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VEGETATION ANALYSIS AND WINTER SEASON CARRYING CAPACITY OF SUB-TROPICAL, SUB HUMID RANGELANDS OF DHRABI WATERSHED, PAKISTAN

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Abstract

Quantitative vegetation assessment of Dhrabi watershed Chakwal, Pakistan was conducted to determine the productive potential and carrying capacity during winter 2008-09. Twelve sites of watershed were selected on the basis of variation in altitude using stratified sampling with line transect method. Overall, average grasses cover was 64.09% in the area with the highest value (73.41%) in the upper zone and lowest (56.33%) in the lower zone. Average trees and shrubs cover was 19.74% with highest value (29.72%) in the middle zone followed by upper (21.54%) and lower zone (7.95%). The range was found in good condition with overall carrying capacity of 2.41 ha/AU/4month. The main dominating plant species found in the area were *Heteropogon contortus* (Sariala ghaas), *Cynodon dactylon* (Khabbal ghaas), *Desmostachya bipinnata* (Dab ghaas) and *Acacia modesta* (Phulai).

Introduction

With only 22% of the world's area suitable for agricultural production, the yearly loss of 5-7 million hectares by land degradation, mostly in those countries that are most "land hungry", seriously jeopardizes future food production (Buring, 1989, Lal & Stewart, 1982). The commitment to feed the world's increasing population requires successful conservation and restoration of diminishing water and land resources (Brown, 1984). Abject poverty, high population growth and degradation of the production base are some of the problems faced in the most developing countries including Pakistan. The rainfed areas (*Barani)* of Punjab province, Pakistan cover about one million hectares and are home to about 2.0 million people, of which 70% live in rural areas depending on agriculture to earn their livelihoods. Dhrabi watershed consists of hilly to semi-hilly watersheds at altitudes between 300 and 400 m above sea level. Annual rainfall varies from 300 to 800 mm with hot summers and moderate winters. The agricultural production system consists of upper catchments and gullied areas (wastelands), covering some 56% of the area, terraced fields along hillsides (39% of area) and irrigated agriculture (5%). Natural forests and rangelands are the major land use in the upper catchments. Agricultural production on the terraced fields depends on runoff water harvesting and soil moisture conservation. These terraced fields were created by leveling with bulldozers during the last 3-4 decades. Subsidized machinery encouraged the farmers to level the hillsides without considering the requirements for water harvesting and safe disposal of surplus runoff during high rainstorms. Irrigated agriculture depends on water storage in small reservoirs created by some 300 small dams owned by the government, communities or individuals and on groundwater wells. The construction of the dams has positively affected the groundwater. At some locations, the groundwater table has risen and the old wells that were once dry have become functional allowing the farmers to extract water using simple animal traction. However, erosion in the upper catchments and transport of soil losses downstream has rapidly reduced the water storage capacity of these small reservoirs, threatening the sustainability of the agricultural systems dependent on them. The study area is water conserved territory, therefore present was planned to evaluate the impact of watershed on the vegetation, productive and carrying capacity of the rangeland.

Materials and Methods

Location and climate: This study was conducted in Dhrabi watershed during winter season in 2008-09, at latitude of 32º 42' to 32º 55' N and longitude 72º 35' to 72º 48' E. Dhrabi watershed covers 200 km^2 drainage area at the outlet of Dhrabi dam. Elevation ranges between 466 and 800 meters. Slope varies from 2 % in plain areas to more than 30% along hill sides. Land degradation in the watershed area dominantly exists in the form of water erosion, soil fertility depletion and soil structure deterioration. Minimum temperature varies from -0.5ºC in January to 16ºC in July/August. Maximum temperature ranges from 24ºC in January to 48ºC in June. Average annual rainfall varies from 600 – 700 mm. The main vegetation type is scrub forest dominated by *Acacia modesta* (Phulai) and *Olea ferruginea* (Kaho). Most palatable grasses are *Cenchrus ciliaris* (Dhaman) and *Cynodon dactylon (*Khabbal*)*. The main land uses include the grazing land, rainfed agriculture on terrace fields, irrigated lands (by wells and dams), unused lands and wet lands (Anon., 2008).

