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TEMPORAL CHANGE DETECTION IN UPLANDS AND GULLIED AREAS THROUGH SATELLITE REMOTE SENSING

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ABSTRACT

Upland and gullied areas, the potential indicators of desertification. can be identified and mapped reasonably and reliably within ± 10% accuracy through Landsat TM false colour composite images in conjunction with ground truth. Due to increased biotic activity, the areal extent of uplands in the Jodhpur district decreased by 20% over a period of 28 years (1958-86). On the other hand, the areal extent of gullied areas, due to increased fluvial activity increased from 198.5 to 242.0 ha during the same period. These temporal changes indicate that the desertic environmental conditions are deteriorating in the region.

INTRODUCTION

The uplands in the form of low hills and eroded rocky surfaces with scattered rock outcrops are subjected to different kinds of weathering and erosion resulting in the formation of rocky/gravelly pediments. In western Rajasthan, such lands cover 9.4% area (Shankarnarayan et al. 1982). Since such lands occupy relatively higher topographic positions they generate large amounts of runoff due to the impervious surfaces and steep slopes (Sharma et al. 1988).

Gullied areas created due to natural and accelerated fluvial processes are closely associated with the uplands. In the western Rajasthan, some of the hillslopes covered with aeolian sands have been dissected by water action into 10 to 25 m deep and 30 to 50 m wide gullies resulting into 'badland' topography (Singh et al. 1989).

The upland and gullied areas are thus the indicators of the desertification processes resulting into the deterioration of arid environment. In order to check the further deterioration of environment and to reclaim the degraded lands, their systematic mapping by using modern tools and to detect temporal changes in the uplands and gullied areas are of paramount significance. Accordingly, a study within the Jodhpur district comprising of 22, 850 km^2 in the northwest Indian arid zone (26°99′ 27°29′ N and 71°59′-73°46′E), was conducted to map and to detect temporal changes in the uplands and gullied areas using satellite remote sensing technique in conjunction with the ground truth. The findings of this study are reported in this paper.

MATERIAL AND METHODS

The enlarged Landsat TM false colour composites of the years 1986 and January 1987 generated by a combination of bands 2,3,4 of 1:50,000 scale, Landsat black and white images of bands 5 and 7 of 1:250,000 scale, Survey of India topographical maps of 1:50,000 scale, magnifying glass, light table and existing wasteland maps of the area were used as basic materials to conduct this study. Landsat TM data were visually interpreted and the boundaries of the upland and gullied areas were delineated on the basis of tone, texture, size, shape, location and association (Anonymous 1986; Anonymous 1989). These were also identified and mapped separately from the topographical maps. The two maps were superimposed on each other and the temporal changes in the areal extent of the uplands and gullied areas were detected.

The areal extent of the upland and gullied areas were calculated by

$$A = C_1C_2 N$$

where A is area of upland/gullied area, C_1 is contraction coefficient of the photo, C_2 is conversion coefficient of the photo and N is area of upland/gullied areas on the photo The area was measured with an electronic digital planimeter having an accuracy of 0.08%. This method of calculation differed by only $\pm$ 5% in comparison with the conventional methods. The temporal changes in the areal extent in uplands and gullied areas were verified in July-September 1987 during a reconnaissance field survey.

RESSULTS AND DISCUSION

Identification and mapping of uplands

In Jodhpur district, 65 representative uplands under different geographical situations were identified and mapped from the Landsat TM false colour composites, Survey of India topographical maps and random field checks. The areal extent of these uplands varied from 30 to 3375 ha estimation of which is within the desired accuracy limit of $\pm$ 10% (Myers 1983). The salient physical characteristics of these lands are rocky, gravelly and stony surface; flat topography interrupted with rock outcrops, shallow deposits in pockets and presence of drainage channels along the joints and fractures. These uplands of variable size and shape exhibit on Landsat TM false colour comopsite whitish grey to dull white and dark brown tone whereas on Landsat black and white image, their mottled texture appears in white to grey and dark grey to dark tone, and contiguous and dispersed patches (Fig. 2). They could be easily and accurately delineated on the Landsat imagery due to their location, shape, pattern and sharp break of slope between them and the surrounding land. Wherever the density of vegetation is more, the uplands appear in the form of red dots and patches on the Landsat TM FCC. The dominant plant species on the uplands are *Euphorbia caducifolia*, *Zizyhpus nummularia*, *Capparis decidua*, *Acacia senegal*, *Elusine compressa* and *D. Sindicum*. The density of water bodies, appearing in light

