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Desertification Mapping in Western Rajasthan

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Abstract Using the 1990 UNEP definition of desertification, an attempt was made to map the desertification hazards in western Rajasthan. The first stage involved the mapping of dominant land uses in different rainfall zones. This was followed by mapping of dominant and associate processes of desertification and their severity for desertification status.

Key words Desertification status, Terrain, Processes, Rangeland

Desertification is one of the serious environmental problems that has attracted the attention of mankind. The United Nations Conference on Desertification, held at Nairobi, Kenya, in 1977, defined desertification as "diminution or destruction of the biological potential of the land and can lead ultimately to desert like conditions" (Anonymous 1977, Dregne 1991). Based on the definition an attempt was made to map the desertification hazards in the Luni Development Block of Jodhpur district (Anonymous 1977, Singh *et al.* 1978). The current definition of desertification, as suggested by United Nations Environment Programme (UNEP) in 1990, is "land degradation in arid, semi arid and dry sub humid areas, resulting from adverse human impact" (Dregne 1991, Rozanov 1992). The hyper arid area (e.g., the Sahara) and the humid climatic belt are now excluded from the purview of desertification.

Using the UNEP, 1990, definition of desertification, attempts are now being made world over to map the status of desertification, as also to find out easier means of collecting mappable information on desertification (Kharin *et al.* 1985, Dregne 1991). The present study was undertaken with a view to map the current status of desertification in western Rajasthan, using available field information and remote sensing data products.

Materials and Methods

Unlike many other deserts, western Rajasthan, forming a part of the Thar or the Great Indian desert, is dominantly an agricultural area and has very high human and animal population (Anonymous 1977). The land utilization pattern has, therefore, a greater role to play in the desertification process. Hence the first stage of mapping was the preparation of a "Dominant Landuse" map of the region (Fig. 1), showing (i) irrigated croplands, (ii) non-irrigated croplands, (iii) rangelands and (iv) degraded forests. Average annual isohyets were superimposed to suggest the control of rainfall on the distribution of croplands and rangelands.

The second stage of mapping involved the identification of dominant and associate processes of desertification and their severity from the available field information and visual interpretaion of remote sensing data products.

Some of the recent methodologies (FAO 1984, Kharin *et al.* 1985, Dregne 1991) were evaluated for the purpose. The FAO (1984) methodology was found easier to apply, provided some quantified and time series data are available on each of the processes and for the whole of the mappable area. Since such data is still lacking for the whole of western Rajasthan the method could not be tested. Therefore, a new methodology which can utilize the available information on the region, was worked out (Table 1 to 4). Since the method amalgamates field and remote sensing data and has a flexible approach it could be used for whole of the western Rajasthan.

