FORAGE 2000 AD

THE SCENARIO FOR ARID RAJASTHAN

CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR-342003
1992

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CONTENTS

INTRODUCTION

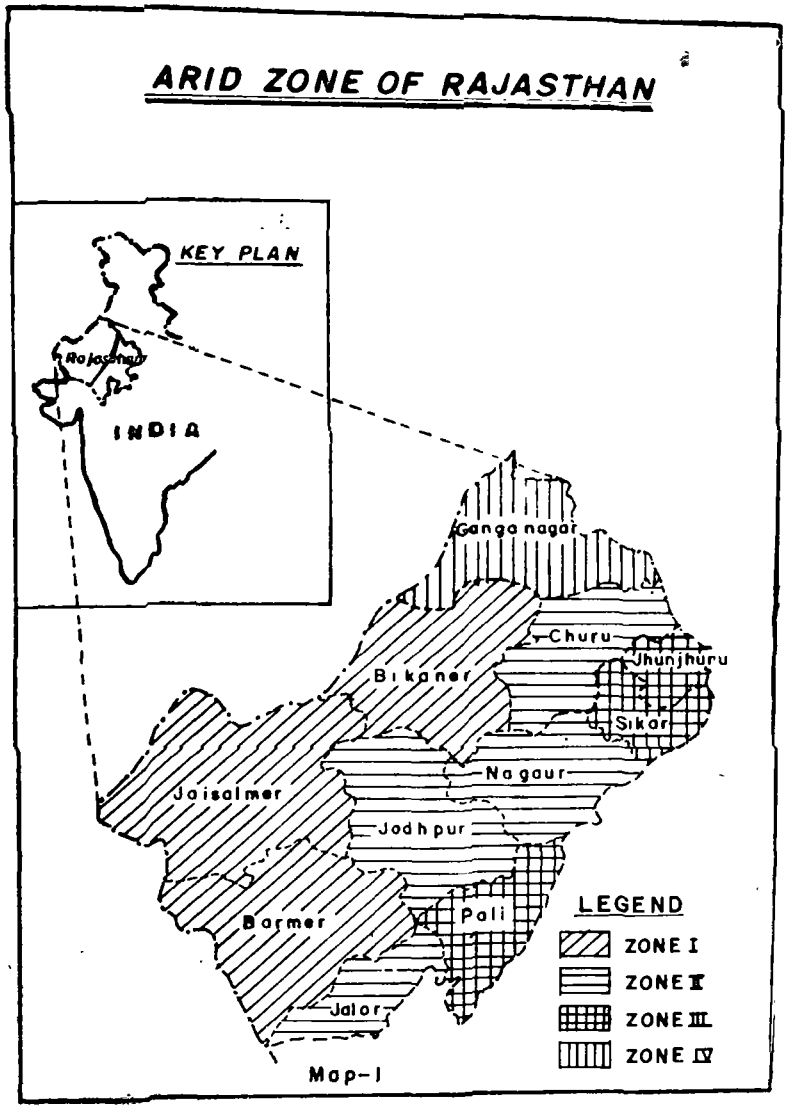
Livestock continues to be the mainstay of the arid region of Rajasthan. However, over the years, the continuous increase in livestock numbers and decline in area under common grazing lands has resulted in shortage in supply of forage in the region. The continued decline in the quantity of available forage has the immediate implication of survival of animals and the wider implication for the preservation of the desert ecosystem. An attempt has been made here to estimate the likely forage/fodder deficit for the expected livestock numbers in 2000 A.D. at the current rates of growth and the likely supply and demand for various livestock products. The alternatives for enhancing the forage supply and, finally, alternative technologies for conserving/improving the arid ecosystem of India have also been discussed.

For this study, the eleven arid districts of western Rajasthan are classified under the four agro-climatic zones on the basis of aridity index (Krishnan, 1968). Accordingly, the districts of Barmer, Bikaner and Jaisalmer come under Zone I, Churu, Jalore, Jodhpur and Nagaur, under Zone II, Jhunjhunu, Pali and Sikar, under Zone III and Ganganagar under Zone IV (Map 1).

The norms adopted for estimating fodder/stover availability and the demands by livestock are as follows :

The demand and supply estimates have been made for three situations, namely, good, normal and drought year. The fodder/stover yield from private holdings is taken to be 50% and 36% of a good year in a normal and a drought year, respectively. For grazing lands, the forage yield in normal and drought year is taken to be 50% and 30% of a good year.

The livestock population converted into Adult Cattle Units (ACU) is projected for the year 2000 taking the present trends in their growth. Similarly, the forage supply from private and grazing land is projected taking into consideration the long term growth trend in land utilization variables and forage availability from these land utilization variables.


ARID ZONE OF RAJASTHAN
KEY PLAN
Rajasthan
INDIA
Ganga nagar
Churu
Jhunjhuru
Bikaner
Sikar
Nagaur
Jaisalmer
Jodhpur
Barmer
Pali
Jalor
LEGEND
ZONE I
ZONE II
ZONE III
ZONE IV
Map-I

Norms adopted for fodder availability and demands

Grazing area	Fodder/ stover (t/ha)	Crop	Grain to stover ratio		Livestock to Adult Cattle Unit
Forest	0.93	Pearl millet	1:2	Cow>3	1.0
Barren	0.19	Hybrid pearl millet	1:1.5	Cow<3	0.75
Permanent pasture	0.90	Sorghum	1:1.75	Calf	0.25
		Maize	1:2	1 yr & below	
Culturable waste	0.19	Wheat	1:1.5	Buffalo>3	1.30
		Barley	1:1.5	Buffalo<3	0.75
Fallow land	0.23	Gram	1:0.50		
Stubble	0.15	Other pulses	1:1	Calf 1 yr & below	0.50
				Sheep	0.15
				Lamb	0.06
				Goat	0.15
				Kid	0.06
				Camel	1.00
				Donkey & Horse	0.75

The forage supply improvement prospects have been examined with reference to availability of grazing land in the above 50 ha category for improved fodder production programme. By taking into consideration the demand and supply prospects of various livestock products, the prospects for reducing livestock number have also been examined.

THE FORAGE PROBLEM

Forage position in 1982-83

For the 1982-83 level of livestock population the forage deficit was of the order of 14.9 mts (million tonnes). The deficit at the zonal levels ranged from 1.0 to 6.4 mts for different zones (Fig. 1). The supply was short by 62 percent for the entire arid zone. Between zones, the shortfall ranged between 30 to 71% (Table 1).