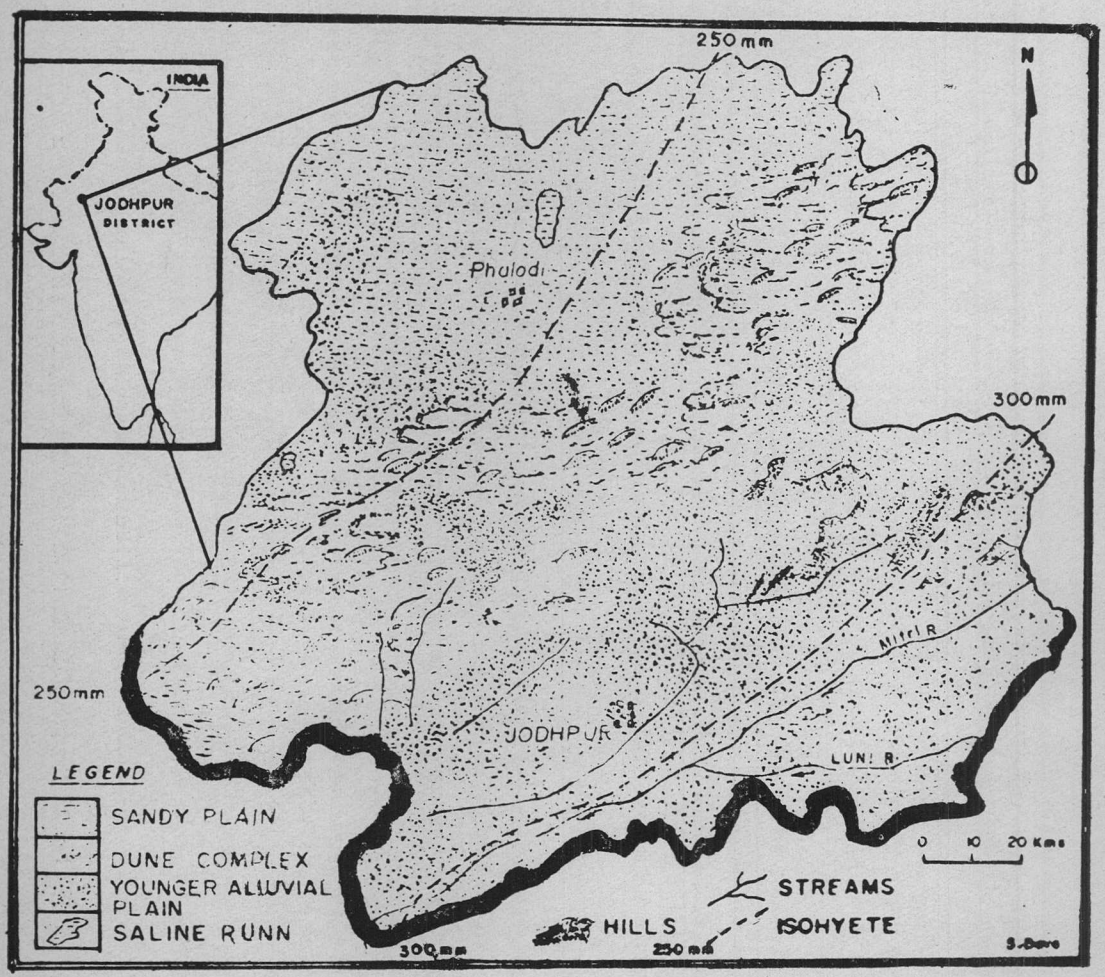

Fig. 1. The study area.

