

# APPLICATION OF REMOTE SENSING TECHNIQUES FOR EXPLORATION AND MANAGEMENT OF GROUND-WATER IN THE MIDDLE LUNI BASIN

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## ABSTRACT

In the middle Luni basin, eleven landforms, which control the development and distribution of different aquifers, have been identified by using remote sensing techniques in conjunction with ground truth. Ten aquifers having different ground-water potentials have been indentified and located. Morpho-hydrological characteristics of these aquifers led to the delineation of the recharge (donor) and recharged (receptor) zones for proper management of ground-water.

## INTRODUCTION

In the Indian desert, water bearing formations are, by and large, covered with thick alluvium and aeolian deposits and their prospecting through conventional methods is very costly and time consuming. Landform features like drainage patterns, slope, rock outcrops and lineaments etc. control the occurrence of ground-water and are conspicuously visible on aerial photographs and Landsat imagery. Aerial and space remote sensing techniques, in conjunction with ground truth, haven been found cheaper and quicker for the analysis of landform features and exploration of ground-water (Chatterji et al., 1978; Singh, 1977, 1981; Moore, 1979). Remote sensing techniques will provide a sound base for detailed geophysical investigations to loc te the potential aquifers under different landforms. In this article, application of remote sensing and ground survey techniques for the exploration and management of ground-water in the middle Luni basin, a part of the Indian desert, has been discussed.

## MATERIAL AND METHODS

The middle Luni basin covering one Landsat scene of path 160 and row 042 was the test area to examine the feasibility of remote sensing techniques in the exploration and management of ground-water. Aerial photographs (1:25,000 scale), enlarged Landsat false colour composite and black and white MSS bands 5 and 7 paper prints (1:500,000 & 1:250,000 scales) and Survey of India topographical sheets (1:50,000 scale) were used for interpreting geomorphological, geological, pedological, vegetation and land use characteristics, and to evaluate associated hydrological conditions.

The middle Luni basin was classified and mapped, on the basis of visual interpretation of aerial photographs, Landsat imagery and field work, into eleven landform units (Singh and Shankarnarayan, 1986). Shallow and deep aquifers occurring under different landforms were also identified and mapped by taking into account depth and nature of the water-bearing material. For proper planning and management of ground-water, the basin was classified into recharge (donor) and recharged (receptor) ground-water zones.

## RESULTS AND DISCUSSION

### Landforms and their Characteristics

Morphological and Landsat spectral characteristics of eleven landforms identified in the basin have been discussed.

#### 1. Hills

As the most conspicuous relief feature, hills are distinctly visible in elongated and circular patterns on aerial photographs, Landsat false colour composite imagery and MSS band 7 image (Fig. 1). They are characterised by joints, fractures, folds, domes tafonis, mesas and inselberg. Due to higher relief, hills are not a productive source of ground-water.

#### 2. Rocky/gravelly pediments and plateaus

These landforms are located at the base of the hills. Morphological characteristics like joints, fractures, drainage patterns and flat rocky surfaces distinctly appear on aerial photographs and Landsat imagery. The rocky surfaces exhibit white to dark grey tone due to higher solar reflectance on Landsat band 7 image (Fig. 1).

#### 3. Flat buried pediments and plateaus

Alluvial and colluvial deposits on the rocky surfaces make these landforms morphologically different than rocky/gravelly pediments and plateaus. Almost level slope, sub-surface lineaments, parallel to sub-parallel drainage patterns, better moisture conditions and vegetation cover, and lower reflectance of such landforms exhibit dark grey to dark tone on Landsat band 5 image (Fig. 2).

#### 4. Sandy undulating buried pediments

These pediments, characterised by undulating topography, irregular slope, deep dissections in the form of gullies and flat interfluves, are clearly visible on Landsat MSS band 5 image. Due to greater reflectance, the high relief features exhibit white to grey tone whereas flat interfluves, with poor reflectance, show dark grey to dark tone on above image.