Fig I- FORAGE DEMAND SUPPLY POSITION-1982-83

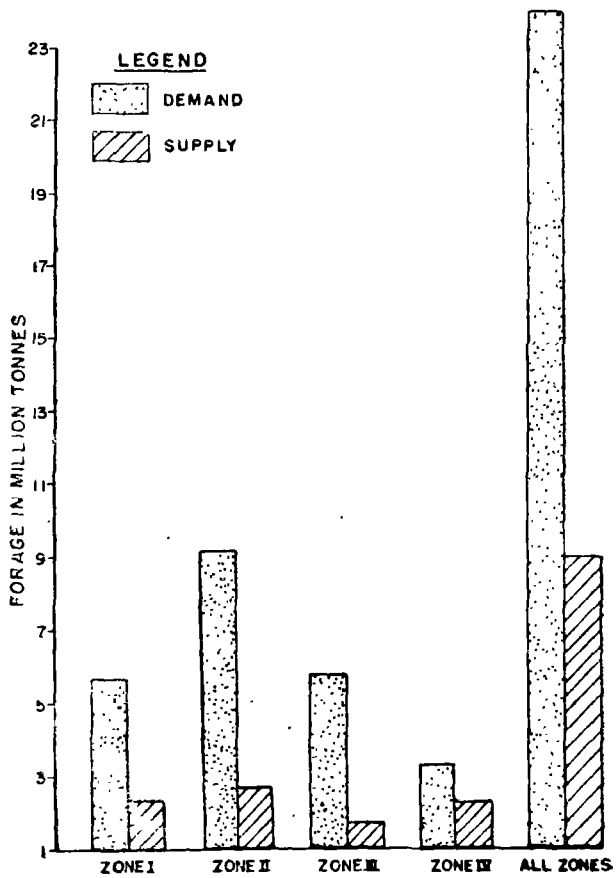


Table 1 : Forage demand-supply position-1982-83

Zones	ACU's (million)	Demand (mts)	Supply (mts)	Surplus/ deficit (mts)	Surplus/ deficit (%)
Zone I	2.27	5.68	2.31	(—) 3.37	(—) 59.4
Zone II	3.67	9.18	2.75	(—) 6.43	(—) 70.1
Zone III	2.31	5.78	1.68	(—) 4.10	(—) 71.0
Zone IV	1.33	3.33	2.30	(—) 1.03	(—) 30.9
All zones	9.58	23.95	9.03	(—)14.92	(—) 62.3

Demand for forage/fodder in 2000 A.D.

Demand for forage is largely governed by the number of livestock and their forage requirement for survival and production. Livestock expressed in terms of adult cattle units (ACU) have shown a continuous increase in all the zones and in the region as a whole as depicted in (Fig. 2). The livestock in ACUs is projected to increase to 11.3 million by 2000 - an increment of 17.6% over that in 1983 (Table 2).

Fig 2- LIVESTOCK PRESSURE (ACUs) ON ARID ZONE GRAZING/FODDER RESOURCES BY 2000 AD

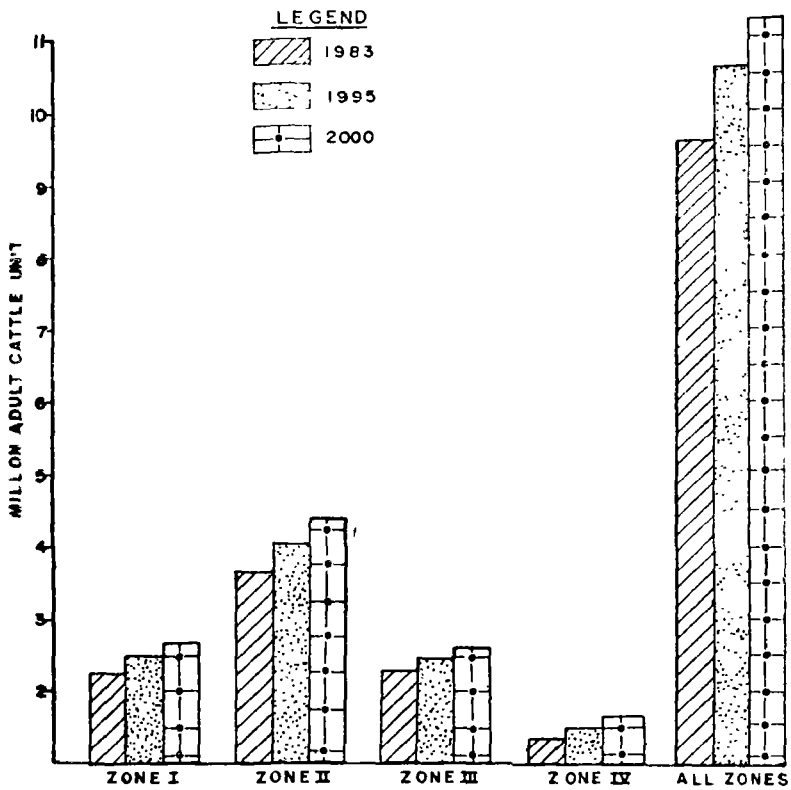
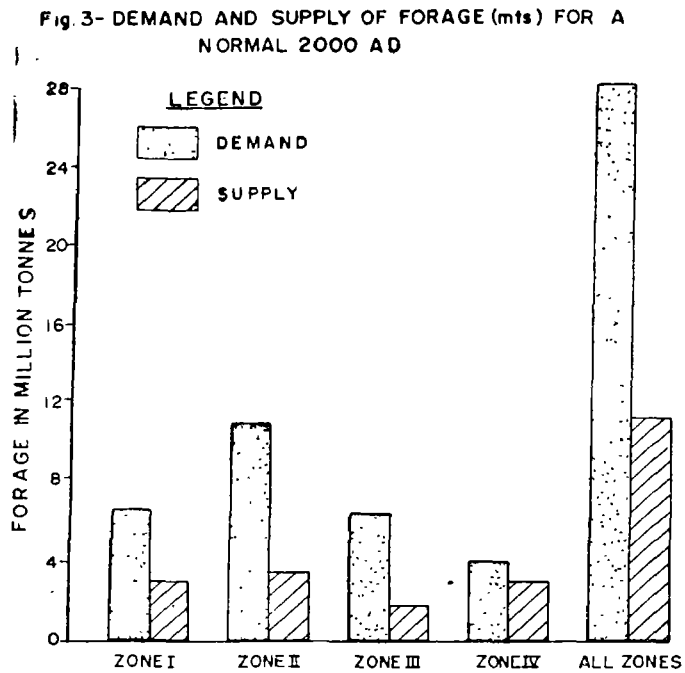


Table 2. Livestock pressure (in million ACUs) on arid zone grazing/fodder resources by 2000 A.D.

Years/zones	Zone I	Zone II	Zone I I	Zone IV	All Zones
1983	2.27	3.67	2.31	1.33	9.58
1995*	2.51	4.17	2.47	1.47	10.62
2000*	2.67	4.42	2.59	1.59	11.27
% change in 2000 over 1983	+17.6	+20.4	+12.1	+19.5	+17.6

* projected.

The demand for forage and fodder by 2000 A.D. is therefore, projected to be 28.2 mts for the entire region (Fig. 3). The zonal demands and zonal supply prospects under three situations representing good, normal and drought situations are presented in Table 3.



It may be noted that the supply prospects were well short of demand in all the zones except in Zone IV and that too in good rainfall years. In the region as a whole, the forage deficit ranged from 8.2 mts in good year to 16.9 mts in normal year and 21.3 mts in case of drought year.

Table 3. Forage/fodder (dry) estimates and balance sheet for arid Rajasthan by 2000 (M tonnes)

Zones	Demand	Supply: Good yr. Situation 1	Supply: Normal yr. Situation 2	Supply: Drought yr. Situation 3	Surplus(+) Deficit (—): Situation 1	Surplus(+) Deficit (—): Situation 2	Surplus(+) Deficit (—): Situation 3
Zone I	6.68	4.96	3.00	1.62	(—) 1.72	(—) 3.68	(—) 5 06
Zone II	11.05	6.14	3.43	2.12	(—) 4.91	(—) 7.62	(—) 8.73
Zone III	6.48	3.26	1.80	1.14	(—) 3.22	(—) 4.68	(—) 5.34
Zone IV	3.97	5.62	3.01	2.00	(+) 1.65	(—) 0.96	(—) 1.97
All zones	28.18	19.98	11.24	6.88	(—) 8.20	(—) 16.94	(—) 21.30
PR*0.5 t. addl. +(1.86 t) for 1/3 of ACUs	30.04	19.98	11.24	6.88	(—) 10.06	(—) 18.80	(—) 23.16

*PR : Production ration.

