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COMMUNITY STRUCTURE OF BROWSE VEGETATION IN CHOLISTAN RANGELANDS OF PAKISTAN

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The rangelands of Cholistan desert is on decline due to multiple stresses and their effects can be visualized on range flora particularly on browse species. Therefore, a phytosociological survey was carried as an initial assessment to determine the vegetation structure of browse and related edaphic features. The analysis of twenty stands has delineated three vegetation associations inhabiting the sandunal, interdunal sandy and clayey saline habitats. Overall, twenty browse communities were documented based on importance value index of each species. Out of which, eight were interdunal sandy communities and six were sandunal and clayey saline communities each. Physico-chemical analysis of soil has revealed that texture of sandunal habitat was sandy; interdunal was sandy loam while clayey saline was clayey. Results exposed that organic matter, and soil nutrients were better at interdunal sandy habitat whereas pH, EC, Na, and soil moisture were high at clayey saline habitat and minimum at sandunal habitat. Further, climatic extremities, overgrazing and anthropogenic activities were observed to be continuous threats to indigenous species. This study indicates that browse communities of Cholistan rangelands are degrading gradually, therefore, they need proper protection, management, and rehabilitation through ecological approaches. This would be possible with the participation of government and native people to make these range resources sustainable.

Keywords: Cholistanrangelands, browse species, phytosociology, community structure, soil analysis

INTRODUCTION

Rangelands cover about 50 % of world land surface and are essentially the larger tracts of natural vegetation, used to support animal production (Friedel *et al.,* 2000). The majority of rangelands are located in vegetation biomes such as grasslands, shrublands, savannas, and deserts. These areas are often characterized by arid climate that experience low rainfall, large daily and seasonal temperature extremities (Williams *et al.,* 1968; Vetter *et al.,* 2006). Pakistan is a sub-tropical country, which consists of vast semi-arid and arid tracks of lands, stretches over 68 million hectares (Majeed *et al.,* 2002). Out of total area of Pakistan (80 million ha), 49 million hectares have been classified as rangelands which are almost consisting of arid to semiarid lands (Mohammad and Naz, 1985).

The rangelands of Pakistan show a great diversity of species composition, structure, productivity and eventually their capacity to support livestock production (Mohammad and Naz, 1985). The rangelands are very important from environmental point of view because they provide vegetation cover, protection for soil, which also ensures sustainable economic production of feed for animals. Especially browse plants (shrubs & tree foliage) beside grasses compose one of the cheapest sources of feed for animals in many parts of the world. Mostly the browse species have the advantage of maintaining their nutritive value and greenness during the dry season when grasses dry up and decline in both quantity and quality (Devendra, 1990; Kibon and Orskov, 1993).

Rangelands, which constitute about 65% of the total area of Pakistan, are degrading due to extreme climatic conditions, unplanned grazing, mismanagement in the utilization of water resources and deforestation (Wahid, 1984; Mohammad, 1989). The herbaceous vegetation of these rangelands only flourishes in the monsoon season, accordingly livestock herds show pitiable health and produce very poor yield of meat and milk. These problems are common everywhere in the world where arid or semiarid rangelands exist. Therefore, developing countries like Pakistan face similar situation in their rangeland's health and productivity (Ahmad and Hasnain, 2001).

The rangelands of Cholistan desert were formerly thriving and prosperous but now largely converting into abandoned patches of land. The vegetation of these rangelands is degrading because the livestock number is increasing; ultimately, carrying capacity of this area is decreasing with passage of time (Rao *et al.*, 1989; Akhter and Arshad, 2006). Sustainability of life in this hot desert rotates around the annual rainfall. During summer season, weather is tremendously severe and harsh; certain xeric plant species survive but suffer high grazing pressure and leading to partial eradication. Resultantly, the palatable species are diminishing out slowly and unpalatable species with less nutritious properties are becoming abundant. Continuous

increase in the human population and multiplying number of livestock is adding towards the desertification of this area (Akhter and Arshad, 2006; Arshad *et al.,* 2008).

In Cholistan rangelands during summer season, the nomadic pastoralists migrate with their cattle, sheep, and goats towards nearby canal-irrigated areas. However, a few male members of some clans remain in the desert for the take care of their camel herds. These camels are seen everywhere in the desert, browsing on the different shrubs and tree species. These browse species are one of the important source of feed for livestock in the arid rangelands of Cholistan desert (Akhter and Arshad, 2006). Due to year round stress, the browse species remain under severe threat and need detail assessment for quick remedy measures. Already no conservational actions have been made to protect these deteriorating range resources because of unavailability of sufficient data. Therefore, this study was being planned to collect the base line data about the community structure of browse species and on the bases of this information to chalk out their management plan in Cholistan rangelands.

MATERIALS AND METHODS

***Description of study area*:**This study was conducted in Cholistan desert, which is sited in southern part of Punjab Pakistan. Cholistan desert is a part of Great Indian desert that is comprised of Thar desert in Sindh, Pakistan and Rajastan desert in India. It extends between longitudes 69^{o} 52′ and 75^{o} 24′ E and latitudes 27^{o} 42′ and 29^{o} 45′ N covering an area of about 2.6 million hectares (Akbar *et al.,* 1996; Arshad *et al.,* 2008). Based on parent material, topography, vegetation and soil this desert can be divided into two geomorphic parts; the southern part is called Greater Cholistan that stretches over about 18,130 km^{2} and northern part is called Lesser Cholistan that is along canal irrigated areas and covers about 7,770 km^{2} (FAO, 1993; Akbar and Arshad, 2000).