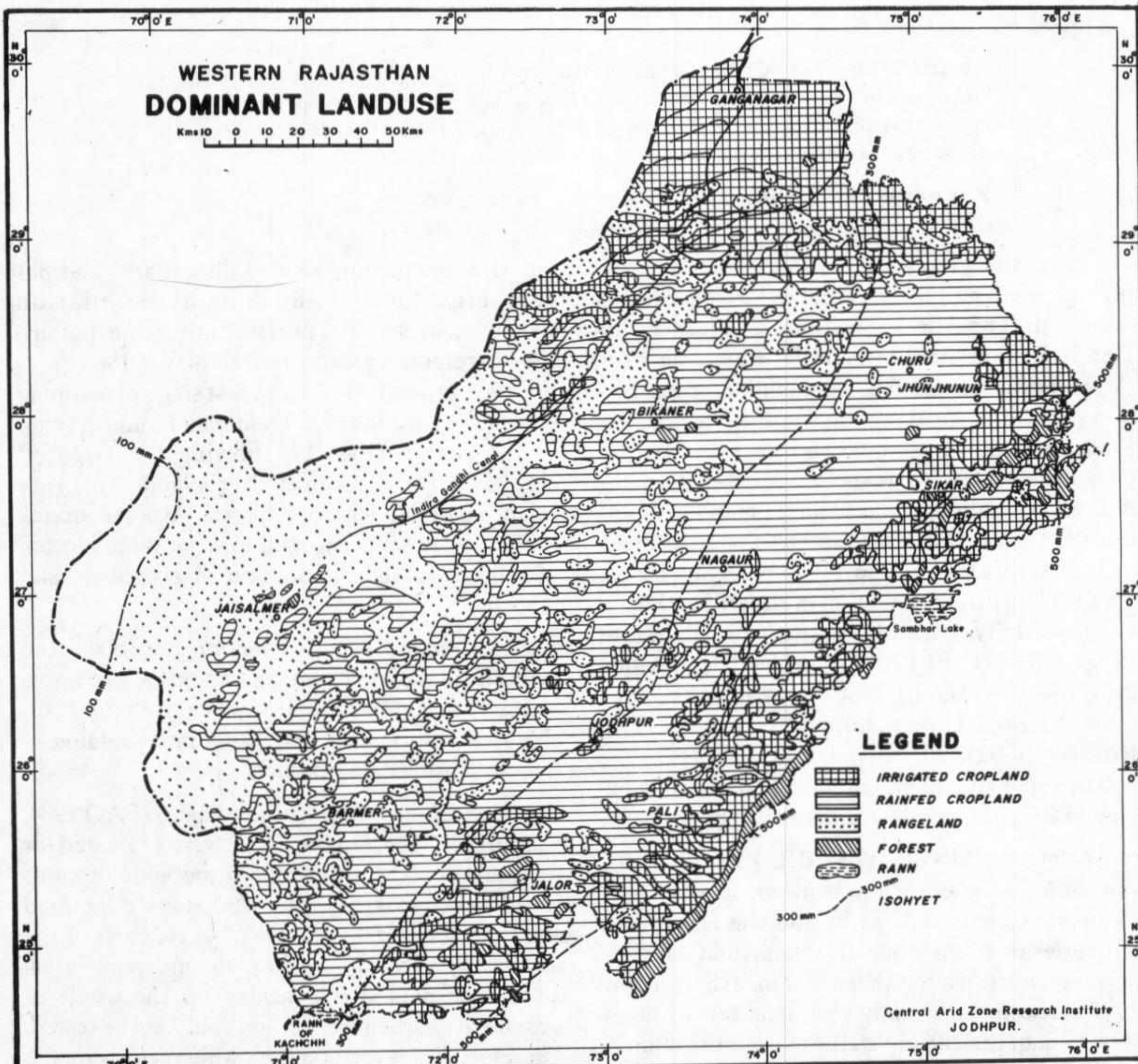

Fig.1. Dominant Landuse

Fig 1 Dominant Landuse

TABLE 1

Table 1 *Criteria for assessing status of desertification due to wind erosion/deposition*

Terrain characteristics	Assessment of desertification status	Severity
Flat older alluvial/colluvial plains with dominantly loamy sand to sandy loam sub soil.	Sand sheeting of upto 30 cm thickness and/or fence line hummocks upto 100 cm over the plains.	Slight (W_1)
(a) East of 300 mm isohyet Moderately sandy undulating older alluvial and interdune plains and sand dunes with loamy sand soils; thickly sand sheeted plains.	Presence of reactivated fresh sand of 50 to 150 cm thickness over stable dunes and sandy hummocks, as well as on fence line hummocks.	Moderate (W_2)
(b) West of 300 mm isohyet Moderately sandy undulating older alluvial and interdune plains and sand dunes with sand to loamy sand soils.	Reactivated and fresh sandy undulations in the form of hummocks and sand ridges of 90-300 cm height and thick sand sheets of 60 to 150 cm thickness between the undulations and fence line hummocks. Reactivated stabilised sand dunes are usually covered with fresh sand deposits of 70 to 200 cm thickness. Interdune and other sandy plains under erosion reveal numerous exposed plant roots to a depth of 40 to 100 cm.	(W_2)
Mostly to the west of 300 mm isohyet; moderately to strongly undulating older alluvial and interdune plains with closely spaced hummocks and high to very high sand dunes with sand to loamy sand soils in sub surface.	Formation of closely spaced sandy undulations in the form of hummocks and transverse and longitudinal ridges of 1 to 4 m height with fresh sand cover. Sand deposits of 100 to 300 cm thickness are usually present between the undulations. Highly reactivated sand dunes covered with fresh sand from all sides and superimposed by barchan dunes of 2 to 4 m height.	Severe (W_3)
Barchan dunes and very thick sand sheets with active sands throughout the profile.	The active and drifting sands in the form of individual and coalesced barchan dunes of 2 to 5 m height, encroaching upon the roads, settlements and agricultural lands.	Very severe (W_4)

TABLE 2

Table 2 *Criteria for assessing status of desertification due to water erosion*

Terrain characteristics	Assessment of desertification status	Severity
(a) East of 300 mm isohyet		
Flat older alluvial plains with 30 to 90 cm deep medium to fine textured soils and good stand of tree vegetation	Sheet erosion imperceptible, but rills of 0.3 to 0.5 m depth and 0.4 to 0.9 m width are usually present.	Slight (V_1)
(b) West of 300 mm isohyet		
Shallow to moderately deep flat older alluvial plains with 7 to 20 cm deep soils and poor stand of vegetation.	*Kankar* exposed in pockets due to sheet erosion. Widely spaced rills are present.	(V_1)
(a) East of 300 mm isohyet		
Gently undulating older and younger alluvial plains, buried pediments and piedmont plains with sand to loamy sand and sandy loam soils..	Sheet erosion as evidenced by few pebbles and *kankar* on the surface. Soil depth is generally less than 30 cm.	Moderate (V_2)
(b) West of 300 mm isohyet		
Hills, rocky/gravelly pediments and flat and sandy undulating buried pediments with sand to gravelly sand and loamy soils.	Rills of 0.6 to 1.2 m depth and 1.0 to 1.7 m width and widely spaced gullies of 4 to 8 m depth and 6 to 15 m width present.	(V_2)
To the east of 300 mm isohyet moderately sloping uplands along the hills, rocky uplands, buried pediments and gently to moderately sloping alluvial and aeolian landforms with sand to gravelly sand and loamy sand to sandy loam soils.	Exposed *kankar* and pebbles, suggesting complete stripping of soil through sheet wash; gullies of 6 to 10 m depth and 7 to 25 m width with narrow interfluves.	Severe (V_3)
To the east of 300 mm isohyet steeply sloping hill ranges and associated obstacle dunes and sandy undulating pediments.	Closely spaced gullies of 10 to 15 m depth and 20 to 40 m width. Almost no mappable interfluve is left.	Very severe (V_4)

TABLE 3

Table 3 *Criteria for assessing status of desertifcation due to salinity alkalinity and waterlogging*

