



## An estimation of feed and fodder availability in the arid Rajasthan

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Received: 13 August 2019; Accepted: 20 September 2019

### ABSTRACT

Animal husbandry is a major economic activity of farming systems of arid Rajasthan contributing more than 50% in the total economy. Regular and assured supply of feed and fodder is essential for sustainable livestock development. The aim of the present study was to estimate the feed and fodder demand and availability for existing livestock based on secondary data collected from different sources. The total annual availability of feed and fodder for livestock in arid Rajasthan worked out to be 38.46 million tons against the requirement of 58.39 million tons. The supply of dry roughages is exceeded by 5.03% against the requirement of 16.71 million tons. The surplus availability of roughages was observed in Hanumangarh, Sri Ganganagar, Jhunjhunu, Sikar, Jalore and Bikaner districts. The highest shortfall of green fodder was observed in Churu followed by Nagaur, Jalore and Sikar district. The demand for concentrate exceeded more than 50% in most of the districts and it was highest in Barmer, Nagaur and Jaisalmer. To mitigate the deficit supply of green and dry fodder, silvopastoral models should be included in the policies for livestock development. The establishment of fodder banks with complete and balanced fodder block making machines in cluster of villages, and promotion of dual purpose crops through extension may need more attention by the state government to mitigate the shortfall of feed and fodder supply.

**Key words:** Arid Rajasthan, Concentrate, Fodder supply, Green fodder, Roughages

Arid regions cover about 12% geographical area of India, comprising 31.7 mha hot arid region, of which 61% fall in western Rajasthan. The arid regions face severe edapho-climatic conditions due to low rainfall with high inter-annual variability, high wind and solar regimes. Animal husbandry sector contributed more than 50% in the total economy of the arid districts and about 8% in the state GDP (Anonymous 2016); provides sustainable year-round income and employment to large number of farmers. Regular and assured supply of feed and fodder is essential to get sustainable production from livestock. Evidences indicate that feed related problems accounted for about 36% loss in dairy animals and losses due to scarcity of dry and green fodder were estimated to be 11.6 and 12.3%, respectively (Birthal and Jha 2005). Mitigating scarcity of dry fodder and managing availability of green fodder round the year is a serious challenge for the livestock policy planners, as majority of the farmers are resource poor and unable to produce and store livestock feed and forages. Attempts have been made in the past to estimate livestock feed and fodder availability and requirement in the country (Ramchandra *et al.* 2007 and Singh *et al.* 2013), and a disaggregated

analysis for demand and supply of livestock feed and fodder in Rajasthan by Chnad *et al.* (2015). However, no comprehensive studies are available for arid Rajasthan. An up-to-date information on the feed and fodder requirement for livestock is essential for planning of livestock development. Therefore, the present study develops a more realistic methodology and estimates feed availability and requirement in arid Rajasthan at district level.

### MATERIALS AND METHODS

The present study was conducted in the 12 western districts of Rajasthan based on the published secondary data on land use, area and production under different crops and livestock population. The requirement of animal feed on dry matter was estimated without converting the species into ACUs. The age and sex of bovine and number of small ruminants and camel were taken as per the 19<sup>th</sup> Livestock Census. In bovines dry matter intake was assumed 2.5% of body weight and in sheep and goat it was 3% and in case of camel, 2% of body weight was taken. The standard body weight of animals was assumed. The dry matter in different feed and fodder was estimated by the factor suggested by Ranjhan *et al.* (1999). The dry matter consumption was worked out to be 8.75 kg for cattle, 10 kg for buffalo, 0.75 kg for small ruminants and 12.5 kg for camel.

