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RESEARCH ARTICLE

POTENTIAL GROUND WATER TARGETING AND WATER MANAGEMENT IN SEMI ARID REGION THROUGH THE APPLICATION OF GEO INFORMATION TECHNOLOGY

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Abstract

Remote Sensing and Geographic Information System has become one of the leading tools in the field of hydro geological science, which helps in assessing, monitoring and conserving groundwater resources. It allows manipulation and analysis of individual layer of spatial data. It is used for analyzing and modeling the interrelationship between the layers. This paper mainly deals with the integrated approach of Remote Sensing and geographical information system (GIS) to delineate groundwater potential zones in semi arid region of southern western hats, kerala. The remotely sensed data at the scale of 1:50,000 and topographical information from available maps, have been used for the preparation of ground water prospective map by integrating geology, geomorphology, soil slope, soil elevation, landuse of the study area. Further, the data on yield of aquifer, as observed from existing bore wells in the area, has been used to validate the groundwater potential map. The final result depicts the favorable prospective zones in the study area and can be helpful in better planning and management of groundwater resources especially in semi arid region. For the ground water resource management water scares area is also identified by using geographic analysis. Based on this construction of ground water recharge structure location were identified by using spatial analysis techniques. Ground water recharge structures like check dams, gully control structures are useful for the sustainable ground water management.

INTRODUCTION

Groundwater is one of the most valuable natural resources, which support human health, economic development and ecological diversity. Overexploitation and unabated pollution of this vital resource is threatening our ecosystems and even the life of future generations. Global environmental change induced by natural variability and human activities influences both water quantity and quality at regional and local scales as well as at the global scale. The proper management of both surface and groundwater resources through systematic inventory, conservation and proper planning is essential for the economic and social development of any country. The available surface water resources are inadequate to meet all the water requirements. Therefore, the demand for groundwater has increased over years. Groundwater resource assessment of a region involves a detailed study of the sub-surface water, including geology and hydrogeology, monitoring and production of well data. Exploitation and utilization of groundwater requires proper understanding of its origin, occurrence and movement, are directly or indirectly controlled by terrain characteristics (Khan and Moharana, 2002). Fresh water is distributed in nature in different forms, such as rain water, river and lake water, spring water, ground water, snow and ice (Sharma, 2005) Groundwater occurrence being a subsurface phenomenon, its identification and location is based on indirect analysis of some directly observable terrain features. The interpretation of satellite data in conjunction with sufficient ground truth information makes it possible to identify and outline various ground features such as geological structures, geomorphic features and their hydraulic characters (Das et al, 1997; Srinivasa Rao et al, 2000); and these may serve as direct or indirect indicators of the presence of groundwater (Ravindran and Jeyaram, 1997; Sree Devi et al, 2001; Gopinath and Seralathan,2004).

The identification and location of groundwater resources using remote sensing data is based on an indirect analysis of some directly observable terrain features like geomorphology, geology, slope, land use/ land cover and hydrologic characteristics. With the capabilities of the remotely sensed data and GIS techniques, numerous databases can be integrated to produce conceptual model for delineation and evaluation of groundwater potential zones of an area (Chaterjee and Bhattacharya, 1995; Krishnamurthy and Srinivas, 1995; Srivasthava and Bhattacharya, 2000; Sarkar et al.2001).Geographic information system (GIS) has emerged as an effective tool for handling spatial data and decision making in several areas including engineering, geology and environmental fields. Remotely sensed data are one of the main sources for providing information on land and water related subjects (Jha et al. 2007). A review of GIS applications in hydrology and water management has been presented by several researchers during mid-nineties and recently such as Kamaraju et al. (1995), Krishnamurthy et al. (1996), Gogu et al. (2001), Sikdar et al. (2004), and Vittala et al.(2005) Leblanc et al.(2007). These reviews indicate that GIS applications in hydrology and water management are essentially in a modeling dominated context.

