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Use of Remote Sensing and GIS Techniques in Delineation of Groundwater Potential Zones

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Abstract

In present study remote sensing and geographic information systems techniques are collectively used to categorize groundwater potential zones in the Dapoli taluka of Ratnagiri District. The conventional maps and SRTM DEM (90 m) data have been used for preparation of the a range of thematic maps like geological, drainage, drainage density, lineament, lineament density, DEM, and slope map for demarcate groundwater potential zones. The each thematic map assigned weight on the basis of its contribution in groundwater potential. The features of each and every thematic map also assigned rank. GIS environment was used to integrate all the thematic maps for computing groundwater potential zones. The groundwater potential zones were classified as excellent, very good, good, moderate and poor. Groundwater potential zones were demarcated on basis of finishing ranking and weight. Accordingly, recognition of potential groundwater zones could be carried out by using combine approach involving remote sensing and geographic information systems.

Keywords: Groundwater potential, Remote Sensing, Geographic Information Systems.

Introduction

Groundwater is one of the most precious natural resources, which hold up human strength, monetary growth, and environmental diversity[1]. The greater part of the Earth's water is saline. The fresh water in lakes and rivers is only a little proportion of the Earth's water. Therefore, groundwater is a key constituent of the water available for use. More than 70 per cent of the rural water supply schemes in eleven the states are based on ground water. Thus, ground water plays a crucial role in the state's economy. Ground water occurs on the earth due to combine effect of different factors viz, geology, climate, ecology, hydrology and physiographic. The ground water exploration carried out on the basis of correct interpretation and combine effect of all these factors[2].

Exploitation of Groundwater and its utilization required proper understanding of its origin, occurrence and movement. It was directly or indirectly controlled by terrain characteristics[3]. Geomorphology, streams density, topography, water bodies, etc all these surface hydrology characteristics engage in recreation of groundwater replenishment. Therefore, recognition and quantization of these features were vital in generating groundwater potential model of a particular area[4]. Remote sensing and GIS is one of an admirable tool for geologists' and hydrologists' in hydrogeological science for monitoring and assessing groundwater[5.] Satellite data provides promptly and baseline information for different parameters viz, geology, geomorphology, landforms, lineaments, land cover widely controlled in locating occurrence and movement of groundwater potential[6,7,]. Several data sets can be integrated to achieve conceptual model for management, storage, retrieval of non-spatial, spatial data[8-9]. Satellite data interpreted in conjunction with ground truething provides a chance for better study and more systematic analysis of various parameters of a terrain. With the capacity of remotely sensed data and GIS technique can be integrated to evaluate ground water potential zones. The different thematic maps were generated to delineate groundwater potential zones in various parts of the Nation[9]. GIS was used to delineate groundwater potential zone[10-13]. Present study was carried out to delineate groundwater potential zones by preparation and analysis of various thematic layers.

Study Area: The study area is part of the coastal line of the western side of Maharashtra (Figure-1). It lies between Latitude 17°33'59.489" to 17°56'22.54"N and Longitude 73°2'56.16" to 73°23'7.915"E and covers an area of 910 km^2.

Materials and Methods

In the present study SRTM DEM was used. The first hand information's were collected from prospect maps. District resource maps collected from GSI, Nagpur, Soil map from NBSS & LUP, Nagpur. Arc GIS 9.3 and ERDAS IMAGINE 9.1 software were used for analysis and mapping. The thematic layers were generated as described in Figure-2. In order to produce thematic maps, hard copy of map was scanned and digitized. Initially, all the images were rectified subsequently improvement, filtering, cataloging and other GIS processes. Existing spatial data was assembled in the digital form to derived and integrate thematic layers like Slope, Stream, stream density, Lithology, Lineament density, Geomorphology, etc. As per the relative contribution characteristics towards recharge suitable weight was assigned to the thematic layers[14, 16] as shown in Table-1.