The availability of roughages from different crops was assessed from production data for the year 2012–13 (Anonymous 2015). Dry fodder from crop-residues of

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various utilizable cereals, pulses and oilseed crops was estimated based on the grain-to-straw ratio taken in earlier studies (Ramachandra *et al.* 2007). The availability of dry fodder from grazing lands was computed by multiplying the area under these lands with factors suggested by Tanwar and Verma 2017 and Bhora *et al.* 2012. Green fodder availability was estimated by using production potential per unit hectare from land classification data for the year 2012–13 (Rajasthan Agricultural Statistics 2015). The availability of green fodder from the gross cropped area (GCA) on the assumption that 2% of the GCA is under fodder cultivation with an average yield of 13.13 tonnes/ha/year (Bohra *et al.* 2012). It was assumed that in arid Rajasthan average fodder yield from forests is around 1.5 tonnes/ha/year. The dry matter content in green fodder was assumed to be 25% (Anandan and Sampath 2015) and in concentrate as 90% for estimation of availability. An extraction ratio of 0.10% was used for rice, wheat, maize and pulses, 0.15% for pearl millet and sorghum, 0.30 for barley and 0.50% for clusterbean for estimation of concentrate availability. To estimate the availability of oilseed cakes, the production of oil seed crops of 2012–13 was multiplied by the factor of 0.60 for ground nut and sesame, 0.67 for mustard, cotton was multiplied by 0.585 (Ramachandra *et al.* 2007). The demand of dry fodder, green fodder and concentrate was estimated by multiplying the annual feed and fodder demand of individual species with the total number of animals of the species as per the 19<sup>th</sup> Livestock Census and summed up district wise. The feed

balance was then computed as % gap between the demand and availability.

## RESULTS AND DISCUSSION

*Estimation of dry fodder availability:* The major sources of dry matter in the arid Rajasthan include grazing lands and cultivated crops. The total dry matter estimated from these resources is 17.549 million tonne of which 14.70% is contributed by the grazing lands and rest by the cultivated crops (Table 1). Among the grazing lands, pastures lands contributed 0.731 million ton dry fodder followed by culturable wastelands (0.628 million tonne). In Jaisalmer district, grazing lands contributed 70.20% in the total dry matter availability and in rest of the districts cultivated crops contributed more than 72% in the dry matter availability. The major contribution of dry fodder comes from rainfed crops among the cultivated crops as net irrigated area in arid Rajasthan is only 7.39% of the total geographical area (Agricultural Statistics of Rajasthan 2015). The dry matter availability from cultivated crops estimated to the tune of 14.970 million tonne of which 60.35% comes from cereals, 12.92% from pulses, 20.83% from guar (cluster bean) and rest 5.91% through groundnut. Among crops, rainfed crops such as pearl millet, maize, sorghum, *khariif* pulses and guar accounts for 59.42% of the dry matter. Among crops, rainfed pearl millet contributed 97.41% in the total dry matter availability of Barmer, followed by 94.01% in Jalore, 81.66% Churu, 75.20% Jodhpur, 64.71% Jaisalmer, 62.50% Jhunjhunu and 46.80% in Nagaur. In IGNP irrigated

Table 1. District wise availability of dry fodder (million tonne) from different sources in arid Rajasthan