Selection of sampling sites: Stratified sampling techniques were used for the selection of sampling sites by dividing the whole watershed area into three zones namely upper, middle and lower zone on the basis of elevation. From each zone four sites were selected randomly and four transects were laid out the basis of soil physiography i.e., transects on flat areas (F), areas of gentle slope (GL) (slope < 15 degree), areas of steep slope (SL) (slope > 15 degree) and gully bed (GB) areas. Altogether, 16 transects from each zone were laid down. Totally 48 transects (12 F, 12 GL, 12 SL, 12 GB) were taken from the whole watershed area.

Cover percentage, vegetation composition, density, frequency and carrying capacity were determined by line transect method (Kent & Coker, 1992). Overall 240 quadrates of 1m^2 each were laid out along the line transect. Following formulas were used for different study parameters.

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$$\text{Percent cover} = \frac{\text{(Sum of intercepts by a species on all the transects)}}{\text{(Total length of all the transects)}} \times 100$$

$$\text{Percent composition} = \frac{\text{(Sum of intercepts by a species on all the transects)}}{\text{(Sum of intercepts by different species on all the transects)}} \times 100$$

$$\text{Density} = \frac{\text{Number of individuals of species in all quadrates}}{\text{Total area sampled}}$$

$$\text{Frequency (\%)} = \frac{\text{Number of quadrates in which a specie occurred}}{\text{Total number of quadrates sampled}} \times 100$$

$$\text{Importance Value Index (IVI)} = \text{Relative Cover} + \text{Relative Frequency} + \text{Relative Density}$$

$$\text{Carrying capacity (ha/AU/Year)} = \frac{\text{Animal forage requirement kg /year}}{\text{Forage production kg /ha}}$$

Results

Floristic composition: Total 38 plant species were recorded from the watershed area in winter season (6 trees, 10 shrubs, 12 herbs, 8 grasses, 2 bushes).

Measurement of vegetation cover: The average understory ground cover (Herbaceous) was found as 64.09%. In upper zone it was 73.41%, in middle zone 62.52% and in lower zone the cover was 56.33%. The main contributor grass species were *Heteropogon contortus* (*Sariala*), *Cenchrus ciliaris* (Dhaman), *Desmostachya bipinnata* (Dab ghaas), and *Cynodon dactylon* (Khabbal). Comparatively low vegetation cover was recorded in transects from flat area (54.16%) and highest from steep slope areas (74.29%) followed by gentle slope and gully bed areas (Table 1).

Tree cover was determined for each tree encountered in $100m^2$ (10x10 m) plot taken at 30^{th} m of each line transect by measuring diameter of crown. On the average tree cover %age in the watershed area was 19.11% which was highest in gully bed areas (24.03%) and lowest in the gentle slope (16.01%) (Table 1). When we compare all three zones of watershed regarding tree cover percentage then we found that it was highest in the middle zone (27.84%) while lowest in the lower zone (7.95%). The main contributor tree species were *Acacia modesta* (Phulai), *Acacia nilotica* (Kikar), *Zizyphus mauritiana* (Ber), *Dalbergia sissoo* (Shisham), *Olea ferruginea* (Kaho), *Dodonaea viscosa (*Snatha*)*.

Measurement of vegetation density: The density of grasses/herbs m^{-2} in watershed area was calculated by counting their number in each quadrate. Overall there were 48 plants of grasses/herbs m^{-2}. However, this number was highest on gentle slope areas (57) followed by gully bed areas (48) and steep slope areas (44). Less density was found on flat area (43) which again indicates more grazing pressure on these areas rather than sloping and gullied areas. Among trees and shrubs component the average density was 163 trees ha^{-1} with more trees in steep slopes and gully beds (192) following by gentle slopes (158) and the lowest (108) in flat areas (Table 2). It indicates that the pressure for deforestation is more on flat areas because of easy access to that area and its suitability for conversion into agriculture land.

