APPRAISAL OF GROUNDWATER POTENTIAL ZONES USING RS-GIS TECHNIQUES
P. C. Hakey                                                   B. N. Umrikar                                                   P. G. Saptarshi

Abstract
The purpose of this paper is to assess the areas with potential of groundwater through rating system established by overlay analysis using Remote Sensing and Geographical Information System (RS-GIS) techniques. The Survey of India toposheet maps on a scale of 1:50,000 were used for the preparation of base map of the study area. In order to prioritize the potential area, six thematic layers, viz. geomorphology, geology, rainfall, Digital Elevation Model, Slope and drainage density were chosen as the influencing factors. The Digital Elevation Model (DEM) has been generated by interpolation of 20 m interval contours. The slope map was derived from DEM to understand the slope of the land. The weights have been assigned to thematic layers based on an expert knowledge. A database was built for managing the various thematic layers generated in GIS framework by using overlay technique. The groundwater potential zones were obtained by overlaying all the thematic maps using the spatial analysis tool in Arc-GIS. During weighted overlay analysis, the ranking has been given to each individual parameter of each thematic map and weights were assigned according to the influence such as geomorphology – 25%, Lithology – 25%, DEM - 15%, slope – 15%, Rainfall - 10% and drainage density – 10% to find out the potential zones of study area. About 27% of the total area falls under the moderate zone, 36% falls under poor zone and 37% of the study area fall good groundwater potential zone. It can be concluded that the approach of this study, and parameters used, is a useful framework for the preliminary understanding of the groundwater potential zones and can be recommended to be applied in such similar areas.

Keywords: Groundwater potential areas, weighted overlay technique, RS-GIS.

Introduction
The data provided by United Nations (UN, UNESCO, and FAO) to Water Consumption Statistics’ web site depict that the agriculture sector accounts for 70% water consumption, compared to 20% for industry and 10% for domestic use. Groundwater is reliable, consistent and cost-effective natural source of supply to fulfill the demand for drinking and agricultural purpose. Therefore, an assessment of this resource is essential for the sustainable management. The overuse of groundwater resources has observed in recent years that generated the problems such as groundwater depletion, water stress, and return flow leading to pollution of groundwater. Remote sensing (RS) and Geographical Information System (GIS) tools are widely used for the development and management of water resources (Dar et al., 2011; Krishna Kumar et al., 2011; Magesh et al., 2011, Madani and Niyazi, 2015).

Assessment of groundwater potential zones using RS-GIS has been attempted by many researchers (Magesh et al 2012; Maggirwar and Umrikar, 2011; Dar et al., 2010; Nagarajan and Singh 2009; Murthy 2000). Several studies on delineation of groundwater potential zones using RS-GIS techniques have been conducted both at an international and national level (Jankowski 1995; Krishnamurthy et al. 1996; Shahid et al. 2000; Sener et al. 2005; Solomon and Quiel 2006). Panigrahi et al. (1995), Krishnamurthy et al. (2000), Rao and Jugran (2003) and Ghayoumian et al. (2005) used Remote Sensing for demarcating zones suitable for groundwater exploration. Application of GIS for groundwater resource assessment has also been reported by Sander (2005), Teeuw (1995) and others.

A comprehensive review on the applications of RS-GIS in groundwater management is presented by Jha et al. (2007), where preparation of various thematic layers, such as geomorphology, lithology, drainage pattern and slope with assigned weightage in a spatial domain have been utilized in
identification of potential groundwater zones. Therefore, the present study focuses on the identification of groundwater potential zones in Velhe Taluka, Pune Maharashtra, India.

**Study Area**

Velhe, is a taluka in Haveli subdivision of Pune district of state of Maharashtra, India. It lies to the southwest of Pune and bounded on the North and South by Mulshi and Bhor talukas of Pune district. The study area lies at latitude of 18°10'00" - 18°23'00" N and longitude of 73°18'00"-73°55'00"E with an areal extent of 490.72 sq km (Fig 1A). The area is covered in Survey of India toposheet 43H/11, 43H/07, 43H/12, 43H/15 and 43H/16.

The study area includes two major water bodies namely Chafet Dam and Panshet Dam. Few villages namely Nivi, Shirkoli, Dapode, Kolavadi, Wangani, Gunjavane and Boravale are included in the Velhe Taluka and are well connected by metal and non-metal road network (Fig 1B).

