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Common Grazing Resources of Hot Arid Zone of Rajasthan, India: Problems and Prospects

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Abstract: The agriculture in the hot arid zone of Rajasthan, India is mainly subsistence farming and pasturelands dominate among different land use systems. These lands provide main support to the huge livestock population of the region. About 60% of the total area of Rajasthan is arid where livestock rearing plays pivotal role in the economy and livelihood of the people. In arid region, animal husbandry sector provides round the year employment with more than 50% of total house hold income as against national average of 22.5%. Common Pool Resources (CPRs) or "commons" are an important component of the agricultural production systems. The CPRs includes community pastures, community forests, government wastelands, common dumping and threshing grounds, river beds, watershed drainages, village ponds and rivers etc. In an estimate common pool comes to around 34.75% of the total geographical area of western Rajasthan. About half of this area is cultivable waste lands, 21% fallow lands (other than current fallow), 14% uncultivable waste lands, 11% permanent pastures and 7% is village forests. Common lands in arid Rajasthan were estimated to contribute 27.90% of dry fodder and 76.30% of green fodder requirement of the livestock in 1960 that decreased to 15.44% and 40.5%, respectively during 2012-13. Traditionally, a close link exists between crop, livestock and common grazing resources in the arid Rajasthan. This complex inter-relationship between CPRs, livestock and crops in arid land farming systems has contributed to the sustainability of dry land agriculture for generations. As the population of both animals and humans rises, there is a proportional increase in competition for food to feed the people that brings agriculture and livestock production into direct conflict. In the present article an attempt has been made to describe the extent and condition of common grazing lands, and examine the problems and prospects of these areas in changing agricultural scenario in hot arid zone of Rajasthan, India.

Key words: Common pool resources, rangeland, orans, gauchars, productivity, management

Common Pool Resources (CPRs) or "commons" are an important component of the rainfed production systems, which is also one of the most neglected even in the schemes and programs that purport to explicitly focus on physical resources. Though a common definition of common pools do not exist, broadly all land, water (including groundwater), seeds, breeds and diverse species of plants, which are collectively used and held, can be categorized as commons. A 'common pool resource' refers to a natural or man-made resource system that is sufficiently large to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use (Ostrom, 1990). The Committee on State Agrarian Relations and Unfinished task of land Reforms defined rural common pool resources as resources to which all members of an identifiable community have inalienable use rights. In the Indian context, CPRs include community pastures, community forests, Government wastelands, common dumping and threshing grounds, river beds, watershed drainages, village ponds and rivers etc. (Jodha, 1985). Common grazing land resources constitute about 15% of the total geographical area of India, of which 23% is community pasture and grazing lands and 16% have been classified as village forests and woodlots (NSSO, 1999). At another level, India has the largest livestock population in the world, with 536.76 million head of livestock. The majority livestock are raised by small and marginal farmers, who depend on common grazing lands to meet the fodder requirements of their animals. In India as a whole, as much as 30% of livestock forage comes from CPRs,

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Table 1. Changes over time in common property resources (CPRs) in western Rajasthan, 1951 to 2010

Characteristics	1951-52	1961-62	1971-72	1977-78	2010-11
Area (m ha)	11.30	9.80	9.20	8.70	7.47
Area as % of total geographical area	60.50	51.10	47.90	45.10	38.12
% decline in CPR area over previous period	-	12.40	6.70	4.50	6.98

Source: Jodha, 1985 and Rajasthan Agricultural Statistics 2010-11.

both forests and non-forests. In arid regions of Rajasthan, common lands provide 66% of the fodder requirement, whereas, crop residues contributed 22% in the total fodder requirements, and the remaining demand of fodder (12%) is met out from the purchased fodder brought from the neighbouring States (Misra *et al*., 2015). The importance of these common resources can also be judged from the fact that about 62% farmers in the rainfed region graze their livestock while only 34% of farmers graze their livestock in the irrigated regions. Traditionally, a close link exists between crop, livestock and common grazing resources in arid region, as grazing is pre-dominate feeding practice among the livestock keepers. This complex inter-relationship between CPRs, livestock and crops in arid land farming systems has contributed to the sustainability of dryland agriculture for generations (Misra *et al*., 2002). As the population of both animals and humans rises, there is a proportional increase in competition for food to feed humans, bringing agriculture and livestock production into direct conflict. This paper describes the extent and condition of common grazing lands, and examines the problems and prospects of these lands in changing agricultural scenario in hot arid zone of Rajasthan, India.