Terrain characteristics	Assessment of desertification status	Severity
	Salinity/alkalinity	
Flat older alluvial plains with sandy to loam and clay loam soils, underlain by weathered granite.	The irrigation with saline groundwater resulted in the development of salinity within soil profile; not visible on the surface. The salt concentration in soil profile is >4 dSm^{-1}	Slight (S_1)
Sand dunes and the flat and undulating interdune plains with sand to loamy sand soils and underlain by less permeable or imprermeable strata.	Irrigation with canal water and presence of impermeable and poor drainage resulted in development of salinity. The salt concentration in soil profile is >4 dSm^{-1}	(S_1)
Flat older alluvial plains with loam to clay loam soils underlain by Kankar and weathered granite or other rocky strata where salinity developes due to rise of saline ground water table.	Soil salinity is developed due to rise of ground water table in the canal command area and in pockets due to use of hignly saline ground water. The ground water table fluctuates between 2 and 3 m depth and salt concentration in the soil profile varies from 4 to 8 dSm^{-1}	Moderate (S_2)
Sand dunes and flat and undulating interdune plains with sand to loamy sand soils underlain by impermeable strata.	Salinization is due to canal irrigation and presence of impermeable strata, rise of ground water table upto 2 m depth and poor drainage conditions and salt encrustations visible on surface. The EC in soil profile varies from 4 to 8 dSm^{-1}	(S_2)
Sand dunes, interdune plains and sandy undulating alluvial plains with sandy to loamy sand, underlain by a thick impervious strata.	Salinization due to above factors where the rise of ground water table is upto 1 m depth below ground level and salt encrustations present. The EC in soil profile ranges between 6 to 12 dsm^{-1}.	Severe (S_3)
	Waterlogging	
Low lying areas between sand dunes and buried courses of drainage channels with loamy sand to sandy loam soils, underlain by impermeable strata.	Waterlogging in pockets; more areas are likely to be waterlogged due to rapidly rising ground water table to the critical limit.	Severe (L_3)
—do—	The deep standing waters in the cultivated fields which have been completely desertified in terms of agricultural productivity.	Very Severe (L_4)

Table 4 a *Criteria for assessing status of desertification due to vegetation degradation in rangelands*

Terrain characteristics	Parameters for assessment of vegetation degradation	Degradation score from rating of parameters	Severity
Dominantly dune covered, or sandy undulating, or rocky and/or shallow soils areas.	Botanical composition of climax species (%), total basal cover; existing biomass as percentage of potential biomass; bssal cover (%) of climax species.	5–8	Slight (d_1)
–do–	–do–	9–12	Moderate (d_2)
–do–	–do–	13–16	Severe (d_3)
–do–	–do–	17–20	Very severe (d_4)

Table 4b *Rating of parameters for assessment of vegetation degradation*

Parameters	Rating				
	1	2	3	4	5
	Parameter values				
Botanical composition of climax species (%)	40–25	25–10	10–1	1	0
Total basal cover (%)	8–4	4–3	3–2	2–1	<1
Existing biomass as percentage of potential biomass	>60	60–40	40–25	25–10	<10
Basal cover (%) of climax species	>50	50–25	25–20	20–5	<5

Table 5 *Comparative salient merits of three recent methodologies for desertification assessment*

Dregne 1991 1	Kharin *et al.* 1985 2	Present study 3
Processes 1. Degradation of vegetation 2. Accelerated water and wind erosion 3. Salinisation and water logging	1. Degradation of vegetation cover by over–use 2. Desertification around desert wells 3. Degradation of vegetation by undergrazing 4. Deflation 5. Water erosion 6. Salinisation of irrigated farm lands 7. Soil salinization by sea level lowering 8. Technogenic desertification	1. Wind erosion/deposition (W), (w) 2. Water erosion (V), (v) 3. Salinisation (S), (s) 4. Waterlogging (L), (l) 5. Vegetation degradation in range lands (d)
Landuse 1. Rainfed cropland 2. Rangelands 3. Irrigation agriculture	Not Considered	1. Irrigated cropland 2. Rainfed cropland 3. Rangeland 4. Degraded forest
Desertification classes 1. Slight–none or slight 2. Moderate 3. Severe 4. Very severe	Used the sum of numerical values of indices for desertification aspect viz. desertification status (DS), desertification rate (DR) inherent risk (IR), domestic animal pressure (AP), population pressure (PP) and calculated desertification hazard (DH) = DS + DR + IR + AP + PP and determined its severity classes like slight, moderate, severe and very severe	1. No apparent desertification – 2. Slight (1) 3. Moderate (2) 4. Severe (3) 5. Very severe (4) Rainfall more than 300 mm and less than 300 mm have been considered for above classes. Where more than one processare operating the associated process has been indicated by small letter.
Moderate and severe degradations can be reversed. Very severe degradation can not be reversed economically. For each category of land use irrigated, rainfed and rangeland, he has given values in percent by which yields decrease and land degradation under three land use categories has been termed as slight, moderate, severe and very severe degradation. Thus besides the satellite imagery, the data on yield decline are also needed for mapping desertification.	Assigned numerical values for desertification classes of the desertification indices to provide desertification like hazard. The decision regarding classs of desertification hazard is based on numerical values and a large data base which eliminate personal error.	This approach is based on the physical manifestations of the degradation processes, rather than the decline in productivity Thus, the satellite data can be used for mapping of surface manifestations, along with other data base and desertification status can be mapped. Because of high variability in rainfall, there is large swing in the plant productivity. However, it has been used in the case of assesment and mapping of desertification in rangelands.

