Pak. J. Bot., 44: 127-136, Special Issue May 2012.

RANGELAND DEGRADATION AND MANAGEMENT APPROACHES IN BALOCHISTAN, PAKISTAN

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Abstract

Rangeland ecosystems have vital role in Balochistan due to many direct services to the society like food, forage, medicines, fuel, building materials, industrial products, and indirect services of maintaining the composition of the environment, mitigating climate and moderating weather, fertilizing and stabilizing soils, disposing of wastes, cycling nutrients, storing and purifying water. Rangelands degradation in Balochistan is a major issue and affecting not only the direct users of pastoral communities but many others benefiting from the environmental services. Some of the indicators of rangelands degradation include reduction in vegetation cover, above ground plant productivity, soil erosion, elimination of soil seed bank, and shift in species composition. Rangeland degradation is site specific due to spatial, temporal variation of vegetation and utilization practices. Studies on recovery of natural vegetation, re-generation of native species, seasonal biomass variations, evaluation of fodder shrubs and community based efforts are being carried out by the Arid Zone Research Centre (AZRC), Quetta in various districts of Balochistan. Above ground dry biomass production varies from 40 to 200 kg/ha in open areas as compared to 200 to 865 kg/ha in protected areas. Heavily grazed grasslands have good recovery potential under favourable climatic conditions. Re-generation potential of native range species is limited due to weak persistent soil seed bank and insufficient rainfall distribution during germination and establishment of seedlings. Biomass availability gradually declines and winter months are critical for grazing. Fodder shrubs like *Atriplex canescens* and *Salsola vermiculata* have potential for establishment of forage reserve blocks with micro-catchment water harvesting techniques. Communities degraded rangelands can be rehabilitated either by grazing management or plantation of drought tolerant fodder shrubs on appropriate sites. A viable and sound rangeland policy and implementation strategies are mandatory for conservation and utilization of the rangeland resources on sustainable basis.

Introduction

Range management and improvement is always a difficult task due to the interactions of various biological, environmental and social factors. Trends have been changed from traditional range management approaches like looking and focusing only on the biological factors and ignoring the social and traditional aspects of range management to community based and co-management approaches. It is hard to determine the value of rangelands in terms of environmental services like carbon sequestration, watershed management, bio-diversity and eco-tourism. In arid and semi-arid areas rangelands are the major free grazing areas for livestock round the year (Ahmad & Islam, 2011; Mirza *et al.,* 2006). However, many factors, climate, human, animals are causing degradation of rangelands. The indicators of rangeland degradation may vary from region to region but the common ones are elimination of preferred species, reduction in plant cover and bio-diversity, reduction in forage production, and increased soil erosion and runoff of rain water with little or no infiltration. All these factors are leading towards desertification. The rangelands of Balochistan (79% of total land area) are also facing similar problems. Therefore, range management must focuses on the protection, improvement and sustainable use of basic resources such as soils, vegetation, endangered plants and animals, wilderness, water and optimum production of goods and services in combination needed by the society. Sustainable land use is the fundamental premise upon which management of rangelands and other critically natural resources is based. Many degraded rangelands of Balochistan still have potential for improvement by natural or artificial re-vegetation, depending upon the kinds and amounts of vegetation remaining, climatic conditions, the feasibility of using grazing management practices and/or range improvement practices to accelerate succession processes, the expected recovery rate and the cost of alternative approaches.

Rangeland productivity in Balochistan is substantially affected due to non-existence of grazing management practices, low and erratic rainfall distribution, and over exploitation of natural resources. Most of the rangelands in Balochistan lie within the arid and semi-arid climatic zones. These ranges are degrading very rapidly in terms of biomass production and desirable range species. Most of the rangelands belong either to tribes or open grazing rangelands. The Pastoralists are facing number of challenges but the major one is shortage of feed and forage for livestock particularly in winter months (Bano *et al.,* 2009; Ahmad *et al.,* 2009). Major range management issues in Balochistan include: open range areas, no clear land ownership, weak community participation, recurrence of drought, and lack of integrated range management approaches. Arid and semi-arid areas are of Balochistan falling within the rainfall zones of 50-200 mm and 250-400 mm, respectively (Kidd *et al.,* 1988). Rainfall patterns are unpredictable with great variations. Range based small ruminant production is the major activity in the area coupled with rainfed agriculture. Sheep and goats are the main livestock of the province. Approximately 87% of the people in Balochistan directly or indirectly drive their livelihood from livestock rearing (Heymell, 1989). In Balochistan, mixed grass-shrub steppe is more common than single plant communities. The range vegetation types in Balochistan changes from south to north along the rainfall distribution. Grazing management may restore vigor and accelerate the spread of desirable species

(Vallentine, 1980). However, in arid and semiarid rangelands, grazing management alone may not accelerate the succession towards desirable species due to limited precipitation (Roundy & Call, 1988). A major concern of arid and semiarid ranges is the progressive reduction of productivity and diversity and how to manage these changes.