Status of Common Grazing Resources

Grazing resources of arid regions have been well documented by ICAR-Central Arid Zone Research Institute, Jodhpur by conducting research at 52 range management and soil conservation centers over last 60 years. *Orans* and *gauchars* are the most important common grazing resources in western Rajasthan, with *orans* accounting for an estimated 8-9% of the arid parts of Rajasthan (Mitra and Paul, 1994). In almost every village in western Rajasthan since time immemorial, a substantial portion of the land has been set aside specifically as grazing land to support animal husbandry on a sustainable basis. According to Jodha (1997) the area under commons often ranged from 9 to 28% of the total village area in drylands of Rajasthan. Such grazing lands often serve as catchment areas for village ponds, and are commonly known as *gauchars* (gau = cattle and char = grazing) (Choudhary *et al*., 2011). The community grazing lands in hot arid zone include (i) village grazing land specially demarcated for the purpose (*Orans* and *Gauchars*), (ii) revenue and other waste land commonly utilized for grazing and (iii) degraded forest land illegally or legally allowed for grazing. In short, except the cultivated land during cropping season, each and every class of land where there is some vegetation is used for grazing at one time or another. After harvesting of crops, even, farmers' fields become another major grazing resource; they become a CPR, as they tend to be available to livestock belonging to all members of the community, not just the landowner. This system of grazing was known as *bhelwars* or *choili* (Mertia and Santra, 2012). These CPRs generally support different species of perennial grasses with scattered thorny trees, bushes and shrubs and some of them have very high forage value.

The area under CPRs has declined over the time. In the last 40 years, the availability of grazing lands has declined by 30-35% in western Rajasthan (Mertia and Santra, 2012). The CPRs have been declining consistently since 1951-52, the first date for which district level data on land utilization are available. The change in grazing lands over period in arid western Rajasthan is given in Table 1 and Figure 1. During early 1950, CPR lands constituted slightly more than 50% of the total geographical area in these areas (Fig. 1). With the expansion of irrigated agriculture and infrastructural development, the land under grazing has decreased gradually from more than 50% in early 1960s to 34.75% in the 2011-2012 periods (Fig. 1). The decline was greatest (12.4%) during 1951-52 to 1961-62, which was also the period of land reforms. Such shrinking of grazing land has increased

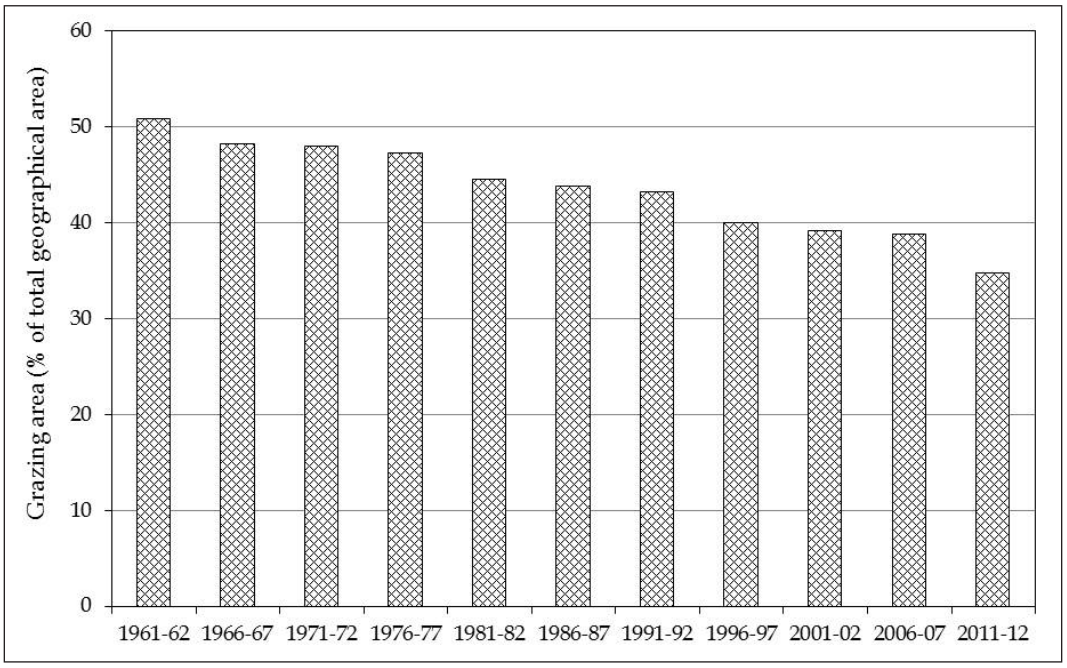

Fig. 1. Trend of grazing land in arid Rajasthan.

the pressure on the already limited resources, leading to a gradual deterioration of forages in the arid Rajasthan. In terms of actual numbers, the area of barren land provided large tracts of grazing land (2,391,000 ha) in 1961-62, and this area decreased to 944128 ha during 2011-12. In terms of acreage in western Rajasthan, 6811111 ha has been under different grazing lands, of which cultivable wastelands constitute 48% of the total acreage under grazing lands followed by 18% under fallow lands and about 12% under permanent pastures (Table 2). In rest parts of the State, however, permanent pastures contributed the highest (36%) in the total grazing resources (374112 ha) followed by cultivable waste lands that contributes 23%.