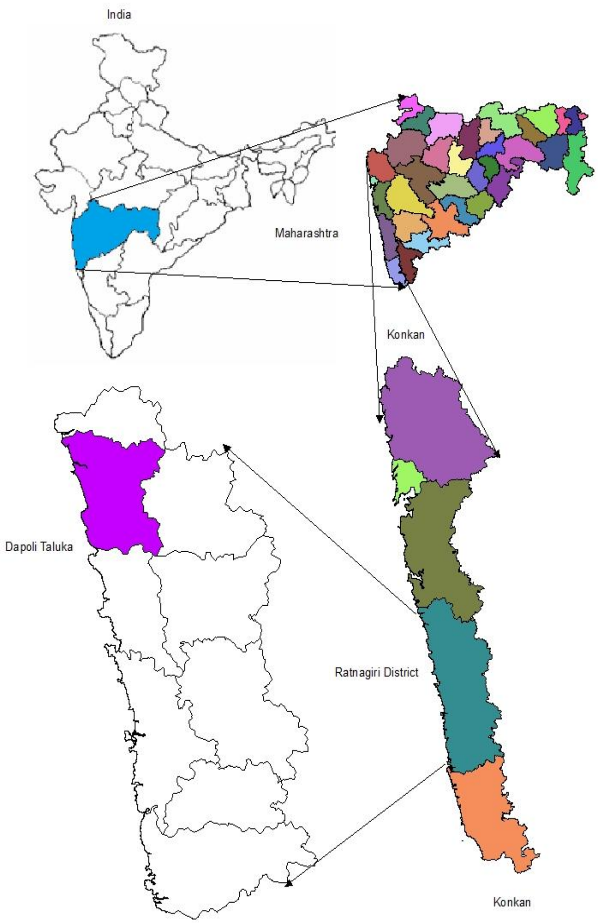

Figure-1
Location map

Interpretation of Satellite Data: All thematic maps were combined in final step in Arc GIS environment. Based on the integration of these thematic maps new thematic map was generated indicating poor, moderate, good, very good and excellent groundwater zone category. Groundwater potential index was calculated by the formula[16] given under:

GWPI = (Gg wGg r + Dg wDg r + Dd wDd r + Lh wLh r + Lt wLt r + Ld wLd r + So wSo r + Ss wSs r)/ Total Weight.

Where: Gg: geomorphology, Dg: drainage, Dd: drainage density, Lh: lithology, Lt: lineament, Ld: lineament density, So: Soil, Ss: slope. With "w" theme weight and "r" feature rank. GWPI is classified as Poor (<3.0), Moderate (3.0-4.4), Good (4.4- 5.8), Very good (5.8-7.1) and Excellent (>7.1).

Table-1
Weight and feature ranking of different thematic map

Themes	Weights	Feature	Rank
Geomorphology	30	Ma-coastal plain	10
		DD1	3
		ED	2
Lithology	20	Mainly flow-3	6
		simple flow-4	4
		lateritic -8	5
		Alluvial-9	9
Drainage density	15	<1	15
(km^2)		1-2	12
		2-3	10
		3-4	12
		4-5	14
Lineament density	15	Very poor	4
		Poor	6
		Moderately high	9
		High	11
		Very high	15
Soil	10	Loamy soil-006	9
		Shallow-012	6
		Loam soil-018	4
		Clay soil-27	7
Land use	5	Agriculture	5
		Wasteland	2
Slope (%)	5	<5	5
		5-10	4
		10-15	3
		15-20	2
		20-25	1
		>25	0