Groundwater is an integral part of the environment, and hence cannot be looked upon in isolation. There has been a lack of adequate attention to water conservation, efficiency in water use, water re-use, groundwater recharge, and ecosystem sustainability. An uncontrolled use of the bore well technology has led to the extraction of groundwater at such a high rate that often recharge is not sufficient. The causes of low water availability in many regions are also directly linked to the reducing forest cover and soil degradation. Groundwater is also very important as it supplies springs and much of the water in the ponds, marshland, swamps, streams, rivers etc. The occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structure, depth of weathering, extent of fractures, slope, drainage pattern, land use and land cover and inter-relationship between these factors. In the study area (map.1), the groundwater forms the principal source of water for domestic and drinking purpose and most of the people depend on dug/tube well for their daily needs. Even though the study area receives high rainfall, the area experiences severe dry condition in the summer seasons. At that time, the people in the area depends on the rationed water supply of local administrative bodies. Besides this, rapid urbanization, developmental activities and the increased population have led to groundwater pollution and water table depletion. Hence, the present study is an attempt to identify and understand groundwater potential zones of Puthenchira region.

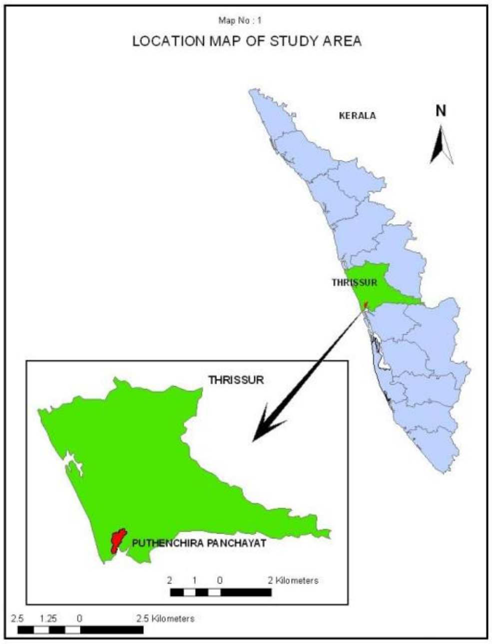
The identification of ground water potential zones is helpful for the conservation and implementation of ground water management plans. For the implementation of ground water management system and watershed conservation strategies, identification of ground water potential zones plays a key role. Geographic information system and Remote sensing together forms an effective tool for the identification of ground water potential zones.

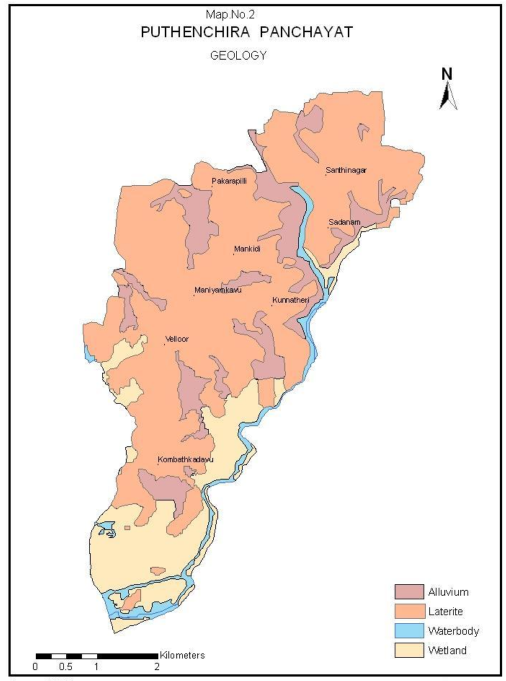
METHODOLOGY

Since the study uses a GIS and Remote sensing based methodology, both spatial and attribute data of the various thematic layers, available in the form of maps and published reports were collected from various sources. Primary data was collected using various techniques to fill any data gaps. Boundary, drainage, contour and road were extracted from the Survey of India Toposheets; geology derived from the GSI map, Soil elevation, soil slope were prepared by using soil survey data and verified by field investigation.

