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Detection of Ground Water Behavior using Remote Sensing in Haryana

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ABSTRACT

With the advancement of technology, the use of remote sensing and geographic information system has increased in detecting the nature of ground water in hard rock system. Ground water exploration is performed with the help of satellite to know the status of ground water. Delineation of groundwater can be done easily with the help of geographic information system. There are many features which are used for the assessment of ground water resources. Some of these features are slope, groundwater recharge and discharge. The big advantage of remote sensing over hydro-geological survey is that in the former method, the cost is moderate. The current article highlights the role of remote sensing & GIS approach in detecting ground water behavior in hard rock aquifer system.

1. Introduction

More relevant information can be obtained with the help of digitizing the satellite data. GIS techniques are helpful in the analysis of large data. The ground water resources are accessed, monitored and conserved with the help of remote sensing and geographic information system.

Analysis of individual layer of spatial data is done in association with the manipulation. Remote sensing and geographic information system are also used for the purpose of modeling and analyzing the interrelationship between layers.

With the use of remote sensing, it has become easier to get the ground water information from inaccessible regions. Few years back, when the data regarding ground water was taken manually then that data was not found to be fully accurate and errors were found in that. But, now with the help of digital technique, the obtained data is very much relevant and accurate.

It is necessary for the management of ground water resources that the relationship between rainfall-water levels can be identified. It is also observed that the ground water level is also decreasing year by year in India. Many of the parts of country are facing the problem of drought as the rainfall is very low in that areas and hence, the ground water level is negligible.

When the water level data was taken manually then it was very difficult to visit in some regions due to no transportation and infrastructure and data gathered was not so much accurate. But, now with the help of technologies like remote sensing and geographic information system, it has become easier to take the accurate and real time data from unreachable areas.

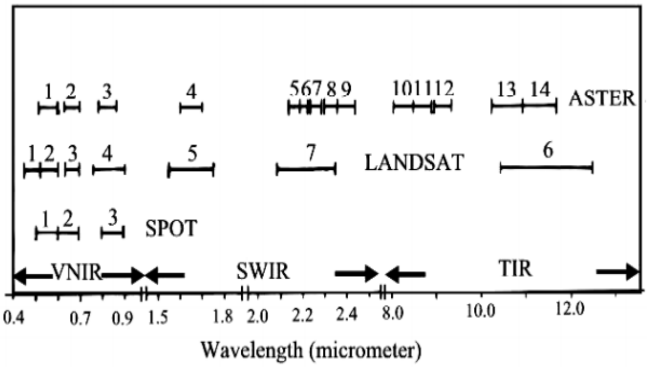

Figure 1. Sketch of the spectral bands in ASTER, LANDSAT and SPOT showing wavelength regions together with the number of bands in each sensor

Most of the total variance is mapped to the first component, with decreasing variance in each of the subsequent components. Thus the first principal component contains most of the information and is usually a high quality image on its own, especially for structural interpretation, and is well suited to edge enhancement.

2. Remote Sensing & GIS Approach in detecting ground Water Behavior in Hard Rock

Groundwater availability in any terrain is largely controlled by the prevalence and orientation of primary and secondary porosity. Groundwater exploration entails delineation and mapping of different lithological, structural and geomorphologic units. Satellite based remote sensing data facilitate the preparation of lithological, structural, and geomorphological maps, especially at a regional scale. These data show major rock groups, structural features, such as folds, faults, lineaments and fractures, and different landforms, due to their synoptic coverage and multispectral capability.

Mapping of lineaments from various remote sensing imagery is a commonly used step in groundwater exploration in hard rock areas. The term hard rock commonly applies to hard and dense rocks that the main part of the groundwater exists and flows in secondary structures, mainly fractures. Crystalline rock types such as meta-volcano-sedimentary, gneiss, meta-igneous and igneous predominate but volcanic rocks are also included in the concept hard rock from a hydrogeological point of view.

The routine procedure for geological lineament extraction from digital remote sensing data usually involves initial digital image enhancement followed by manual interpretation. There have been significant approaches for the evaluation and automatic detection of lineaments and curvilinear features from satellite images.

The availability of multispectral and multi-sensor data and image enhancement techniques provide an opportunity to prepare more reliable and comprehensive lineament maps. The extensive ground coverage and high resolution of satellite images enables regional and local lineament analysis.

Remote sensing data provide accurate spatial information and can be economically utilized over conventional methods of hydro geological surveys. Digital enhancement of satellite data results in extraction of maximum information and an increased interpretability. GIS techniques facilitate integration and analysis of large volumes of data. Whereas field studies help to validate results further. Integrating all these approaches can offer a better understanding of groundwater controlling features in hard rock aquifers.

All image data have been made available for input in a format that is suitable to ENVI (the Environment for Visualizing Images) software package (V. 3.5). The image processing was done on a PC based system.

The spectral information in multispectral satellite images enables the identification of different vegetation types, bedrock and soils, based on their spectral signature in different wavelength bands.

In this study remote sensing methods were applied to identify major lithologies and lineaments. The main goal in using remote sensing techniques for groundwater exploration is to identify and isolate regional and subregional factors of significance to groundwater occurrence in a cost-effective and rapid manner.