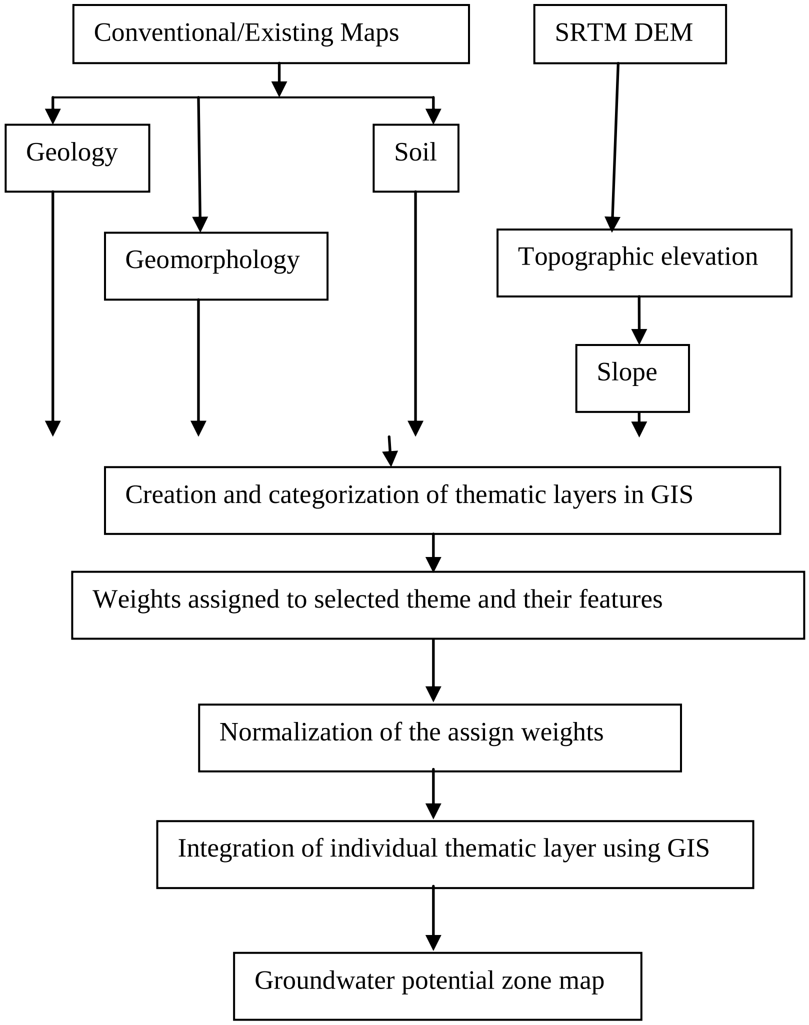

Figure-2
Groundwater potential evaluation flow chart

Results and Discussion

Soil: The Dapoli taluka has several major soil types (Figure-3) including shallow, well drained, clayey soil, slightly steepy with severe erosion was found in the north east part of the study area covers 56.66 km^2. Shallow, well drained, loamy soil, moderate sloping land with severe erosion can be found 86.00 km^2 towards the western coast line near creak. Shallow, well drained, loamy soil, moderate steeply sloping undulating land with severe erosion covers major part of the study area i.e. 483.53 km^2. Slightly deep, well drained, loamy soil, slightly slope with moderate erosion found in North West corner and lies north east corner to south east corner covers 284.23 km^2.

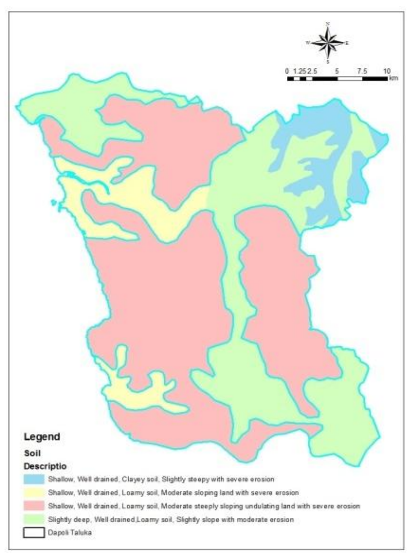

Figure-3
Soil map

Lithology: It is a very significant characteristic in predicting groundwater potential zones. A lithology map is prepared using digitizing Geological Survey of India district resource map (Figure-4). Major parts of Dapoli taluka are underlain by Diveghat formation, Laterite, Purandargarh formation and Alluvium.

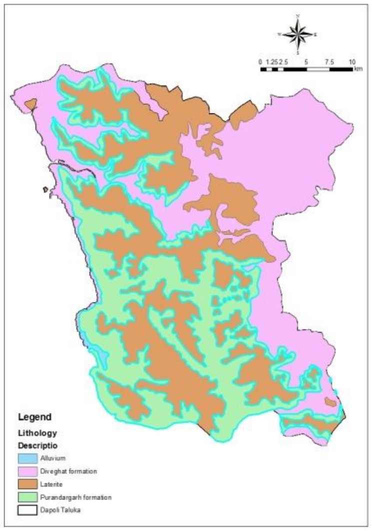

Figure-4
Lithology Map

Geomorphology: Major parts of Dapoli taluka are underlain by Terrace/Rocky bench plateau on Deccan trap covers 677.63 km^2 area, Coastal plain lies in 209.20 km^2 and Denudational hills and valleys on Deccan trap. In 23.57 km^2 area. Geomorphological map is prepared based on digitizing the various geomorphological units have been demarcated as shown in Figure-5.