Rangeland types: Balochistan has six major ecological zones (cool temperate highlands, cool temperate mid-highlands, hot arid lowlands plains, hyper arid desert zone, coastal sub tropical zone, hot arid low plains canal irrigated) with eighteen micro-climatic conditions. The rangelands in Balochistan can be distributed into six types of landscapes, including mountains, uplands, piedmont, desert, flood plains and coastal plains. Generally, the rangelands of Balochistan categorized as Central Balochistan ranges (spread over Quetta and Kalat divisions), a Mediterranean climate, mean annual precipitation varies from 100 to 400 mm. Altitude ranges from 1000 to over 3000 m. Common range species are *Cymbopogon jwarancusa, Chyrsopogon aucheri, Juniperus macropoda, Pistacia* sp., *Fraxinus xanthoxyloides, Caragana ambigua, Prunus eburnean, Othonnopsis intermedia, Artemsia species, Seriphidium quettensis, Haloxylon griffithii, Alhagi camelorum*, P*eganum harmala, Othonnopsis intermedia.* Western Balochistan Ranges cover the desert areas of Chaghi, Kharan, Panjgur, Makran, Turbat, Gwadar and Lesbela districts. Rainfall is scanty (50-150 mm). Common range species are *Cousinia alepidea, Haloxylon griffithii, Alhagi camelorum, Saccharum ravannae, Stipa plumose, Tamarix* sp. *Zygophyllum atriplicoides*. *Suaeda fructicosa, Salsola* sp., *Panicum antidotale, Aeluropus repens* and *A. macrostachyus*. Eastern Balochistan Ranges are located in Zhob and Loralai districts of Balochistan. This region has better rainfall both in winter and monsoon seasons. Common range species are *Cymbopogon jwarancusa*, *Chrysopogon aucheri*, *Tetrapogon villosa*, *Pennisetium orientale*, *Pancium antidotale*, *Stipa pennata*, *Saccharum species*, *Poa bulbosa*. *Alhagi Camelorum*, *Ebenus stellatus*, *Caragana ambigua*, *Berberis Balochistanica*, *Prunus eburnea*, *Convolvulus* species, *Pistachia khinjuk*, *Acacia modesta*, *Olea cuspidate.*

Grazing systems: Nomadic, Transhumant and sedentary are the common pastoral systems in Balochistan. Nomads have no rangeland land resources but they are the major user of rangelands. Nomadic flocks move continuously in search of forage and migrate from uplands to lowlands in winter and from lowlands to uplands in spring. Transhumant flock owners have some dryland agricultural activities and also migrate along with the families to lowlands. Sedentary flock owner raise few animals on orchards, crop stubbles and also stale feeding. Two new nomads groups (Commercial nomads and Nomad Transhumant) have also been identified in Balochistan. The main characterizes of Pastoral communities are described in Table 1.

Table 1. Characteristics of pastoral communities in Balochistan.

Pastoral type	Characteristic
Nomadic	No ownership of Rangelands, Depends on animal production on rangelands, Continuous movement, winter in lowlands, summer in uplands, Purchase fodder crops during winter, flock size vary from 200-700. Camels and donkeys are also important flock composition
Baloch Nomads	Baloch nomads are always local nomads, do not cross international boundaries.
(i) Brahvi Nomads	Roam in districts of Quetta, Mastung, Kharan, Kalat, Khuzdar, Balochi sheep is common in flocks, Brahvi nomads have become transhumant
(ii) Murri Nomads	Found in districts Kohlu, Bibrik sheep dominates, Migrate in two directions (during summer Districts Loralai, Killa Saifullah, during winter towards districts Sibi and Kacchi)
Pashtoon Nomads (Locally called Powinda)	Generally in northern Balochistan Districts of Pishin, Killa Saifullah, Ziarat, Loralai, Zhob and also Afghanistan, migrate in winter towards warmer areas of Khyber Pakhtunkhwa, Punjab, Sindh and Balochistan
International Nomads	Mostly Pashtoon nomads, cross the international boundary of Pakistan and Afghanistan, also reported to enter in the Central Asian States
Afghan Refugees	Accidental nomads, greatly built pressure on rangeland resources, key operators to induce shifts and changes in historically classified socio-economic systems of Pastoralists
Commercial Nomads	Mostly Pushtoon and Afghan, do not own any flock, establish camps in the suburbs of a good livestock market, buy few animals when prices are low, regular market visit, daily buy and sale on some profit
Nomad Transhumant	Have fixed one point on summer ranges, occupied rangelands with no recognized ownership (classical example in Kuchlak area), flock number less than 100, family members also work as a labor, some have tractors, migrate during winter and summer
Transhumant	Own some agricultural property, dryland crop production, shorter spatial movement, small flock size than nomads (20-80)
Sedentary	Permanent settlement, do not migrate, keep livestock mainly for domestic use, actively involved in irrigated agriculture. Flock size may range from 5-15.

Source: MINFAL, ICIMOD, NADRI, 2000. FAO, 1983

Rangeland degradation: Rangeland degradation is occurring as a result of no grazing management plans, removal of vegetation for fuel wood and no clear authority of rangeland ownership. The major indicators of rangelands degradation are shift in species composition, loss of range biodiversity, reduction in biomass production, less plant cover, low small ruminant productivity, and soil erosion (Ahmad & Ehsan, 2012). Perennial grasses and palatable shrub species are confined to only in some protected Forest Areas. The degradation of rangeland in Balochistan is site specific and depends on the existing vegetation, grazing pressure, grazing accessibility, human population, availability of stock water, and tribal conflicts (Ahmad & Islam, 2011). Perennial grass like *Chrysopogon aucheri* a highly palatable species is gradually replacing by low palatable species of *Cymbopogon jwarancusa* and shrubs like *Artemisia* species or *Haloxylon* species. Even at many rangelands these shrub species have been replaced by unpalatable shrub species like *Peganum harmala* and *Othonophsis intermedia* with clear evidence of soil erosion. Pastoral communities have some realization about the rangeland degradation by assessing their livestock production or health, forage availability and traveling in search of forage. However, the impact of rangeland degradation on other services like carbon sequestration, conservation of plant and wildlife biodiversity, water harvesting and spreading, infiltration, and many other environmental services are either not monitored, documented or disseminated the information among the various sectors of the society. Recovery of range vegetation at some sites in Balochistan is still possible by protection and proper utilization while severely degraded rangelands may not return to their original state even when rested for a longer time and require heavy investment for rehabilitation.