The analysis of secondary data statistics from land use of the state reveals that, of the total available area, fallow lands (other than recent fallows from the previous growing season) contributed at least 18.3% towards grazing. The highest amount of grazing area was contributed by cultivable wastelands (48%), further, the least contribution towards grazing was from the forests (7%). Permanent pastures also contributed less (12%). The higher contribution by cultivable wastelands may

Table 2. Changes in grazing resources (in ha) in the arid Rajasthan over quinquennial interval

Year	Forests	Permanent pastures	Uncultivable wastelands	Cultivable wastelands	Fallow lands (other than current fallows)	Total grazing land
1961-62	163000 (1.63)	712000 (7.14)	2391000 (23.98)	4641000 (46.54)	2064800 (20.71)	9971800
1965-66	145000 (1.49)	749000 (7.71)	2397000 (24.67)	4620000 (47.55)	1805000 (18.58)	9716000
1971-72	166000 (1.77)	776000 (8.25)	2345000 (24.93)	4617000 (49.09)	1501000 (15.96)	9405000
1976-77	245382 (2.65)	815291 (8.80)	1097969 (11.85)	5403666 (58.34)	1700715 (18.36)	9263023
1982-83	333114 (3.84)	857949 (9.88)	1030975 (11.87)	5014519 (57.75)	1446735 (16.66)	8683292
1987-88	416667 (4.40)	853216 (9.02)	1044568 (11.04)	4827353 (51.02)	2319448 (24.52)	9461252
1991-92	448263 (5.28)	848226 (10.00)	1012767 (11.94)	4503711 (53.09)	1669967 (19.69)	8482934
1996-97	470205 (6.00)	832905 (10.62)	1022506 (13.04)	4037003 (51.49)	1478227 (18.85)	7840846
2001-02	420952 (5.48)	809553 (10.55)	1060831 (13.82)	3741821 (48.74)	1643645 (21.41)	7676802
2006-07	428041 (5.62)	814136 (10.69)	956756 (12.56)	3706063 (48.67)	1710125 (22.46)	7615121
2011-12	493358 (7.24)	811692 (11.92)	944128 (13.86)	3314416 (48.66)	1247512 (18.32)	6811111

Figure in parenthesis is the per cent of the total grazing resources.

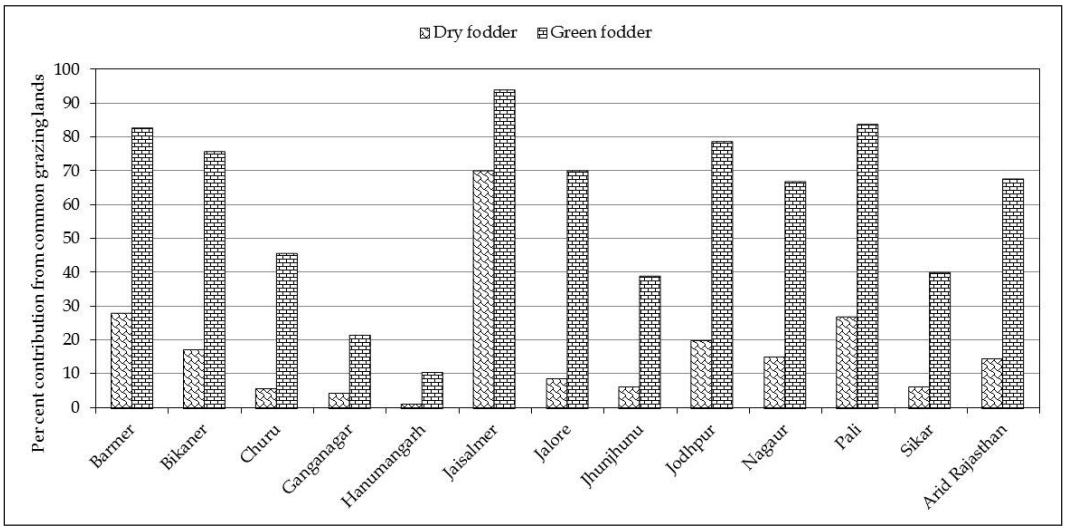

Fig. 2. Contribution of common grazing land in fodder availability in arid districts of Rajasthan during 2012-13 (Adapted from secondary data sources).

be an indication that the pastures are not as productive as the cultivable wastelands. This could possibly be a result of past crop residues contributing towards improving soil fertility, hence possibly increasing forage resources. As most of the grazing is in permanent pastures, the productivity of livestock in arid and semi-arid region of India is low compared to other regions.