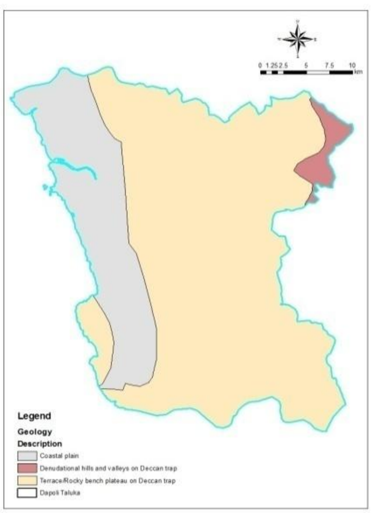

Figure-5
Geomorphology Map

Slope: The slope theme resulting by means of SRTM DEM data of the study area. The slope of the area is directly proportional to the surface runoff i.e. greater the slope the higher the velocity of the flow and hence smaller will be the recharge. Based on the analysis, slope is classified into seven categories as shown in Figure-6. Maximum area falls under the class 5-10% (223.84 km^2) and minimum under the slope class >35 % (13.57 km^2). The area falls under slope class <5% (187.11 km^2), 10-15% (197.95 km^2), 15-20% (146.88 km^2), 20-25% (94.00 km^2) and 25-35% (46.94 km^2), respectively.

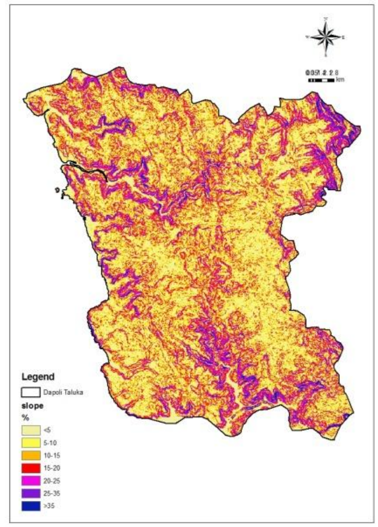

Figure-6
Slope Map

Drainage: The drainage area of watershed is a sole most significant feature affecting the degree of peak flows. Satellite data is used to prepared surface drainage map. Stream order presented from order I to V as shown in Figure-7.

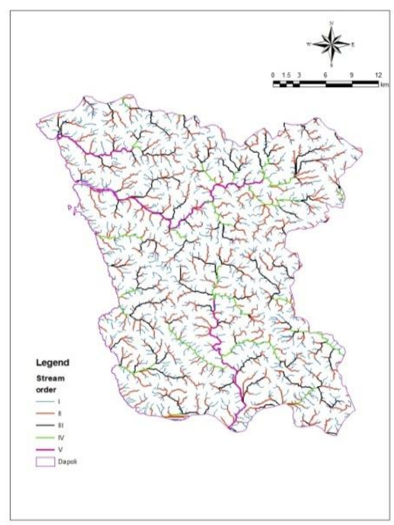

Figure-7
Drainage map

Drainage Density: Drainage map is used to derive the drainage density map. Low drainage density area was delineated from drainage density map. It indicates a poorly drained watershed. The habitation time for water is more in this area thus, indicative of a suitable location for groundwater recharge. Drainage Density diagram is as shown in Figure-8.

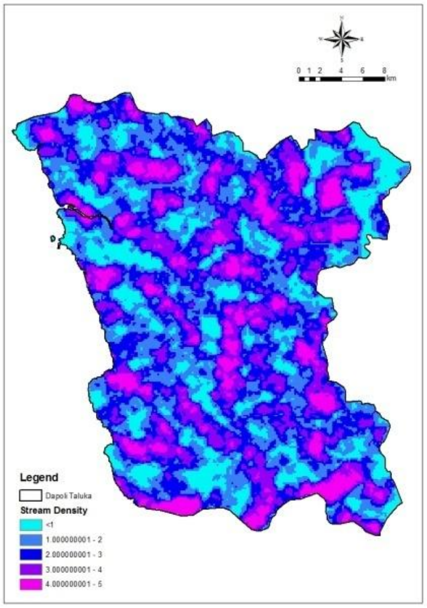

Figure-8
Drainage Density Map

Lineament: It gives an idea about underground faults and fractures, indicative of the happening of groundwater[17] and performs as space for groundwater flow. A lineament map prepared from the district resource map. The Lineament map of study area is as shown in Figure-9.