**Methodology**

The base map, contour and drainage network was digitized in GIS environment for study area using Survey of India (SOI) toposheets of 1:50,000 scale. The slope map was prepared from contour data in ArcGIS Spatial Analyst module. The drainage density map was prepared using the fishnet tool in ArcGIS. TRMM satellite data was downloaded to generate the layer of rainfall. Geological Survey of India (GSI) resource map was used to obtain the geology and geomorphology of study area. These thematic layers were converted into a raster format before they were brought into weighted overlay GIS environment.

The groundwater potential zones were obtained by superimposing all these thematic maps in terms of weighted overlay analysis using the spatial analysis tool in ArcGIS 10. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned to each class of that particular feature. Table 1 shows the weights, ranks and scores of each theme and thematic unit respectively. The methodology adopted for the present study is shown in Figure 2.

**Results and Discussions**

Rainfall: Precipitation is the major source of groundwater recharge in hard rock terrain hence the Tropical Rainfall Measuring Mission (TRMM) data has been utilized to generate the rainfall...
thematic layer. The rainfall is categorized into nine different classes (Fig. 3). The rainfall increases towards the western part of the study area.

Digital Elevation Model: The elevation ranges between 1400 and 117 m above ms1 in the study area. High elevation is observed in the central part of the study area indicating water divide line. The peripheral parts of Velhe Taluka experiences low elevations (Fig. 4).

Slope: Slope of the land plays vital role in recharging surface water. Steep slopes aggravate surface runoff whereas gentle slopes and flat areas enhance the residence time of rainwater on the ground. The area experiences steep slopes in the central and peripheral parts (Fig. 5).

Geomorphology: There were high level plateau region and denudational region identified from the resource map obtained from sell division of GSI (Fig. 6). The major part of the study area depict high level plateau and towards the southeastern region denudational features of deccan basalt are observed.

Lithology: The lava flows from the study area have been divided into Simple basaltic lava and megaphenocryst (Fig. 7). Major part of the total area is covered with Diveghat formation followed by 30% Purandargarh formation. simple basaltic lava flows.

Drainage density: Drainage density is the function of topography, landform, geology, and land use pattern (Horton, 1945; Strahler, 1957). The rock permeability is inversely proportional to drainage density. The study area has been grouped into five classes (Fig. 8).
Delineation of groundwater potential zones

The thematic maps such as rainfall, elevation, geomorphology, geology, drainage density and slope were converted into grid (raster) format. All the thematic raster maps had an equal square grid size of 30 m. Each theme was assigned a weight depending on its influence on the occurrence, movement and storage of groundwater. Various units in each thematic map were assigned relative ranks (Table 1). The weights were assigned to each theme according to their preferences in groundwater potentiality.

Table 1  Rank and weightage of different parameters for groundwater potential zones

<table>
<thead>
<tr>
<th>Sr no</th>
<th>Criteria</th>
<th>Classes</th>
<th>Rank</th>
<th>Weights (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geology</td>
<td>Simple Basaltic Lava Flows</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Basaltic Lava Flows</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Megaphenocryst</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Slope in degrees</td>
<td>0-20</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-50</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;50</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DEM</td>
<td>00-500</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500-800</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;800</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Geomorphology</td>
<td>Region of high level Plateaus (over 900m)</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unit of Denudational Origin Deccan Trap</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rainfall in mm</td>
<td>0-1500</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1500-2500</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;2500</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Drainage Density per sq km</td>
<td>0-0.5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;1</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

The resultant map was classified into three prospect zones namely poor, moderate and good. The poor groundwater potential zone is concentrated in the middle region of the study area due to the presence of steep slopes and hard compact basalt. This indicates that, geology, geomophology and slope play a vital role in groundwater escalation. About 27% of the total area falls under the moderate zone, 36% falls under poor zone and 37% of the study area fall good groundwater potential zone (Fig. 9).
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Fig. 1. A. Study area location map B. Village boundary map of Velhe Taluka, District Pune.

Fig. 4: Digital Elevation Model of the study area.
Fig. 5: Slope map of the study area.

Fig. 6: Geomorphology of the study area.

Fig. 7: Geology of the study area.
Conclusion
For sustainable growth of river basin integration of spatial techniques like Remote Sensing and GIS are very helpful. Delineating the groundwater potential zones in Velhe Taluka, Pune, Maharashtra, India was necessary for the sustainable water resource planning. The use of RS - GIS techniques has made this task manageable. The weighted overlay analysis was found suitable in assessment of groundwater potential zones.

References:
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