It is an arid sandy desert where mean annual rainfall varies from less than 100 mm in the west to 200 mm in the east, mostly received in monsoon season (July to September). Prolonged drought spells are common after each 10 years (Baig *et al.,* 1980; Akbar *et al.,* 1996). Rainwater is collected in locally made water pools called 'tobas' (FAO, 1993). Underground water is at depth of 30-50 m that with some exceptions is brackish containing salts 9,000-24,000 mgL^{-1} (Baig *et al.,* 1980). Temperature is high in summer and mild in winter without frost. The mean summer temperature (May-July) is 34-38^{o}C with the highest reaching over 51.6^{o}C (Arshad *et al.,* 2003).

The vegetation of this desert consists of xerophytes, adjusted to low moisture, extremely high temperature, and more salinity with wide variation of edaphic factors. The scarce vegetation of Cholistan commonly comprises perennial shrubs with dispersed small trees. Several ephemeral and annual species emerge after rains, complete life cycle in short duration and dry up after producing seeds (Arshad *et al.,* 2008).

The soil of Cholistan desert is mostly alkaline, saline, and gypsiferous composed of schists, gneiss, granites, and slates. Sand dunes are common in Cholistan and reach an average height of about 30 m in Lesser Cholistan and about 100 m in Greater Cholistan (Arshad and Rao, 1994; Akbar and Arshad, 2000).

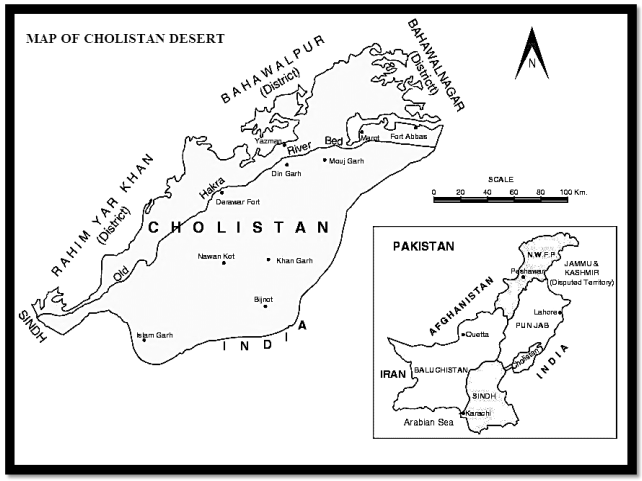

Figure 1. Map of Cholistan desert modified after Akhtar and Arshad (2006)

***Phytosociological survey*:**A reconnaissance survey was conducted in order to have an impression of site conditions, to collect information about accessibility, to do an overview of plant assemblages and to determine the sampling and data collection methods. After going through the topographic map of the area followed by frequent visits during initial stages of study, research area was divided into 20 stands to cover the variations of physiognomy and physiography. These stands were almost located over transition zone between lesser Cholistan and greater Cholistan on the bed of old Hakra River. During surveys, stands were sampled in areas where the botanical composition was homogenous and were representative of specific area that needed to be surveyed.

Data was collected after monsoon season from September to November 2009. In order to calculate the quantitative vegetation parameters, Line Transect and Quadrate methods were used (Braun-Blanquet, 1932; Curtis and Mclntosh, 1951; Chul and Moody, 1983; Mueller-DumboisandEllenberg, 1974). The importance Value (IV) for each species was calculated by direct summation of relative density, relative frequency, and relative cover. Based on importance value, sampled vegetation was delineated into different plant communities (Curtis andMclntosh, 1951; Chuland Moody, 1983). At each stand

five transects(100 meter each) with fifty quadrates (1x1 meter square each) were used to sample the vegetation.

The specific stand position was determined by a GPS (Global Positioning System) named Garmin eTrex. The geographic coordinate's latitude, longitude, and altitude were taken from the center of each stand.

***Soil analysis*:**Soil sample of 1 kg was collected along each transect from the depth of 0-30 cm. Five soil samples are collected from each stand. These samples were pooled together to form one composite sample, air-dried, thoroughly mixed, and passed through 2 mm sieve to liberate it from gravel and boulders. The collected samples were stored in polythene bags and labeled for physical and chemical analysis in soil laboratory (Jackson, 1967; Allen and Stainer, 1974). Soil analysis was done according to the methods of Hand Book No. 60 (U.S. Salinity Lab. Staff, 1954) unless otherwise mentioned. Brief descriptions of analytical methods are as follows. The soil pH was noted by using saturated soil paste as prepared before and stabilized over night (Kent Eil 7015) (Method 21a). Electrical conductivity was determined with digital Jenway conductivity meter model 4510 (Method 3a and 4b).In soil samples, moisture contents were measured with the help of ScalTec Moisture analyzer with 110 ºC. Phosphorus was determined by taking 2.50 g soil and adding 0.50 M $NaHCO_3$solution adjusted to pH 8.5 (with the help of 50% w/w NaOH) according the methods of Page *et al.,* (1982). Flame photometer (Jenway PFP7) was used to estimate the Sodium and Potassium (Rhoades, 1982). For organic matter soil (1g) sample was mixed thoroughly with 10 mL 1N potassium dichromate solution and 20 mL concentrated sulphuric acid. Then 150 mL of distilled water and 25 mL of 0.5 N ferrous sulphate solution were added and the excess was titrated with 0.1 N potassium permanganate solution to pink end point (Moodie *et al*., 1959). Saturation percentage was calculated by using (Method 27a) given formula.