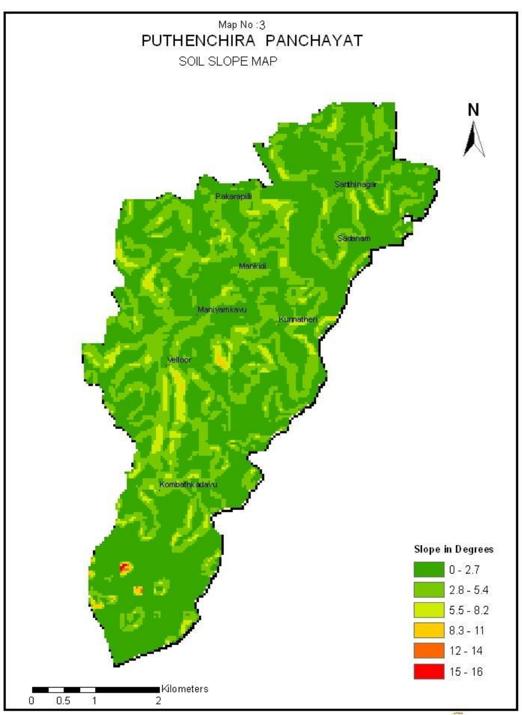
Recent land cover and geomorphology were interpreted using satellite image acquired by the Indian Remote Sensing Satellite. IRS – 1D LISS-III digital data (April 2008) used for the study. Visual interpretation of the standard FCC with band combination 432 as well as digital classification of data using ERDAS 8.6 image processing software was carried out for the preparation of land cover map. The thematic layers prepared include, drainage networks, geomorphology, geology, slope and land use/ land cover of the area. Geographic Information System (Arc GIS 9) was used for the preparation of thematic layers. The layers used for the analysis are, geology (Map.2), geomorphology (Map.4), soil slope (Map.3), soil elevation (Map.5),land use (Map.6), Depth to water level (Map.7).

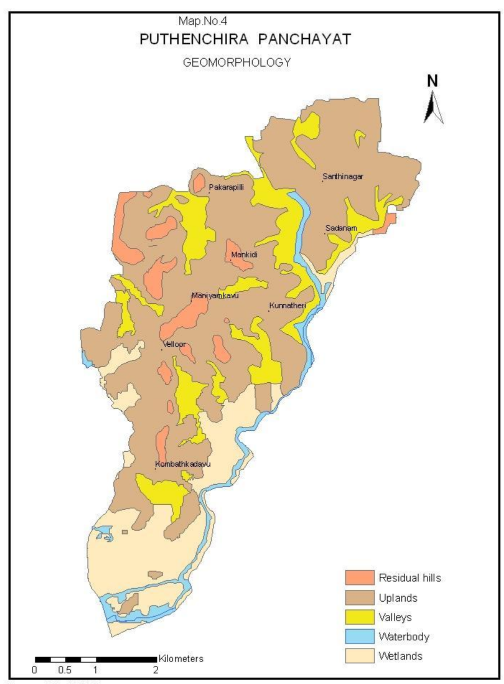
The multi criteria evaluation techniques (MCE) were used for assigning weightages and scores to various themes and feature classes by assessing the importance of it in groundwater occurrence (Table.1).