Contribution of common grazing lands

The CPRs are an important source of livelihood for millions of poor and marginalized people in India. Communities depend on CPRs for collecting fodder, grass, wood for fuel and other household material. Jodha, (1986) documented the role of common grazing lands in the rural economy in a study based on 82 villages in 7 Indian states. He found that while common pastures, though important resource for poor people lacking access to private lands and other productive resources, were not highly productive. The common grazing lands were particularly important to poor people in drought years when crops failed and other income sources were not available. On an average, around 20% of rural households, both landless and landholders depend on CPRs to graze their livestock, while 13% of households collected fodder from CPRs. They tend to be a particularly important grazing resource during the rainy season. Since animals are excluded from farmers' fields during this season, many households, particularly those with little private grazing land of their own depend almost entirely on CPRs. Changes in migration pattern and livelihoods of the shepherd communities are clearly visible due to reduction in CPR lands. There has been migration to faraway places (100-500 km), which can have negative influences on the social bonding of families. (Louhaichi *et al*., 2013). Further analysis of secondary data statistics from Livestock Census of Rajasthan and Land Use of the state revealed that, of the total available dry and green fodder in arid Rajasthan, common grazing lands contributed 14.70 and 67.79%, respectively (Fig. 2) during 2011-12. The dry fodder contribution ranged from 1.27% (Hanumangarh) to as high as 70.20% in Jaisalmer district of the total dry fodder availability. Similarly, green fodder contribution from common grazing lands followed the similar trend and minimum was estimated for Hanumangarh (10.57%) and maximum from Jaisalmer (93.96%).

Productivity of grazing lands

Primary productivity of grazing land in the Asian region is much lower than the world average. The productivity is as low as 0.1 t ha^{-1} yr^{-1} in the desert areas to as high as 16 t ha^{-1} yr^{-1} in warm grasslands (Roy and Roy, 1996). In Thar desert, relative grazing capacity estimated in sandy soil was 4.5 sheep per ha for *Cenchrus ciliaris*, 2.5 sheep ha^{-1} for *Cenchrus setigerus*, 4.1 sheep ha^{-1} for *Panicum antidotale* and 6.9 sheep ha^{-1} for *Lasiurus sindicus* (CAZRI, 1983). Tanwar and Verma (2017) have estimated productivity

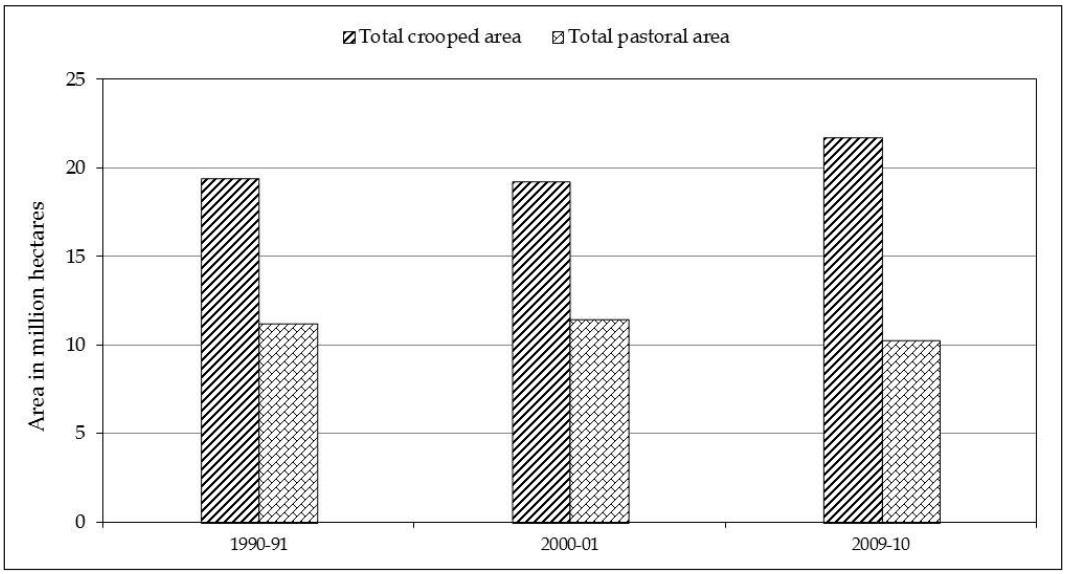

Fig. 3. Decadal change in pastures and cropped area in Rajasthan (modified from Rohekar and Jitendra, 2016).

of 0.19 t dry matter ha^{-1} annum^{-1} for barren and uncultivated land and 0.93 t ha^{-1} for forest lands. Similarly, green fodder productivity varied from 1.0 t ha^{-1} for barren and uncultivated land, culturable wasteland, current fallow and other fallow to 5.0 t ha^{-1} for permanent pastures. The World Bank (1999) estimated that 40% of the potentially productive CPR pastures are either not productive or producing well below their productive capacity. Over the decades, many of ecologically important pasture lands have lost their capacity to regenerate as the occurrence of native grasses and wood species of trees and shrubs have continuously declined and reached below a critical threshold (Roy and Singh, 2013).