Saturation percentage

$$= \frac{\text{Mass of wet soil-Mass of oven dry soil}}{\text{Mass of oven dry soil}} \times 100$$

RESULTS

Based on importance value index of each plant species, 20 types of browse communities were identified on different landforms in Cholistan rangelands. The structure of these communities is being described along with their habitat and edaphic features (Table 1&2).

1. *Haloxylon-Calligonum-Leptadenia* community (HCL): At stand one *Haloxylonsalicornicum* (IV=67.09), *Calligonum polygonoides* (IV=40.55) and *Leptadeniapyrotechnica*, (IV=15.43) browse community was present. It was a sandunal habitat consisting of 3-5 m high sandunes. Total 12 species were recorded in this stand, out of which 03 species were shrubs, 05 species were herb, and 04 species were grasses. The total importance value contributed by shrubs was 123.07, by herbs 82.28 and by grasses 94.65, while importance value contributed by three dominant browse species was 123.07. Based on soil analysis, texture of this community was sandy with soil moisture 0.48 % and organic matter 0.26 %. While other features of soil were as pH 7.89, EC 2.08, Na 22.07 ppm, K 30.12 ppm and P 4.2 ppm.

2.*Haloxylon-Suaeda-Pulicaria*community (HSP): *Haloxylon recurvum* (IV=79.41) *Suaedafruticosa* (IV=65.54) and *Pulicari arajputanae*(IV=29.10) community was present at stand two. It was flat clayey saline area. This community was composed of total 11 species in which, 01 species was of tree, 03 species of shrubs, 05 species of herb, and 02 species of grasses. In this stand, contribution towards total importance value was 3.85 by trees, 174.05 by shrubs, 45.57 by herbs, and 76.53 by grasses. The importance value contributed by three dominant browse species was 174.05. Soil texture of this habitat was clayey and concentration of soil moisture and organic matter was 0.92% and 0.21%, respectively. Other constituents of soil in this community were as pH 8.45, EC 10.43, Na 76.43 ppm, K 25.43 ppm, P 2.12 ppm.

3. *Leptadenia-Aerva-Crotalaria* community (LAC): At stand three *Leptadeniapyrotechnica* (IV=74.71) *Aervajavanica* (IV=54.53) and *Crotalaria burhia* (IV=40.51) community was existed. It was interdunal sandy area. This community was composed of 01 species of tree, 06 species of shrubs, 03 species of herbs, and 04 species of grasses. The importance value of three dominant browse species (LAC) was 169.75 and overall contribution to total importance value by trees was 5.04, by shrubs 216.18, by herbs, 5.79 and by grasses 72.99. Physico-chemical analysis of soil showed that texture of this community was sandy loam, consisting of 0.71% soil moisture and 0.85% organic matter. Whereas, contents of pH were 8.25, EC were 2.68 and Na, K, and P were as 29.17 ppm, 70.22 ppm and 5.21 ppm, respectively.

4. *Crotalaria-Leptadenia-Haloxylon* community (CLH): *Crotalaria burhia*(IV=60.31), *Leptadeniapyrotechnica* (IV=49.09) and *Haloxylonsalicornicum* (IV=38.21) community was situated at stand four. Overall 16 plant species were recorded, out of which 02 were trees, 06 were shrubs, 03 were herbs and 05 were grasses. This community was located on interdunal sandy area. In this stand, importance value added by three dominant (CLH) browse species was 147.61; overall, importance value contributed by trees was 03.18, shrubs 195.24, herbs 6.4 and grasses 95.18. Soil texture of this community was sandy loam with pH 08.14 and EC 04.41. The concentration of Na, K, and P in this community was 36.25 ppm, 41.64 ppm, and 04.32 ppm respectively. While, the concentration of soil moisture was 0.54% and organic matter was 0.49%.

Table 1. Community structure and importance value index (ivi) of browses

Stand No.	Browse Communities	No. of Species					IV Contributed by					
		Trees	Shrubs	Herbs	Grasses	Total species	Trees	Shrubs	Herbs	Grasses	Total IV	Three dominant Browses
1	*Haloxylon-Calligonum-Leptadenia*	0	3	5	4	12	0	123.07	82.28	94.65	300	123.07
2	*Haloxylon-Suaeda-Pulicaria*	1	3	5	2	11	3.85	174.05	45.57	76.53	300	174.05
3	*Leptadenia-Aerva-Crotalaria*	1	6	3	4	14	5.04	216.18	5.79	72.99	300	169.75
4	*Crotalaria-Leptadenia-Haloxylon*	2	6	3	5	16	3.18	195.24	6.40	95.18	300	147.61
5	*Calligonum-Haloxylon-Crotalaria*	1	4	6	4	15	1.02	169.76	53.91	75.31	300	167.09
6	*Suaeda-Haloxylon-Salsola*	1	7	3	3	14	1.32	187.91	19.64	91.13	300	160.38
7	*Haloxylon-Calligonum-Aerva*	0	5	5	4	14	0	145.02	63.08	91.9	300	133.97
8	*Crotalaria-Aerva-Haloxylon*	2	4	5	6	17	8.62	122.79	76.87	91.72	300	107.69
9	*Calligonum-Haloxylon-Aerva*	0	4	6	2	12	0	148.71	106.9	44.39	300	143.07
10	*Aerva-Crotalaria-Calligonum*	0	5	8	4	17	0	156.25	56.86	86.89	300	111.91
11	*Suaeda-Salsola-Haloxylon*	2	4	4	3	13	3.69	212.28	14.25	69.78	300	209.08
12	*Calligonum -Haloxylon-Leptadenia*	0	3	5	3	11	0	122.11	128.98	48.91	300	122.11
13	*Haloxylon-Suaeda-Tephrosia*	1	4	4	3	12	3.31	221.19	11.15	64.35	300	200.95
14	*Salsola-Crotalaria-Haloxylon*	0	7	5	3	15	0	189.54	33.93	76.53	300	144.75
15	*Haloxylon-Suaeda-Calotropis*	1	5	4	2	12	3.32	205.81	7.54	83.33	300	187.26
16	*Salsola-Leptadenia-Capparis*	1	5	3	3	12	1.43	201.88	21.48	75.21	300	158.71
17	*Leptadenia-Salsola-Haloxylon*	2	7	3	2	14	5.68	163.47	36.21	94.64	300	111.69
18	*Haloxylon-Calligonum-Crotalaria*	1	3	7	4	15	1.92	138.10	62.34	97.64	300	138.10
19	*Aerva-Salsola- Calotropis*	1	4	6	2	13	1.76	140.11	23.27	134.86	300	127.59
20	*Suaeda-Haloxylon-Abutilon*	0	3	6	2	11	0	175.85	40.25	83.90	300	175.85

