal of dung for manuring crops and for fuel, and removal of nutrients in animal products are major avenues of nutrient loss while the invasion by shrubs slows nutrients in herbaceous species. Currently the major sources of input into the soil nutrients pools appear to be from animal urine, fixation from atmosphere and mineral decomposition.

Only a small fraction of the nutrients used by crops are returned through crop residues like barley straw, and the nutrients removed in form of animal products and dung are completely lost from the system.

Secondly, unpalatable species of shrubs directly compete with the herbaceous plants for soil nutrients and block these nutrients from entering the active soil-plant-animal nutrient cycling path. Lastly, the exposed soils in heavily grazed rangelands are susceptible to loss of topsoil and therefore soil nutrients are poor particularly on steep slopes.

In Lunana the main cause of poor soil condition in the flat areas was due to flooding which left thick layers of sands. Such rangelands will take years to recover unless intervened with appropriate nutrient inputs. Manure from night camps and milking yards are either left on the ground or heaped into piles around the herder's camp and not used for any purpose. Consequently, the areas around the camps are very fertile and infested with weeds.

Shrub Encroachment

In the past, shrub invasion has been periodically eliminated through burning. Following the ban of fires in early 1970s, encroachment by shrubs particularly, unpalatable species of Rhododendron, Junipers and Berberis have increased. This has brought the following consequences.

- i) Spatial reduction of grazing areas thereby increasing pressure on the accessible areas;
- ii) Competition for light, nutrient and moisture with meadow species;
- iii) Blocking of nutrient from the active natural cycling process in the range ecosystem;
- iv) Probable reduction of habitats and food supply for rodents and other herbivores like musk deer; and,
- v) Reduction of animal movements between grazing areas thereby increasing pressure on stock paths.

The encroachment by inedible shrubs and trees into semi-arid rangelands represent a plant community change that may be viewed either as a change for the better in terms of ground cover and soil erosion control, or as a change for the worse if considered for grazing due to reduction in grazing areas. Across the sites assessed in this study, moist and dry alpine shrubs (MAS and DAS) accounted for an average of 10 and 15% respectively, but with ranges between 0 and 50% for MAS and 0 and 30% for DAS. However, the north facing slopes which are mainly covered by MAS have little economic value since they are not suitable for grazing. The sunny faces which are generally south facing are the most critical ecological sites of the rangelands which are nearly always subjected to continuous grazing by both wild and domestic animals. On these sites shrubs occupy an average of 18% of the ground in the 16 locations surveyed ranging from 0 to 60%.

Herding Systems
The type of land ownership and grazing rights dictates the present herding system. Grazing lands were registered in an ad hoc manner based on visual estimation of areas by non-technical personnel from the government in the early 1970s. It was not revised since then. No cadastral surveys were carried out on the areas allotted to individual and groups, and no legal provisions exist as to the use of the lands apart from declaring that grazing lands are not to be used for other purposes (Land Act, 1979). The Draft Pasture Policy (1985) aimed at addressing this problem is yet to be rectified and approved. As a result, most traditional herding systems are breaking down under increased pressure from new herders over whose sharing of the resources the traditional herders have little control, particularly when the new herders are offshoots from the traditional herder families.

Improvement of Rangelands

Guiding Principles and Justifications
The guiding principles of rangeland improvement should be the environmental compatibility and long-term sustainability. The evaluation of a programme of rangeland development must be based not only on profitability, but also on the effects of the proposed development on soil conservation and animal welfare. It must also be looked upon as a means of retaining a way of life for the herders rather than just the profits that keep them farming. The conservation of assets, particularly the primary asset, soil, is also important. The improvement of highly eroded lands and poor soils may imply substantial financial investment and will not be profitable to herders. However, substantial technological and financial support for such improvement could be justified in terms of the conservation of land, the prolongation of the effective life of

the water heads and catchment areas which are highly vulnerable to erosion and silting.