Range management/improvement approaches: Range management is a combination of many factors like biological (vegetation, animals), physical (climate, topography etc.) and social (need, importance and participation). The objectives of range management programs may vary but optimizing the return by manipulating the range eco-system is the ultimate goal of any range management intervention. In Balochistan various activities on range management and improvement were carried and some important studies are highlighted.

Rangeland monitoring: The dynamics of the degradation process in Balochistan is poorly documented largely because of the fact that very little quantitative information is available on the intensity of degradation as a result of overgrazing/over-exploitation of the rangelands. Long-term range monitoring studies were conducted to assess rangeland dynamics and trends in terms of biomass availability and permanent vegetation cover. The measurements of long-term changes in biomass and vegetation cover were taken on three rangeland vegetation types: Tomagh (bunch grass vegetation type), Kovak/Zarchi (*Haloxylon-Artemisia* shrub steppe) and Hazarganji (*Artemisia* species pure stand). Range vegetation attributes at various sites is presented in Table 2. The percent vegetation at various sites ranged from 8.6% to 18.7%. *Artemisia* species, *Haloxylon griffithii*, *Cymbopogon jwarancusa* and *Chrysopogon aucheri* are the main grazable species. At Tomagh the open grasslands productivity was very low as compared to the protected grassland sites (Table 2). As most part of the Western mountain region falls in the typical arid, semi arid continental Mediterranean zone, occurrence of dry spells is not un-common to this region. The analyses of long term rainfall data of Quetta valley (average 250 mm per annum) suggests that out of ten years, three years are above average, while three years are average and the remaining four years are below average (Kidd *et al.,* 1988). Forage biomass data collected from the range sites in a typical mountain region show that the rangeland productivity is more a function of seasonal rainfall rather than the grazing pressure alone.

Shrubs biomass of native range species: Biomass production is an important component of rangelands. Shrub biomass can be estimated by various destructive and non-destructive methods. Shrub biomass of nine native range species was estimated by dimensional method at a protected site. For small shrubs 50 plants at random were picked. For each plant canopy dimensional (D1, D2) and plant height was recorded whereas for large shrubs 15 plants were used for recording various data. After recording data, each plant was harvested and fresh standing weight was recorded immediately. After oven drying the plants, leaves and wood were separated and weight was recorded. The canopy cover and canopy volume was calculated by using the formula: Canopy cover= $1/4\pi D1D2$ and Canopy Volume=$1/6\pi\ D1D2.h$. Regression equations for each species were developed for calculating the standing biomass, grazable biomass and wood production per plant. Average plant height, longest crown diameter, shortest crown diameter, canopy cover, canopy volume, standing fresh biomass, grazable forage and wood per plant of various native range shrub species are presented in Table 3. The grazable forage per plant of various species ranged from 4 to 102 g/plant. The regression equations calculated by using canopy cover and canopy volume as an independent variables are presented in Tables 4 & 5. These equations will help both range managers and researchers for calculating the shrub biomass production in range management and range improvement program.

Biological recovery of range vegetation: Studies were carried out to determine the potential of biological recovery of heavy grazed grasslands and shrub land by protecting the area from grazing. Dry matter forage production was recorded in open and protected exclosures. Dry matter forage production and carrying capacities of different sites are presented in Table 6. The calculation of carrying capacity is based on the average live weight of Balochi ewe (33 kg), forage requirements @ 3.0% of live body weight (1 kg/day), proper use factor (50%), assumptions of no fuel wood extraction and ignoring the animal grazing preference. Although, the concept of carrying capacity is not fully applied in the ranges of Balochistan due to spatial, temporal, topographic variation in vegetation and opportunistic grazing approach of nomads. Forage productivity was estimated with 1x5 m^2 quadrate randomly placed at different range areas. Twenty samples were taken from each area. The vegetation inside the quadrate was clipped at ground level, separated into species and oven dried. The dry matter forage production was converted into kg/ha. Above ground dry matter biomass productivity inside exclosure of shrub land was 199 kg/ha compared to protected site of 320 kg/ha. Total rainfall and above ground biomass productivity inside and outside exclosures of grassland are presented in Table 7. Annual total rainfall varies from 115 mm to 334 mm from 1996 to 2002. The rainfall distribution during spring 2003 was better and 207 mm rains were received from January to May, 2003. The rainfall of 2000 and 2001 was less than 120 mm. Above ground biomass productivity inside exclosure vary from 224 kg/ha to 605 kg/ha compared to outside exclosure of 17 to 279 kg/ha (Table 7). Grassland at Tomagh has responded more vigorously to protection and biological recovery. Heavy grazed grasslands of Tomagh have potential of biological recovery if protected from grazing at least three to four years depends on rainfall distribution (Table 7).