Fig 2 Desertification status

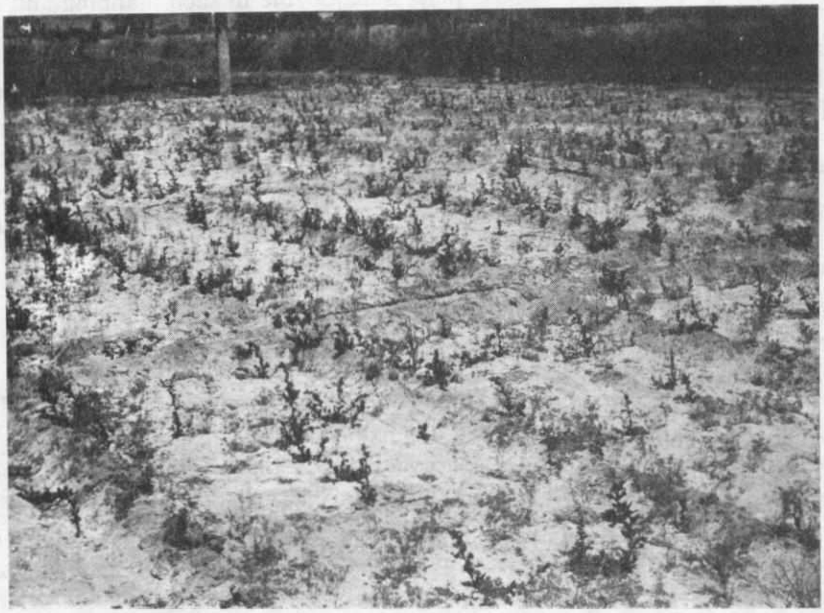

Fig 3 Degraded Land by irrigation with saline-sodic water in Pali Jalor area.

Fig 4 Landsat MSS (band 5) view of land degradation due to salinity alkalinity (A) in the pali-Jalor area.

Results and Discussion

Areas to the west of 100 mm annual rainfall do not generally experience man induced degradation and, hence, could be considered as naturally degraded. The salt affected lands (Fig 3), with large mappable areas and having milky white to bluish green tone (Fig 4) on the false colour composites (FCC) of satellite imagery, are the naturally formed ranns and other salt flats which could hardly be restored for gainful utilization. These have, therefore, been considered as naturally degraded.

For the rest of the area the processes were grouped under (i) wind erosion/deposition, (ii) water erosion, (iii) salinity/alkalinity and (iv) waterlogging. The severity classes identified were (i) slight, (ii) moderate, (iii) severe and (iv) very severe. Areas without apparent signs of degradation were also identified. Mapping was possible through visual interpretation of FCC and aerial photographs and corroborating the information from field. The dominant and associate processes were identified on the basis of interpreter's judgment.

Superimposed on the above pattern was the associated vegetation degradation pattern in the rangelands (Table 4 a & 4 b). The severity classes of degradation were same as in case of the processes.

Using all the above information a "Desertification Status" map was prepared (Fig. 2). It has a self explanatory legend.

The method was found to be useful for mapping the problems of desertification under Indian conditions. The units chosen are flexible and easily understandable to different users. Remote sensing plays a major role in such mapping and could be supplemented by sample field surveys. The comparative salient merits of the present method and those by Dregne (1991) and Kharin et al. (1985) are summarised in table 5.

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