Several surveys and studies have been conducted on the possibility for improvement of the rangelands (Roder, 1983 & 1990; Gibson, 1991; Gyamtsho, 1996). Based on the findings of these studies, several measures can be taken to improve the rangelands

Land Ownership and Property Rights

Any change in yak rearing system, however, must begin with a systematic survey to determine exact areas of grazing lands, and a review of land tenureship arrangements. Ultimately it should aim to allocate winter grazing lands on permanent ownership basis to herders in order to facilitate fodder conservation systems, and allocate summer pastures on long-term leases to individuals or a group of herders based on the present status of the use of each site. Once the information on area and ownership is established, institutions must be built into the community organisation to oversee the proper use and maintenance of grazing lands. The formation of User Group Associations (UGA) for different rangelands to oversee the timing and duration of grazing, management and maintenance of the pastures, control of stock numbers etc. must be given priority. The park management could monitor the functions of these UGAs with administrative and legal support from the *dzongkhag* administrations. This is not a new concept but an improvement on the systems which exists in a loose form in the use of some pastures in Laya, e.g Omtsa and Tsherijathang.

There is enough evidence from this study to show that policies have a lasting effect on the condition of the rangelands. The uncertainty concerning land ownership of grazing lands needs to be resolved in favour of vesting more responsibility with herders. This will be the prerequisite for any success in the improvement measures discussed in the pasture policy. The leasing systems need to be revised and regularised, and complimented by an appropriate in-built grazing right distribution and utilisation system. Selected winter pastures could be allocated to an individual herder or a group of herders on private ownership basis if the benefits from improvement measures are to be reaped. Such a delineation of property rights would have a long lasting impact on the future sustainable use of the rangelands for farming as well as the conservation of biodiversity.

Grazing Management

The introduction of appropriate measures to control grazing within the natural limits of the rangelands will be crucial in halting the degradation of rangelands. Protection from grazing is the cheapest means of range recovery and reclamation. It was seen from the experiment that protection from grazing alone has the potential to increase herbage biomass and ground cover. Similar results were obtained from alpine pastures in Pakistan where Mohammad (1986) reported that one-year closure resulted in four times forage yields and reseeding increased the density of grasses by 15%, and increased plants cover by about 30%. Rafi (1965) recommended a minimum period of five years of complete protection before initiating proper grazing management practices.

Although conventional grazing management systems as practised in the west will not be applicable, several options appear promising for improving rangelands through the adoption of better grazing management practices. The formation of UGA for each of the major summer and winter grazing areas should be the triggering point for improvement. This UGA should be entrusted with overseeing the number of animals per herd, the movement of animals in and out of pastures at prescribed times, participation in range improvement measures and the collection of grazing fees on an annual basis. The management of the Jigme Dorji National Park should have the capacity to advise and monitor the functions of the UGAs. The allocation of grazing rights to individuals must be based on stocking capacity of each site. Stocking capacity is determined usually in terms of Adult Units (AU) per area. However, the difficulty will lie initially in adopting suitable criteria for defining AU.

Improvement of fodder conservation through establishment of high yielding hay meadows in winter pastures will greatly facilitate grazing management and reduce pressure on winter grazing grounds. When such a scheme is successfully implemented in place, the productive units of animals can be fed with hay in feedlots near the camps, and would reduce pressure on the limited area of exposed meadows following snowfall.

Manipulation of yak herd composition offers another opportunity to indirectly improve grazing management. However, this is a long-term approach, and it has to be preceded by measures to reduce mortality in young replacement stock over winter and spring to build up herders' confidence and meet their need for security.

Species diversification of livestock has the potential to reduce pressure off the rangelands from high levels of competition between domestic and wild ungulates. Rearing of cattle and horses around the villages in Laya and Lingshi, and sheep in Lunana will reduce the dependence on yaks, and thereby, the level of competition that exist between yaks and blue sheep which share the same habitats.