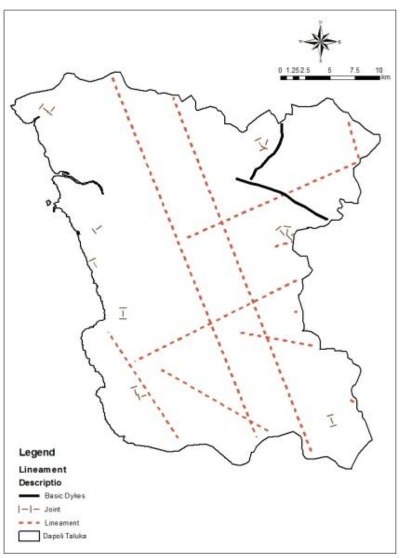

Figure-9
Lineament Map

Lineament Density: A lineament density map is derived from the above Lineament map. The lineament density of study area is classified into very high, high, moderately high, poor, very poor and nil, respectively. The study area shows a poor density in nearly all area as shown in Figure-10.

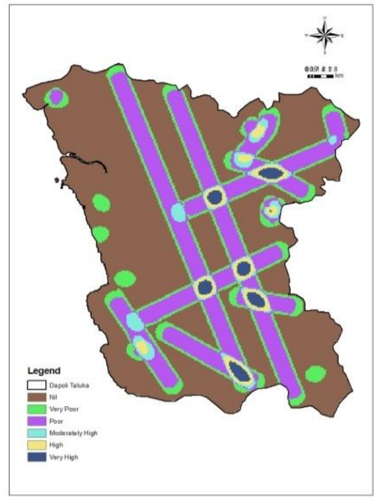

Figure-10
Lineament Density Map

Spatial Analysis: The thematic maps generated were integrated in GIS environment to demarcate the groundwater. The groundwater potential area is qualitatively placed into different zones viz, poor, moderate, good, very good and excellent. A specific weight was assigned to each theme. Rank was allotted to each characteristic. Every factor had divergent influence in different area. Therefore, every factor was assigned a weight depending upon their involvement towards ground water potentiality. Table-1 represents weight allocated to various classes of all the thematic maps and rank of each features. All the themes were transformed to raster format after weight and ranks assigned to themes and features. All thematic maps are then incorporated step by step using normalized method. Using GWPI formula all thematic maps integrated in Arc GIS environment. An ultimate groundwater potential map is shown in Figure-11.

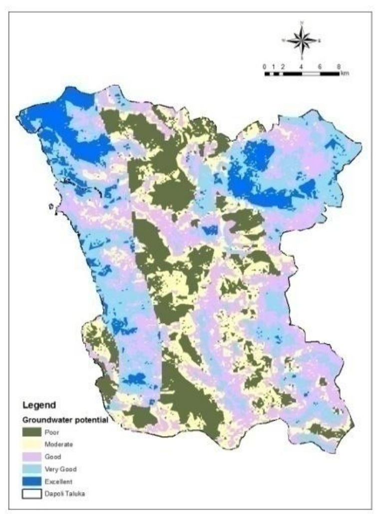

Figure-11
Groundwater potential map

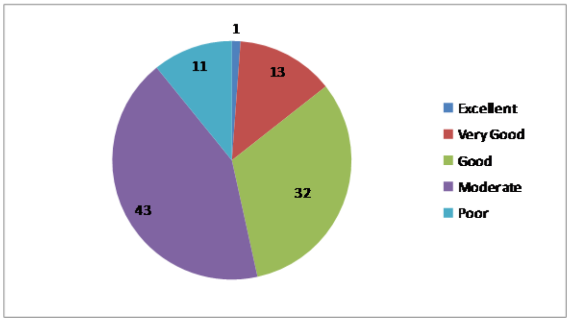

Figure-12
Distribution of Groundwater potential zones

The present study categorized into five groundwater potential zones (Figure-12). Excellent groundwater potential is available in 1.16 per cent. