

## Desertification control and rangeland management in the Thar desert of India

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### ABSTRACT

India has about 2.34 million km<sup>2</sup> of hot desert called 'Thar' in the western part, mostly covering the state of Rajasthan. After independence strenuous efforts were made towards desertification control, ecological regeneration and restoration of the Thar desert in order to reclaim the productivity of the vast unproductive desert land. For this purpose a 649 km long man made canal was made to bring Himalayan water into the water starved desert. Although Thar desert is 'highly generic' i.e. it becomes lush green with slightest precipitation, its natural rates of regeneration have been very slow due to intense biotic pressure (overgrazing, extraction of fodder and fuelwood).

Introduction of fast growing exotic species of trees and grasses from isoclimatic regions of the world for stabilization of shifting sand dunes; creation of 'microclimates' through shelterbelt plantations; and creation of 'fencing and enclosures' for regeneration of indigenous species have proved highly successful towards the control of desertification, ecological regeneration and restoration of the Thar desert. The degraded Thar desert ecosystem shows tremendous resilience for regeneration when the influence of biotic factors is removed.

The native people of the Thar desert have a grand tradition of preserving village grazing lands called 'gochars', and green woodlands called 'Orans'. Orans are preserved in the name of local diety. The villagers take a vow not to cut down any tree or branches of trees from the Orans. Only the grasses and palatable herbs can be used as fodder for the cattle. Orans and gochars are like 'mini-biosphere reserves' in the Thar desert and have greatly helped in the maintenance of ecological stability of the region.

Thar desert holds a big potential for development into a rangeland. The highly nutritive fodder grasses *Lasiurus indicus*, *Cenchrus ciliaris*, *C. setigerus* and *Cymbopogon jwarancusa* are well adapted to the Thar desert environment.

**Key words:** aerial seeding, enclosures, fencing, Orans, shelterbelt plantation, village grazing lands.

### INTRODUCTION

In India there are about 2.34 million km<sup>2</sup> of hot desert called 'Thar'. It represents one of the most inhospitable arid zones of the world, spreading mostly through western Rajasthan, Gujarat, South-Western Punjab, Haryana and part of Karnataka. About 85% of the great Indian desert lies in India and the rest in Pakistan. About 91% of the desert, i.e. 2.08 million km<sup>2</sup>, falls in Rajasthan covering about 61% of the geographical area of the state. The Aravali hills, older than the Himalayas, intersect the State to the north-east and in the west lies the great Indian desert the 'Thar'.

The Indian desert is characterized by high velocity wind, huge shifting and rolling sand dunes; high diurnal variation of temperature; scarce rainfall; intense solar radiation and high rate of evaporation. Thar desert receives between 100 to 500 mm of rainfall every year, 90% of which is received between July and September. The sandy soils of the desert have a rapid infiltration rate of water, poor fertility, low humus content due to rapid oxidation and high salinity. All conditions are very hostile for the existence of life, yet, large human and livestock populations inhabit the area. The Indian desert is highly fragile with poor primary *producers* but large liabilities i.e. the *consumers* causing severe impediments in its 'ecological regeneration' and 'desertification control' efforts.

Archeological evidence suggest that the region was once a flourishing green country-side with thick forests and river-systems of which 'Saraswati' and 'Yamuna' were the most important. Epigraphic evidence by Landsat Satellites Imagery support this evidence. The onslaught of man and his domestic animals on the local ecosystem changed the panorama of the region from a land of plenty to the land of poverty in less than 5000 years. The artifacts discovered in the Pushkar and Luni basin of Rajasthan prove that man lived here as early as 5000 B.C. Perhaps the over-exploitation of land and water resources since the earliest times has made the Rajasthan desert as a 'man-maintained' if not 'man-made'. The word desert gives the impression of a vast, treeless undulating expanse of sand. The great Indian desert 'Thar' does not conform to this popular notion. The desert is not an endless stretch of sand dunes, bereft of life or vegetation. During certain periods it blooms with a colourful range of trees and grasses and abounds in amazing variety of birds and animal life. Thar desert is highly 'generic' for it become lush green with slightest precipitation. The soil is full of dormant seeds of various species which sprout with little moisture.

After independence, India paid much attention towards desertification control and ecological restoration of the Thar desert. A water canal called the Indira Gandhi Canal was constructed to bring the sweet Himalayan waters to the desert region. The IG Canal, 649 km long, has a capacity to flow 524 m<sup>3</sup> of water/sec. With the canal water, the entire scenario of the Thar desert is changing fast. The 'desert ecosystem' appears to be transforming into an 'ever-green' forest ecosystem in the Command Area of the canal (Sinha 1993).

#### STRATEGIES TOWARDS DESERTIFICATION CONTROL IN THE THAR DESERT

Desert Afforestation Research Station to Control desertification was set up in Jodhpur in 1952. The State Forest Department made a humble beginning towards desertification control in 1958 by taking up afforestation in the Command Areas of IG canal in Ganganagar district. The major afforestation programmes implemented were: 'sand dune fixation work'; 'silvipastoral plantations'; 'village fodder and fuelwood plantation'; 'shelterbelt plantation'; 'ecological regeneration; restoration and rehabilitation of degraded desert lands'; 'afforestation on barren hills; re-seeding of old pastures and farm forestry'.

#### *Introduction of fast growing 'exotic' tree species*

The indigenous tree species growing in the Thar desert are not only few in number but are also extremely slow growing. Therefore, greater attention was focused on the introduction and selection of fast growing exotic tree and shrub species from isoclimatic regions of the world. In this effort about 115 *Eucalyptus* species, 73 *Acacia* species and 170 miscellaneous ones from various countries including Mexico, USA, Latin America, former USSR, Africa, Israel, Peru, Kenya, Australia, Chile, Sudan and Zimbabwe and the Middle East, were introduced. *Acacia tortilis* an exotic from Israel for sand dune stabilization, *Prosopis juliflora*, suitable for fast biomass production, *Acacia nubica* for sand dune stabilization, *Colophospermum mopane* and *Dichrostachys glomerata* for fodder purpose and *Eucalyptus cameldulensis* are few exotics suited for low rainfall area. A number of the exotic tree species like *Eucalyptus cameldulensis*, *E. melanophloia*, *Acacia tortilis*, *A. cillata*, *A. raddiana*, *A. senegal*, *A. sieberiana*, *A.*

*aneura*, *A. salicina*, *Colophospermum mopane*, *Dichrostachys glomerata*, *Brasilettia millis*, *Schinus molis* and *Prosopis juliflora* have emerged very promising for the Indian desert. Of all the exotic species tried, '*Acacia tortilis*' from Israel has been adjudged the best 'fuel-cum-fodder species' for the desert. Since its introduction, it has found a 'niche' not only in Rajasthan desert but also in other States of India. *Acacia tortilis* which has shown performance in growth and survival equal to or better than the indigenous *Acacia senegal*, is very promising (Muthana and Arora 1973). However the desert dwellers are not happy. They want *Acacia senegal* to be planted on large scale. This species of *Acacia senegal* is of great socio-economic value for them. Besides yielding fodder and fuel it also gives a valuable 'gum resin'. They are also somehow linked with the chain of the great Indian majestic bird of the Thar desert called 'godawan' which is threatened with extinction. Godawan feeds on the insects which thrive on the gum resins of *Acacia senegal*.

### *Stabilization of shifting sand-dunes*

In low-rainfall areas (150 mm to 400 mm), huge shifting sand dunes are commonly found, particularly near human habitations. Techniques of afforesting the shifting dunes were standardized after 10 years of experimentation. These techniques consist of: (i) protection against biotic interferences; (ii) treatment of shifting sand-dunes by fixing barriers in parallel stripes or in a 'chess-board' design, using the local shrub material starting from the crest of the dunes to protect the seedlings from burial or exposure by the blowing of sand; (iii) afforestation of such treated dunes by direct seedling and planting. The two species commonly used for erecting 'brush-wood barriers' (micro-windbreaks) are *Zizyphus nummularia* and *Crotalaria burhia* (Kavia and Harsh 1993).

The indigenous and exotic species which have proved successful in sand dune stabilization are: trees – *Acacia senegal*, *Prosopis juliflora*, *Albizzia lebeck*, *Cordia rothii*, *Dalbergia sissoo* (in regions with mean annual rainfall of 250 mm) and *Zizyphus jujuba*; shrubs – *Calligonum polygonoides*, *Cassia auriculata*, *Ricinus communis* and *Zizyphus nummularia*; grasses – *Lasiurus indicus*, *Panicum turgidum* and *Erianthus munia*. Among exotic species, *Eucalyptus oleosa* (Australia), *Acacia tortilis* (Israel), *Parkinsonia aculeata* and *Acacia victoriae* (Australia), *Acacia albida* (Middle East) were found to be very promising, especially as these species were found to be frost resistant. *Acacia albida* was used to stabilize 60,000 hectares of sand-dunes in the Thar desert (Anonymous 1988).

Phog (*Calligonum polygonoides*) needs special mention. It is a very useful species of the Thar desert. It is a naturally growing shrub on the sand dunes. It has a massive network of underground root which works as effective 'sand binder'. Other species occurring on sand dunes are *Aerva psuedotomentosa*, *Leptadenia pyrotechnica*, *Citrullus colocynthis*, *Lasiurus indicus*, *Calotropis procera*, etc. Other suitable species for planting on sand dunes are *Colophospermum mopane* and *Prosopis cineraria*.

### *Shelterbelt plantations to reduce wind velocity*

Shelterbelts and tree-screens consisting of a row of trees viz. *Acacia tortilis*, *Tamarix articulata* and *Azadirachta indica* flanked by two rows (one on each side) of smaller trees like *Acacia senegal*, *Prosopis juliflora* etc., with two rows (one on each side) of

shrubs like *Aerva tomentosa*, *Zizyphus spinachristi*, *Calligonum polygonoides* were found to be very effective for Thar desert. In the Bikaner region rows of *Eucalyptus cameldulensis* and *Dalbergia sissoo* have also worked as effective shelterbelts and tree screens for creation of 'micro-climates' (Sinha 1993). Shelterbelts reduced the wind velocity by 20–46% on the leeward side for 2H–10H during the monsoon period (H= height of shelterbelt). Soil loss was also considerably reduced. Rajasthan State Forest Department has so far covered about 38,000 row km area under shelterbelt, road side, railway line and canal side plantations since 1978 by adopting the technology developed at CAZRI, Jodhpur (Kaul 1969).

#### *Ecological regeneration through aerial seeding*

Aerial seeding of seed pellets of *Cenchrus ciliaris*, *Acacia tortilis* and *Colophospermum mopane* was done in 56 ha of military range areas in Barmer district of Rajasthan at two sites: the dunny sandy plain of Jalipa and the rocky hill ranges of Jasai village. The programme was undertaken in collaboration with the military. Two methods of seeding, i.e., seeding by helicopter and manual broadcasting of pellets were used. Data on establishment and growth were recorded twice, i.e., at sowing and maturity stages. The manual broadcasting of pellets was found better than aerial seeding by helicopter. Under controlled conditions in the Jasai area, the plant population at sandy and rocky area were 6 and 3 individuals per m<sup>2</sup>, respectively. The controlled sites were seeded manually (Anonymous 1995).

Aerial seeding was also done in Bikaner on the left bank of the IG Canal in Sardarpura (300 ha) and Motigarh (400 ha). The seed mixture consisted of seeds of *Acacia tortilis*, *Colophospermum mopane*, *Dichrostachys nutans*, *Prosopis cineraria*, *Zizyphus rotandifolia*, *Citrullus colocynthis* and *Lasiurus indicus* at the rate of 14 kg/ha. *A. tortilis* recorded highest germination and seedling density followed by *C. colocynthis* (Anonymous 1995).

#### *Ecological restoration and regeneration of the mined wastelands*

Two mined wastelands, one of gypsum and the other of limestone were selected for ecological regeneration. Four plots of one hectare each were demarcated to have four treatments, i.e., control, development of micro-catchment area, half moon structure development and ridge and furrow system, so that the planting pits (60 cm) might receive additional rain water as run-off. Seven indigenous and exotic species of trees and four of shrubs were selected for plantation. In general, 5 m × 5 m spacing in plant to plant and row to row was adopted. Plant species included *Salvadora oleoides*, *S. persica*, *Acacia tortilis*, *Azadirachta indica*, *Prosopis juliflora*, *Tamarix articulata*, *Pithecelobium dulce*, *Dichrostachys nutan*, *Cassia stnitii*, *Cercidium floridun* and *Caesalpinnea ceraria* (Anonymous 1995).

The rooted slips of grasses like *Cenchrus ciliaris*, *C. setigerus* and *Cymbopogon jwarancusa* were also transplanted as a single row in the ridge and furrow system. 1.5 ha of mining muck heaps and the rocky substrata were used for plantation. The muck heaps were reshaped to create slopes and inverted terraces for rainwater harvesting. At the rocky site 'half-moon' structures were developed with 3 m and 5 m spacing. More than 90% of the plants survived. Live hedges and biofences of *Prosopis juliflora* were raised at both the sites with 1 m × 1 m spacing to protect the plantation.

### *Ecological regeneration through fencing and enclosures*

The Thar desert shows tremendous resilience for regeneration when it is protected by fences and enclosures for a certain period of time. A chain of long term enclosure has been established by CAZRI and the State Forest Department on a variety of desert habitats such as hills, rocky gravelly pediments, flat pediments, sandy undulating pediments, flat aggraded older alluvial plains, sand dunes and shallow saline depressions (see Tables 1 and 2). The recommended duration of protection is from 5 to 20 years. There is good growth of vegetation, both trees and grasses, upon protection. Desertification is completely halted in such regions.

**Table 1.** The limits of natural regeneration of rangelands in various habitats of the Thar Desert. (Source: K.A. Shankarnarayanan in Ishwar Prakash (ed.) 1988, Desert Ecology).

District	Rainfall (mm)	Desert Habitats	Soil texture	Duration of protection (in years)	Grass cover
Pali	450	Hill	Gravelly	10	<i>Chrysopogen fulvus</i>
Jodhpur	250	Hill (top)	Gravelly	20	<i>Aristida, Dropstium</i>
Jodhpur	250	Hill (slope)	Gravelly	20	<i>Aristida, depressa</i>
Jodhpur	250	Hill (base)	Gravelly	18	<i>Eleusine compressa</i>
Jodhpur	250	Flat-buried loamy pediments	Loamy	18	<i>Dichanthium, Cenchrus</i>
Pali	450	Loamy pediments	Loamy	20	<i>Ermopogon, Aristida</i>
Bikaner	450	Loamy pediments	Loamy	20	<i>Cenchrus, Aristida</i>
Jaisalmer	150	Sandy undulating buried pediments	Sandy	18	<i>Lasiurus indicus</i>
Pali	150	Flat aggraded older alluvial plain	Clay loam	18	<i>Cenchrus</i> spp. <i>Zizyphus</i>
Sirohi	450	Flat aggraded older alluvial plain	Clay loam	18	<i>Dichanthium annulatum</i> <i>Acacia nilotica</i>
Barmer	200	Sandy undulating aggraded older alluvial plain	Sandy	18	<i>Cenchrus</i> spp.
Bikaner	250	Sandy undulating aggraded older alluvial plain	Sandy	20	<i>Lasiurus indicus</i> <i>Cymbopogon, Cenchrus</i>
Sikar	450	Sandy undulating	Sandy	18	<i>Cenchrus</i>
Bikaner	250	Sand dune (slope)	Sandy	20	<i>Aristida, Cenchrus</i>
Bikaner	250	Sand dune (slope)	Sandy	20	<i>Aristida</i>
Bikaner	250	Sand dune (slope)	Sandy	20	<i>Panicum antidotale</i>
Jodhpur	250	Shallow	Clay loam	20	<i>Sporobolus marginatus</i>

**Table 2.** Time sequence of regeneration of rangelands in various habitats of the Thar desert. (Source: K.A. Shankarnarayanan in Ishwar Prakash (ed.) 1988, Desert Ecology).

Desert habitats	Duration of enclosure (in years)	Grass cover
Hills	7	<i>Chroisopogon fulvus</i> , <i>Eremopogon foveolatus</i> , <i>Heteropogon contortus</i>
Rocky/gravelly pediments	12	<i>Eleusine compressa</i> <i>Dactyloctenium indicum</i>
Rocky/gravelly pediments with contour bunding	6	<i>Eleusine compressa</i> <i>Dactyloctenium indicum</i>
Flat buried pediments (high rainfall and heavy soils)	6	<i>Dichanthium annulatum</i>
Sandy undulating buried pediments (low rainfall)	6	<i>Lasiurus indicus</i> , <i>Panicum antidotale</i>
Flat aggraded older alluvial Plains	4–6	<i>Lasiurus indicus</i> <i>Panicum antidotale</i>
Sand dunes	18	<i>Panicum turgidum</i> <i>Cenchrus prieurii</i>
Shallow saline Depressions	6	<i>Sporobolus marginatus</i> <i>Dichanthium annulatum</i>

### POTENTIAL FOR RANGELAND DEVELOPMENT IN THE THAR DESERT

Natural regeneration of trees, shrubs and grasses in the Thar desert is very slow (see Tables 1 and 2). The biotic pressure is so intense in the arid region of Rajasthan that the forest floor is grazed clean and the plants are browsed severely by the huge population of livestock hampering the regeneration process.

#### *Improved strains of pasture grasses and legumes for Thar desert*

For achieving a breakthrough in the yield of different promising grasses and legumes, an exhaustive germ-plasm of over 1600 plants has been built up at the Central Arid Zone Research Institute (CAZRI) Jodhpur, Rajasthan and maintained in nursery. An active variety construction programme with manifold objective is under way. A number of promising cultivars have been identified. The important cultivars are: CAZRI-358, 75, Molopo, Buffel of *Cenchrus ciliaris*; 76, 175, 296 of *C. setigerus*; 317, M-20-5, 319 of *Lasiurus indicus*; 490, 491 of *Dichanthium annulatum*; 331, 333 of *Panicum antidotale*; 144, 1258, 1462, 1626 of *Lablab purpureas*; 752, 466, 1433 of *Clitoria ternatea*. These varieties provide high and nutritive forage over a greater part of the year. They are drought hardy, stable, persistent and aggressive in rangeland and possess high seed yield ability, fast regeneration and good germination.

Several areas of the Thar desert are highly saline which hinders growth of grasses and palatable herbs. Salt tolerance of various pasture species has been identified after yearly monitoring of their occurrence and yield and the results have been successfully utilized in the rangeland development in the salt affected areas of the Thar desert (see Table 3).

**Table 3.** Salt tolerance of various pasture species of the Thar desert. (Source: Progress in Arid Zone Research (1952-87), CAZRI, Jodhpur).

Highly salt tolerant (>16 mmhos EC)	Tolerant (8–16 mmhos EC)	Semi-tolerant (4–8 mmhos EC)	Sensitive (<4 mmhos EC)
<i>Sporobolus marginatus</i>	<i>Cenchrus setigerus</i>	<i>Heteropogon contortus</i>	<i>Dichanthium annulatum</i>
<i>Eleusine compressa</i>	<i>Aristida</i> spp. <i>Eremopogon foveolatus</i> <i>Sehima nervosum</i>	<i>Zizyphus nummularia</i>	<i>Eragrostis</i> spp.

### *Discovery of new high yielding pasture grass varieties in the Thar desert*

1. *Cenchrus ciliaris* ('Marwar Anjan'), (CAZRI-75): It is a selection from an entry in the germplasm received from Australia. In August 1985 CAZRI released this variety for cultivation in the arid and semi-arid parts of India. Marwar Anjan is a tall, thick stemmed, erect and drought hardy perennial. Its leaves are broad, long, droopy and remain green up to maturity. It has a wide adaptability, high tillering ability and is good in regeneration. It possesses a stout root/rhizome system. It gives 2 to 3 cuttings per year. It yields 70 quintals of green fodder and 30 quintals of dry matter per hectare under desert conditions. It has 8% protein and about 60% digestibility. It produces 1 to 1.5 quintal/ha seed even after one cutting of fodder. It is persistent and aggressive variety for rangelands and remains productive for four to five years under proper management systems. It is sown at the onset of the monsoon with the seed rate of 5 to 6 kg/ha (Anonymous 1988).
2. *Cenchrus setigerus* ('Marwar Dhaman'), (CAZRI-175): It is a selection from exotic material and well adopted in the arid and semi-arid regions of India. 'Marwar Dhaman' is excellent for grazing purpose due to its thin stem and leafy foliage. It is a drought hardy perennial grass which forms clumps at the base. It is an early maturing variety, flowers between 45 to 55 days, high in tillering, with good regeneration abilities and capable of giving 2 to 3 cuts per year under rainfed conditions. It provides an average yield of 40 quintal/hectare green fodder and 5 quintal/hectare dry matter in desertic regions, whereas in semi-desertic areas, the yield becomes doubled. It contains 9.5% crude protein and has 65% digestibility at half bloom stage. Its pasture remains productive for 4 to 5 years. It is moderately resistant to major insect pests. (Anonymous 1988).

The use of these improved grasses for reseeding the depleted 'orans' or 'village grazing lands' (gochars) assume significance for meeting the grazing needs of desert livestock.

### *Silvipasture development in the Thar desert: a traditional practice*

Growing trees and grasses together has been a traditional practice in the Thar desert. It is being revived on large scale for rangeland development. Among nine tree species tried, *Acacia tortilis* showed survival of 98% followed by *Dichanthium nutans* (88%), *Acacia senegal* (83%) and *Acacia indica* (65%), whereas *Prosopis cineraria* and *Albizia lebbek* showed only 5 to 10% survival. *Hardwickia binata*, *Colophospermum*

*mopane* and *Zizyphus nummularia* showed 28 to 35% survival. Maximum height was recorded in the case of *A. tortilis* (291 cm) followed by *A. indica* (240 cm) and *A. senegal* (175 cm) and lowest in *P. cineraria* (77 cm). Collar diameter recorded in *A. tortilis*, *A. indica* and *A. senegal* was 8.21, 6.88 and 4.46 cm respectively.

Dry forage yield of *Cenchrus setigerus* in the interspaces between the trees was 2020 kg/ha in the plots of *A. tortilis* and 2500 kg/ha in *A. indica*. Dry forage yield of grass under other tree species ranged from 2750 to 2980 kg/ha as against 3000 kg/ha under pure pasture without trees. *Cenchrus ciliaris* (CAZRI-75) and *Cenchrus setigerus* (CAZRI-175) were sown between rows of neem (*Azadirachta indica*), subabool (*Leucaena leucocephala*) and Israeli babool (*Acacia tortilis*) planted in 1988 at 5 m × 5 m spacing. The growth of trees were reduced, but growth of grasses were better under the system. The fodder yield was more under *Azadirachta indica* as compared to grass under *Leucaena leucocephala* and *Acacia tortilis* (Anonymous 1993) (Table 4).

**Table 4.** Yield of forage (kg/ha) under different tree species. (Source: Annual Report of CAZRI, Jodhpur, 1992–93).

Tree species	<i>Cenchrus ciliaris</i>	<i>Cenchrus setigerus</i>
Control (without any tree)	2570	2100
<i>Azadirachta indica</i>	4350	3430
<i>Leucaena leucocephala</i>	3100	2570
<i>Acacia tortilis</i>	2720	2950

*Acacia leucophloea*, *A. auriculiformis*, *A. nilotica*, *A. senegal*, *A. tortilis*, *Albizia lebbeck*, *Cassia siamea*, *Dalbergia sissoo*, *Derris indica*, *Parkinsonia aculeata*, *Prosopis cineraria* and *P. chilensis* are some important multipurpose nitrogen fixing trees recommended for silvipasture and rangeland development in the Thar desert (Sivaji et al. 1993). Under the rangeland development scheme, controlled and rotational grazing has been introduced. Some of the areas have been reseeded with perennial and nutritive grasses like *Cenchrus ciliaris*, *Cenchrus setigerus*, *Dichanthium annulatum* and *Lasiurus sindicus*.

Significant achievement has been made in the mass production of nutritive fodder 'sewan grass' (*Lasiurus sindicus*) for the desert livestock. This revolutionary grass, besides contributing in the development of good rangeland in the Thar desert, has significantly helped in stabilizing the blowing sand dunes and expansion of the desert (Sinha 1996). In the Jaisalmer district of Thar desert, schemes have been launched for the cultivation of green fodder in 200 ha, pasture development in 3,000 ha, and the establishment of one hundred 'wood lots' and 'nurseries'.

#### *Village grazing lands and protected fodder lands in the Thar desert*

In the earlier days, each and every desert settlement had well guarded common property land resource such as good pasture land called 'gochar', and natural woodland called 'oran'. The 'orans' (Forests of God) were designated to honour village diety or saint and are preserved meticulously on socio-religious grounds. It is like a mini 'biosphere' reserve for the village and the propagules released from gochars and orans

help regenerate vegetation in other areas. Cutting of trees is completely prohibited in the orans as the God and Goddess would become unhappy and the whole village would be punished by some natural calamity, such as severe drought or flood. The villagers take a vow and promise not to cut down any tree or cut branches of trees from the orans. Only the grasses and other underground palatable herbs can be used as fodder for the cattle.

### *Concluding remarks*

Fuelwood and fodder production in the Thar desert has an impact on its ecological regeneration. Over-exploitation of fodder and fuelwood, the two basic necessities of life for the desert people, causes ecological destruction of the desert ecosystem and enhances desertification. The degraded rangelands of the Thar desert show tremendous resilience for regeneration when the influence of biotic factors are removed. This is evidenced in the form of triggering off a progressive ecological succession in grass and tree/shrub cover, which quickly attain a stage of sustainable utilization.

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