Nutrient Management

The experiment clearly showed that nutrient deficiency is a major factor limiting growth and productivity during the short growing period between May and September when temperature and soil moisture conditions are favourable. The application of mineral N and P fertilisers resulted in highly significant increase in yields. However, high rates above 48 kg $P_20_5ha^{-1}$ per year does not appear to be beneficial since the plants may not have been able to utilise all the mineral P during the short growing season. The biggest benefit, however appear to be the increase in legume content of the sward following protection and P application.

It is apparent that improvement of the soil nutrient cycling would result in the minimum increase in biomass production and range condition improvement. Therefore, methods of improving nutrient inputs into the soil such as reduction of dung removal through better crop husbandry practices and alternative sources of fuel needs to be given priority. Better distribution of dung on the pastures from stock camps needs to be advocated.

While the high cost and logistics of transportation of mineral fertilisers to such remote areas rule out any large scale pasture improvement using fertilisers, there is merit in selective and discriminate use of chemical P fertilisers for initially favouring legumes for improving intensively managed protected hay meadows. There is no reason why individual households cannot transport a horse-load of superphosphate for this purpose. Once P levels are replenished, maintenance supply can be achieved from manuring with yak dungs. Such a system is successfully practised in the management of pastures in the Swiss Alps with similar growing conditions (J Noesberger, personal communications, May, 1996). The extent of leaching is not known but expected to be high in summer and hence non-water soluble from a P fertiliser may be of benefit.

In highly nutrient deficient and acidic soils, as found in Lingshi rangelands, it may be worth investigating the possibility of lime application besides fertiliser P if any meaningful recovery of vegetation is to be achieved. If found beneficial, the argument against the cost and logistics of such a practice may not be as valid as it sounds if the plots allotted for improvement per household are less than half a hectare. However, the long-term effects of liming of soil fertility needs to be borne in mind as it has a history of impoverishing the soils in the long run (Robson and Pitman, 1983). Once satisfactory levels of ground cover by desirable species are achieved, maintenance can be achieved through intensive manuring with regular checks on fertility status. On high altitude summer pastures, better distribution of dungs at the end of each grazing season would greatly enhance pasture growth in the following season. This could be achieved through herder education, and implemented under the supervision of the UGAs.

The sand covered winter pastures of Lunana present special problems of soil structure and fertility building. A strategy to hasten the process of reclamation would be to allot small plots from the affected areas to individual herders for establishing hay meadows. This can be achieved by camping of yaks overnight on the plots for a period of time to accumulate dung and urine which can be reinforced with mulch and composts from forests and shrubs in the surrounding slopes to build up soil organic matter and nutrient content. Such plots can be sown with high yield seeds introduced and local species of legumes and grasses, and intensively managed as hay plots.

Regular monitoring of the status of nutrients in the soil will be required in managing the soil fertility. Chemical soil analysis- soil testing- is a comparatively rapid and inexpensive procedure for obtaining information on nutrient availability in soils as a basis for recommending fertiliser application. Fertiliser trails in different locations would be required to test the information gained from the soil analysis.

Introduction of Exotic Legumes

The results show little value in introducing exotic high producing species like white clover and lotus. Promising local legumes like gueldenstadtia and vetch are productive with no apparent difference in herbage quality. While the results did not reflect the aggressive colonization by white clover in 1995 due to early spring defoliation and root damage in some plots by blue sheep, there is enough evidence to suggest that indiscriminate use of this species may result in competing out native species. More long-term research will scale adoption for high altitude pasture improvement. From observations on the demonstration plot which was established through soil cultivation, red clover was found to be very high yielding and may be a useful plant for establishing hay meadows in mixture with local grasses. Since it does not spread like white clover, it may be used safely in the winter pastures. In the summer pastures, it may be best to work with local legumes only.

Shrub Control

The control of shrubs in areas where soil erosion is not a threat needs to be taken up not only to open space for grazing but also to improve the nutrient cycling process and create habitat for plants and animals. Shrubs can be controlled either through prescribed and supervised burning. This is a standard rangeland management tool adopted in the United States and Australia. Gibson (1991) indicated that there is little harm in burning alpine brush areas on slopes less than 25% in the high altitude areas of Bhutan.