Measurement of vegetation composition and frequency percentage: *Acacia modesta* (Phulai) was the main contributing species among trees and was found in all three zones and in each type of soil physiography. Totally 78 trees were found in all transects. Highest contribution in Spp Composition was presented by *Acacia modesta* (Phulai) with composition of 70.51% and frequency of 54.17% followed by *Zizyphus mauritiana* (Beri) with composition of 11.51% and frequency of 18.75% (Fig. 1). More species diversity was found in upper zone with 6 species of trees/shrubs while in middle and lower zone 3 species were found. *Dalbergia sissoo* (Sheesham), *Olea ferruginea* (Kaho), *Acacia nilotica* (Kikar) and *Dodonea viscosa* (Snatha) was only found in upper zone while *Prosopis juliflora* (Jangli kikar) was found in middle zone and *Capparis decidua* (Karen) was found in lower zone. In grasses component the area was dominated by *Heteropogon contortus* (Sariala ghaas) with composition percentage of 29.40 and frequency of 60.42%. The reason is that in winter season Sariala grass becomes hard and rough with sharp awns which damages not only livestock but also human beings, so it becomes unpalatable. Similar is the case in *Desmostachya bipinnata* (Dab ghaas) whose blades of leaf becomes sharp making it unpalatable for livestock.

Importance value index (IVI): *Heteropogon contortus* (Sariala ghaas) showed maximum importance value of 80.02 from the herbaceous vegetation followed by *Cynodon dactylon* (Khabbal) 55.91. From trees and shrubs point of view the vegetation was dominated by *Acacia modesta* (Phulai) with importance value of 185.42.

Range carrying capacity: To study the carrying capacity, 1 m^2 quadrates were laid (along the 50m long line transect) at an interval of 10 m on alternate side of the transect line. The vegetation biomass falling within the quadrate was clipped with cutter/knife at 4 cm above the ground level and dried for 24 hours at 65°C in oven and dry weight in grams was recorded. The dry weight was converted into kilogram per hectare (kg/ha). The proper use factor (PUF) was taken as 50% to calculate available forage. The animal unit (AU) was assumed, a cow having 360 kg weight, requiring 9 kg dry matter forage per day, 1620 kg/6 months or 3285 kg/year.

The overall carrying capacity of the watershed area was recorded 2.41 ha/AU/4month (Table 3), which indicates that range is in good condition. There is no extra grazing pressure of livestock in this area during winter season. When we compare different zones of watershed then we see that the upper zone is in better condition with carrying capacity of 1.87 ha/AU/4month. This may be due to more vegetation cover of grasses (73.41%). Another reason may be less number of livestock per farmer in this zone calculated by conducting a livestock survey in whole watershed. According to that survey there are 9.7 numbers of animals per farmer in the upper zone while in middle zone this number exceeds to 20.7 and in lower zone it is 22 animals per farmer.

Table 1. Site wise and parameter wise vegetation cover percentage.

Zones and sites	Study parameters								Site wise mean value	
	Flat area		G. Slope		S. Slope		Gully Bed			
Upper zone	**Grasses cover**	**Trees cover**	**Grasses cover**	**Trees cover**	**Grasses cover**	**Trees cover**	**Grasses cover**	**Trees cover**	**Grasses cover**	**Trees cover**
Chak Khushi	53.62	0.79	83.09	83.02	82.83	15.22	79.84	71.29	74.85	42.58
Khairpur	68.13	0.47	70.05	0.64	75.61	46.52	78.46	2.54	73.06	12.54
Cedit college	72.69	1.11	73.52	1.13	88.74	11.25	74.14	1.73	77.27	3.81
Nikka dam	68.63	73.15	75.29	31.65	85.22	1.33	44.72	2.83	68.47	27.24
Mean	**65.77**	**18.88**	**75.49**	**29.11**	**83.10**	**18.58**	**69.29**	**19.60**	**73.41**	**21.54**
Middle zone										
Doo mail	63.83	0.33	68.91	10.75	73.61	21.00	56.73	34.00	65.77	16.52
Tootan Wali	53.35	23.75	61.36	5.25	54.67	41.09	60.16	88.73	57.39	39.71
Ratta Shareef	49.47	99.35	66.98	9.14	70.32	29.21	64.85	21.23	62.91	39.73
Dhook Mohri	54.77	0.24	61.66	9.62	68.30	12.88	71.24	38.83	63.99	15.39
Mean	**55.36**	**30.92**	**64.73**	**8.69**	**66.73**	**26.05**	**63.25**	**45.70**	**62.52**	**27.84**
Lower zone										
Rehna Sadaat	44.75	3.14	66.71	0.68	79.32	15.90	63.05	25.83	63.46	11.39
Dhook Chohi	42.95	23.88	69.15	16.61	80.66	1.83	58.75	0.54	62.87	10.72
SAWCRI Side	35.21	0.11	44.08	15.90	57.42	12.88	36.93	0.22	74.41	7.28
Spill way Side	42.48	0.39	46.30	7.69	74.84	0.98	58.79	0.61	55.60	2.42
Mean	**41.35**	**6.88**	**56.56**	**10.22**	**73.06**	**7.90**	**54.38**	**6.80**	**56.33**	**7.95**
Overall mean	**54.16**	**18.89**	**65.59**	**16.01**	**74.29**	**17.51**	**62.31**	**24.03**		
Overall cover % age	**Grasses cover = 64.09%**				**Trees cover = 19.11%**					