The rate of biological recovery might be slow as expected in the arid and semiarid climatic zones. The rate of recovery is also related with the rainfall distribution rather than total rainfall distribution. However, very long-term protection may not yield better results due to accumulation of dead old material which reduced both quality and quantity of grasses (Ahmad *et al.*, 2009; Bano *et al.*, 2009). Strong vegetation recovery response has been reported even under desert conditions with mean annual rainfall as 60-80 mm under deep and permeable soils (Le Houerou, 1992).

Table 2. Range vegetation characteristics at various sites in Balochistan.

Vegetation parameters	**Hazarganji *Artemisia* pure stand (open grazing)**	**Kalat (Kovak) *Artemisia-Haloxylon* shrub steppes (open grazing)**	**Ziarat (Tomagh) *Cymbopogon-Chrysopogon* grassland (open grazing)**	**Ziarat (Tomagh) *Cymbopogon-Chrysopogon* grassland (protected)**
% Vegetation	8.6	14.8	12.8	18.77
% *Artemisia* species	7.3	11.8	0.00	0.00
% *Haloxylon griffithii*	0.00	2.6	0.00	0.00
% *Astragalus* species	0.8	0.00	0.00	0.00
% *Cymbopogon jwarancusa*	0.00	0.00	10.44	16.45
% *Chrysopogon aucheri*	0.00	0.00	2.04	2.01
% Annuals	0.2	0.3	0.15	0.93
% Litter	0.1	0.4	0.06	0.37
% Rock	6.8	0.3	1.56	1.62
% Bare Soil	84.6	84.6	85.58	79.24
Total above ground biomass (kg/ha)	273.75	1012	15.33	287.25
Above ground biomass *Artemisia* species (kg/ha)	242.5	902	0.00	0.00
Above ground biomass *Haloxylon griffithii* (kg/ha)	0.00	105.5	0.00	0.00
Above ground biomass *Astragalus* species (kg/ha)	27.25	0.00	0.00	0.00
Cymbopogon jwarancusa Biomass (kg/ha)	0.00	0.00	13.33	259
Chryoposon aucheri Biomass (kg/ha)	0.00	0.00	2	28.25
Above ground biomass annuals (kg/ha)	4	2.5	0.00	0.00
Leaf/wood ratio *Artemisia* species	0.2766	0.18	0.00	0.00
Leaf/wood ratio *Haloxylon griffithii*	0.00	0.23	0.00	0.00
Leaf/wood ratio *Astragalus* species	0.723	0.00	0.00	0.00
Grazable dry matter *Artemisia* species (kg/ha)	67.076	162.36	0.00	0.00
Dry Wood of *Artemisia* species (kg/ha)	175.42	739.64	0.00	0.00
Grazable dry matter of *Astragalus* species (kg/ha)	5.586	0.00	0.00	0.00
Dry wood of *Astragalus* species (kg/ha)	21.66	0.00	0.00	0.00
Grazable dry matter of *Haloxylon griffithii* (kg/ha)	0.00	24.26	0.00	0.00
Dry wood of *Haloxylon griffithii* (kg/ha)	0.00	81.23	0.00	0.00

Table 3. Average plant height, longest crown diameter, shortest crown diameter, canopy cover, canopy volume, standing fresh biomass, grazable forage and wood per plant of various species.

Species	Plant height (cm)	Longest crown diameter (cm)	Shortest crown diameter (cm)	Canopy cover (cm^2)	Canopy volume (cm^3)	Standing fresh weight per plant (g)	Grazable forage per plant (g)	Dry wood per plant (g)
Seripdidium quettense	40.76 ± 1.29	41.00 ± 1.97	36.94 ± 1.89	1326.65 ± 121.40	5866.94 ± 6289.14	122.47 ± 9.98	43.49 ± 3.15	42.42 ± 3.12
Ebenus stellata	41.08 ± 1.62	44.84 ± 2.33	36.98 ± 2.16	1484.89 ± 161.86	67296.57 ± 8616.44	126.20 ± 4.68	16.77 ± 0.77	82.42 ± 2.77
Haloxylon griffithii	33.12 ± 1.03	42.88 ± 1.52	35.12 ± 1.25	1247.05 ± 86.44	42635.91 ± 3574.75	177.35 ± 12.24	65.26 ± 4.41	43.03 ± 2.47
Berberis balochistanica	98.75 ± 13.58	81.87 ± 14.7	68.12 ± 11.8	5296.29 ± 1460.03	648140.20 ± 21954	1081.87 ± 242	85.62 ± 22.76	711.25 ± 145.72
Caragana ambigua	60.66 ± 3.89	70.33 ± 7.50	65.00 ± 7.04	4152.26 ± 840.85	269281.20 ± 57525	772.26 ± 108.7	102.20 ± 20.20	730.50 ± 203.56
Astragalus anisacanthus	29.64 ± 0.82	26.66 ± 0.88	23.90 ± 0.91	529.23 ± 36.70	16511.80 ± 1423.69	63.51 ± 1.76	4.80 ± 0.19	56.44 ± 1.59
Prunus eburnean	87.33 ± 7.08	62.53 ± 7.00	49.33 ± 6.41	2823.90 ± 882.10	319602.30 ± 14934	1543.00 ± 296	90.33 ± 11.78	1078.00 ± 195.95
Astragalus stocksii	72.00 ± 3.57	71.00 ± 5.79	60.66 ± 5.31	3686.88 ± 580.32	277759.00 ± 51295	896.33 ± 140.5	50.66 ± 8.10	625.00 ± 106.00
Convolvulus stocksii	49.53 ± 2.55	57.00 ± 3.95	42.60 ± 5.13	2068.47 ± 403.81	101084.50 ± 23910	534.33 ± 88.33	67.33 ± 8.98	254.60 ± 48.30

Table 4. Regression equations for predicting standing fresh biomass, grazable biomass, and dry wood production per plant of shrub species in Balochistan (canopy cover as an independent variable).