There is abundant evidence of the declining productivity of common grazing lands in arid zone of India (Tewari and Arya, 2005). The degraded grasslands are able to produce only 10-20% herbage yield in comparison to that of non-degraded ones (Prasad *et al*., 2017). Many reasons have been cited for lower productivity and degradation of these grazing lands. Factors like increase in livestock population leading to increased grazing pressure, larger areas brought under cultivation, increase in human population, greater commercial exploitation of commons, little or no planned efforts on parts of community and local governments to conserve and regenerate commons and non-implementation of laws to protect and conserve the commons are mainly responsible for shrinking area and depletion of productivity of commons (Joshi, 1995). Further, these common lands are situated in ecologically sensitive zone. Specific topographical and climatic characteristics of the region add to the risk of degradation of the vegetation cover and soil erosion. Besides, these pastures are traditionally used for open grazing and are left without fencing, leading to encroachments and over grazing by the animals (Patel and Kashwan, 2008). An important cause of the decline in grazing lands is the increase in density of animals per unit of common grazing land. In the arid zone as a whole, the density of livestock increased from 50 animal per 100 ha of grazing land in 1951-52 to 135.1 during 2019 (Table 4). About 70% of grazing land in arid Rajasthan comes under poor to very poor condition having productivity below 500 kg ha^{-1} year^{-1} with carrying capacity of 0.13 ACU ha^{-1} (Pratap Narain and Rajora 2005).

Traditional management systems and strategies

Historically, management of common lands followed at least three different patterns. In some places they were accessible to all, due to insufficient pressure on resources. This leads to maintenance of productivity level since last several decades. In others, powerful landowners such as *zamindars*, who acted as "gatekeepers" enforced management to make sure that the common lands were not overexploited (Gadgil and Guha, 1992; Bentley, 1984). While this

system was good for the condition of the land, it was inequitable, with benefits dominated by the landlords. In a third kind of situation, democratic village-level institutions resulted in sophisticated, equitable ways of sharing both rights and responsibilities for managing common lands (Agarwal and Narain, 1989; Arnold and Stewart, 1991). Although the latter situation is sometimes presented as the historical norm in rural India, there is little evidence that it prevailed beyond a minority of villages.

According to Jodha (1985) in old days a system of taxation for use of *orans* and *gochar*s and punishment for wrongful use was followed scrupulously as monitoring mechanism (Jodha, 1985; Osman *et al*., 2001). This system of monitoring and taxation helped in maintenance and efficient use of traditional resources and fodder supply, although sometimes this was misused by ruling class to exploit villagers. Now, the traditional management systems for management of common grazing resources (that involve protection, development and regulated use of CPRs) have practically disappeared after independence. This is a side effect of certain institutional reforms particularly the introduction of new system of elected village council (*gram panchayat*). The dependence of *panchayat* on community votes, in Jodha's opinion, compelled them to avoid unpopular measures like reinforcing CPR-user obligations. This led to domination by the village influentials who have little interest in CPRs consequently making these new institutions ineffective (Jodha, 1985; Roy and Roy, 1996; Misra *et al*., 2015). Management systems for utilizing common grazing lands include uncontrolled grazing (i.e. passive management), privatization, and special projects that aim to raise productivity while also restricting access through social institutions. In addition, with the decline in area and productivity of common lands people have looked to other areas for getting fodder or earning their livelihoods. Dadibhavi (2000) has suggested some of the policy issues for the effective management of CPRs that included discontinuing of the government policy of distribution of grazing land and wasteland to poor and industrialists. Further, *panchayats* should be given power to prevent encroachment of CPR and also initial investment for the revival must be borne by the government.

Problems of common pasture lands

The pasture lands of arid regions are different from other rangelands of the country and are subjected to various degrees of uncertainties, i.e. low and erratic rainfall, high wind velocity, huge shifting and rolling sand dunes; high diurnal variation of temperature; intense solar radiation and high rate of evaporation, and limited soil fertility. Occurrence of drought is a common phenomenon besides edaphic constraints. With the advancement in irrigation technologies, the pastoralists had to face new external pressures, such as crop expansion into high quality rangelands and acquisition of land by governments for infrastructure. The main threats to common pasture lands in arid region are:

Privatization, encroachment and urbanization: Privatization of common lands is the source of the decline in the area of common land. Privatization has taken place through both legal and illegal means. In many areas, state governments launched populist campaigns to distribute common lands to landless people. Illegal privatization is also common as people encroach on common lands, claiming them as their own private plots. This phenomenon has been widespread in India for decades (Jodha, 1997). Often common pastures are converted to cultivated land. PRA conducted in Jodhpur, Jaisalmer and Nagaur districts of Rajasthan shows that approximately 20 to 40% of common grazing lands have been encroached by the neighboring field farmers for the purpose of extending their farm areas (Misra *et al*., 2015). Typically the powerful and well-connected people drive the encroachment process. Jodha (1997) stated that 50 to 80% of the privatized common grazing lands in different states went to the people who already had relatively more land. Findings of other workers (Iyengar and Shukla, 1999; Misra *et al*., 2015) in Gujarat, Bundelkhand and Andhra Pradesh suggest that the poor and landless are equally responsible to encroach on productive common lands.

Conversion of grazing land to cropland: Traditionally, agriculture in arid Rajasthan was of sustenance in nature where farmers cultivated crops only in the half of their land and remaining half was left fallow for grazing

Table 3. Per cent change (over 1961-62 situation) in the gross cultivated area vis a vis some grazing lands in arid Rajasthan

Year	Barren and uncultivable wastelands	Cultivable wastelands	Fallow lands (other than current fallows)	Gross cropped area
1965-66	0.25	-0.45	-12.58	5.93
1971-72	-1.92	-0.52	-27.31	9.85
1976-77	-54.08	16.43	-17.63	15.87
1982-83	-56.88	8.05	-29.93	21.88
1987-88	-56.31	4.02	12.33	20.79
1991-92	-57.64	-2.96	-19.12	37.02
1996-97	-57.24	-13.33	-28.63	39.27
2001-02	-55.63	-19.37	-20.40	-22.23*
2006-07	-58.68	-20.15	-17.18	51.79
2012-13	-59.50	-28.78	-26.76	58.51

Source: Land Use Statistics, Government of Rajasthan. * Due to severe drought.

by domestic animals (Rohekar and Jitendra, 2016). However, after the Indira Gandhi Canal brought water into seven arid north-western districts, agriculture in this part of Rajasthan had witnessed a major shift. The coinciding Green Revolution meant the population leaned further towards agriculture, adopting tube well- and canal-fed irrigation and intensive cropping practices. Sen and Gupta (1978) reported that fallow land in the arid districts of Ganganagar fell by 25%, in Barmer by 21%, in Churu by 28% and in Bikaner by 10% between 1957-58 and 1963-64. Analysis of Land Use Statistics of Rajasthan (Table 3) also showed that during 1961-62 to 2012-13, the approximate area under barren and uncultivable wastelands fell by 60%, cultivable wastelands by 29% and fallow lands (other than current fallows) by 27% whereas the area under gross cropped area rose to 59% in arid Rajasthan. The decadal change in the pastoral and cropped area for whole Rajasthan is depicted in Figure 3. A report submitted by the Agro-Economic Research Centre of Gujarat's Sardar Patel University to the Union Ministry of Agriculture stated that from 1990-91 to 2009-10, the gross cropped area in Rajasthan increased from 19.4 million ha to almost 22 million ha. In the same period, land under permanent pastures reduced from 1.9 million ha to 1.7 million ha, and cultivable waste land dipped almost 20% to 4.5 million ha (Rohekar and Jitendra, 2016).

Uncontrolled grazing and excessive grazing pressure: Uncontrolled grazing is the norm on India's common lands (Turtan *et al.*, 1997). Many grazing lands were traditionally managed as CPRs but lack of institutional support and the disintegration of community management structures have contributed to the decline of these systems. In the arid zone as a whole, the density of livestock increased from 50 animal per 100 hectares of grazing land in 1951-52 to 140.5 during 2012 and 135.1 during 2019 (Table 4; Tewari and Arya, 2005; Livestock Census, 2019). This increase was partly due to an increase in livestock population. According to 19th Livestock Census, the number of animals in the arid zone increased by 41% between 1951 and 1961 and by 15% between 1995 and 2012. Local grazing pressures are surpassing the recommended stocking rates of the rangelands at an enormous pace. The pressure was 0.87 ACU ha^{-1} in 1981 which increased to 1.02 ACU ha^{-1} in 2001 and 1.55 in 2012 against the optimum desirable density of 0.2 ACU ha^{-1} (Tewari and Arya, 2005). In general, the grazing pressure ranges 1-4 ACU ha^{-1} as against carrying capacity of 0.2-0.5 ACU ha^{-1}. The rangelands are overgrazed and are not properly managed which leads to low fodder productivity. About 70% of grazing land comes under poor to very poor condition having productivity below 500 kg ha^{-1} with carrying capacity of 0.13 ACU ha^{-1} (Pratap Narain and Rajora, 2005). The impact of grassland degradation includes the loss of biodiversity due to the conversion or fragmentation of habitats; soil degradation, particularly erosion due to the loss of vegetation cover; and soil compaction from high livestock-stocking densities. Continuous overgrazing of these natural pasture lands (*gauchars* and *orans*) which were once dominated by the palatable grasses and shrubs has adversely affected seed

Table 4. Livestock Population (millions) and density per 100 ha in arid Rajasthan

Year	Livestock population (million)	Density of livestock (per 100 ha)
1951	10.34	49.7
1956	13.40	64.4
1961	13.72	65.9
1966	16.21	77.9
1972	16.28	78.2
1977	19.13	91.9
1983	23.13	112.1
1988	17.77	85.4
1995	26.22	129.0
2001	29.25	140.6
2007	29.11	140.2
2012	30.18	140.5
2019	27.85*	135.1

Source: Tewari and Arya, 2005 and Livestock Census, 2019.
* does not include, horses and ponies, mules, donkeys

production and regeneration especially in the pre-seeding period. Study conducted by Mertia and Santra (2012) revealed that uncontrolled grazing had significantly reduced stand density of grass tussocks (5700 tussocks ha^{-1}) and their regeneration in openly grazed pasture in comparison to those pastures which were subjected to controlled grazing (9200 tussocks ha^{-1}). Overgrazing in turn has resulted in the gradual replacement of palatable plants by unpalatable grasses and shrubs. Large areas of *gauchars* and *orans* have become totally bereft of palatable grasses and shrubs, greatly decreasing their capacity to support livestock on a sustained basis.

The other problems associated with CPRs encompass conflicts between and within villages (heterogeneity), absence of long-term plan and security of use rights and the poor management of communal lands. All these reasons are attributed to the poor productivity from the CPRs.

Issues for consideration to revitalize common grazing resources

Research conducted at ICAR-Central Arid Zone Research Institute (CAZRI), ICAR-Indian Grassland and Fodder Research Institute (IGFRI) and elsewhere showed that improved natural rangeland can support four times of the present carrying capacity. In Rajasthan, *Cenchrus ciliaris*, *Cenchrus setgerus*, *Lasiurus sindicus*, *Dichanthium annulatum* and *Panicum antidotale* are dominant perennial grasses together with annuals that are available for grazing during monsoon. During post monsoon period sparsely scattered trees/shrubs having top feed value also provides green fodder for browsers. The adaptive fodder tree/shrub species are *Ziziphus nummularia*, *Prosopis cineraria*, *Ailanthus excelsa*, etc. The actions that need greater attention for increasing the productivity of the CPRs of arid Rajasthan are described in the following sub-sections.

Development of CPRs: Protection, reseeding and soil-water conservation measures are the essential components for proper maintenance of CPRs. Natural succession of the high yielding perennial grasses is rather a time consuming process. Reseeding of suitable perennial grasses adapted to the specific agro-climatic conditions is the best recourse for increasing the forage as well as animal productivity. Increase in forage yield was recorded from 30 to 122% in "poor" and 29 to 107% in "fair" class of rangeland after 3-5 years of reseeding (CAZRI 1992). Further, utilization of pasture through controlled grazing increased the life and productivity of pasture. CAZRI has clearly demonstrated on the basis of 20 years of research on rangeland improvement and utilization that grazing conducted on the basis of carrying capacity can increase the productivity from poor to very good over a period of 15 years even in the hyper arid regions of Thar desert (Mertia, 1992). Studies conducted here indicate that with adequate protection from overgrazing and following concept of grazing on the basis of carrying capacity, aiming at 70% foliage utilization level, forage yield increased by 148, 92 and 116%, respectively in poor, fair and good condition class of grasslands after two years (Ahuja, 1977). Soil conservation measures, contour furrows at a distance of 8-10 meters across the slope, contour bunds and trenches positively influenced forage yield of rangelands. An increase of 639% in forage yield was recorded over control by adopting moisture conservation technique (Ahuja, 1984).

Silvi-pastoral system: A large number of exotic and indigenous trees including fodder trees were introduced by CAZRI, Jodhpur. The most promising amongst the fodder trees are *Acacia tortilis*, *Albizzia lebbek*, *Acacia*

nilotica, *Hardwickia binnata*, *A. indica, Ailanthus excelsa* and *Prosopis cineraria*. Some of these trees have been successfully propagated in silvi-pastoral system. Suitable models have also been developed for different rainfall situations. Simultaneously dissemination of pasture improvement technology is being advocated (Kumawat and Misra, 2017). Various silvi-pastoral systems were found to be very important for increasing fodder production from marginal, sub-marginal and other wastelands. Production could be increased to 5-7 t ha^{-1} of green fodder against only 2-4 t ha^{-1} without a tree component (Yadava *et al*., 2018).