Fig. 2. Segment of Landsat band 5 showing image characteristics of (a) uplands.

blue to dark tone on Landsat TM FCC, is the highest in the upland thereby indicating that these lands are hydrologically potential zones (Sharma et al. 1989). Besides, the uplands are severely dissected due to the higher drainage density resulting in the greater surface runoff volumes from such areas.

Identification and mapping of gullied areas

In the study area 89 gullied areas, varying from 15 to 338 ha, were identified and mapped from the Landsat TM false colour composite, Survey of India topographical maps and field checks. On Landsat TM FCC, the gullied areas appear in white to grey and light yellow and on black and white images in white to grey and dark grey to dark tones, respectively and in irregular and broken shapes, very coarse to coarse texture and dendritic to sub-dendritic drainage patterns (Fig. 3). They occur at the foot of uplands in the form of drainage channels and streams and distinctly appear on the Landsat TM FCC, and Survey of India topographical map. The beds of these gullies are covered with loose and unconsolidated sediments and their banks are severely dissected; vertical dissection vary from 2 to 4 m. The depth and width of the gullies range from 3 to 8 m and 2.5 m to 5.3 m respectively. Soil texture along the gullies ranges from sand to gravelly sand and loamy sand to sandy loam. Dominant plant species in the gullied areas are *Capparis decidua*, *Acacia senegal*, *Calligonum polygonoides* and *Leptadenia pyrotenchnica*.

Temporal changes in uplands and gullied areas

The superimposition of maps of uplands prepared from the Survey of India topographical maps of 1958 and Landsat TM FCC of 1986 revealed that over a period of 28 years, the areal extent of uplands decreased from 30 to 3973 ha in 1958 to 30 to 3375 ha, in 1986, (average 20%) under various landforms (Table 1). This decrease in uplans is attributed to the cultivation of large rocky/gravelly areas of sandstone and limestone formations in Bilara, Jodhpur and Osian tehsils due to the availability of ground water. The other factors responsible for the reduction in areal extent of the uplands are mining activities, construction of dwellings and development of industries.

On the other hand, the superimposition of maps of gullied areas prepared from the Survey of India topographical maps of 1958 and Landsat TM FCC of 1986

Table 1. Temporal changes in the areal extent of uplands and gullied areas in the Jodhpur district

	Mean areal extent (ha)		Reduction/ increase in the area (%)	No. of samples
	1958*	1986**		
Uplands	385.7	310.2	20	65
Gullied areas	198.5	242.0	22	89

* Based on Survey of India topographical maps.

** Based on Landsat TM false colour composite.

Fig. 3. Segment of Landsat band 5 showing image characteristics of (a) gullied area.

revealed an increase in the areal extent of gullied areas from 198.5 to 242.0 ha (22%) over a period of 28 years (Table 1). In fact, 53 newly developed gullied areas ranging from 30 to 338 ha were added in the district during this period. The increase in the areal extent of gullied areas has been caused by increased fluvial activities as a result of nine abnormal high rainfall years during this period and unprotected marginal lands.

As a result of decrease in uplands and increase in gullied areas, large acreage of land has been desertified due to the natural and accelereted desertification processes. To check the further degradation of this fragile ecosystem, suitable soil and water conservation measures and afforestation should be taken up immeidately.

CONCLUSION

It has been concluded that the Landsat TM false colour composites in conjunction with the ground truth are very useful tool to map and to detect the temporal changes in the areal extent of uplands/gullied areas which are potential indicators of desertification. The decrease in the areas of uplands and increase in the gullied areas over a period of 28 years (1958-86) indicate that the desertic environmental conditions are deteriorating due to natural and accelerated desertification processes.

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