Table 1: Remote Sensing data used in the study

Sensor	Band	Wavelength (μm)	Spatial Resolution (m)
LANDSAT TM	1	0.45 – 0.52	
	2	0.52 – 0.60	
	3	0.63 – 0.69	30
	4	0.76 – 0.90	
	5	1.55 – 1.75	
	7	2.08 – 2.35	
SPOT	1	0.50 – 0.59	
	2	0.61 – 0.68	20
	3	0.79 – 0.89	
ASTER	1	0.52-0.60	
	2	0.63-0.69	15 (VNIR)
	3	0.78-0.86	
	4	1.60-1.70	
	5	2.145-2.185	
	6	2.185-2.225	
	7	2.235-2.285	30 (SWIR)
	8	2.295-2.365	
	9	2.360-2.430	
	10	8.125-8.475	
	11	8.475-8.825	
	12	8.925-9.275	90 (TIR)
	13	10.25-10.95	
	14	10.95-11.65	

The procedure takes full account of any correlations that exist between different bands and provides a single preferred choice, determined by the statistics of a scene or subscene. The method entails the calculation of the 6 by 6 variance-covariance matrix for a scene or subscene, ignoring the TM thermal band. Then the determinants of 3 by 3 submatrixes from the 6 by 6 matrix are calculated. The band triplets are ranked from highest (best band triplet) to lowest (worst band triplet) determinant.

3. Analysis

The full potential of remote sensing and GIS can be utilized when an integrated approach is adopted. Integration of the two technologies has proven to be an efficient tool in groundwater studies. For effective groundwater exploration and exploitation it is important to study the different parameters in an integrated approach. The integration of multiple data sets, with various indications of groundwater availability, can decrease the uncertainty and lead to 'safer' decisions.

The Geographic information system offers spatial data management and analysis tools that can assist users in organizing, storing, editing, analyzing, and displaying positional and attribute information about geographical data.

Principal components analysis (PCA) is a widely used digital image processing technique by which a multi-spectral data set is transformed into a new decorrelated coordinate system. It is a mathematical transformation that generates new images, referred to as components or axes, which are linear combinations of the original bands.

An attempt was made to avoid linear features that do not correspond to geological structures e.g. artifacts introduced by the digital filters. This includes man-made linear features such as roads and crop-field boundaries. Lineament mapping was done separately for each of the data sets, that is Landsat TM, SPOT and DEM images.

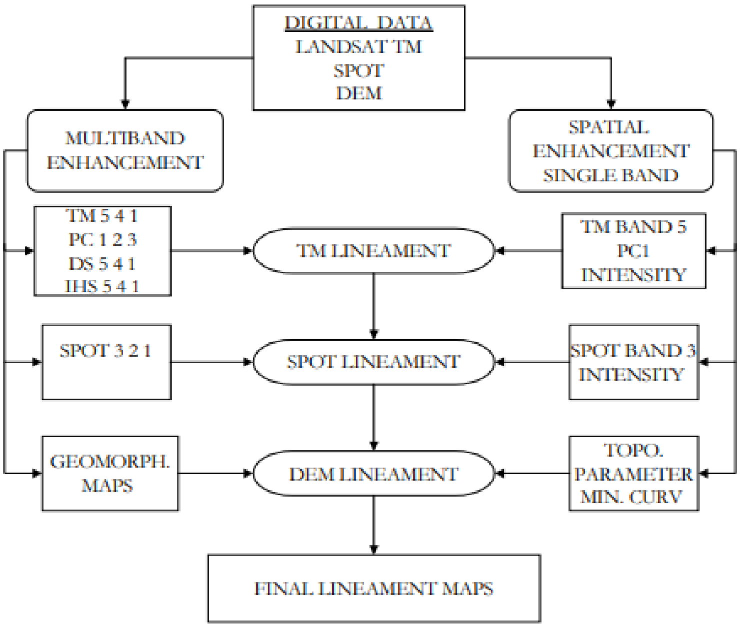

Figure 2. Flow chart depicting methodology of lineament mapping.

The visual interpretation of the remote sensing data was carried out by interactively digitizing the specific features of interest such as lithology and lineaments. The feature identifications were based on the recognition of boundaries between different assemblages of tone/color, texture, various shapes and patterns as well as interrelationships between features that may have geological significance in the imagery.

4. Conclusion

The model derived through integration of various thematic maps demonstrates the hydro geological significance of rock types, structures and different landform types. The integrated approach adopted provides a basis for designing suitable groundwater exploration plans. Alluvium and basalts have high groundwater potential due to high primary porosity and permeability. In both aquifers, areas with high lineament density are the most favorable sites and should be given high priority for groundwater exploration.

Groundwater exploration in basaltic rock aquifers should include the underlying deeply weathered crystalline rocks because they form multiple aquifer systems often with high yields. In metamorphic and igneous intrusive rock aquifers groundwater exploration should focus on lineaments, which coincide with drainage channels with valley fill deposits. Lineament intersections and dyke swarms should be considered as targets for future groundwater development. Combinations of parameters such as local depressions, lineament intersections, dyke swarms, thick alluvial cover and deeply weathered horizons are best sites for high yields.

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