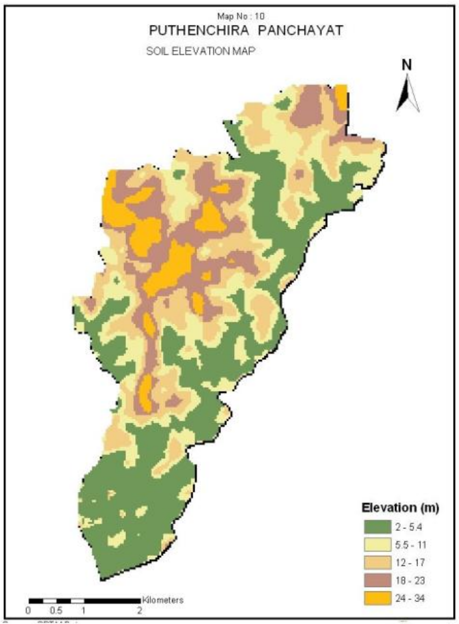


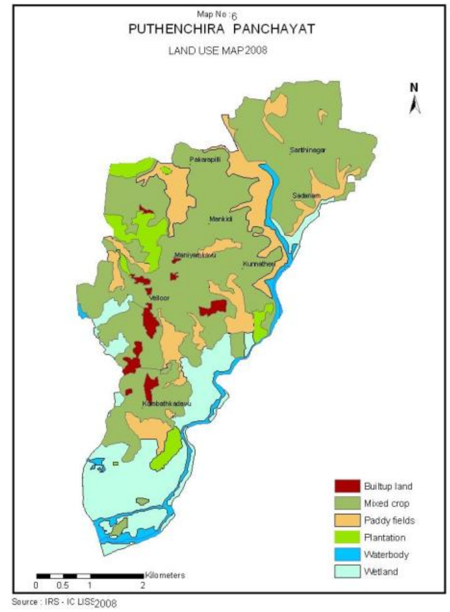
Source : GSI Map

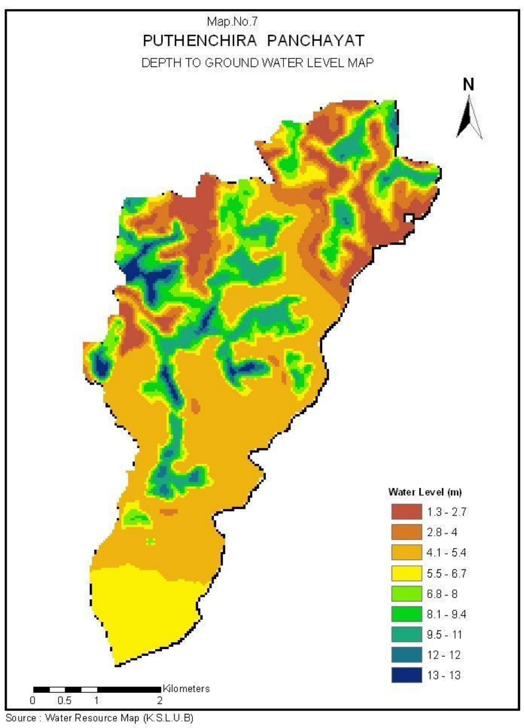


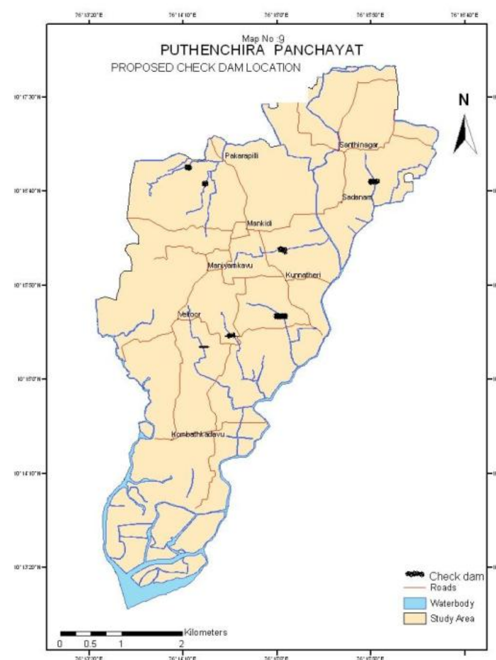


Source : IRS - IC LISS 2008









After assigning the weightages and scores to the themes and features, all the themes were converted to raster format using ‘Spatial analyst’ extension of ArcInfo. While converting to raster, the scores assigned to the individual features were taken in the value field. Then, the individual themes were normalized by dividing theme weightages by 100. The ‘Raster Calculator’ option of spatial analyst was used to prepare the integrated final groundwater potential map (GPM) of the area. The map algebra in the raster calculator is,

The flow chart of the process is illustrated (Figure: 1.)