Species	Dependent variable	Independent variable	Equation	R^2
Seripdidium quettense	Standing biomass	Canopy cover	Y=30.68 + 0.069x	0.70
	Grazable biomass	Canopy cover	Y=0.017 + 20.05x	0.46
	Dry wood	Canopy cover	Y=15.40 + 0.020x	0.63
Ebenus stellata	Standing biomass	Canopy cover	Y=123 + 0.0021x	0.0055
	Grazable biomass	Canopy cover	Y=17.08 - 0.00021x	0.0019
	Dry wood	Canopy cover	Y=77.69 + 0.0031x	0.034
Haloxylon griffithii	Standing biomass	Canopy cover	Y=61.33 + 0.093x	0.43
	Grazable biomass	Canopy cover	Y=36.41 + 0.023x	0.21
	Dry wood	Canopy cover	Y=29.14 + 0.011x	0.15
Berberis balochistanica	Standing biomass	Canopy cover	Y=354.90 + 0.137x	0.68
	Grazable biomass	Canopy cover	Y=20.03 + 0.012x	0.63
	Dry wood	Canopy cover	Y=279.89 + 0.081	0.66
Caragana ambigua	Standing biomass	Canopy cover	Y=754.70 + 0.0042x	0.0011
	Grazable biomass	Canopy cover	Y=43.94 + 0.014x	0.34
	Dry Wood	Canopy cover	Y=281.47 + 0.059	0.49
Astragalus anisacanthus	Standing biomass	Canopy cover	Y=52.85 + 0.020x	0.17
	Grazable biomass	Canopy cover	Y=3.97 + 0.0015x	0.083
	Dry wood	Canopy cover	Y=46.92 + 0.17x	0.17
Prunus eburnean	Standing biomass	Canopy cover	Y=665.76 + 0.310x	0.85
	Grazable biomass	Canopy cover	Y=58.42 + 0.112x	0.72
	Dry wood	Canopy cover	Y=541.49 + 0.189x	0.73
Astragalus stocksii	Standing biomass	Canopy cover	Y=282.64 + 0.166x	0.47
	Grazable biomass	Canopy cover	Y=41.37 + 0.0025x	0.032
	Dry wood	Canopy cover	Y=161.92 + 0.125x	0.47
Convolvulus stocksii	Standing biomass	Canopy cover	Y=218.38 + 0.152x	0.49
	Grazable biomass	Canopy cover	Y=38.54 + 0.0139x	0.39
	Dry wood	Canopy cover	Y=90.85 + 0.079x	0.44

Table 5. Regression equations for predicting standing fresh biomass, dry grazable biomass, and dry wood production per plant of shrub species in Balochistan (canopy volume as an independent variable).

Species	Dependent variable	Independent variable	Equation	R^2
Seriphidium quettense	Standing biomass	Canopy volume	Y=44.05 + 0.0013x	0.71
	Grazable biomass	Canopy volume	Y=24.06 + 0.0003x	0.41
	Dry wood	Canopy volume	Y=18.89 + 0.0004x	0.65
Ebenus stellata	Standing biomass	Canopy volume	Y=127.40 - 1.78x	0.001
	Grazable biomass	Canopy volume	Y=17.57 - 1.190x	0.017
	Dry wood	Canopy volume	Y=80.35 + 3.07x	0.0091
Haloxylon griffithii	Standing biomass	Canopy volume	Y=79.10 + 0.0023x	0.45
	Grazable biomass	Canopy volume	Y=39.25 + 0.00061x	0.24
	Dry wood	Canopy volume	Y=29.32 + 0.0003x	0.21
Berberis balochistanica	Standing biomass	Canopy volume	Y=495.35 + 0.00090x	0.67
	Grazable biomass	Canopy volume	Y=32.47 + 8.20x	0.62
	Dry wood	Canopy volume	Y=362.53 + 0.00053x	0.66
Caragana ambigua	Standing biomass	Canopy volume	Y=765.66 + 2.45x	0.00016
	Grazable biomass	Canopy volume	Y=43.95 + 0.00021x	0.37
	Dry wood	Canopy volume	Y=286.23 + 0.00089x	0.53
Astragalus anisacanthus	Standing biomass	Canopy volume	Y=54.88 + 0.0005x	0.18
	Grazable biomass	Canopy volume	Y=4.08 + 4.33x	0.096
	Dry wood	Canopy volume	Y=48.70 + 0.0005x	0.17
Prunus eburnea	Standing biomass	Canopy volume	Y=951.86 + 0.0018x	0.86
	Grazable biomass	Canopy volume	Y=68.65 + 6.78x	0.74
	Dry wood	Canopy volume	Y=718.98 + 0.0011x	0.73
Astragalus stocksii	Standing biomass	Canopy volume	Y=331.81 + 0.0020x	0.55
	Grazable biomass	Canopy volume	Y=42.80 + 2.83x	0.032
	Dry wood	Canopy volume	Y=192.05 + 0.0015x	0.57
Convolvulus stocksii	Standing biomass	Canopy volume	Y=262.38 + 0.0026x	0.53

Table 6. Average dry matter forage production in different range areas.

Location	Vegetation type	Dry matter forage production (kg/ha)		Carrying capacity ha/ewe/year	
		Protected	Open	Protected	Open
Tomagh, Ziarat	*Cymbopogon jwarancusa*, *Chrysopogon aucheri*	438.00	88	1.67	8.29
Kovak, Kalat	*Artemisia quettensis*, *Haloxylon griffithii*	320.00	199.68	2.27	3.65

Table 7. Total annual rainfall (mm) and (mean ± SE) above ground grasses biomass production (DM kg/ha) inside and outside exclosures at Tomagh during spring season.

Year	Total annual rainfall (mm)	Biomass production (DM kg/ha) inside exclosure	Outside exclosure
1996	187	560.00 ± 51.08	187.33 ± 20.34
1997	316	605.50 ± 85.15	279.00 ± 13.52
1998	334	468.50 ± 50.35	136.50 ± 22.91
1999	300	575.50 ± 34.47	68.00 ± 2.62
2000	110	287.25 ± 75.69	17.00 ± 3.08
2001	179	224.00 ± 24.67	24.50 ± 8.65
2002	115	228.50 ± 19.92	16.00 ± 1.65
2003*	207	601.55 ± 49.52	37.50 ± 11.70

DM = Dry matter, *Rainfall from January 2003 to May 2003

Grazing response of perennial bunchgrasses: Grazing response of perennial bunchgrasses (*Cymbopogon jwarancusa* and *Chrysopogon aucheri*) was determined at Range & Livestock Research Station, AZRC Tomagh (Ziarat district) from 2007 to 2009. Annual long-term rainfall (average 1985-2007) was reported 258 mm and maximum rainfall occurs from January to April. During August, 2007 the experiments was initiated on seven protected range exclosures. These exclosures were protected from grazing for the last three years. Harani breed ewes were used for this experiment. In each exclosure 13 Harnai ewes with age 3-4 years were allowed for grazing. The ewes were also offered supplemental ration (cotton seed cake 45%, barley grain 45%, wheat straw 9% and common salt 1%). This ration was offered @ 500 gram daily during three reproductive stages i.e., flushing (before breeding) during 15-30 September, 2007, gestation during 15 December, 2007 to 15 January, 2008 and early lambing during 1-30 March, 2008. Monthly weight gain of these ewes were recorded and also compared with another ewes group allowed for grazing in open range area and also offered similar rations. The length of grazing period was varied in each exclosure according to the size and availability of forage production. The grazing was initiated on 14th August, 2007 and then stopped during January, 2009 (Table 8). The animals were allowed for grazing from morning to evening. The utilization was about 90% in each exclosure as the open grazed areas. Before the start of the grazing, total above ground biomass in each exclosure was sampled. In each exclosure three $1m^2$ quadrates were used for biomass sampling. The sampling was carried out at random in each exclosure. Plants were clipped within $1m^2$ quadrate at ground level. Each sample was separated by species wise. The samples were dried at 60°C for 48 hours and dry matter production was calculated on ha basis. Biomass production was again monitored in May and October, 2008 after three months rest period of vegetation. Plant height and tillers/plant of grazed and un-grazed areas was also recorded.

Table 8. Grazing cycle adjusted according to the growth and forage availability.

Grazing cycles	Grazed/Rested
14th August 2007 to 9th March, 2008	Grazed
10th March 2008 to May, 2008	Rest
June to July, 2008	Grazed
August to October, 2008	Rest
November-08 to January, 2009	Grazed

Total rainfall during 2008 was recorded 214.8 mm at Tomagh with winter and summer distribution. Rainfall in April, 2008 (30.4 mm) and in July and August, 2008 (20.8 mm and 95.2 mm) provided good soil moisture for the recovery of vegetation after grazing. Total rainfall during 2009 from January to December was recorded 428.4 mm. The rains during 2009 received during winter, spring and summer seasons. Total average above ground dry biomass in exclosures before grazing was 820 kg/ha. After grazing and three months rest period the total average above ground biomass was 482 kg/ha in May, 2008 and 251 kg/ha in October, 2008. The results indicate that at least three months rest period during active growth period of natural perennial bunchgrasses are required for recovery of vegetation. Grazing in protected grassland had increased the tillering capacity of both *Cymbopogon jwarancusa* and *Chrysopogon aucheri* (Table 9). The ewes grazed in the protected exclosures maintained body weight while ewes grazed in the open range area reduced the body weight. The forage availability of rangelands during the critical feed supply period (fall & winter) can be overcome by proper grazing and management practices like resting the some area for winter grazing.

Table 9. Plant height (cm) and Tiller per plant of *Cymbopogon jwarancusa* and *Chrysopogon aucheri* in grazed and un-grazed blocks.

Species	Plant Height (cm)		Alive Tillers/Plant		Dead Tillers/Plant	
	Grazed	Un-grazed	Grazed	Un-grazed	Grazed	Un-grazed
Cymbopogon jwarancusa	68.11 ± 1.89	67.87 ± 2.19	45.40 ± 1.33	18.50 ± 0.885	0	28.13 ± 1.66
Chrysopogon aucheri	34.84 ± 1.31	46.53 ± 1.04	43.97 ± 1.75	28.23 ± 1.32	0	35.0 ± 1.08

Regeneration ecology of native species: *Chrysopogon aucheri* and *Cymbopogon jwarancusa* are the dominant bunchgrasses in grassland ecosystems of upland Balochistan. These grasses are found on a wide variety of soils over a wide range of elevations, and play an important role in ecosystem level processes (Ahmad *et al.,* 2000a). Both species provide major source of forage for small ruminants. *Chrysopogon aucheri* is more susceptible to heavy grazing than *Cymbopogon jwarancusa* due to its greater palatability. Management strategies aimed at reversing the degradation of *Cymbopogon-Chrysopoggon* grasslands require an understanding of many aspects of plant recruitment. Regeneration of most grass species depends on the production of viable seeds, patterns of seed dispersal, seed predation, seed bank dynamics and the presence of suitable microsites and environmental conditions for germination and seedling establishment (Aguiar & Sala, 1997; Russell & Schup, 1998). Experiments were conducted to determine how seed attributes, seed dispersal mechanisms, seed bank dynamics, seed predation and seedbed microhabitats influence the regeneration of *Chrysopogon aucheri* and *Cymbopogon jwarancusa*. Field studies were conducted during the 1996 and 1997 growing season in a *Cymbopogon-Chrysopogon* grassland at Chilton National Park, to determine, the morphology and viability of seeds, pattern of dispersal of spikelets from plants of both species to the soil surface, movement of spikelets of these species on the soil surface, the loss of spikelets of both species to predators, and spatial and temporal patterns of soil seed reserves in different microhabitats, and role of microhabitats and precipitation on the germination and establishment of *Chrysopogon aucheri* and *Cymbopogon jwarancusa*.

Cymbopogon jwarancusa was superior to *Chrysopogon aucheri* in several aspects of plant recruitment. *Cymbopogon jwarancusa* produced more filled and viable caryopses than *Chrysopogon aucheri*. Spikelet morphological features and dispersal time were similar for both species; however, *Chrysopogon aucheri* solely dispersed triplet spikelet, whereas *Cymbopogon jwarancusa* dispersed paired spikelets and groups of spiklelets (partial racemes, entire racemes, and partial inflorescence). Paired spiklelets and partial racemes of *Cymbopogon jwarancusa* dispersed further from parent plants than triplet spikelets of *Chrysopogon aucheri*. Ant (Tica verona) predators appeared to have a greater preference for *Chrysopogon aucheri* spikelets than *Cymbopogon jwarancusa* spikelets. Both species had a weakly persistent seed bank; however, *Cymbopogon jwarancusa* had greater numbers of spikelets in the soil surface layer of representative microhabitats than *Chrysopogon aucheri (*Ahmad *et al.,* 2000abc*)*. Perennial grasses usually have a transient seed bank (Kinucan & Semeins, 1992) and livestock grazing can have a significant impact on aboveground vegetation and the soil seed bank in many grassland communities.

Seedbed microhabitats and precipitation strongly influenced the emergence and survival of seedlings of both species. The gravel interspaces provided the best sites for seedling establishment and survival. Seedlings of both species emerged and survived in most of the microhabitats under natural spring precipitation; however, applying supplemental water to simulate a wet spring enhanced emergence and survival. *Cymbopogon jwarancusa* had more seedlings emerging and surviving than *Chrysopogon aucheri* in all microhabitats except under the canopies and dead centers of *Chrysopogon aucheri* plants. Plant establishment by seedling recruitment is only successful when plant requirements for seed germination, seedling establishment and subsequent growth are matched with the micro-environmental factors of the seedbed (Harper, 1977). Monsoon rains in late July encouraged emergence of both species, although all seedlings died by the end of the growing season. Both species are capable of natural regeneration when protected from livestock grazing; however, it appears that *Cymbopogon jwarancusa* has a distinct advantage over *Chrysopogon aucheri* during the initial stages of plant recruitment. Recruitment of both species is probably very sporadic because of the variability in the amount and distribution of precipitation within and between years.

Seriphidium and *Artemisia* are the dominant range shrub species in highlands of Balochistan and provide grazing and fuel wood material (Ahmad *et al.,* 2007). Regeneration ecology of *Seriphidium quettense* was studied at a protected site in Chilton National Park Hazarganji. Seed dispersal of this species start in early winter and continued till early spring. Wind and rains are the primary seed dispersal sources. Disperal unit is capitulum most often without outermost whirl of phyllaries. Generally one achene per capitum but two to three achenes were also found. Mean seed dispersal distance was 23 to 40 cm from parent plant to ground surface. Higher soil seed bank densities were recorded under the plant canopies and in the upper (0-2 cm) soil layer (Table 10). Rainfall during March and April promoted seed germination. Seedling growth rate was extremely slow under natural conditions and seedlings need to be protected from grazing and trampling for successful establishment of plant population (Gul *et al.,* 2007) and supplemental watering is also required in case of limited rains during the first year of growth (Ahmad *et al.,* 2010).