Source	Barmer	Bikaner	Churu	S.Ganganagar	Hanuman garh	Jaisal- mer	Jalore	Jhunjhunu	Jodhpur	Nagaur	Pali	Sikar	Arid
Forests	0.032	0.088	0.006	0.056	0.017	0.042	0.022	0.037	0.007	0.017	0.080	0.057	0.461
Pastures	0.183	0.046	0.034	0.000	0.004	0.093	0.043	0.035	0.110	0.065	0.082	0.036	0.731
Wastelands	0.023	0.005	0.000	0.000	0.000	0.069	0.015	0.003	0.028	0.011	0.026	0.003	0.184
Culturable wastelands	0.039	0.126	0.003	0.005	0.001	0.431	0.004	0.001	0.004	0.003	0.009	0.002	0.628
Fallow lands	0.063	0.034	0.009	0.014	0.004	0.024	0.018	0.006	0.066	0.019	0.022	0.008	0.287
Current fallow	0.063	0.034	0.009	0.014	0.004	0.024	0.018	0.006	0.066	0.019	0.022	0.008	0.287
Total grazing lands	0.405	0.333	0.062	0.090	0.029	0.683	0.120	0.089	0.280	0.133	0.242	0.114	2.579
Bajra	0.751	0.033	0.374	0.013	0.137	0.033	0.942	0.610	0.570	0.263	0.107	0.877	4.710
Jowar	0.003	0.001	0.000	0.000	0.000	0.001	0.009	0.000	0.054	0.044	0.170	0.000	0.282
Maize	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.000	0.053
Rice	0.000	0.000	0.000	0.029	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.104
Moth	0.150	0.041	0.086	0.001	0.025	0.000	0.035	0.000	0.043	0.018	0.000	0.001	0.401
Cowpea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.002	0.000	0.019	0.036
Mung	0.011	0.006	0.025	0.028	0.013	0.004	0.078	0.014	0.028	0.026	0.053	0.010	0.296
Guar	0.101	0.584	0.209	0.579	0.960	0.077	0.091	0.161	0.139	0.033	0.053	0.133	3.118
Wheat	0.017	0.230	0.062	0.937	0.884	0.017	0.050	0.315	0.133	0.212	0.145	0.327	3.332
Barley	0.000	0.012	0.022	0.195	0.074	0.000	0.001	0.051	0.001	0.043	0.015	0.138	0.553
Gram	0.000	0.262	0.152	0.194	0.074	0.137	0.003	0.145	0.003	0.078	0.061	0.092	1.201
Groundnut	0.002	0.431	0.100	0.009	0.021	0.021	0.030	0.011	0.154	0.023	0.003	0.080	0.885
Crops	1.037	1.600	1.030	1.985	2.262	0.291	1.238	1.322	1.124	0.742	0.659	1.678	14.970
Total dry fodder	1.442	1.933	1.092	2.075	2.292	0.973	1.358	1.411	1.403	0.876	0.901	1.793	17.549

districts, viz. Bikaner, Sri Ganganagar and Hanumangarh, wheat straw contributed 83.33, 79.81 and 75.62% in the total dry matter availability from the crops, respectively. The moth bean is the lone pulse contributed 93.17% in the dry matter availability from pulses in Barmer and irrigated gram (chickpea) is contributed 97.13% dry matter of the district in Jaisalmer in pulses. In Jalore district, mung bean contributed 67.24% in the dry matter available from the pulses while in rest of the nine districts gram is the dominating pulse contributed considerably in dry matter availability from the pulses. In arid Rajasthan, guar estimated to supply 3.118 million tonne dry matter of which 30.79% is contributed by Hanumangarh, 18.73% by Bikaner and 18.57% by Sri Ganganagar. Groundnut is estimated to supply 0.885 million tonne dry matter. Among different districts, Hanumangarh contributed highest followed by Sri Ganganagar, Bikaner and Sikar in the total dry matter availability in arid Rajasthan. These four districts contributed 46.12% of the total dry fodder production of the state.

*Estimation of green fodder availability:* The total green fodder production in arid Rajasthan during 2012–13 was estimated 17.960 million tonnes (Table 2). Major part of the green fodder comes from grazing lands (67.79%). In arid Rajasthan, area under cultivated fodder crops is only 2% of gross cropped area (Tanwar and Verma 2017). Four districts, viz. Sri Ganganagar, Hanumangarh, Jhunjhunu and Sikar contributed 53.45% of the total green fodder availability due to larger area under irrigated crops. Permanent pastures and grazing land and culturable waste lands accounted 60.50% of the fodder availability. There is a wide inter-district variability in green fodder availability from different sources. In drier and salt affected districts, viz. Jaisalmer, Barmer, Pali, Jodhpur, Bikaner, Jalore and Nagaur, contribution from grazing lands is 93.96, 82.83, 83.79, 78.81, 75.67, 70.14 and 66.90% of the respective districts' green fodder availability while in rest of the districts where irrigated area is higher, the contribution of green fodder from cultivated forage crops is higher. The