The deficit in forage for the same population with an additional allowance of 0.5 tonne for productive livestock works out to 10.0, 18.7 and 23.1 mts in the situations of good, normal and drought years, respectively.

Irrigation and dry forage supply

Provision of irrigation should ordinarily lead to increased fodder yield through increased cropping intensity and higher yields. An examination of per hectare yields of crop residue including grazed stubble revealed that per hectare yields of dry fodder on dry matter basis (DM) in irrigated tract of Zone IV (Ganganagar) was more (952 $kgha^{-1}$) than that in Zone I to III which are rainfed Zones (Table 4).

Table 4. Crop residue (dry) yields (kg ha^{-1})

Zones	Crop residue**
Zone I	229
Zone II	478
Zone III	813
Zone IV (Irrigated)	952
All Zones	564

**includes crop stubble grazed.

However, the magnitude of difference in forage yield (139 kg/ha) between Zone III, which falls under slightly better rainfall regime (arid zone standard), and irrigated Zone IV indicate that the difference is not much. The shifts in cropping pattern in favour of dwarf varieties and commercial crops under irrigated conditions may be one of the reasons for the lower difference in forage yields. Another factor may be the paucity of data regarding the green fodder production activity on the

farms. The inference is that the forage increments on irrigated farms cannot be taken for granted unless there is sustained efforts towards this direction.

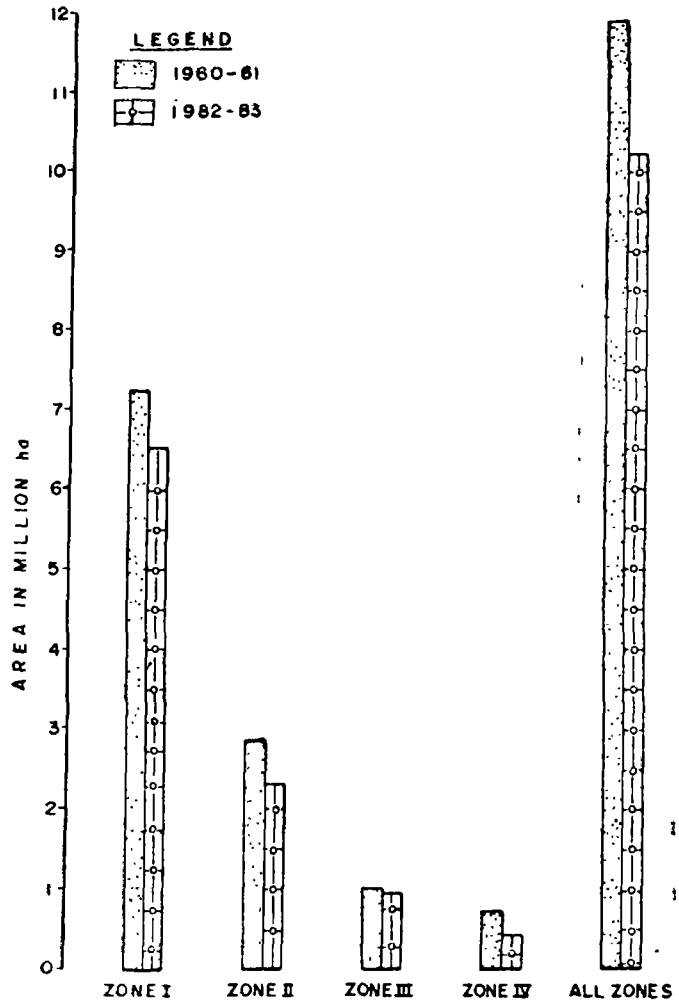
Decline in grazing lands and forage supply

The decline in the area under grazing lands including forests in the region was of the order of 1.7 mha (million hectare) between 1960-61 and 1982-83 (Table 5). The highest decline was observed in Zone IV (44%), followed by Zone II (19%) (Fig. 4). The average productivity of grazing lands is estimated at 295 kg/ha. On the basis of average productivity, the decline in the availability of dry forage due to area decline, would be of the order of about 0.5 mts in 1982-83 compared to that in 1960-61. All the Zones have witnessed decline in forage production, although the decline in the different Zones might have been to different degrees.

Table 5 : Grazing lands in arid Rajasthan (Mha)

Zones/years	1960-61	1982-83	Decline (%)
Zone I	7.22	6.50	(—) 10.6
Zone II	2.85	2.30	(—) 19.3
Zone III	1.07	0.98	(—) 8.5
Zone IV	0.72	0.42	(—) 43.9
All Zones	11.89	10.20	(—) 14.2

Fig 4 - GRAZING LANDS IN ARID RAJASTHAN



SUPPLY PROSPECTS OF LIVESTOCK PRODUCTS

Growth of human population

The analysis of growth rates of human population from 1901 to 1981 for the four agro-climatic zones and the projections on the basis of trends revealed that the population shall touch 19.8 m by 2000. The projected population in the different Zones for the years 1991 and 2000 are presented in Table 6.

Table 6 : Human population in arid Rajasthan (Million)

Zones/years	1981	1991*	2000*	Percent increase in 2000 over 1981
Zone I	2 21	2.63	3.25	46.9
Zone II	5.38	6.45	7.90	46.9
Zone III	3.86	4.57	5.51	42.6
Zone IV	2.03	2.51	3.15	55.2
Total arid zone	13.48	16.16	19.81	46.9

* Projected

It may be noted that the population would increase at the rate of 2.3 per cent per annum in most of the Zones (I-III) and all Zones combined. Only in Zone IV (Ganganagar) the growth rate will be slightly over 2.5 per cent per annum.

The growth rates, however, indicate that by 2000 there will be 6.3 m additional mouths to be fed or slightly more than 0.3 m additional mouths every year. For this the food production should keep pace with the growth of population.

Growth of livestock

The number of livestock is projected to be 29.6 m by 2000 on the basis of analysis of trend (1956-1977). This figure represents an increase of more than one hundred percent (120%) over that in 1956. The projected livestock population as well as different types for the different Zones are presented in Table 7. It may be noted from the Table that except for cattle, all other types of animals are projected to increase enormously in all the Zones. Among the different types of animals, goats are projected to increase at a faster rate in Zone II and III. Cattle, on the other hand, are projected to increase in Zone IV only.