Table 2: Soil physio-chemical analysis of browse communities

Stand No.	Browse Community	Depth cm	pH	EC ds/m	Na ppm	K ppm	P ppm	Soil Moisture %	Organic matter %	Saturation %	Texture
1	*Haloxylon-Calligonum-Leptadenia*	0-30	7.89	02.08	22.07	30.12	4.20	0.48	0.26	17	Sandy
2	*Haloxylon-Suaeda-Pulicaria*	0-30	8.45	10.43	76.43	25.43	2.12	0.92	0.21	61	Clayey
3	*Leptadenia-Aerva-Crotalaria*	0-30	8.25	02.68	29.17	70.22	5.21	0.71	0.85	27	Sandy Loam
4	*Crotalaria-Leptadenia-Haloxylon*	0-30	8.14	04.41	36.25	41.64	4.32	0.54	0.49	28	Sandy Loam
5	*Calligonum-Haloxylon-Crotalaria*	0-30	8.11	01.97	15.76	27.98	4.12	0.32	0.38	19	Sandy
6	*Suaeda-Haloxylon-Salsola*	0-30	8.37	12.13	90.18	21.95	1.98	0.76	0.19	63	Clayey
7	*Haloxylon-Calligonum-Aerva*	0-30	8.08	01.33	18.35	32.76	3.87	0.35	0.27	17	Sandy
8	*Crotalaria-Aerva-Haloxylon*	0-30	8.28	02.34	28.32	62.43	7.68	0.65	0.66	29	Sandy Loam
9	*Calligonum-Haloxylon-Aerva*	0-30	7.91	01.45	17.45	26.53	4.08	0.34	0.29	16	Sandy
10	*Aerva-Crotalaria-Calligonum*	0-30	8.31	04.21	35.12	65.28	6.54	0.72	0.92	27	Sandy Loam
11	*Suaeda-Salsola-Haloxylon*	0-30	8.53	11.45	82.17	20.54	2.57	0.91	0.18	61	Clayey
12	*Calligonum -Haloxylon-Leptadenia*	0-30	7.96	0.92	14.67	28.65	3.86	0.46	0.37	18	Sandy
13	*Haloxylon-Suaeda-Tephrosia*	0-30	8.49	09.84	62.64	24.99	2.78	0.87	0.22	63	Clayey
14	*Salsola-Crotalaria-Haloxylon*	0-30	8.11	03.86	31.27	54.21	5.52	0.69	0.73	28	Sandy Loam
15	*Haloxylon-Suaeda-Calotropis*	0-30	8.36	10.06	69.21	20.05	2.54	0.75	0.18	62	Clayey
16	*Salsola-Leptadenia-Capparis*	0-30	8.33	03.98	33.12	46.75	6.04	0.64	0.81	28	Sandy Loam
17	*Leptadenia-Salsola-Haloxylon*	0-30	8.26	02.84	27.26	68.76	7.08	0.58	0.56	29	Sandy Loam
18	*Haloxylon-Calligonum-Crotalaria*	0-30	8.05	02.04	20.59	31.22	3.42	0.37	0.34	19	Sandy
19	*Aerva-Salsola- Calotropis*	0-30	8.30	04.57	37.24	43.54	5.34	0.53	0.87	27	Sandy Loam
20	*Suaeda-Haloxylon-Abutilon*	0-30	8.55	11.98	83.09	22.72	2.96	0.83	0.23	61	Clayey

5. *Calligonum-Haloxylon-Crotalaria* community (CHC): At stand five *Calligonumpolygonoides* (IV=100.06), *Haloxylonsalicornicum* (IV=52.91) *and Crotalaria burhia* (IV= 14.12) community was dominant. It was generally sandunal area. This community was consisting of 15 plant species, which included 01 tree, 04 shrubs, 06 herbs, and 04 grasses. In this stand, total importance value contributed by trees 01.02, shrubs 169.76, herbs 53.91 and grasses 75.31. The contribution of importance value of three dominant browse species (CHC) was 167.09. Based on soil analysis texture of this community was sandy with pH 08.11 and EC 01.97. The contents of Na, K, P, were 15.76 ppm, 27.98 ppm, and 4.12 ppm, respectively whereas organic matter and soil moisture were 0.38% and 0.32%.

6. *Suaeda-Haloxylon-Salsola* community (SHS): Stand six was located on clayey saline area. *Suaedafruticosa* (IV=80.41), *Haloxylonrecurvum* (IV=59.54) and *Salsolabaryosma* (IV= 20.43) community was composed of total 14 plant species in which 01 was tree, 07 were shrubs, 03 were herbs and 03 were grasses. The contribution to total importance value by trees was 01.32, by shrubs 187.91, by herbs 19.64 and by grasses 91.13. Overall, the contribution of importance value by three dominant browse species (SHS) was 160.38. Physico-chemical analysis of soil showed that this community was located on clayey texture with pH 8.37 and EC 12.13. The concentration of Na was 90.18, K was 21.95, and P was 1.98, while soil moisture and organic matter were as 0.76% and 0.19%, respectively.

7. *Haloxylon-Calligonum-Aerva* community (HCA): In stand seven, *Haloxylonsalicornicum* (IV=72.35), *Calligonumpolygonoides* (IV=46.08) and *Aervajavanica* (IV=15.54) community was dominating. This area was covered by sandunes. This community was comprised of 05 species of shrubs, 05 species of herbs and 04 species of grasses. The contribution to total importance value by shrubs was 145.02, by herbs 63.08 and by grasses 91.90. However, importance value of three dominant browse species was 133.97. Soil texture of this stand was sandy with pH 08.08 and EC 01.33. The concentration of Na was 18.35, K was 32.76, and P was 3.87, whereas, concentration of soil moisture and organic matter was 0.35 and 0.27%, respectively.

8. *Crotalaria-Aerva-Haloxylon* community (CAH): *Crotalaria burhia*(IV=38.31) *Aervajavanica* (IV=37.22) and *Haloxylonsalicornicum* (IV=32.16) community was present at stand eight. It was mainly interdunal sandy area. Total 17 plant species were recorded in sampling, out of which 02 were trees, 04 were shrubs, 05 were herbs and 06 were grasses. Importance value of three dominant browse species was 107.69. Overall, contribution to total importance value by trees was 8.62, by shrubs 122.79, by herbs 76.87, and by grasses 91.72. In this community, texture of soil was sandy loam with pH 8.28 and EC 2.34. The concentration of Na was 28.32, K was 62.43, and P was 7.68, while the soil moisture and organic matter was 0.65% and 0.66%, respectively.

9. *Calligonum-Haloxylon-Aerva* community (CHA): At stand nine, *Calligonumpolygonoide s*(IV=74.43) *Haloxylonsalicornicum* (IV=55.32), *and Aervajavanica* (IV=13.32) community was dominant. It was sandunal area. In this community, total 12 plant species were recorded in which 04 species were shrubs, 06 were herbs and 02 were grasses. Importance value of three dominant plant species was 143.07 while contribution to total importance value by shrubs was 148.71, by herbs 106.9 and by grasses 44.39. Soil texture of this community showed that it was sandy soil with pH 7.91 and EC 1.45. The contents of soil Na, K, P, were 17.45, 26.53, and 04.08 respectively, while soil moisture was 0.34% and organic matter was 0.29%, respectively.

10. *Aerva-Crotalaria-Calligonum* community (ACC): *Aervajavanica* (IV=51.29) *Crotalaria burhia* (IV=33.97) and *Calligonumpolygonoides* (IV= 26.65) community was located on interdunal sandy area. In this stand, total 17 plant species were recorded in which 05 were shrubs, 08 were herbs and 04 were grasses. The total importance value added by three dominant browse species was 111.91, while importance value contributed by shrubs was 156.25, by herbs 56.86 and by grasses 86.89. Texture of soil was sandy loam with pH 8.31 and EC 4.21. The values of Na, K, P, was 35.12, 65.28, and 6.54 respectively, while soil moisture was 0.72% and organic matter was 0.92%.

11. *Suaeda-Salsola-Haloxylon* community (SSH): In stand eleven *Suaedafruticosa* (IV=110.15), *Salsolabaryosma* (IV=58.32*)* and *Haloxylonrecurvum* (IV=40.61) community was dominant. Habitat of this community was clayey saline area. This community was composed of 02 species of trees, 04 species of shrubs and herbs each and 03 species of grasses, overall 13 species were recorded during sampling. Importance value contributed by trees was 03.69, by shrubs 212.28, by herbs 14.25 and by grasses 69.78. However, contribution of three dominant browse species was 209.08. According to soil analysis of this stand, texture of soil was clayey with pH 8.53 and EC 11.45. The contents of Na, K, P, were 82.17 ppm, 20.54 ppm and 2.57 ppm respectively, while soil moisture was 0.91% and organic matter was 0.18%.

12. *Calligonum-Haloxylon-Leptadenia*community (CHL): *Calligonumpolygonoides* (IV=55.87) *Haloxylonsalicornicum* (IV=44.12) and *Leptadeniapyrotechnica* (IV=22.12) community was dominant at stand twelve. This community was located over sandunal area. Total 11 plant species were identified in which 03 were shrubs, 05 were herbs and 03 were grasses. Total importance value added by shrubs was 122.11, by herbs 128.98 and by grasses 48.91. While importance value contributed by three dominant browse species was 122.11. According to soil analysis of this area, texture of soil was sandy with pH 07.96 and EC 0.92. The

contents of Na, K, P, were 14.67 ppm, 28.65 ppm, and 03.86 ppm respectively, while soil moisture and organic contents were as 0.46% and 0.37%.

13. *Haloxylon-Suaeda-Tephrosia* community (HST): This stand was located on clayey saline area. *Haloxylonrecurvum* (IV=98.34) *Suaedafruticosa* (IV=76.96) and *Tephrosiauniflora* (IV=25.65)community was composed of total 12 plant species out of which 01 was tree, 04 were shrubs, 04 were herbs and 03 were grasses. Importance value contributed by three dominant browse species was 200.95, while total importance value contributed by trees was 3.31, by shrubs 221.19, by herbs 11.15 and by grasses 64.35. Texture of soil in this community was clayey with pH 8.49 and EC 9.84. The values of Na, K, P, were 62.64 ppm, 24.99 ppm, and 2.78 ppm respectively, whereas soil moisture was 0.87% and organic contents was 0.22%.

14. *Salsola-Crotalaria-Haloxylon* community (SCH): At stand fourteen *Salsolabaryosma* (IV=65.29) *Crotalaria burhia*(IV=52.14)and *Haloxylonsalicornicum* (IV=27.32) community was present. It was interdunal sandy area. This community was composed of 07 species of shrubs 05 species of herbs and 03 species of grasses. Total importance value contributed by shrubs was 189.54, by herbs 33.93, by grasses 76.53, while importance value added by three dominant browses was 144.75. Texture of soil was sandy loam with pH 8.11 and EC 3.86. The contents of Na, K, P, were 31.27 ppm, 54.21 ppm, and 5.52 ppm respectively while concentration of soil moisture was 0.69% and organic matter was 0.73%.

15. *Haloxylon-Suaeda-Calotropis* community (HSC): *Haloxylonrecurvum* (IV=100.25) *Suaedafruticosa* (IV= 55.87) and *Calotropisprocera* (IV= 31.14) community was present on clayey saline patch. This community was consisting of 01 species of trees 05 species of shrubs 04 species of herbs and 02 species of grasses. Total 12 plants species were recorded in this stand. Total importance value contributed by trees was 03.32, by shrubs 205.81, by herbs 07.54 and by grasses 83.33, while importance value added by three dominant browses was 187.26. In this stand, texture of soil was clayey with pH 8.36 and EC 10.06. The values of Na, K, P, were 69.21 ppm, 20.05 ppm, and 2.54 ppm respectively, while soil moisture was 0.75% and organic contents was 0.18%.

16. *Salsola-Leptadenia-Capparis* community (SLC): In this stand *Salsolabaryosma*(IV=74.38) *Leptadeniapyrotechnica* (IV=55.12) and *Capparis deciduas* (IV=29.21) community was dominating. It was interdunal sandy area. Out of total recorded species, 01 was tree, 05 were shrubs, 03 were herbs and 03 were grasses. Importance value added by three dominant browses was 158.71. While importance value of trees was 01.43, by shrubs 201.88, by herbs 21.48 and by grasses 75.21. Soil texture of this community was sandy loam with pH 8.33 and EC 3.98. The concentration of Na, K, P, was 33.12 ppm, 46.75 ppm, and 6.04 ppm respectively, while soil moisture was 0.64% and organic matter was 0.81%.

17. *Leptadenia -Salsola-Haloxylon* community (LSH): At stand seventeen *Leptadeniapyrotechnica* (IV=47.43) *Salsolabaryosma* (IV=41.84) and *Haloxylonsalicornicum* (IV=22.42) community was dominating. It was interdunal sandy area. During sampling in this stand, total 14 plant species were recorded in which 02 were trees, 07 were shrubs 03 were herbs and 02 were grasses. In this community, contribution to total importance value by trees was 5.68, by shrubs 163.47, by herbs 36.21, and by grasses 94.64; however, importance valued of three dominant browses was 111.69. In this community, texture of soil was sandy loam with pH 8.26 and EC 2.84. The values of Na, K, P, were 27.26 ppm, 68.76 ppm, and 7.08 ppm respectively, while soil moisture was 0.58% and organic matter was 0.56%.

18. *Haloxylon-Calligonum-Crotalaria* community (HCC): *Haloxylonsalicornicum* (IV=67.32) *Calligonumpolygonoides* (IV=47.66) *Crotalaria burhia*(IV=23.*12)* community was located on sandunal habitat. In this stand 15 plant species were recorded out of which 01 was tree 03 were shrubs 07 were herbs and 04 were grasses. Total importance value by trees was 1.92, by shrubs 138.1, by herbs 62.34 and by grasses 97.64. The importance value contributed by three dominant browser species was 138.10. At this stand, texture of soil was sandy with pH 8.05 and EC 2.04. The concentration of Na, K, P, was 20.59 ppm, 31.22 ppm, and 3.42 ppm respectively, while soil moisture 0.37% and organic matter was 0.34%.

19. *Aerva-Salsola-Calotropis community* (ASC): At stand nineteen *Aervajavanica* (IV=53.12) *Salsolabaryosma* (IV=48.04) and *Calotropisprocera*(IV= 26.43)community was located. It was interdunal sandy habitat. In this community total 13 plant species were recorded, in which 01 species was tree, 04 were shrubs, 06 were herbs and 02 were grasses. In this stand importance value contributed by three dominants, browse species was 127.59. Overall, Importance value contributed by trees was 1.76 by shrubs 140.11, by herbs 23.27 and by grasses 134.86. Soil texture of this community was sandy loam with pH 8.3 and EC 4.57. The values of Na, K, P, were as 37.24 ppm, 43.54 ppm, and 5.34 ppm respectively, however soil moisture was 0.53% and organic matter was 0.87%.