contribution of forage crops in the total fodder availability among districts is highest in Hanumangarh (89.43%), followed by Sri Ganganagar (78.37%), Jhunjhunu (60.85%), Sikar (59.94%) and Churu (54.15%). Though availability of green fodder from grazing lands is the major source of fodder, its availability varied considerably depending upon the monsoon. Further, supply of green fodder from these grazing lands is restricted to post rainy season only up to November and during rest part of the year animals deprived off from the green fodder. Suresh *et al.* (2007) also reported that common property resources (CPRs) constitute a major source of green fodder for 85–99% of the farmers in Rajasthan.

*Estimation of concentrates availability:* The availability of concentrate estimated from different crops in arid Rajasthan is 2.954 million ton (Table 3). The contribution of cereals, pulses, guar and oil seeds in total concentrate availability is 26.07, 3.86, 31.04 and 39.03 %, respectively. Among cereals, rainfed pearl millet is the dominating cereal in Barmer, Jalore, Jodhpur, Churu, and Sikar. In Jaisalmer, the contribution from rainfed pearl millet and irrigated wheat in the availability of concentrate is equal. In IGNP irrigated districts, viz. Bikaner, Hanumangarh and Sri Ganganagar, wheat accounted 82.14, 73.33 and 66.20% in the concentrate availability of these districts from cereals. The availability of concentrate from rainfed guar is considerable in arid districts of the Rajasthan (0.917 million tone) which is 31.04% of the total concentrate availability in these areas. Rajasthan is the second largest oilseed producing state in the country with first in rapeseed and mustard and second in groundnut production (Anonymous 2015). In arid Rajasthan concentrate availability from the oilseeds is estimated to be of 1.153 million tonne which is 39.03% of the total concentrate availability. Rapeseed and mustard holds the prime position with a contribution of 26.37% in the concentrate availability from oilseeds followed by groundnut (8.97%). Groundnut is the principle oilseed crop in Bikaner while mustard is dominating in rest

Table 2. District wise availability of green fodder (million tonne) from different sources in arid Rajasthan

District	Forests	Permanent pastures and grazing land	Barren and Uncultivable wastelands	Culturable waste lands	Fallow lands (other than current fallows)	Current fallows	Misc tree crops and groves	Total grazing lands	Cultivated fodder crops	Total
Barmer	0.051	1.018	0.123	0.207	0.334	0.350	0.000	2.084	0.432	2.516
Bikaner	0.141	0.254	0.028	0.664	0.180	0.207	0.003	1.477	0.475	1.952
Churu	0.010	0.188	0.001	0.015	0.050	0.058	0.000	0.320	0.377	0.698
Sri Ganganagar	0.091	0.001	0.002	0.027	0.073	0.068	0.007	0.268	0.971	1.239
Hanumangarh	0.028	0.023	0.000	0.003	0.019	0.043	0.000	0.116	0.981	1.097
Jaisalmer	0.067	0.516	0.362	2.267	0.128	0.111	0.000	3.451	0.222	3.673
Jalore	0.035	0.237	0.078	0.023	0.094	0.084	0.000	0.552	0.235	0.787
Jhunjhunu	0.060	0.197	0.016	0.006	0.033	0.027	0.000	0.339	0.527	0.866
Jodhpur	0.010	0.611	0.145	0.023	0.345	0.278	0.000	1.413	0.381	1.793
Nagaur	0.028	0.360	0.056	0.015	0.099	0.212	0.000	0.770	0.382	1.151
Pali	0.130	0.456	0.139	0.048	0.115	0.088	0.000	0.977	0.189	1.166
Sikar	0.092	0.201	0.018	0.009	0.043	0.046	0.000	0.409	0.613	1.021
Arid Rajasthan	0.744	4.061	0.968	3.305	1.512	1.573	0.011	12.175	5.785	17.960