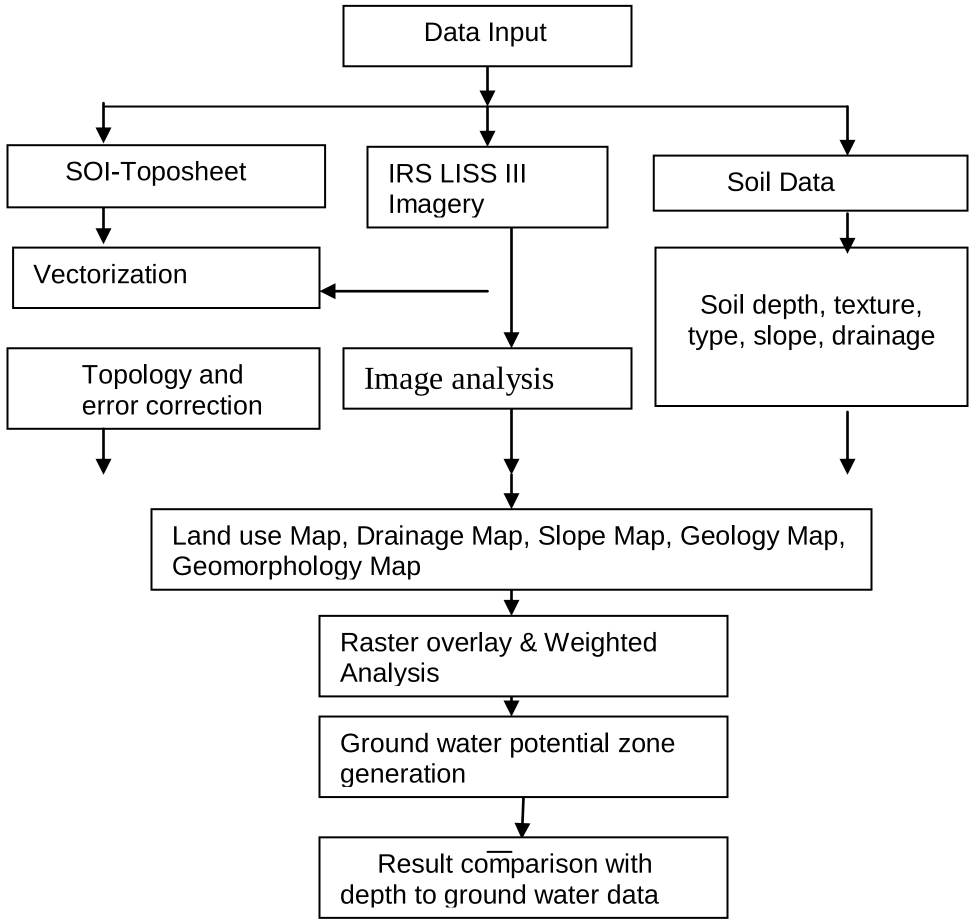


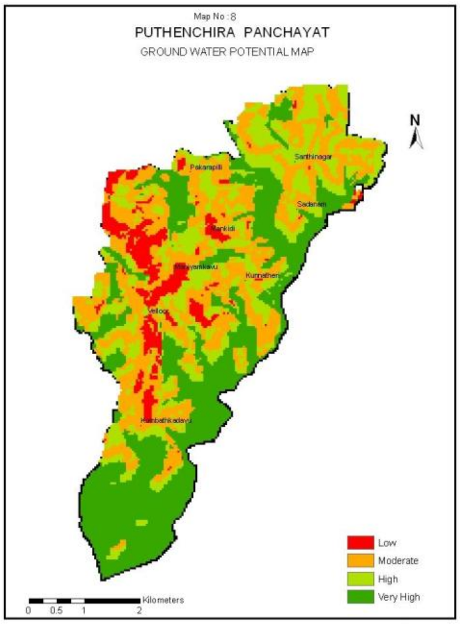
Table. 1 Weightages and Ratings assigned to parameters and classes for assessing Ground water potential

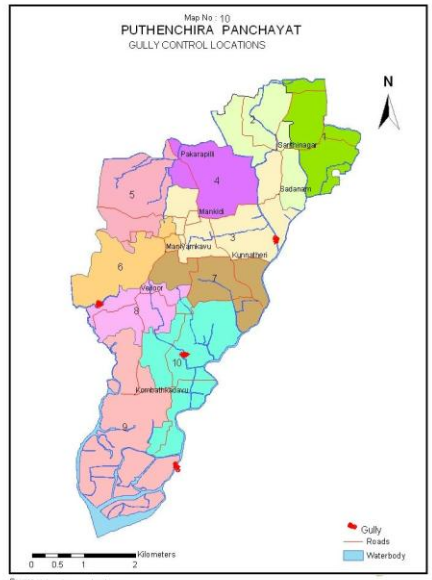
Sl No.	Parameters/ weightages	Sub classes(map units)	Score
1	Geomorphology (Weight=2)	Flood Plain/water bodies	5
		valleys	5
		uplands	3
		Structural Hills, Denudational Structural Hills	1
2	Soil Slope (Weight=1.5)	Gentle, very gentle (0-5)	5
		Moderate (5 -10)	3

		moderately steep, steep (10-16)	1
3	Geology (weight= 1)	waterbody	8
		wetlands	6
		Laterite	2
		Aluvium	3
4	Land use (weight=1.5)	Wetlands/Water body	5
		Paddy fields	5
		Mixed	3
		Built up land	1
		Plantation	2
5	Depth to Ground water (weight = 2)	1-4	5
		4-8	3
		8-16	1
6	Soil elevation (weight = 2)	2-5	6
		5-8	3
		8-14	2
		14-34	1