20. *Suaeda-Haloxylon-Abutilon* community (SHA) *Suaedafruticosa* (IV= 85.17) *Haloxylonrecurvum* (IV=73.34) *Abutilon muticum*(IV=17.34) community was located on clayey saline area. In this stand, total 11 plant species were recorded in which 03 were shrubs, 06 were herbs and 02 were grasses. Total importance value contributed by shrubs was 175.85, by herbs 40.25 and by grasses 83.90. Whereas, importance value added by three dominant browse species was 175.85. In this community, soil texture was clayey with pH 8.55 and EC 11.98. The

contents of Na, K, P, were 83.09 ppm, 22.72 ppm, and 2.96 ppm respectively, while soil moisture was 0.83% and organic contents were 0.23%.

DISCUSSION

Phytosociology is generally concerned with methods for recognizing and defining plant communities, and is collectively termed as classification(Barbour *et al.,* 1987; Kent and Coker, 1997). The major purpose of classification is to make a set of plant communities for a particular area under investigation (Gabriel and Talbot, 1984). In Cholistan rangelands flora differs greatly in species composition, hence dynamic rhythm of plant life was seen changing in magnitude as one passed through desert; whereas sharp changes were there with reference to topographic features, variability of soil and distances among habitats.

The phytosociological classification of vegetation of Cholistan rangelands is summarized in Table 1. A total 25 browse species were recorded, not all of identified species were used in the classification of plant communities. There were total twenty browse communities recognized in the rangelands of Cholistan desert. It has been observed that sampling time and seasonal activities change the structure of communities. In the studied area, woody and perennial species almost remained same whereas shape of community changed due to the prevalence of annuals (Therophytes) during monsoon, which shows seasonal aspect. Several authors (Bredenkamp, 1975; Coetzee, 1993; Bredenkamp and Brown, 2003) agreed that the differences in floristically defined plant communities were mostly linked with habitat variables such as topography (landform, aspect, & slope), geology, and altitude, although soil texture, rockiness, and depth are also necessary components.

Vegetation assessments are a prerequisite for any ecological or habitat related research (Van Rooyen *et al*., 1981). Based on vegetation diversity, investigated area can be divided into three different habitats including sandunal, interdunal sandy and clayey saline habitats. Sandunal habitat was consisting of medium to high, generally unstabalized shifting dunes and was highly sandy. At sandunal habitat six browse communities were observed including the *Haloxylonsalicornicum Calligonumpolygonoides Leptadeniapyrotechnica* (HCL), *Calligonumpolygonoides Haloxylonsalicornicum Crotalaria burhia* (CHC), *Haloxylonsalicornicum Calligonumpolygonoides Aervajavanica* (HCA), *Calligonumpolygonoides Haloxylonsalicornicum Aervajavanica* (CHA), *Calligonumpoly gonoides Haloxylonsalicornicum Leptadeniapyrotechnica* (CHL) and *Haloxylonsalicornicum Calligonumpolygonoides Crotalaria burhia* (HCC).

Interdunal sandy habitat was consisting of small sandy hummocks of sandy loam soil. Eight browse communities were located at interdunal habitat, consisting of *Leptadeniapyrotechnica Aervajavanica Crotalaria burhia* (LAC), *Crotalaria burhia Leptadeniapyrotechnica Haloxylon salicornicum* (CLH), *Crotalaria burhia Aervajavanica, Haloxylonsalicornicum* (CAH), *Aervajavanica Crotalaria burhia Calligonumpolygonoides* (ACC), *Salsolabaryosma Crotalaria burhia Haloxylonsalicornicum* (SCH), *Salsolabaryosma Leptadeniapyrotechnica Capparis deciduas* (SLC),

Table 3. Name, location, and topography of each stand

Sr. No.	Stand Name	GPS Location	Elevation	Topography
1	Mansora	N: 29°12.161´ E: 072°15.427´	398 ft	Sandunal
2	Kalapahar	N: 29°10.430´ E: 072°05.569´	384 ft	Clayey saline
3	Chaklihar	N: 29°11.315´ E: 071°57.648´	389 ft	Interdunal sandy
4	Januwali	N: 29°05.056´ E: 072°09.933´	406 ft	Interdunal sandy
5	Khirsir	N: 29°10.339´ E: 072°08.749´	391 ft	Sandunal
6	Haiderwali	N: 29°02.672´ E: 072°10.200´	382 ft	Clayey saline
7	Mojgarh Fort	N: 29°01.059´ E: 072°08.106´	392 ft	Sandunal
8	Chelanwala Toba	N: 28°57.261´ E: 072°03.089´	369 ft	Interdunal sandy
9	Khanser	N: 28°59.227´ E: 071°55.299´	352 ft	Sandunal
10	AldinMor	N: 28°47.988´ E: 071°45.770´	340 ft	Interdunal sandy
11	Dingarh Fort	N: 28°57.454´ E: 071°51.910´	365 ft	Clayey saline
12	Dingarh Fort	N: 28°57.182´ E: 071°49.362´	371 ft	Sandunal
13	Nidamwala Toba	N: 28°52.963´ E: 071°44.270´	355 ft	Clayey saline
14	Mehmodwala Toba	N: 28°47.939´ E: 071°45.770´	334 ft	Interdunal sandy
15	Lakhan	N: 28°52.232´ E: 071°42.731´	351 ft	Clayey saline
16	Chananpir	N: 28°56.832´ E: 071°40.057´	353 ft	Interdunal sandy
17	Baylawala	N: 29°23.466´ E: 071°39.563´	410 ft	Interdunal sandy
18	Derawar fort	N: 28°49.208´ E: 071°28.129´	334 ft	Sandunal
19	Derawar fort	N: 29°23.465´ E: 071°39.560´	345 ft	Interdunal sandy
20	ChasmaDhar	N: 28°39.864´ E: 071°15.632´	323 ft	Clayey saline