Evidences from the United States show that prescribed burning results in effective decrease in competition from shrubs, shrub cover, stem densities of shrubs, improved access to forage and better grazing distribution by livestock rather than remaining along the trails (Cook et al. 1994). However, depending on the shrub species, unless appropriate post-burn measures are taken, abundant shrub regrowth occurs and livestock distribution problems emerge as animals show preference for grazing in burned areas.

Success of burning depends on willingness of resource managers to understand and appreciate the importance of fire in maintaining a desired ecosystem. Pre-burn vegetative composition, soil moisture and fertility, fire intensity, precipitation and grazing following burning, and other factors are likely to contribute to variations in vegetative response among studies (Wright, 1985). Burning generally increases the production of herbaceous species. In one study in the United States, the total herbaceous current year's production averaged 2.2 times higher on the burns compared to controls until third year (Cook et al. 1994). Shrub survival varied among species and the type of burns. However, shrub cover declined between 35 to 50% of pre-burn levels. Burning significantly increased crude protein of herbs in all years and sites sampled, the protein content on the burns averaging 60% higher than on control.

When considering prescribed burning as a means to improve habitats for ungulates the short and long-term effects of fire on dietary and habitat needs of ungulates should be considered. In the United States repeated burning at frequent intervals (e.g. 5 years) is recommended to maintain high forage quality, and herbaceous productivity in general are unknown.

In the fragile terrain of the study area, where steep topography necessitates the retention of vegetation cover, introduction of goats would not be a sound measure for shrub control. The Royal Government of Bhutan has a rigid policy restricting the rearing of goats in free ranching conditions and this should be observed. Blue sheep were not seen browsing on shrubs. They preferentially graze on meadows. However, more studies need to be done on the woody diet habits of both domestic animals and wild herbivores in the high altitude rangelands. Mechanical clearing through slashing may not be practically and economically viable due to high labour demands. Hence burning offers the only alternative for controlling scrub vegetation. However, the introduction of prescribed burning systems should be preceded by thorough survey on the suitability of local topography, climate, soil and vegetation for such treatments.

Reseeding

The need to reseed is apparent in the heavily overgrazed pastures around Lingshi and the flood-washed valley floors of Lunana. Reseeding should, however, be carried out by local species as far as possible and discriminate use of exotic legumes and grasses except in the hay meadows where higher yielding exotic species can be used less discriminatorily. Appropriate mixture of grasses, legumes and herbs should be used in the seed mixture for such purpose. It is possible that mixtures of species with different root characteristics (distribution or function) could be used to exploit the soil volume more efficiently than monoculture of the component (Cornish, 1987). This could be achieved by exploiting different depths of the soil profile, or with roots intermingling in the same volume but exploiting different resources, mixtures of grasses and symbiotic legumes being the obvious example.

There are several local grass species which could be used for reseeding purpose to increase herbage production. The most promising are *Eymus, Bromus, Festuca* and *Calmagrostis* species. Species for forbs like *Bistorta* and *Cyananthus* may also have a place since they are valued highly as forage and seed production should be relatively easy. In Pakistan *dlymus Juncus, Festuca spp., Lolium pereme, Poa sinaica, Phleum alpanlcum, Medicago falcate, T. pratense, Artemesia marita and Indigofera gerardiana* are recommended for reseeding alpine rangeland (Mohamed, 1989). To facilitate the supply of seeds, a seed production scheme should be initiated whereby seeds collected by local people could be purchased by the government along the same terms as practised by the National Fodder Seed Production Centre in Bumthang.

Conclusion

The high altitude rangelands of Bhutan have sustained generations of yak herders, providing them forage for their herds and income from the collection of medicinal and incense plants. More recently, they have become important areas for recreation with the advent of tourism. Their importance in maintaining the integrity of Bhutan's river systems are getting increasing recognition. In order to ensure that the goods and services by these rangelands are sustained and further enhanced, urgent policy, legal and technical interventions are required.

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