RESULTS AND DISCUSSION

The present study mainly aims to identify the groundwater potential zones of the area. The basic knowledge of the geology of the area associated with the information provided by the GIS overlying of the mentioned layers permitted the identification of many sites suitable for further field investigation. In the resultant groundwater potential map of Puthenchira region of Thrissur district (Map.8), the area is delineated into four classes on the basis of the prospects, (1) Very high / Excellent (2) high(3) Moderate, and (4) Low/Poor.





Source : Morphometric data

The map shows that the river courses (waterbody), flood plain, associated with gentle slope are classified into excellent to very good ground water potential zones. The areas under well drained, crop land area, high drainage density, and wetland were grouped under good water potential areas while the residual hills with moderate slopes and landuse such as agriculture plantations are grouped under moderately good prospect zone. The high hilly areas with steep slopes, underlain by basic rock are classed under poor water potential zones.The well data collected in the field survey is correlated with output maps shows that the wells situated in the river course areas, flood plain are excellent groundwater potential regions. Its water table level is (>1.5) and water table in valley fill areas were crops and agriculture area is in between (2-2.5). But the water level in the wells in the higher areas underlined by hard crystalline rocks are deeper, mostly drying up in summer season. The groundwater potential zone is compared with Depth to ground water map that are prepared from the water level data collected from the field. The accuracy of the analysis was estimated and the result was very good.

The new check dam locations were identified based on maximum flow accumulation occurring and the region were low water potential area was considered. The new chek dam locations were identified using hydrology tools in Arc GIS. The proposed check dam locations were shown in (Map9). The new location of gully control structures were identified based on the field investigation by using GPS and morphometric analysis of the river and the region were maximum erosion will occur region was selected for the site. The gully control structure is shown in (Map.10).

The study has demonstrated that the modern tools of Remote Sensing and GIS in combination with ground truth data can provide an effective method for integrating various spatial data and delineating groundwater potential zones in any area.

Finally, it is concluded that the remote sensing technology has great potential to revolutionize groundwater monitoring and management in the future by providing unique and new data to supplement the conventional field data. Rapidly expanding GIS technology will play a central role in handling the voluminous spatio-temporal data and their effective interpretation, analysis, and presentation, though such applications will raise some new problems. More and more RS- and GIS based applied groundwater research is also required in conjunction with field investigations to effectively exploit the expanding potential of RS and GIS technologies, which will perfect and standardize current applications as well as evolve new approaches and applications in the future. The newly constructed check dam will increase the ground water potentiality of that region and Gully control structures will reduce the soil erosion of that region.

References

Chaterjee, R.S. and Bhattacharya, A.K., 1995 Delineation of drainage pattern of coal basin related inference using satellite remote sensing techniques. Asia Pacific Rem. Sen. J 1: 107- 114.

Das, D., Behara, S.C., Kar, A., Narendra, P. and Guha, S., 1997. Hydrogeomorphological Mapping in Groundwater Exploration using remotely sensed data – A case study in Keonjhar District, Orissa. J. Indian Soc. of Remote Sensing 25: 247-259. 13

Gogu, R.C., Carabin, G., Hallet, V., Peters, P. and Dassargues, A., 2001. GIS-based hydrogeological databases and groundwater modeling. Hydrogeol J 9:555–569.

Gopinath, G. and Saralathan, P., 2004. Identification of groundwater prospective zones using IRS-1D LISS III and Pump test methods. J. Indian Soc. of Remote Sensing 32: 329- 342

Hrkal, Z., 2001. Vulnerability of groundwater to acid deposition, Jizerské mountains, northern Czech Republic: construction and reliability of a GIS-based vulnerability map. Hydrogeol J 9:348– 357.

Jha, M.K., Chowdhury, A., Chowdary, V.M. and Peiffer, S., 2007. Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. Water Resour Manage 21:427–467.

Khan, M.A. and Moharana, P.C., 2002. Use of remote sensing and Geographical Information System in the delineation and characterization of groundwater prospect zones. J. Indian Soc. Of Remote Sensing 30: 132- 141.