Table 7 : Livestock Population in arid Rajasthan (Millions)

Zones/Years		1956	1977	1995*	2000*
Zone I	Cattle	0.95	0.80	0.22	0 32
	Buffaloe	0.07	0.07	0 04	0.03
	Sheep	1.34	2.32	2 91	2.09
	Goats	1.03	1.89	2.55	2 81
	Total livestock	3.53	5.37	5.15	5.62
	ACUs	1.57	1.87	1.44	1.67
Zone II	Cattle	1.64	1.74	1.45	1.40
	Buffaloe	0.31	0.49	0.53	0.56
	Sheep	2 03	2.80	3.61	3.88
	Goats	1.22	2.44	6.61	8.04
	Total livestock	5.37	7.71	12.52	14.23
	ACUs	2.78	3.58	4.13	4.59
Zone III	Cattle	1.00	1.11	1.01	1.00
	Buffaloe	0.25	0.51	0.66	0.71
	Sheep	1.05	1.23	1.54	1.61
	Goats	1.08	1.44	3.11	3.60
	Total livestock	3.48	4.41	6.47	7.07
	ACUs	1.80	2.42	2.87	3.20
Zone IV	Cattle	0.31	0.48	0.51	0.66
	Buffaloe	0.12	0.31	0.44	0.48
	Sheep	0.32	0.33	0.31	0.31
	Goats	0.18	0.40	0.98	1.16
	Total livestock	1.02	1.64	2.48	2.79
	ACUs	0.68	1.22	1.58	1.82
All Zones	Cattle	3.91	4.13	3.18	3.39
	Buffaloe	0.75	1.38	1.67	1.78
	Sheep	4.75	6.68	7.47	7.88
	Goats	3.49	6.17	13.25	15 61
	Total livestock	13.40	19.13	26.42	29.66
	ACUs	6.83	9.09	10.02	11.28

Total livestock includes other animals like camel, etc.

* Projected Population.

The problem of feeding nearly 15.8 m additional livestock may pose a serious challenge, if the growth of livestock continues as the trend suggests. The growth of smaller animals like sheep and goats, which mostly depend on rangelands for their sustenance, threaten the fragile range eco-system of the desert.

Production of milk

Milk production in the arid districts of Rajasthan was estimated at 1.1 mts in 1972. (Anon 1980). The arid districts were estimated to produce 48% of the total milk produced in the State. No such estimates are available for the later years.

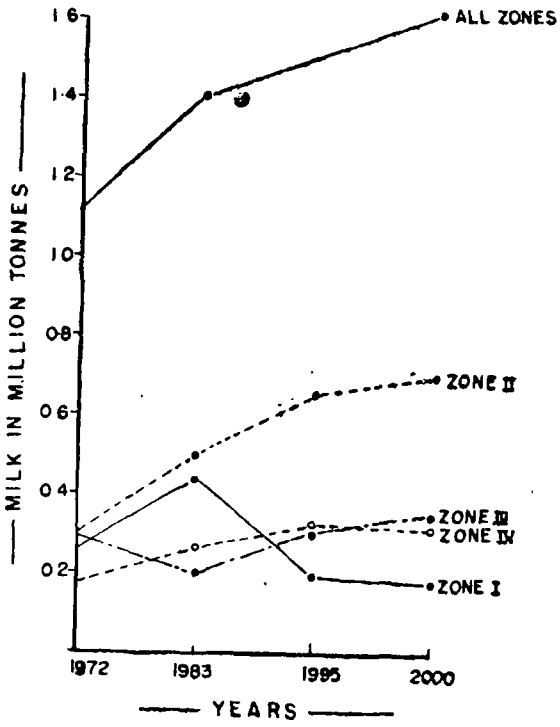
However, by taking the average yields of the milking animals (cow, buffaloe and goat) and the likely percentage of such animals in the total herd, estimates of milk production have been made for different Zones and presented in Table 8. It may be seen from the table that in the 11 arid districts, milk production is projected to rise to 1.6 mts from about 1.1 mts in 1972 (Fig. 5). The increase in the quantity of milk production is significant because, as noted earlier, the cattle population was not found to increase significantly in most of the arid zone, which means that the increased milk production comes from yield increases of existing stock or a higher milch

Table 8 : Supply of milk in arid Rajasthan (Mts)

Zones/Years	1972	1983*	1995*	2000*
Zone I	0.26	0.44	0.20	0.18
Zone II	0.39	0.50	0.66	0.71
Zone III	0.29	0.20	0.31	0.35
Zone IV	0.18	0.26	0.33	0.37
Total	1.12	1.40	1.50	1.61

* Estimated.

Fig 5- SUPPLY OF MILK IN ARID RAJASTHAN



to dry cow ratio. An examination of zonal milk production reveals that milk production in Zone I is likely to fall which will be made good by increases in the remaining three Zones.

Availability of milk

It may be noted from the Table 9 that the per capita availability of milk in the region by 2000 A.D. will be 223 grams. The availability in different Zones ranged from 154 grams in Zone I to 319 grams in Zone IV (Fig. 6). The daily per capita requirement of milk has been reported to be 210 grams. By this yardstick, the availability was slightly less than the requirement in Zones I and III whereas, it was surplus in all other Zones and in the region as a whole.

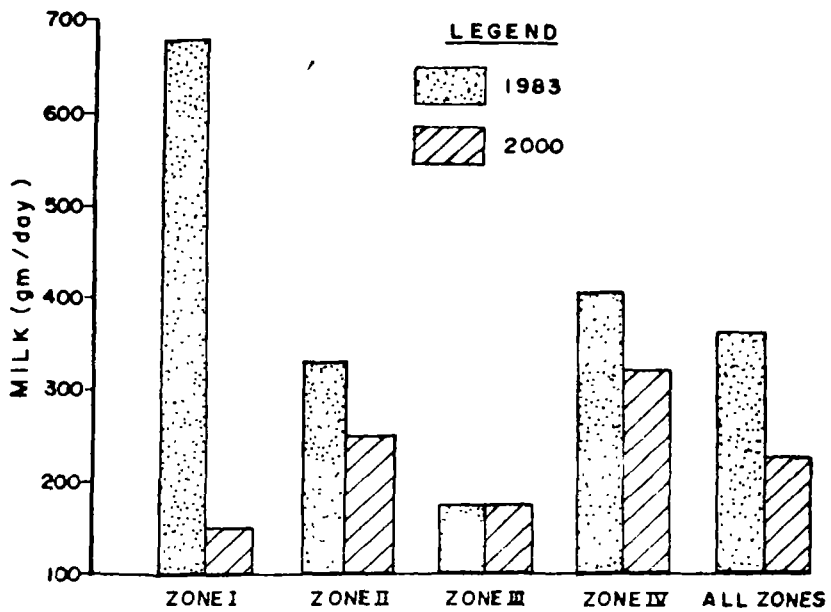
Table 9 : Availability of milk per capita per day in arid Rajasthan (Grams)

Zones/Years	1971	1983	2000
Zone I	477	682	154
Zone II	268	331	247
Zone III	252	175	174
Zone IV	356	405	319
Average	312	356	223

Production of meat

The production of meat/mutton in the region is projected to be 71,573 tonnes by 2000 from an estimated production of 50,470 tonnes in 1983. The production of

Fig 6- AVAILABILITY OF MILK PER CAPITA PER DAY IN ARID RAJASTHAN.



meat is estimated on the basis of number of sheep and goats ordinarily likely to be available in a given year. The proportion of sheep and goat available for slaughter every year was put at 32 and 36 per cent, respectively (Anon. 1980). The production of meat at zonal level is presented in Table 10. It may be noted from the Table that more than 50 per cent of total meat production in the region is projected to come from Zone II. It is also observed that the production of meat in all the Zones have shown an increasing trend all along.