Table 3. District wise dry matter availability from concentrate (million tonne) in arid Rajasthan

Crop	Barmer	Bikaner	Churu	Sri Ganganagar	Hanuman-garh	Jaisalmer	Jalore	Jhunjhunu	Jodhpur	Nagaur	Pali	Sikar	Arid
Bajra	0.045	0.002	0.022	0.001	0.008	0.002	0.056	0.037	0.034	0.016	0.006	0.053	0.283
Jowar	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.003	0.003	0.010	0.000	0.017
Maize	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002
Rice	0.000	0.000	0.000	0.002	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008
Wheat	0.002	0.023	0.006	0.094	0.088	0.002	0.005	0.032	0.013	0.021	0.014	0.033	0.333
Barley	0.000	0.003	0.005	0.045	0.017	0.000	0.000	0.012	0.000	0.010	0.003	0.032	0.128
Total grain crops	0.047	0.028	0.034	0.142	0.120	0.004	0.062	0.080	0.051	0.050	0.037	0.117	0.770
Moth	0.009	0.002	0.005	0.000	0.001	0.000	0.002	0.000	0.003	0.001	0.000	0.000	0.024
Cowpea	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.002
Mung	0.001	0.000	0.001	0.002	0.001	0.000	0.005	0.001	0.002	0.002	0.003	0.001	0.017
Gram	0.000	0.015	0.009	0.011	0.004	0.008	0.000	0.009	0.000	0.005	0.004	0.005	0.071
Total pulses	0.010	0.018	0.015	0.013	0.007	0.008	0.007	0.010	0.004	0.007	0.007	0.007	0.114
Guar	0.030	0.172	0.061	0.170	0.282	0.023	0.027	0.047	0.041	0.010	0.016	0.039	0.917
Sesame	0.001	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.003	0.000	0.020	0.000	0.033
Groundnut	0.001	0.129	0.030	0.003	0.006	0.006	0.009	0.003	0.046	0.007	0.001	0.024	0.265
Mustard	0.009	0.040	0.029	0.254	0.093	0.017	0.054	0.078	0.054	0.056	0.045	0.050	0.779
Cotton	0.000	0.000	0.000	0.024	0.036	0.000	0.000	0.000	0.005	0.008	0.002	0.000	0.075
Total oil cakes	0.010	0.170	0.059	0.280	0.136	0.024	0.070	0.081	0.108	0.071	0.068	0.074	1.153
Total concentrate	0.097	0.388	0.170	0.605	0.545	0.058	0.166	0.219	0.204	0.138	0.127	0.238	2.954

of the districts except Churu and Jodhpur where both oilseed crops shared equal importance. District wise analysis showed that Sri Ganganagar accounted 20.48% followed by Hanumangarh (18.45%) and Bikaner (13.13%) in concentrate production. These three districts accounted to the tune of 52.06% of this part of the state.

**Feed and fodder demand and supply:** The annual demand for livestock feed and fodder is estimated to be 58.39 million tonnes on dry matter basis (Table 4) which comes around 52% of whole Rajasthan. However, the estimated demand seems much higher than that was estimated by Chand *et al.* (2015) for whole Rajasthan based on 2007 Livestock Census. The estimated demand for roughages, green fodder and concentrate worked out is 16.71, 30.17 and 11.51 million tonnes, respectively for arid Rajasthan. Of the total demand estimated for concentrate, cattle require 53.99% and 46.01% by buffaloes. There was a wide inter-district variability in the feed demand due to variability in the livestock population as well as its composition. The highest demand for feed and fodder exist in Barmer, Bikaner, Jodhpur and Nagaur districts due to large number of livestock. These four districts required about 45% of the roughages and green fodder of the arid Rajasthan and 41% of concentrate. The supply of dry fodder on dry matter basis is 17.55 million tonnes which is excess to the tune of 5.03% against requirement in the arid Rajasthan. However, there is deficit supply for green fodder and concentrate in these regions. The gap between demand and supply is -40.47% for green fodder and -74.34% for concentrate. The

