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DELINEATION OF GROUNDWATER POTENTIAL ZONES AND IDENTIFICATION OF ARTIFICIAL RECHARGE SITES IN DHARTA WATERSHED, UDAIPUR, RAJASTHAN, USING RS & GIS

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Abstract: Groundwater is a precious resource of limited extent. A systematic planning of groundwater exploitation using modern techniques is essential for the proper utilization and management of this precious but shrinking natural resource. In the present study, Geographical Information System (GIS) is used to integrate multi parametric data to generate several thematic maps, delineate groundwater potential zones and identify sites of artificial recharge in the Dharta watershed, Udaipur, Rajasthan (India). The thematic layers considered to delineate groundwater potential zones are geomorphology, recharge, geology, soil, slope, topographic elevation and transmissivity, which were prepared using conventional maps and data. All these themes and their individual features were then assigned weights according to their relative importance in groundwater occurrence and the corresponding normalized weights were obtained based on the Saaty's analytical hierarchy process. The thematic layers were finally added using Arc GIS software to yield groundwater potential zone map of the study area. Thus, three different groundwater potential zones were identified viz., 'good', 'moderate' and 'poor'. The area having 'good' groundwater potential is about 10.7 km2 which is about 19.62 per cent of the total study area. The thematic layers used in this study to determine artificial recharge zones are transmissivity, recharge, topographic elevation, soil and slope. These layers were combined using boolean logic analysis to delineate zones of suitability for artificial recharge structures. The area suitable for artificial recharge is 7.84 km2 which is 14.37 per cent of the total study area.

Key words*: artificial recharge zoning, GIS, groundwater management, remote sensing, water scarcity*

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INTRODUCTION

Artificial groundwater recharge has emerged as basic tools for the sustainable management of vital freshwater resources (both groundwater and surface water). The concept of using modern techniques like remote sensing and geographical information systems (GIS) in groundwater management studies is comparatively new. As groundwater is dynamic and interdisciplinary in nature, an integrated approach of remote sensing (RS) and GIS technique is very useful in various groundwater management studies. Remote sensing can provide diverse datasets over a large inaccessible area that can be efficiently handled and analyzed in a GIS framework. Applications of RS and GIS in groundwater management such as artificial recharge have been reported by a limited number of researchers (Saraf and Choudhury 1998; Ghayoumian *et.al.* 2005; Anbazhagan *et.al.* 2005; Ravi Shankar and Mohan 2005; Alivia Chowdhury *et.al.* 2009). They considered a varying number of thematic layers, such as geology, geomorphology, soil, slope, topographic elevation, recharge, aquifer transmissivity, land use/ land cover. A set of weights for the different themes and their individual features was decided based on personal judgments considering their relative importance from the artificial recharge viewpoint. These thematic maps were then integrated in a GIS framework to identify suitable zones for artificial recharge. The study area is severely afflicted with water scarcity problems. Therefore, aquifer replenishment through artificial recharge is necessary to sustain groundwater resources of the area on a long-term basis. Process based techniques like numerical modeling of groundwater systems (flow and/or transport) demand lots of spatiotemporal field data, which are unfortunately not available in the study area. Bearing this fact in mind, a methodology has been proposed in the present study for the delineation of artificial recharge zones and the identification of possible sites for artificial recharge in the Dharta watershed, Udaipur, Rajasthan, using RS, GIS and multi-criteria decision-making (MCDM) techniques with available field data and conventional maps.

Study Area. Dharta watershed is located at Bhinder Block of Udaipur District. The area is bounded by longitudes $74^0$08' to $74^0$15'E & $24^0$30' to $24^0$36'N latitudes and falls in Survey of India (SOI) topo sheets of 45L6, 45L12.It is situated at distance of 12 km. from Tehsil headquarter and covering an area of about 54.53 km^2.The watershed is characterized by sub-tropical and sub-humid to semi-arid climatic conditions. The average annual rainfall of the basin is 60.90 cm, about 90 per cent of which is experienced during the rainy season through Arabian Sea monsoon winds.

MATERIAL AND METHODS

Delineation of Dharta watershed and Selection of Observation Wells. The extent of the Dharta watershed (Figure 1) was extracted by digitizing boundaries of the basin from the geometrically rectified topo sheets. The boundaries of the watershed on the topo sheets were identified and located based on watershed approach. Groundwater levels over the Dharta watershed were monitored in 30 selected open dug wells for the study period. Four wells were selected for conducting pumping tests. The location of these wells is given in the Fig. 1.