Table 10 : Production of meat (mutton) in arid Rajasthan (tonnes)

Zones/years	1972	1983*	1995*	2000*
Zone I	8,498	16,476	14,050	15,057
Zone II	14,561	20,794	31,168	36,243
Zone III	8,738	9,990	14,160	15,839
Zone IV	2,102	3,210	3,884	4,434
Total	33,899	50,470	63,262	71,573

*Estimated.

Availability of meat

The availability of meat per capita is presented in Table 11. The availability of meat per capita per annum (assuming 50% of the population as meat eating) worked out to 7.22 kg in 2000. This figure is slightly less than the availability in 1983. The per capita per day availability worked out for the region as a whole to be 20 grams in 2000 A.D. (Fig 7). The per capita per day requirement as per nutritional standards is 7 grams. It is, therefore, clear that the availability of meat is nearly three times the nutritional requirement of the people in most of the Zones of the region.

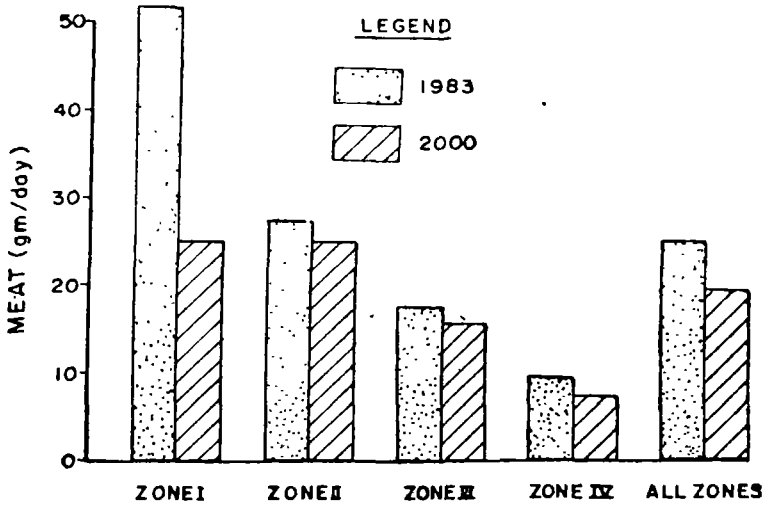
Table 11 : Availability of meat per capita per annum (kg)

Zones/years	1983	2000
Zone I	18.89	9.28
	51.75*	25.41*
Zone II	10 03	9.17
	27.48*	25.12*
Zone III	6.45	5.75
	17.67*	15.75*
Zone IV	3.56	2.81
	9.75*	7.70*
Average	9.35	7.22
	25.6*	19.80*

* Indicates grams per capita per day.

Note : Assuming 50% of the population as meat eating.

Fig 7- AVAILABILITY OF MEAT PER CAPITA PER DAY IN ARID RAJASTHAN



Production of wool

Wool production in arid Rajasthan is projected to fall to 12,067 tonnes by 2000 A.D. from the estimated production of 13,491 tonnes in 1983. The contribution of individual Zones to total wool production is presented in Table 12. It may be noted from the Table that nearly 50 per cent of the total wool production in the region came from a single Zone (Zone II). Table 12 reveals that although the wool production in 2000 has been projected to show an increase over the production figure for 1972 it may be less than that in 1983. Wool production is estimated on the basis of number of sheep. Both sheep population and production at their peaks in 1983 from where the population of sheep has declined leading to lower production of wool in the zones and the region as a whole.

Table 12 : Production of wool in arid Rajasthan (tonnes)

Zones/years	1972	1983*	1995*	2000*
Zone I	1,933	4,669	3,035	3,154
Zone II	3,707	5,452	5,629	6,045
Zone IiI	1,606	1,838	2,002	2,096
Zone IV	713	1,532	772	772
Overall	7,959	13,491	11,438	12,067

*Estimated

PROSPECTS OF BALANCING FORAGE BUDGET

Gr. zing lands

The order of fodder deficit envisaged for a normal year in 2000 A.D. is of the order of 16.9 mts (Table 13) the deficit ranging from 0.9 mts in Zone IV to 7.6 mts in

Table 13. Prospects of increasing forage supply through improvements in range land

Zones	Fodder deficit for a normal 2000 A.D. (mts)	Expected Yields/ha		Required land for meeting the deficit		Available	
		Protected (tonnes)	Protected with improvement (tonnes)	Protected (mha)	Protected + improvement (mha)	Total	Over 50 ha size (mha)
Zone I	(—) 3.68	0.85	1.54	4.32	.39	6.51	2.15
Zone II	(—) 7.62	1.76	2.16	4.32	3.53	2.30	0.30
Zone III	(—) 4.68	1.22	2.05	3.83	2.28	0.98	0.09
Zone IV	(—) 0.96	—	—	1.14	0.63	0.42	0.02
All Zones	(—)16.94	—	—	13.61	8.83	10.21	2.56

Zone II. The order of forage increments obtainable with only protection and protection with improved management practices, ranged from 0.85 tonne per ha to 1.76 tonnes per ha for the protected range lands and 1.54 tonnes per ha to 2.16 tonnes per ha for protection with improvments, for different zones. At the yield rates expected of improved range practices, the area required for meeting the deficit ranged from 0.6 mha in Zone IV to 3.5 mha in Zone II, for a total of 8.8 mha for the entire region. The available common property resource (CPR) grazing lands for the region was 10.0 mha of which 6.5 mha was from Zone I alone. The range protection and improvement practices, to be successful, need to be executed on large chunks of say 50 to 100 ha blocks. The CPRs of this dimension (above 50 ha in size) in the region was found to be only 2.5 mha. Out of the total area of this size the largest area (2.1 mha) was in Zone I. Assuming that the area of 2.5 mha is brought under improved practices with protection, the forage availability, at the yield rates of improved conditions, would be about 4.2 mts only. So the CPR grazing logistics do not promise much in terms of meeting the forage-fodder deficit in the region by 2000 AD if the livestock growth continues at the present rate (Table 14).

Table 14. Forage deficit after improvements of range lands

Forage yield/Zones	Zone I	Zone II	Zone III	Zone IV	All Zones
Expected yield from improved pasture of 50 ha and above size class (mts)	3.30	0.65	0.18	0.04	4.17
Likely deficit after improvement (mts)	(—)0.27	(—)6.97	(—)4.50	(—)0.93	(—)12.67*

* The supply prospects indicate that the livestock has to be reduced by 5.1 m ACUs by 2000 A.D. in order to balance the forage demand and supply position in the region.

(b) Crop land reduction/rationalisation

Increases of acreage under crops has been endangering the desert eco-system. Therefore, it is envisaged that the acreage under crops should not exceed 45% of arable areas in Zones I and II and not more than 60% in Zones III and IV (Table 15). It was noted that on the basis of the above yard stick, an area of 1.61 mha could be released for its utilization for improved range practices The balancing exercise reveals that a net addition of 2.3 mts of forage could be made available, provided the lands released are brought under improved grasses. This can support an addional livestock population of 0.9 m ACUs. However, it is difficult to expect the released acreage to be put to grassland improvement, because most of the acreage expected to be released are from individual ownership holdings, which are not amenable to grassland development by Government or other organisations, because the programme needs blocks of land sufficiently large to be effiiciently managed.