contribution of dry fodder towards overall dry matter is 45.63% and green fodder and concentrates shares 46.70% and 7.67% in total dry matter available in the arid Rajasthan (38.46 million tonnes). However, earlier studies (Chand *et al.* 2015 and Narain and Kar 2005) reported deficit supply of dry matter in the arid Rajasthan. During drought years, the shortage become more acute and goes up to 2/3rd of the demand (Narain and Kar 2005). The surplus availability of roughages is observed to the tune of 89.26% in Hanumangarh followed by 68.29% in Sri Ganganagar, 58.43% in Jhunjhunu, 35.61% in Sikar, 25.93% in Jalore and 10.92% in Bikaner, as irrigated area in these districts is more than 30% of the total reported area. The highest shortfall for roughages is in Nagaur (-49.13%) followed Barmer (-33.64%). The gap between demand and supply is not uniform for green fodder and concentrate among the districts. The highest shortfall for green fodder is observed in Churu (64.65%) followed by Nagaur (63.14%), Jalore (59.69%) and Sikar (57.32%). The demand for concentrate is exceeded more than 50% in most of the districts except in Sri Ganganagar (-39.50%) and Hanumangarh (-46.57%), where it is in minus of the availability. The gap in the demand and supply is highest in Barmer (-90.93%), Nagaur (89.13%) and Jaisalmer (86.51%) due to large livestock population and short supply of concentrate from the rainfed crops. Chand *et al.* (2015) also reported surplus supply of dry matter in three IGNP irrigated districts, viz. Hanumangarh, Sri Ganaganagar and Bikaner.

Though government has promoted fodder development

Table 4. Requirement and availability of feed and fodder (million tonnes) in arid Rajasthan (2012–13)

District	Dry Fodder			Green Fodder			Concentrate		
	Requirement	Availability	Gap %	Requirement	Availability	Gap %	Requirement	Availability	Gap%
Barmer	2.17	1.44	-33.64	3.92	2.52	-35.71	1.07	0.10	-90.93
Bikaner	1.74	1.93	10.92	3.14	1.95	-37.90	1.15	0.39	-66.26
Churu	1.10	1.09	-0.91	1.98	0.70	-64.65	0.75	0.17	-77.33
Sri Ganganagar	1.23	2.07	68.29	2.22	1.24	-44.14	1.00	0.61	-39.50
Hanumangarh	1.21	2.29	89.26	2.19	1.10	-49.77	1.02	0.55	-46.57
Jaisalmer	1.22	0.97	-20.49	2.20	3.67*	66.82	0.43	0.06	-86.51
Jalore	1.08	1.36	25.93	1.96	0.79	-59.69	0.91	0.17	-81.76
Jhunjhunu	0.89	1.41	58.43	1.60	0.87	-45.63	0.76	0.22	-71.18
Jodhpur	1.87	1.40	-25.13	3.37	1.79	-46.88	1.26	0.20	-83.81
Nagaur	1.73	0.88	-49.13	3.12	1.15	-63.14	1.27	0.14	-89.13
Pali	1.15	0.90	-21.74	2.08	1.17	-43.75	0.77	0.13	-83.51
Sikar	1.32	1.79	35.61	2.39	1.02	-57.32	1.11	0.24	-78.56
Arid Rajasthan	16.71	17.55	5.03	30.17	17.96	-40.47	11.51	2.95	-74.34