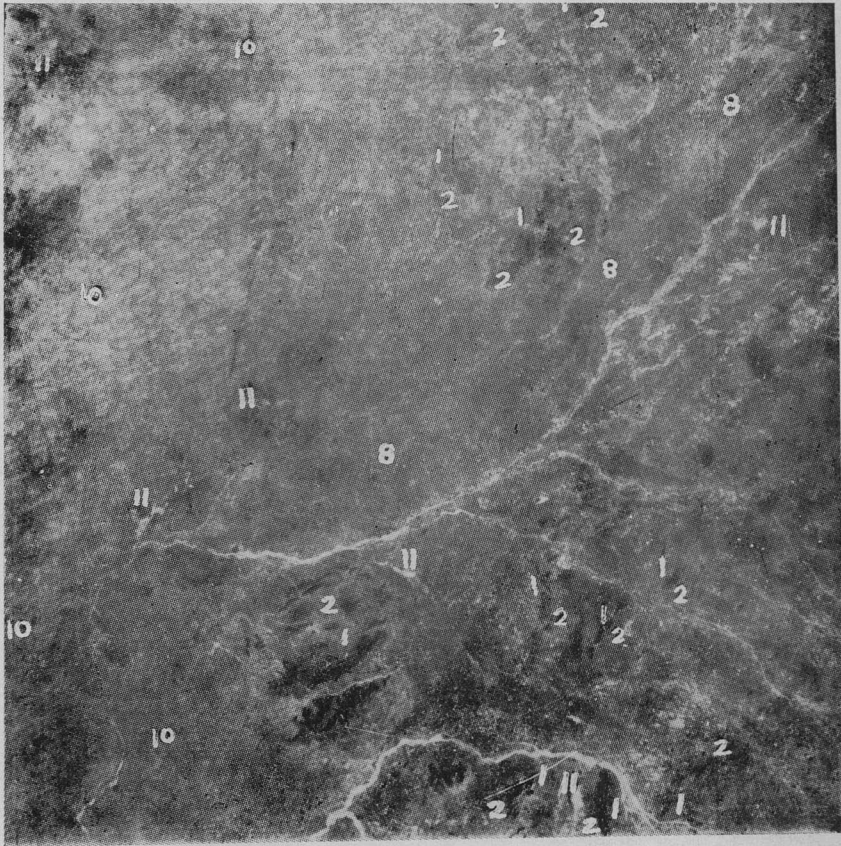


Fig. 1. Hills 2. Rocky/gravelly pediments and plateaus 8. Sandy undulating aggraded older alluvial plains 11. Sand dunes and interdune plains

5. *Light to medium flat aggraded older plains*

These plains are characterised by almost level slope, shallow to moderately deep sediments, short drainage channels and sheet to rill erosion. The variations in the texture of sediments of the plains cause tonal variations. The coarse textured sediments, due to higher reflectance, show white tone and the medium textured sediments, with low reflectance, exhibit dark grey tone on Landsat MSS band 5 image (Fig. 2).

6. *Medium to fine textured flat aggraded older alluvial plains*

Excepting depth and texture of the sediments. these plains are morphologically similar to the above landform unit. Moderately deep to deep sediments of medium to heavy texture exhibit dark grey to dark tone on Landsat MSS band 5 image (Fig. 2)

The variations in the spectral characteristics indicate variations in the texture of the sediments.

7. *Saline flat aggraded older alluvial plains*

These plains are characterised by heavy textured saline sediments, impeded drainage conditions, poor percolation and salinity hazards. The manifestations on the saline and non-saline areas in the form of mottled tone are distinctly visible on Landsat MSS band 5 image.