Alternatively, one can think of motivating the owners of lands who have acreage above 6 ha to devote their land to raising leguminous crops with grass. It is estimated

Table 15. Alternative strategy for increased forage

Zones	Net sown area reduced (%)	Area released (mha)	Loss of crop residue and stubble (mts)	Forage yield after improvement (mts)	Net increase in forage (col 5-4) (mts)
1	2	3	4	5	6
Zone I	9	0.24	0.05	0.37 @ 1.54	0.32
Zone II	20	0.84	0.40	1.81 @ 2.16	1.41
Zone III	11	0.17	0.14	0.34 @ 2.05	0.20
Zone IV	20	0 32	0.17	0.50 @ 1.54	0.33
All Zones	15	1.57	0.76	—	2.26

@ Yield rates per ha.

that nearly 82, 69 and 32 per cent of land holdings in Zone I, II and III, respectively are in the size category of more than 6 ha (Anon. 1971). If these land holders could devote a part of their lands for grass and legume production exclusively, the problem of forage deficit could be solved to some extent. The problem lies in convincing the farmers to adopt such measures and disseminating the available technology to the farmers. Then, there should be a very efficiently organised market for the farmer who takes up the technology.

Taking an average of 70% of individual holdings in the region to be in the above 6 ha category, the total area under this category works out to 8.5 mha. If about 20% of land (1.7 mha) under this size group could be devoted to grass with legumes. forage production (@ 1.5 t/ha) of 2.5 mts could be achieved. This quantity of forage can support an additional livestock population of 1.0 m ACUs.

(c) Current fallows

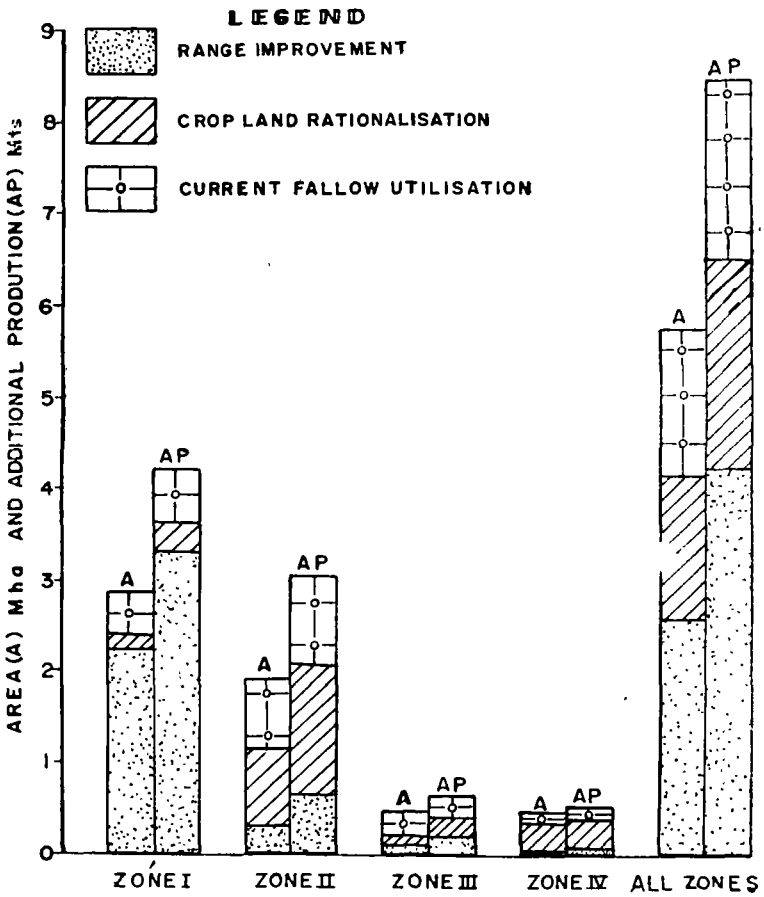
In the eleven arid districts of Rajasthan about 7-8 per cent of arable lands (1.5 to 1.6 mha) remains under current fallow every year (Table 16). These lands under individual ownership are invariably kept fallow for recuperation of fertility status for cropping after 2 to 3 years. Cultivation of grass with legumes can serve the same purpose, because legumes are known to fix nitrogen in the soil. Therefore, this has been considered as another alternative. The net forage production from devoting current fallows to crops is presented in Table 16. It may be noted that with the above strategy, about 0.8 m additional ACUs can be supported by bringing in about 1.5 mha of current fallow lands under grass with legumes.

Table 16. Forage production prospects from current fallows

Zones	Area under current fallows (mha)	Present forage production (mts) @ 0.23 t/ha	Forage production with improvement (mts) @ 1.5 t/ha	Net increase (mts)
Zone I	0.47	0.11	0.70	0.59
Zone II	0.78	0.18	1.16	0.98
Zone III	0.20	0 05	0.30	0.25
Zone IV	0.11	0.03	0.17	0.14
All Zones	1.56	0.37	2.33	1.96

The alternatives considered indicate that about 1.8 m additional ACUs can be supported by bringing in 1.6 mha of crop land and 1.5 mha of current fallows under improved grass/legumes, leaving about 3.2 m ACUs to be eliminated by 2000 A.D. (Fig. 8) to balance the fodder budget.

Fig 8- PROSPECTS OF FORAGE SUPPLY IMPROVEMENT.



(d) Livestock reduction

The livestock in terms of ACUs is projected to reach 11.2 m ACUs by 2000 A.D. Out of this about 8.3 m ACUs will comprise cattle, buffaloe, sheep and goats. The projected forage and fodder availability is sufficient only to meet the requirement of only about 45% of the total ACUs in the region. With range improvements about 4% more of ACUs can be supported which leaves about 5.1 m ACUs to fend for themselves. Alternatively, these ACUs should be eliminated to balance the demand-supply equation for forage and fodder. The composition of different types of animals as per 1983 livestock census (Table 17) indicate that for every milking cow there were 3.45 other cattle consisting of dry cows, young female, adult male and young male in the ratio of 1.06, 1.12, 0.59 and 0.68 respectively. Similarly, in the case of buffaloe, for every milking buffaloe, there were 0.70, 1.38, 0.14 and 0.43 dry buffaloe, young female, adult male and young male buffaloe, respectively making

Table 17. Bovine stock composition—1983

Type of Animals	Milking	Female		Male		Total non milking
		dry >3 yrs	Heifers + young	>3 yrs	Heifers + young	
Cattle	889464	948221	996677	515514	609149	3069561
Ratio	1 :	1.06	1.12	0 59	0.68	3.45
Buffaloe	368380	259762	507028	50448	158334	975572
Ratio	1 :	0.70	1.38	0.14	0.43	2.65
Cattle + Buffaloe	1257844	1207983	1503705	565962	767483	4045133
Ratio	1 :	0,96	1.19	0.45	0 61	3.21

a ratio of 1:2.65 in the region. Taking the total number of milking cows and buffaloes, the ratio works out to 1:3.21. If this ratio can be reduced to 1:2.21, about 1.3 m cattle can be done away with, without in any way affecting milk production or milk-production potential. Further, the area is surplus is milk and, therefore, if it is possible to reduce the cattle population by say 1/3, then a total of 1.6 m cattle and buffaloe can be dispensed with causing only marginal impact on milk production potential. The sheep and goats are really in excess of the need. Therefore, a reduction by 1/3 of their population will mean that the pressure on foraging resources would be less by 1.2 m ACUs. So, it may be seen that about 2.5 to 2.8 m ACUs could be eliminated without practically affecting production. This order of reduction at the initial stage (right now) should take care of annual increments (at the current growth rates) for the next ten years till 2000 A.D. when the number should be less by 5.1 m of the projected 11.2 m ACUs in 2000 A.D.