Management of pasture in watershed: Currently, many watershed development projects aim to revive the productivity of remaining common grazing lands (Misra *et al*., 2014; Kerr *et al*., 2000). They aim to use a combination of technical and institutional means to move the supply of products such as fuel and fodder from a low-level equilibrium to a high-level one. The technical work involves interventions related to soil and water conservation and planting vegetation to raise pasture productivity, besides transforming herds from mainly relatively unproductive grazing animals to mainly high productive stall-fed animals (Kerr *et al*., 2000). In addition, many projects also seek to develop institutions for managing government lands based on principles of common property resource management. Typically they encourage villagers to establish users' committees that are expected to develop and enforce management plans in a way that satisfies the needs of every interest group for better management of CPRs. In short, they try to create the kind of ideal, democratic arrangement mentioned in the preceding paragraphs.

Grassland utilization: Rangeland herbage should be used carefully and smartly. In established or natural grasslands, deferment of grazing schedules helps allow vegetation to reproduce and disperse seed. Rangelands re-seeded with perennial species should not be grazed for the first year. Grazing may be permitted in the second year after seed dispersal (Ahuja, 1977), and should not exceed the carrying capacity of the grassland in subsequent years. Fencing, either vegetative or mechanical, is a prerequisite for the introduction of controlled grazing in most dry areas. With effective fencing, pasture yield may increase three fold in five years. In most of the grasslands, deferred-rotational system is followed for better utilization of the herbage (Yadava *et al*., 2018). Furthermore, mixed herd grazing is advocated for utilization of all the rangeland herbages. An area containing both grasses and shrubs may be best used by a combination of different ruminant species with diverse grazing habits (Dayal *et al*., 2015).

Supplementary feeding of animals: The studies conducted by Bohra *et al.* (2012) in western Rajasthan indicated that animals that depends only on grazing, suffer from Ca, P, Mn, Cu and Co deficiency, and also from vitamin A. Therefore, supplementation of multi-nutrient mixture helped in increasing livestock productivity on the one hand and maximizes the carrying capacity of the grazing lands on the other (Patidar *et al*., 2014).

Participation of local peoples and institutions: Chopra *et al*. (1989) opined that people's participation can be an alternative to government for effective development of CPRs with preservation. According to them as a process, it is evolutionary in nature and as an institution it is bound by the people possessing common interest leading to development. The participation of local bodies/communities is essential for sustenance of developed pastures on the community lands. The guidelines issued by the NRAA for watershed programs emphasized implementation by either registered village bodies or *panchayats*. The Hariyali guidelines 2003, however, emphasized implementation only through the *panchayati raj* institutions. Participatory studies clearly indicate that the role played by village institutions in sustaining the community lands is crucial (Misra *et al*., 2015). The facilitating agency needs to spend sufficient time to understand the local scenario, both social and geophysical, and design interventions fitting into local conditions.

The Way Forward

The revitalization of CPRs is crucial for protecting livelihoods, as well as for biodiversity conservation and for the improvement in arid micro-climatic conditions. Dialogue continues on the status of common property resources, the available legal framework and issues related to its conservation through strengthening of local institutions and capacity building of stakeholders. Policies and programs to tackle

the issue of dependence on common lands for fodder and also to maintain its productivity are vague. Although stall feeding of productive livestock and producing fodder in high yielding agricultural areas is recommended, the economics of raising fodder in hot arid areas or of the relative merits of stall feeding is not fully understood. Compared to extensive system of grazing, stall feeding is very expensive. Hence, high yielding cattle breeds cannot be supported by rural poor through stall feeding in most of the dry regions. Creative strategies clearly need to be explored for the management of rangelands and pasture that involves the integration of various operations such as fencing, soil and water conservation, improved grazing management practices. Managed rotational grazing is the only economically viable system for the majority of residents residing near forest lands in the arid and semi-arid tracts. Thus, programs promoting livestock development continue as there are no conflicts with wasteland and forest rehabilitation programs, but the institutional arrangements for this and the technical prescriptions are still poorly developed.

Information on the effect of the deterioration of the common lands on the well being of poor people will provide important insights about the extent of priority that needs to be given to revitalize common lands. Projects on the revival of the common lands will also have to be strengthened for environmental rehabilitation or for build up of social capital. Outcome of such developmental projects shall depend on the priority issues. Such research can also help to provide insights into the indirect benefits of working to promote improved common pasture management institutions. The policy aspects of common grazing lands have not been addressed in the recent past either at national or state levels, and these lands had been the soft targets for un-planned activities. Therefore, utmost attention of the policy planner is required towards a sustainable feed, fodder and grazing land development policy, which will also have implications for institutionalizing common lands development with a regional and farmer focus.

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