Table 10. Re-generation characteristics of *Seriphidium quettense.*

Plant height (cm)		27.8 ± 4.32
Number of seeds (achne/plant)		392 ± 4.32
Seed viability (cm)		55.0 ± 5.25
Mean seed dispersal distance (cm)		39.9 ± 1.03
Soil seed bank (Seeds/m^2)	Minimum	5.0 ± 3.4
	Maximum	48.0 ± 13.0
Seedling growth in natural condition (cm)		2.94 ± 0.11
Seedling growth in pots (cm)		25.78 ± 5.11

Potential multi-purpose fodder shrubs for range improvement: Various exotic shrub species were evaluated in Balochistan for range rehabilitation and establishment of forage reserve blocks. *A. canescens* and *A. lentiformis* have potential in highland areas of Balochistan due to their cold tolerant characteristics. These species can survive under the extreme winter temperature of –15°C (Mirza *et al.*, 2000). *A. amnicola* or river saltbush originated from Western Australia and has excellent productivity and feed value, drought tolerant but is fairly cold sensitive. It is a highly productive and palatable shrub but sensitive to over-browsing and frost. *Atriplex amnicola* has potential in the plain areas of Balochistan. *Atriplex nummularia* or old man saltbush has good ecological adaptation, production potential, overall palatability, and feed value. Drought tolerance is fairly high and the plants can grow with mean annual rainfall of 250 mm. However, old man saltbush is not cold tolerant. The pants are sensitivity to over-browsing and a full 8-10 month rest period appears necessary after defoliation. The biomass and productivity of *Atriplex* species is highly variable, depends upon the ecological condition of the soil and climate as well as the management applied. Dry matter biomass production of *Atriplex* species recorded up to 2.5 t/ha in Balochistan. Young leaves and twigs show a much better forage quality, with higher nitrogen content and a lower amount of ashes and salts. The crude protein content in leaves of *Atriplex* species ranged of 12-18%. Like other halophytes, *Atriplex* species have low energy values because of high ash contents. Grazing of *Atriplex* species with wheat/Barley straw could lead to a well balance ration and fulfill the nutritional requirements of small ruminants (Thomson *et al.,* 1997).

Salsoal vermiculata commonly called saltwort is an exotic Mediterranean arid zone fodder species. This species belongs to the Chenopodiaceae family. *S. vermiculata* has the potential of self-regeneration and establishment under good rainfall years (Murad, 2000). *S. vermiculata* initiate new growth in late winter or early spring (depends on rainfall distribution) and provides a considerable amount of palatable forage for small ruminants. It is not an ever-green species, however, if sufficient rains occur during winter months it retains new vegetative growth. Maximum growth has been observed from April to May. Its height ranges between 35 and 110 cm. Crown cover ranges from 45 to 57 cm^2. Forage production ranged from 250-650 kg/ha with an equal amount of wood production. Crude protein content ranged from 15-18% (Ahmad *et al.,* 2006; Ahmad & Islam, 2005).

Community based range management approach: Sustainability of any range management program depends on the involvement and participation of local communities. Therefore, efforts have been directed to initiate CO-management rangeland approach in Balochistan. Community based range management and improvement activities were carried out in Mastung, Kalat, Ziarat and Loralai districts of Balochistan. At Mangochar (Kalat) five hundred hectares of degraded rangeland was protected with community participation. The main range vegetation of the area include: *Haloxylon grifithii*, *Artemisia* species, *Peganum harmala*, *Hertia intermedia, Astragalus stocksii*, *Convolvulus leiocalycinus, Poa bulbosa, Saccharum* species, *Cymbopogon jwarancusa*, *Chrysopogon aucheri.* Above ground dry matter forage production at community protected site was increased from 40/ka to 190 kg/ha. Similarly at Mastung, improvement in range productivity has been recorded from 40 to 300 DM kg/ha with better biodiversity of range species. The community also collected some native medicinal plants like *Achillea santolina*, *Matricaria lasiocarpa*, *Ziziphora clinopodiodes* from the protected site. Fodder shrubs like *Atriplex canescens* and *Salsola vermiculata* were also established on community degraded rangelands under micro-catchment water harvesting structures. The community based experienced indicate that involvement of community at all decision level is very essential for any sustainable range management and improvement program (Ahmad *et al.*, 2009; 2011).

Conclusion

Utilization of rangelands without any grazing management plan and extraction of vegetation for fuel wood are the major causes of rangeland degradation. Feed scarcity particularly in winter months is the major constraint of small ruminant production. Increase in forage production in the plain areas of Balochistan may delay the early spring migration of nomads from summer grazing areas. Provision of stock water particularly in mountain rangelands during summer months may provide additional grazing period. Reseeding either with native or exotic grass species is not feasible, uncertain and very costly intervention. Pitting of flat lands encouraged seed trapping, water and seedling establishment. Eradiation of less preferred species like *Haloxylon griffthii* is not desirable due to high erosion risk and difficult to establish a cover of preferred species. Re-generation of native species should be given more emphasis because they evolved under the extreme climatic and grazing. Effective protection of the range area is pre-requisite for the success of any range management program. However, fencing is too expensive, traditional systems for resting some range areas should be encouraged. At least four to six years protection of vegetation from grazing is essential for recovery of heavily grazed rangelands and proper utilization. The use of hay, concentrates or mineral supplements during breeding, lambing and lactation is essential for small ruminant production. De-stocking is hard because the higher herd size is considered the wealth of the nomads. However, it is possible to raise a lamb of marketable size in one season from February-March to October-November of the same years with grazing and supplemental feeding. Conflict resolution for land ownership and resource utilization is very important and all the stakeholders should be involved with responsibilities before the implementation of any community based range management interventions. Creation of a separate Range Management Directorate under the Balochistan Forest Department is vital for planning, policy, research and development of a holistic range management approach and shift in range projects to range programmes approach.

Acknowledgment

The financial and technical supports of various Centres/Institutes particularly Agricultural Linkages Program (ALP) PARC, Pakistan Science Foundation (PSF), International Centre for Agricultural Research in the Dry Areas (ICARDA) and International Centre for Integrated Mountain Development (ICIMOD) are highly acknowledged for carrying out various range management and improvement studies.

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(Received for publication 16 April 2012)