Direct intervention for stock/herd reduction will be open to criticism and opposition in the present setup. Therefore, this has to be brought about by persuation and market interventions. One of the interventions could be setting up of market infrastructure for meat, wool, milk and other animal products like skin, hides, bones, hoof, etc. At the initial stages it may even be necessary and worthwhile to offer an incentive price which is higher than the ruling market price, particularly for live animals like sheep and goats, which are readily marketed. This will encourage reduction in numbers at a faster rate. Emphasis in breeding sheep/goat should be for meat/mutton purposes rather than for wool/milk/hair. Reduction in cattle numbers would be the greatest challenge because of the prevailing sentiment against cow slaughter. However, this sentiment is not so strong with respect to male stock. With the advent of mechanisation, the demand for draught power is dwindling. So with proper policy initiatives it may not be difficult to bring about reduction in male stock. As for female cattle, as noted earlier, there are 1.07 dry adult cows for each milking cow. This is rightly so because of wide intercalving period. If this intercalving period can be reduced, then it may be possible to convince the farmer to maintain smaller herds for better results. Further, it is also necessary to improve the hardy local breeds by selective breeding of high producing animals.

On the research side there is an urgent need to work on the impact of enriched locally available forage/fodder on acceptability, protein and nutrition enhancement properties of treated straw. It is particularly necessary to know whether it is possible to meet the protein and nutrition requirement of animals with reduced supply of forage, without in any way affecting the production potential and growth of the animals. Side by side, it is also necessary to work out the economics of enrichment vis-a-vis additional fodder/forage production activity.

ECONOMICS OF ALTERNATIVE ENTERPRISES FOR ARID ZONE

The populations of human and livestock, as projected, indicate that the arid zone has to sustain additional heads of human and livestock with the same natural resource that is presently available. This can be done by increasing the yields of present enterprises or by adopting new enterprises within the existing resources constraint. As of now the use of natural resources has been sufficiently stretched both in terms of area extension to crops and livestock holdings on owned and common property resources. It is feared that the arid ecosystem cannot withstand the present degree of use intensity on land resource base any more. The technologies evolved by the CAZRI and their economic viability (Anon, 1983) hold promise for increasing the production of the arid eco-system. Some of these technologies and the returns on their adoption are given below.

The returns from different technologies were estimated at 1980-81 prices. Since then the costs and returns have changed, which has been taken care of by multiplying the 1980-81 returns by a common factor which represents roughly the real increase in agricultural income in the state of Rajasthan since 1980-81, at constant prices.

The returns from different technolcgies is presented in Table 18. It may be noted that tree system ensured a return of Rs. 1942.00 per ha. Similarly, grass system

Table 18. Economics of alternative enterprises

Systems	Net income (Rs. ha^{-1}) 1980-81	1987-88*
Animal system (Sheep/goat)	461.00	464.00
Tree system (*A. tortilis P. juliflora*)	1930.00	1942.00
Grass system (*C. ciliaris C. setigerus, L. sindicus*)	1310.00	1318.00
Horticulture system (budded *ber*)	1692.00	1702.00

Source : Outlines of technology for reconstruction of arid zone (1983), Technical Bulletin No. 7, CAZRI, Jodhpur

* Estimated on the basis of annual increase of agricultural income in Rajasthan State at constant prices (1971-72) between 1971-72 and 1985-86, Singh, I.J. (1989).

ensured a return of Rs. 1318.00 per ha. Arid zone horticulture with ber plantation gave a return of Rs. 1702.00 per hectare. Compared to the above, the returns from improved sheep and goat husbandry gave a return of Rs. 464.00 per hectare per annum.

The technologies enshrined in forestry, grass production and *ber* plantation involve low intensity land use systems, which are highly suited to the arid eco-system. These technologies, besides being less degrading, are resource augmenting technologies, the adoption of which can control soil erosion and thus can play a significant role in preserving and improving the desert eco-system.

SUMMARY

1. In the 11 arid districts of Rajasthan, the livestock population was 9.6 million adult cattle units (ACUs) in 1983. Fodder deficit was of the order of 14.9 million tonnes (-62%) on dry matter basis.

2. The livestock in terms of ACUs is projected to increase to 11.3 million heads by 2000 A.D. when the demand for forage and fodder would be 28.2 mts. on dry matter basis.

3. The supply prospects of forage for livestock in 2000 A.D. for a situation of good rainfall, normal rainfall and drought year have been projected to be 20.0, 11.2 and 6.9 mts, respectively. Forage availability for a normal 2000 would be short by 16.9 mts (-60%). The deficit will be of the order of 29% and 76% in case of a good and a drought year.

4. Irrigation infrastructure may not necessarily lead to increased dry matter supply through stover owing to shift to commercial crops which yield less or no animal fodder.

5. The average productivity of grazing lands is estimated at 295 kg ha^{-1}. On the basis of average productivity, the decline in forage supply due to decline in grazing land (1.7 million hectares) between 1961-1983, is estimated to be 0.5 mts.

6. The production of milk in arid Rajasthan is projected to increase from 1.4 mts in 1983 to 1.6 mts in 2001.

7. The production of meat/mutton is estimated to go up to 71,500 tonnes in 2000 compared to the production of 50,500 tonnes in 1983.

8. The production of wool is projected to be 12,000 tonnes in 2000 against the production of 13,500 tonnes in 1983.

9. The availability of meat per capita per annum is projected to be 7.22 kg in 2000 against the availability of 9.35 kg in 1983.

10. The availability of milk per capita per day is estimated to be 223 grams in 2000 compared to 356 grams in 1983.

11. Milk, meat and wool have been found to be in excess of demand in the arid zone as a whole.

12. The prospects of increasing forage supply through improved range practices is estimated at 4.2 mts only.

13. The prospects for balancing the forage/fodder deficit, therefore, lies in reducing the livestock numbers by nearly 5.0 million ACUs by 2000. It is surmised that a reduction of this order is not going to seriously affect the production or production potential of the livestock sector.

14. A 15 per cent (1.6 mha) reduction in area under crops and diverting the released land for improved range practices could result in a net increase of 2.3 mts of forage which can support an additional 1.0 million ACUs in the region.

15. In the region about 1.5 mha land remains under current fallows every year. If cultivation of grasses with legumes are taken up on these lands a net increase of 2.0 mts of forage can be obtained, which can support another 0.8 million ACUs. The alternatives still leave about 3.2 million ACUs to be eliminated to balance the fodder budget by 2000.

APPENDIX—I

ANIMALS FOR OPTIMUM PRODUCTION

In view of the harsh climate of the desert, the choice of speoies and breeds of animals for this tract should basically be such that the animals have

1. Low body water turn over rate (BWTR)
2. Low basal metabolic rate (BMR)
3. Low glomerular filtration rate (GFR)
4. Low sweating rate (SR).

It is possible to find such animals in sheep and goats in the region.