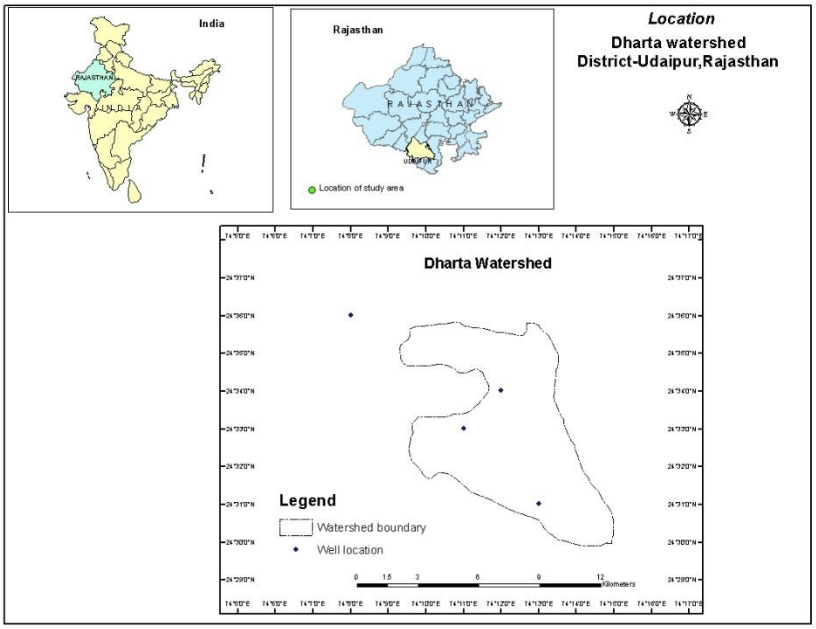

Figure 1. Map showing the study area and monitoring wells location of pumping test sites

Generation of Thematic Layers. The thematic layer of geomorphology was prepared from SOI topo sheets. The soil layer was prepared by digitizing the soil map obtained from the NBSS&LUP, Udaipur at 1:250,000 scale. Topographic elevation layer was generated from the topographic data downloaded from USGS (2004). Slope map was prepared from Digital Elevation Model (DEM), which was taken from SRTM website (USGS, 2004). Groundwater level fluctuation for individual 30 observation wells were computed for two years (viz. 2012 and 2013) and then mean of these two years was considered for generating the thematic layer on groundwater fluctuation. The point map was created in the Arc GIS 9.3.1 software using these values. This point map was then interpolated to get a raster map by using Inverse Distance Weighing Moving Average (IDWMA) Method. Transmissivity values obtained in pumping tests were used to prepare a thematic layer on transmissivity. Recharge for the study area was estimated using Water Table Fluctuation Method. These values were used to prepare a thematic layer of Recharge.

Selection of Thematic layers for identification of Artificial Recharge Zones. A Remote Sensing and GIS based method is found to be very useful in suitability analysis for artificial recharge sites in the hard rock terrain (Saraf and Choudhary, 1998). The thematic layers used in this study for determining recharge zones are transmissivity, recharge, topographic elevation, soil and slope. All the five thematic layers were combined using Boolean Logic Analysis to delineate zones of suitability for artificial recharge structures. The prime task in this method is to identify the criterion and to formulate the set of logical conditions to extract the suitable zones. With this criterion, the output has only two classes: suitable or unsuitable. The areas in which the defined conditions of the information layers are fulfilled together, a value of 1 is given whereas

the remaining part will have a zero value. The criteria considered in this study for demarcating suitable zones for artificial recharge are:

Table 1. Suitability Criteria for Artificial Recharge Zone

Thematic Layer	***Suitability Criteria***
Slope	*1-3 & 3-8 %*
Transmissivity	*360-390 m^2/day*
Recharge	*2-4 cm/year*
Topographic elevation	*<470 m*
Soil	*Clayey Soil, Fine Loamy Soil*

RESULTS AND DISCUSSION

Zones of Groundwater Potential and Artificial Recharge. The groundwater potential map of Dharta watershed (Fig. 2) reveals three distinct classes (zones) representing 'good', 'moderate' and 'poor' groundwater potential in the area. The area covered by 'good' groundwater potential zone is about 10.70 km^2 (19.62 per cent).The north and northeastern portion of the study area falls under moderate groundwater potential zone. It encompasses an area of 17.33 km^2 which is 31.78 per cent of the total area.