Leptadeniapyrotechnica Salsolabaryosma Haloxylon salicornicum (LSH) and *Aervajavanica Salsolabaryosma Calotropisprocera* (ASC).

Whereas, clayey saline habitat was consisting of plain hard crust of soil called dahar, impervious to water and remain plant less. It was flattened habitat shape up by the flow of water through the area or after the removal of upper deposit of fine silt. Whereas at clayey saline habitat six browse communities were observed including the *Haloxylonrecurvum Suaedafruticosa Pulicariarajputanae* (HSP), *Suaedafruticosa Haloxylonrecurvum Salsolabaryosma* (SHS), *Suaedafruticosa Salsolabaryosma Haloxylonrecurvum* (SSH), *Haloxylonrecurvum Suaedafruticosa Tephrosiauniflora* (HST), *Haloxylonrecurvum Suaedafruticosa Calotropisprocera* (HSC) and *Suaedafruticosa Haloxylonrecurvum Abutilon muticum* (SHA).

The species variations in plants from site to site may be due to composition of soil, elevation of selected sites, nature of disturbances like human interferences, grazing pressure, distance of study sites from population areas etc. All the factors determine the category of species in which the species fall (Ahmad *et al*., 2007). The relationship of certain plant species to certain soils at different places is very common. Within Cholistan rangelands, a number of different soil types and dominant plant species are found (Arshad and Akbar, 2002; Arshad *et al.,* 2007). Based on results the most dominant browse species at sandunes were *Calligonumpolygonoides* and *Haloxylonsalicornicum*. At interdunal habitat *Aervajavanica Salsolabaryosma Leptadeniapyrotechnica* and *Crotalaria burhia*species were common. Whereas at compact saline 'dahars' without any soil cover are dominated by *Suaedafruticosa* and *Haloxylonrecurvum* (Rao *et al*., 1989; Chaudhary, 1992; Arshad and Akbar, 2002). Similarly, while exploring Cholistan desert Rao *et al*. (1989) documented that phytosociological assemblages are indicator of soil types as the edaphic factors effect the vegetation more than any other factors.

The soil topography and chemical composition are very important in plant distributions. Association of soil features with vegetation was estimated for defining the most effective factors responsible in the distribution of vegetation types in Cholistan rangelands. Physico-chemical analysis of soil showed that soil texture of sandunal habitat was sandy; interdunal was sandy loam whereas clayey saline habitat was clayey nature. Results revealed that pH, EC, Na contents, and soil moisture were high at clayey saline communities and minimum at sandunal areas. In typical saline communities moisture was remained available for longer period (Arshad and Akber, 2002). These soils are regarded as highly saline with very high conductivities. Whereas concentration of organic matter, P, K was better at interdunal habitat which may be due to better vegetation cover at interdunal areas. Overall percentage of organic matter in the soil of Cholistan desert was poor, that obviously indicate the aridity causing in sparse vegetation cover (Rao *et al*., 1989). Our results were in line with Arshad*et al.* (2008) who has studied the vegetation distribution in relation to edaphic factors in Cholistan desert.

To study the vegetation of Cholistan rangelands, much stress was paid on plant communities. The vegetation of Cholistan desert has not been studied properly until now. No actual information was existing about the browse communities of Cholistan desert; however, our work corroborate with the work of some earlier researchers in this area (Rao *et a1*., 1989; Arshad and Rao, 1995; Arshad*et a1*., 2002; Arshad and Akbar, 2002). The criterion of classification used in current research was highly supported by the studies of Austin and Heyligers, (1989), Kirk-Patrick (1990), Smitheman and Perry (1990), Malik *et al.,* (2007), Iqbal *et al.,* (2008), Hussain *et al.,* (2009) and Rashid *et al.,* (2011) who supported the above criteria and has described plant communities of different areas of the world.

***Conclusion*:**Based on results it was concluded that floral diversity of Cholistan rangelands was deficient due to inadequacy of rainfall, lack of interest and over exploitation. Prolonged droughts of several years also affect the distribution of vegetation and growth patterns in this area. At places, mainly close to rainwater collecting ponds, over grazing and heavy exploitation marred the vegetation structure and failed to sustain its optimal posture. Conservation of vegetation especially within disturbed sites is more normally, demands an exclusive and urgent protection challenge. There is vibrant need of research and developmental actions to circumvent and address the problems faced by those species having poor score and low importance value index. It is further recommended that detailed vegetation surveys (qualitative and quantitative) should be carried out to compile the floristic inventory and to provide the complete vegetation map of area. For this herders' knowledge about plant species will be important in developing local herbarium and it will serve as base line information for further studies.

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