Kamaraju, M.V.V., Bhattacharya, A., Reddy, G.S., Rao, G.C., Murthy, G.S. and Rao, T.C.M., 1995. Groundwater potential evaluation of West Godavari District, Andhra Pradesh State, India – A GIS approach. Ground Water 34(2):318–325

Krishnamurthy, J. and Srinivas, G., 1995. Roll of geological and geomorphological features in groundwater exploration: a study using IRS LISS data. Int. J. Remote sensing 16(14): 2595-2618.

Krishnamurthy, J., Venkatesa Kumar, N., Jayaraman, V. and Manivel, M.,1996. An approach to demarcate groundwater potential zones through remote sensing and geographical information system. Int. J. Remote sensing 17(10): 1867-1884.

Leblanc, M., Favreau, G., Tweed, S., Leduc, C., Razack, M. and Mofor, L., 2007. Remote sensing for groundwater modelling in large semiarid areas: Lake Chad Basin, Africa . Hydrogeol J 15: 97–100.

NRSA., 2000. Rajiv Gandhi national drinking water mission: Technical guidelines for preparation of groundwater prospects maps. NRSA, Department of Space, Hyderabad, India.

Pradeep, K.J., 1998. Remote Sensing techniques to locate groundwater potential zones in Upper Urmil River Basin, District Chhatarpur- Central India. J. Indian Soc. of Remote Sensing 26: 135-147.

Ravindran, K.V. and Jeyaram, A., 1997. Groundwater prospects of Shahbad Tehsil, Basan District, Eastern Rajasthan. A Remote Sensing Approach. J. Indian Soc. of Remote Sensing 25: 239-246.

Sankar, K., 2002. Evaluation of groundwater potential zones using remote sensing data in Upper Vaigai River Basin, Tamil Nadu, India. J. Indian Soc. of Remote Sensing30: 119-129.

Saraf, A.K. and Choudhury, P.R., 1998. Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. Int. J. Remote sensing 19(10): 1825-1841.

Sarkar, B.C., Deota BS, Raju PL, Jugran DK (2001) A Geographic Information System approaches to evaluation of groundwater potentiality of Shamri micro-watershed in the Shimla Taluk, Himachal Pradesh. J. Indian Soc. of Remote Sensing 29: 152-163.

Sikdar, P.K., Chakraborty. S., Adhya, E. and Paul, P.K., 2004. Land use/land cover changes and groundwater potential zoning in and around Raniganj coal mining area, Bardhaman District, West Bengal: A GIS and remote sensing approach. J Spatial Hydrol 4(2):1–24

Soman, K., 2002. Geology of Kerala. Geological Society of India, Banglore, Pp. 34-39.

Sree Devi, P.D., Srinivasalu, S. and Kesava Raju, K., 2001. Hydrogeomorphological and groundwater prospects of the peregu river basin by using remote sensing data. Environ Geol 40:1088-1094.

Srivasthava, P.K. and Bhattacharya, A.K., 2000. Delineation of groundwater potential zones in a hard rock terrain of Baragarh District, Orrissa using IRS data. J. Indian Soc. Remote sensing 28(2&3): 129-140.

Srinivas Rao, Y., Reddy, T.V.K. and Nayudu, P.T., 2000. Groundwater targeting in hard rock terrain using fracture pattern modelling, Niva river basin, Andhra Pradesh, India. Hydrogeol J 8:494-502

Srinivasa Vittala, S., Govindaiah, S. and Gowda, H.H., 2005. Evaluation of groundwater potential zones in the sub – watersheds of North Pennar River Basin Around Pavagada, Karnataka, India, Using Remote sensing and GIS techniques J. Indian Soc. of Remote Sensing 33: 483- 493.

Thomas, A. and Sharma, P.K., 1999. Hydrogeomorphological mapping in assessing groundwater by using remote sensing data- A case study in Lehra Gaga Block, Sangrur District, Punjab. J. Indian Soc. of Remote Sensing 27: 31-42.

Thornbury, W.D., 1990. Principle of geomorphology. Willey Eastern Limited, New Delhi, 594p

Tiwari, A. and Rai, B., 1996. Hydromorphogeological Mapping for Groundwater Prospecting using Landsat MSS Images- A case study of part of Dhanbad District, Bihar. J. Indian Soc. Of Remote Sensing 24: 281-285