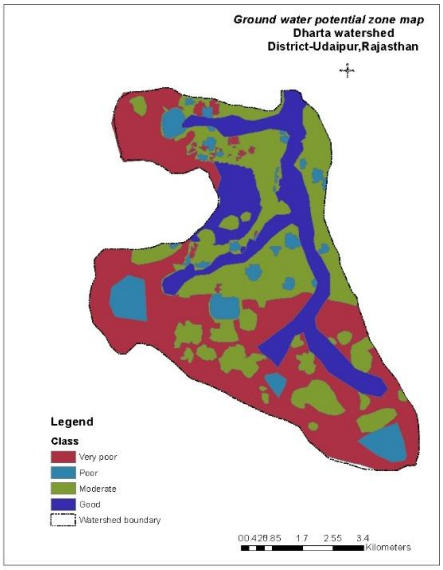

Figure 2. Groundwater potential zone map of Dharta Watershed

However, the groundwater potential along the boundaries of the study area is very poor. It covers an area of 21.91 km^2 which is 40.17 per cent of the total area. The 'poor' groundwater potential is due to presence of girdle of hills surrounding the study area. 7.84 km^2 of the area which is 14.37 per cent of the study area is suitable for artificial

recharge which lies in the northern part. The area suitable for artificial recharge is 7.84 km^2 which is 14.37 per cent of the total study area.

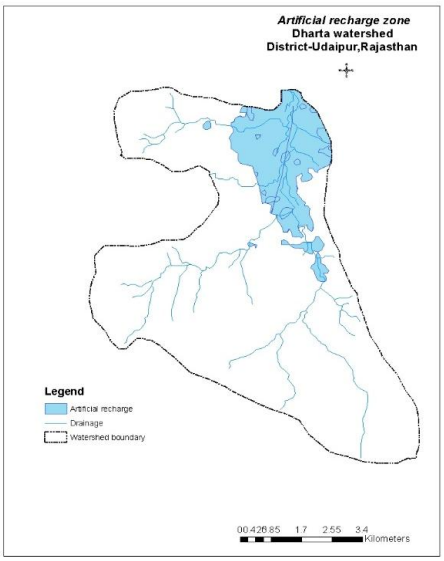

Figure 3. Map showing zones favorable for Artificial Groundwater Recharge

CONCLUSIONS

The application of GIS & Remote sensing technique is demonstrated as the best tools for the identification of groundwater potential zones and artificial recharge zone in the Dharta watershed. This potential map will serve as the basis of information to local authorities and planners about the suitable area for prospective exploration of groundwater and construction of different structure of artificial recharge. These maps also help in water management in the area for domestic and agriculture uses.

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MAPIRANJE POTENCIJALNIH ZONA PODZEMNIH VODA I IDENTIFIKACIJA VEŠTAČKIH IZVORA DOPUNE U OBLASTI DHARTA WATERSHED, UDAIPUR, RAJASTHAN, UPOTREBOM RS I GIS

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Sažetak: Podzemna voda je dragocen izvor ograničenog obima. Sistematsko planiranje korišćenja podzemne vode upotrebom savremenih tehnika je osnova pravilne upotrebe i upravljanja ovim dragocenim prirodnim resursom. U ovom istraživanju je korišćen GIS za integraciju više parametara i dobijanje nekoliko tematskih mapa potencijalnih izvora podzemne vode. Tematski slojevi su: geomorfologija, obnova, geologija, zemljište, nagib, topografska elevacija i prenosivost, koji su pripremljeni upotrebom konvencionalnih mapa i podataka. Sve ove teme i njihovi pojedini entiteti su vrednovani prema značaju za pojavu podzemne vode. Tematski slojevi su na kraju dodati Arc GIS programom u mapu potencijalnih zona podzemne vode. Tako su identifikovane tri različite zone: 'dobra', 'umerena' i 'slaba'. Oblast u klasi 'dobra' ima oko 10.7 km^2 što je oko 19.62% cele oblasti.

Ključne reči*: zoniranje veštačke dopune, GIS, upravljanje podzemnim vodama, daljinska detekcija, nestašica vode*

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