8. *Sandy undulating aggraded older alluvial plains*

These plains constitute alluvial deposits overlain by thick aeolian sands in the form of hummocks and sand dunes, flat surfaces between undulations and irregular

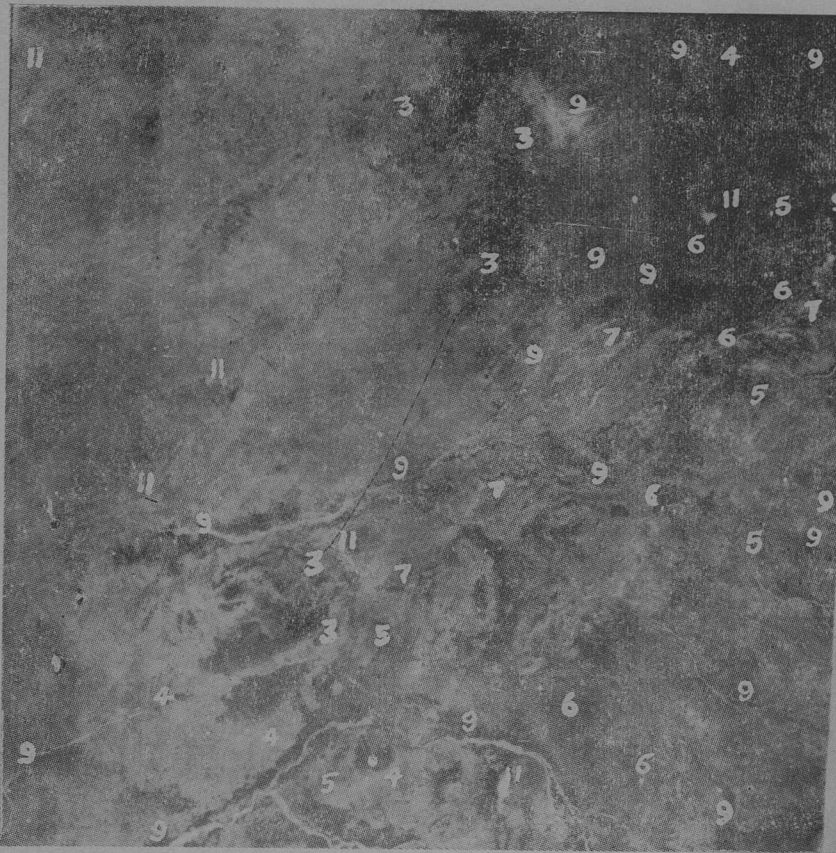


Fig. 2. Flat buried pediments and plateaus 4. Sandy undulating buried pediments 5. Light to medium flat aggraded older alluvial plains 6. Medium to fine textured flat aggraded older alluvial plains 7. Saline flat aggraded older alluvial plains 9. Younger alluvial plains and graded river beds 11. Saline depressions

slopes. Due to high and low reflectance, the undulating and flat areas exhibit white and dark grey tone on the Landsat MSS band 7 image.

#### 9. *Younger alluvial plains and graded river beds*

The younger alluvial plains occur on either side of the river beds in narrow strips. These are characterised by almost level slope, meander scars, sand bars, point bars, levees and absence of carbonate pan. The younger alluvial plains distinctly appear in dark grey to dark tone on Landsat band 5 image, in all the seasons. The graded river beds exhibit white tone in dry season and dark tone in rainy season on Landsat MSS band 5 image.

#### 10. *Sand dunes and interdune plains*

Sand dunes of different shapes and sizes have gentle windward slope, steep leeward slope and these occur in continuous chain. Flat and sandy undulating interdune plains surrounded by stabilized sand dunes are characterised by undulations, flat surfaces, irregular and almost level slopes and short drainage channels. Sand dunes and sandy undulating interdune plains, due to higher infrared reflectance, distinctly appear in white and grey tone on Landsat MSS band 7 image and flat interdune plains, with low reflectance, exhibit dark grey tone.

#### 11. *Saline depressions*

Saline depressions of different shapes and sizes have almost level slope, dry and wet surfaces and salt encrustations. These largely occur at the confluences of the prior drainage channels. Spectral characteristics of the saline depressions are almost similar in all the four Landsat band and distinctly appear in white tone on Landsat bands 5 and 7 imagery.

### **Aquifers and their Characteristics**

Based on the morpho-hydrological and Landsat spectral characteristics, ten types of aquifers developed under different landforms were identified. Their salient characteristics are given in Table 1.