Table 2. Site wise and parameter wise grass density/m^2 and trees density/ha.

Zones and sites	Study parameters								Site wise mean value	
	Flat area		G. Slope		S. Slope		Gully Bed			
Upper zone	**Grasses density**	**Trees density**	**Grasses density**	**Trees density**	**Grasses density**	**Trees density**	**Grasses density**	**Trees density**	**Grasses density**	**Trees density**
Chak Khushi	17	0	27	200	43	300	55	300	36	200
Khair pur	59	0	84	100	53	500	65	100	65	175
Cedit college	44	0	80	100	52	200	104	0	70	75
Nikka dam	55	800	69	400	63	100	33	100	55	350
Mean	**44**	**200**	**65**	**200**	**53**	**275**	**64**	**125**	**57**	**200**
Middle zone										
Doo mail	64	0	94	100	51	400	48	400	64	225
Tootan Wali	44	100	75	200	41	200	55	300	54	200
Ratta Shareef	46	100	54	200	40	100	33	300	43	175
Dhook Mohri	53	0	60	100	63	100	71	400	62	150
Mean	**52**	**50**	**71**	**150**	**49**	**200**	**52**	**350**	**56**	**188**
Lower zone										
Rehna Sadaat	41	100	24	0	30	300	22	400	29	200
Dhook Chohi	33	200	32	100	20	0	21	0	27	75
SAWCRI Side	25	0	34	100	31	100	33	0	31	50
Spill way Side	29	0	47	300	36	0	34	0	37	75
Mean	**32**	**75**	**34**	**125**	**29**	**100**	**28**	**100**	**31**	**100**
Overall mean	**43**	**108**	**57**	**158**	**44**	**192**	**48**	**192**		
Overall density	**Grasses density = 48 m^{-2}**				**Trees density = 163 ha^{-1}**					

Table 3. Site wise winter season carrying capacity (Ha/Au/4month).

Study parameters	Total forage (Kg/ha)	Available forage (Kg/ha)	WSCC (Ha/Au/4month)	Range condition
Flat area	687.5	343.8	3.14	Fair to Good
G. Slope	893.3	446.7	2.42	Good
S. Slope	1174.1	587.1	1.84	V. Good
Gully Area	888.3	416.7	2.59	Good
Overall average CC	**897.1**	**448.5**	**2.41**	**Good**

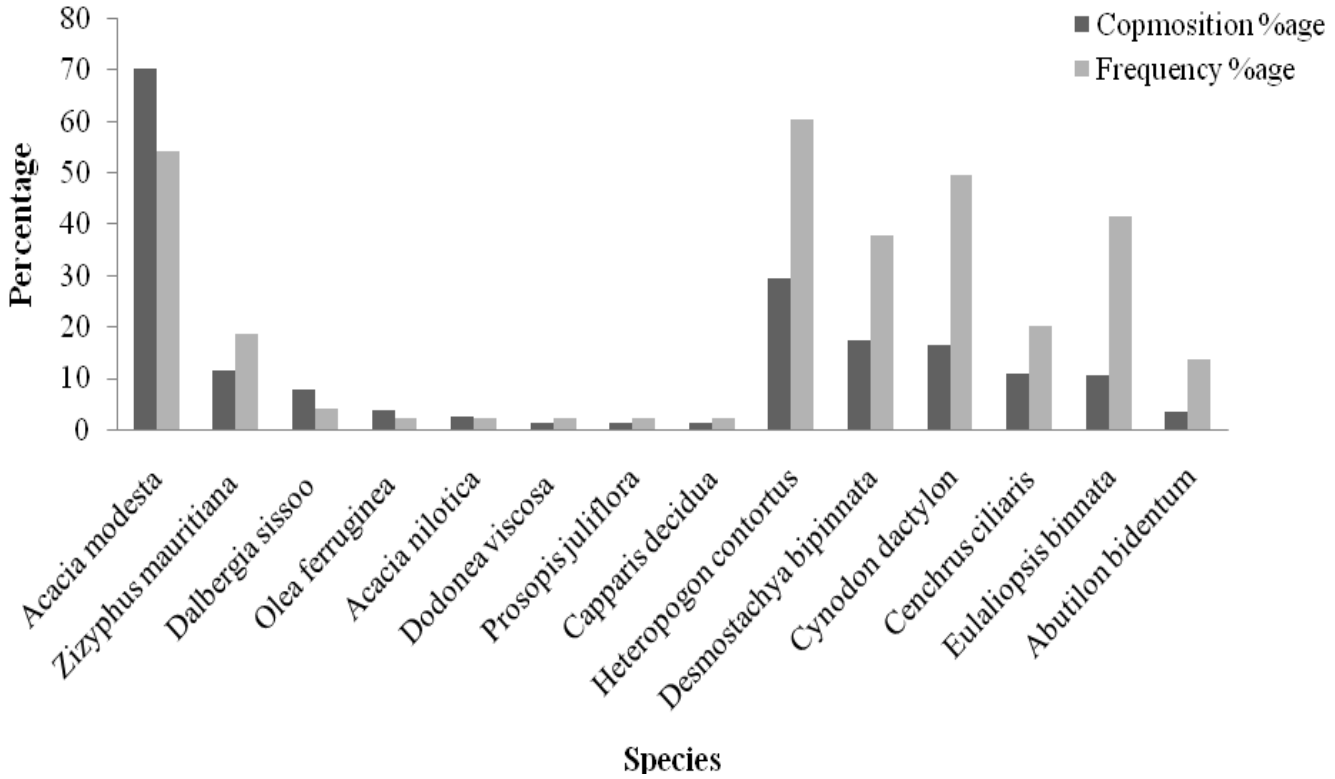

Fig. 1. Specie wise vegetation composition and frequency %age.

Discussion

Results revealed that herbs were dominating in the area with reference to cover (64.09%) along with number of plants m^{-2} (48), followed by trees/shrubs cover (19.11%) with 163 plants/ ha^{-1}. *Acacia modesta* was the main contributing tree species, while *Heteropogon contortus* was the main grass species. Good cover percentage in the upper zone was due to high elevation and less number of livestock calculated from a survey conducted in the watershed, that's why the range in this zone is in very good condition with carrying capacity of 1.87 ha/AU/4month, while in the lower zone the cover was with lowest value due to more livestock pressure for grazing and the range is in fair to good condition with carrying capacity of 3.29 ha/AU/4month. Another factor is the dependence of local people on natural resources. Upper zone is known as an industrial area and the people have job opportunities there and pay less attention towards agriculture and forestry while the people in the lower zone totally depend on agriculture and livestock rearing. Similarly vegetation density was good in the upper zone, while it was lowest in lower zone showing more deforestation rate. When we compare different soil characters then the flat areas are facing more grazing pressure and deforestation as indicated by less cover percentage, low density and low carrying capacity. The difference present between zones and soil physiography was mostly due to human interference.

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