While selecting sheep/goats for breeding the following additional characteristics, particularly blood biochemical polymorphic traits like:a) blood potassium types, b) erythrocyte glutathione levels (G-SH), and c) haemoglobin types need careful scrutiny. Experiments have suggested that under arid conditions the animals with the following characteristics should ensure optimum production :

Sheep : Combination of low glutathione-haemoglobin A, low potassium and low body water turnover rate (GSH^h- HB-A-K^L K^L – Low BWTR type)

Goat : Combination of high glutathione, low body water turnover rate (GSH^h – Low BWTR type)

Cattle : Low body water turnover rate (Low BWTR type).

Water use economy in desert animals

Water being a scarce commodity in the desert, economy in its use is an important consideration. Experiments have indicated that water deprived marwari sheep and goats can survive for 13 days and donkeys for 9 days, in a temperature regime of 40°C or below. In other words, these sheep and goats can be maintained on an economised water budget. Watering six times a month, excluding the severe summer months (April to June) should not affect the health or productivity of these animals.

APPENDIX—II

CONSERVATION OF FORAGES

Hay making : Desert grasses like *Cenchrus ciliaris Lasiurus sindicus, Dichonthium annulatum* and *Panicum antidotale* are suitable for hay making. In order to have optimum nutrients in the hay, the plants should be harvested at the pre-flowering to flowering stage in the morning hours and kept on ground/tripod/farm fences, etc., for sun drying.

Hay making methods

(i) Ground method, (ii) Tripod method, (iii) Farm fencing (for legumes), (iv) Use of thatched hut open on all sides with sacks having open bottoms and length across the wind direction. Freshly cut grass contains approximately 75 per cent water whereas a good hay should contain only 10 per cent moisture. When kept dry in stacks hay will invariably store well for long periods of upto 3 years without any further decline in quality. To reduce the chances of any possible damage, stacked hay may be covered by a canvas torpaulin.

Silage making : It is preserved as green and succullent fodder for use of animals. It is prepared when plants are about to flower. The following types of silos can be used :

1. Tower silo,
2. Pit silo, and
3. Trench silo.

In order to have good silage, green harvested fodder should have about 65 to 70 per cent moisture content. Too succullent forages like berseem and lucern should be kept in the field for about 4-6 hours before ensiling. Fodder should be properly chaffed with chaff cutter before ensiling and carefully packed when the silos are being filled up.

For leguminous and highly proteinous forages, addition of molasses @ 50 kg per tonne of ensilage material is essential. Preservatives like common salt @ 18-20 kg per tonne of chaffed material may be used.

APPENDIX—III

IMPROVING RANGELAND PRODUCTIVITY

The main results of the studies carried out at different range management and soil conservation areas of CAZRI, Jodhpur, for improving range land productivity in arid regions of Rajasthan are given below :

Protection

The forage yield on range lands after two years of protection and controlled grazing increased by 148.3, 91.9 and 116.3 per cent in 'poor', 'fair' and 'good' condition classes, respectively.

Moisture conservation

Contour furrowing at a distance of 8-10 metres across the slope on shallow soils with rolling topography increased forage yield by 638.7% over control.

Reseeding

Increase in forage yield due to reseeding after 3-5 years was in the range of 30 to 122 per cent in 'poor' and 29 to 107 per cent in 'fair' type of range lands.

Time of sowing

Premonsoon sowing of grass seeds give 36% higher forage yield over monsoon sowing.

Fertilizer application

Forage yield of grass increased by 78% by application of 20 kg N ha^{-1} during normal year.

Improved system of grazing

Deferred rotational grazing system increased forage production by 47% over continuous grazing system.

Grass species

Lasiurus sindicus (Sewan) gives high yields (4 tonnes ha^{-1}) on sandy soils with annual rainfall of 250 mm and below.

Cenchrus setigerus and *Cenchrus ciliaris* produce good tonnage of 2 to 3 t ha^{-1} on light to medium textured soils with annual rainfall of 300 mm and above.

Dichanthium annulatum gives high forage yield (3.3 t ha^{-1}) on heavy textured soils under annual rainfall of above 400 mm.

Sporobolus helvolus performs well (1.5 t ha^{-1}) on heavy textured saline soil. *Cymbopogon* and *Cenchrus* species give good yields (1.5 to 2 t ha^{-1}) on gravelly soils.

Effect of improved technology on range productivity

Effect of range management practices in increasing forage yield and carrying capacity is shown in Appendix-Table 1.

Appendix—Table 1. Effect of improved technology on carrying capacity (ACU per 100 ha)

S. No.	Particulars	Average Rainfall	
		300 mm and below	Above 300 mm
1.	Present	4-8	14-20
2.	After protection	8-20	24-30
3.	After moisture conservation, reseeding, etc.	20-30	40-48
4.	Increased carrying capacity due to improved practices	16-22	26-28
5.	Increased yield of forage (2.5 t/ACU)	40-55	65-70

APPENDIX-IV

IMPROVEMENT OF THE NUTRITIVE VALUE OF FEEDS

Desert top feeds

Tree leaves utilized as animal feed are commonly called top feeds. Fresh tree leaves provide considerable quantity of water to the livestock. In addition, top feeds are rich in protein and calcium, but presence of nutritional constraints, like tannins and lignins in these feeds, adversely affect their nutritive value. On dry matter (DM) basis, *P. cineraria* and *Z. nummularia* leaves contained 14.2% and 12.6% crude protein, respectively, whereas the digestibility of the crude protein fraction were as low as 22% and 32%, respectively. Nutritive value of *P. cineraria* leaves can be improved by inactivating the tannin content by treating the leaves with % ferric chloride. Tannins can be removed by soaking *P. cineraria* leaves in about 5.0% sodium carbonate solution for 24 hours and subsequently washing with water. Protein availability from *Z. nummularia* leaves can be improved by simple formal-dehyde treatment.

Roughages

Feeding of roughages Include wheat, barley, rice, sorghum and pearl millet straws: These crop residues are rich in fibre and poor in crude proteins. palatibility and digestibility of the nutrients of these feeds can be augmented by treatment of these roughages with calcium hydroxide/sodium hydroxide solution/anhydrous ammonia and urea-molasses mixture. One of the following techniques can be used for treating the straws.

Nutritive value of straws can be improved by treating with ammonia and urea so that anhydrous ammonia and urea make 3% and 4-5% of total weight of the straws.

Urea-molasses blocks

These blocks provide nitrogen to ruminal micro organisms in the summer and thus, improve digestion of ingested straws. Use of these blocks can replace partially the need of more expensive protein concentrates and are thus, especially useful for the livestock inhabiting drought prone areas of our country.

Microbial treatment

Nutritive value of high fibrous feeds can be improved by treating with certain fungi such as whiterot. These fungi appear to be capable to delinking chemical

barriers between the lignin and carbohydrate moiety of the straws, which interferes and reduces the digestibility of polysaccharides of the roughages.

Appendix Table II : Forage estimation (kg ha^{-1}) under different rainfall situations

Rainfall situation	Under existing conditions	Under improved conditions
Zone I		
1. Normal rainfall years	850.7	1538.0
2. Above normal rainfall years	1488.2	2060.3
3. Below normal rainfall years	464.9	803.7
Zone II		
1. Normal rainfall years	1763.5	2160.5
2. Above normal rainfall years	2144.0	2794.0
3. Below normal rainfall years	1824.0	2213.5
Zone III		
1. Normal rainfall years	1224.0	2049.5
2. Above normal rainfall years	2554.5	3543.5
3. Below normal rainfall years	988.5	1957.5

Note—20% post harvest losses (Trampling losses & unutilized forage)

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