### **Management of Ground-water**

Based on the morpho-hydrological, physiographic, drainage, slope and Landsat spectral characteristics, recharge (donor) zone and recharged (receptor) zone of ground-water have been identified for the proper planning and management of ground-water (Fig. 3).

The recharge zone (donor) is associated with uplands having steep slope and high drainage density while the recharged (receptor) zone occurs on low land with gentle

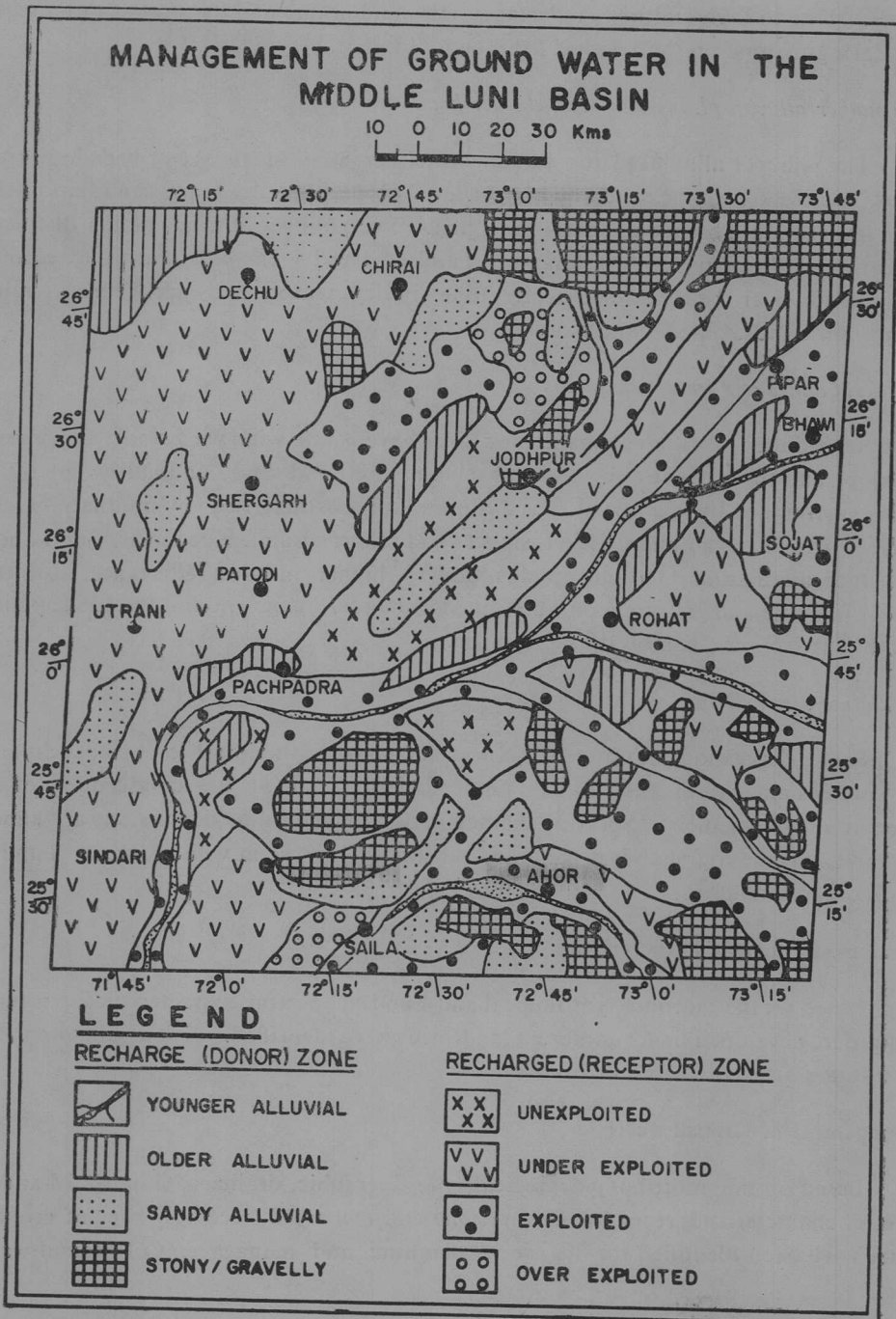


Fig. 3. Recharge (donor) and recharged (receptor) zones of ground-water

Table 1. Types and characteristics of aquifers in the middle Luni basin

| Aquifer type              | Depth of water<br>(m. b. g.l) | Occurrence  | Geomorphic features   |
|---------------------------|-------------------------------|---|---|
| Blown sand                | 6-20                          | Dunes, interdune plains, sandy undulating, aggraded older alluvial plains                     | Deep, highly permeable sandy deposits; concretions layer weakly developed; widely spaced drainage channels; |
| Younger alluvial          | 8-15                          | Younger alluvial plains, river beds   | Terraces, point bars, sand bars, natural levees, meander scars; braided drainage channels                   |
| Older alluvial            | 6-18                          | Flat and sandy aggraded older alluvial plains   | Deep, unconsolidated alluvial sediments; lineardrainage pattern; widely spaced drainage channels            |
| Riverine sand             | 5-10                          | Valleys of prior drainage channels with well sorted sand and gravels                          | Terraces, wide filled valleys; linear drainage lines with characteristic shape and patterns                 |
| Jodhpur sandstone         | 20-46                         | Rocky/gravelly and buried pediments, flat and sandy undulating aggraded older alluvial plains | Thick aeolian and alluvial deposits; well developed lineaments; dendritic and parallel drainage patterns    |
| Malani rhyolite           | 10-25                         | Rocky gravelly and buried pediments, sandy undulating aggraded older alluvial plains          | Poorly developed lineaments and drainage patterns; hard rocky strata, thin stratified zone                  |
| Siwana and Jalore granitæ | 25-40                         | Flat aggraded older and younger alluvial plains   | Well developed lineaments and drainage patterns; structurally weak zone present; deposits thick, permeable  |
| Ademallite                | 80-100                        | Rocky/gravelly and flat buried pediments around Sumerpur                                      | Hard rock strata; less developed lineaments   |
| Aravalli slate            | 40-50                         | Flat aggraded older and younger alluvial plains, in small pockets south of Sojat              | Cleavage and stratification poor; widely spaced drainage channels, no sub-surface drainage channels         |
| Phyllite                  | 45-110                        | Younger and older alluvial plains   | Lineaments and drainage patterns poorly developed; sediments impermeable                                    |

slope and poor drainage density. It is not suitable for ground-water exploitation as it adversely affects the recharge of 'receptor' zones. Instead, to augment the ground-water potentials of the adjoining recharged or 'receptor' zones, these zones should receive suitable recharge measures like trenching, pitting, bunding and flooding.

Recharged (receptor) zone has been delineated (Fig. 3) on the basis of well inventory, pump test, extent of aquifer, recharge and discharge potentials, etc. for proper management of ground-water and to check the adverse effects on the adjoining areas.

The unexploited zone is associated with Aravalli slate and Malani rhyolite. The exploitation of ground-water under this zone will be uneconomical because of its poor ground-water potential.

The under-exploited zones have moderate to good ground-water potentials and are associated with Jodhpur and Nagaur sandstone. These occur under sand dunes and interdune plains, flat and sandy undulating aggraded older alluvial plains. The exploitation of ground-water under this zone will be economical and it is, therefore, suggested that the development programme for the development of additional ground-water resources should be undertaken in these areas.

The ground-water potentials of the under-exploited zone have not been fully exploited. There is further scope for the exploration and development of ground-water in the western and eastern parts of the middle Luni basin.

The fully exploited zone, associated with the older and younger alluvial plains and buried pediments, should not be considered for further exploitation of ground-water to avoid adverse effects on the adjoining areas. The over-exploited zone associated with friable Jodhpur sandstone and sandy alluvium occurs under flat buried pediments and sandy older alluvial plains near Tiwari, Mathania and Saila. The ground-water from these zones should be used judiciously and rationally so that the water table is not further depleted and land degradation could be avoided.

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