programmes through various schemes, yet fodder scarcity is the major concern in arid Rajasthan. Surplus availability of roughages was observed in Hanumangarh, Sri Ganganagar, Jhunjhunu, Sikar, Jalore and Bikaner districts, whereas highest shortfall of green fodder was observed in Churu, Nagaur, Jalore and Sikar district. The demand for concentrate is exceeded more than 50% in most of the districts and it was highest in Barmer, Nagaur and Jaisalmer. To mitigate the deficit supply of green and dry fodder, proven silvopastoral models need to be included in the policies for livestock development in arid Rajasthan. The establishment of fodder banks and complete fodder block making machines in cluster of villages and promotion of dual purpose fodder crops through extension need more attention by the state government to mitigate the shortfall of feed and fodder supply.

#### REFERENCES

- Agricultural Statistics of Rajasthan 2015. *Agricultural Statistics of Rajasthan 2012–13*. Directorate of Economics and Statistics, Department of Planning, Rajasthan, Jaipur.
- Anandan S and Sampath K T. 2015. *The Indian Feed Inventory*. National Institute of Animal Nutrition and Physiology, Bangalore, India.
- Anonymous 2015. *Agricultural Statistics at a Glance 2015*. Directorate of Economics and Statistics, Government of India, Ministry of Agriculture and Farmers Welfare, New Delhi.
- Anonymous 2016. *Dairying in Rajasthan—A Statistical Profile 2016*. [http://nddb.org/sites/default/files/NDDB\\_Rajasthan\\_21-9-16\\_Final.pdf](http://nddb.org/sites/default/files/NDDB_Rajasthan_21-9-16_Final.pdf).
- Birthal P S and Jha A K. 2005. Economic losses due to various constraints in dairy production in India. *Indian Journal of Animal Sciences* **75**(12): 1470–75.
- Bohra H C, Patel, A K, Rohilla P P, Mathur B K, Patil N V and Misra A K. 2012. *Feed production technologies for sustainable livestock production in arid areas*. Central Arid Zone Research Institute, Jodhpur, India.
- Chand P, Sirohi S, Sirohi S K and Chahal V P. 2015. Estimation of demand and supply of livestock feed and fodder in Rajasthan: a disaggregated analysis. *Indian Journal of Animal Sciences* **85**(11): 1229–34.
- Narain P and Kar A. 2005. *Drought in Rajasthan: Impact, coping mechanism and management strategies* (Eds.) Narain P and Kar A. Central Arid Zone Research Institute, Jodhpur.
- Rajasthan Agricultural Statistics 2015. *Rajasthan Agricultural Statistics at a Glance for the Year 2013–14*. Commissionerate of Agriculture, Rajasthan, Jaipur
- Ramachandra K S, Taneja V K, Sampath K T, Anandan S and Angadi U B. 2007. *Livestock Feed Resources in Different Agroecosystems of India: Availability, Requirement and their Management*. National Institute of Animal Nutrition and Physiology, Bangalore.
- Ranjhan S K, Sen K C and Ray S N. 1999. *Nutritive value of Indian cattle feeds and feeding of animals*. Indian Council of Agricultural Research, New Delhi.
- Singh K M, Singh R K P, Jha A K and Abhay Kumar. 2013. *A Micro Analysis of Fodder Production and Marketing in India: The Case of Bihar*. MPRA Paper No. 53548, [https://mpra.ub.uni-muenchen.de/53548/1/MPRA\\_paper\\_53548.pdf](https://mpra.ub.uni-muenchen.de/53548/1/MPRA_paper_53548.pdf).
- Suresh A, Gupta D C, Mann J S and Singh V K. 2007. *Sheep production in semi-arid zones—Management and Economics*. Research bulletin, Central Sheep and Wool Research Institute, Avikanagar, Rajasthan, India.
- Tanwar P S and Verma H K. 2017. Feed and fodder availability in Punjab state vis-à-vis livestock population—An estimate. *Indian Journal of Animal Sciences* **87**(7): 879–84.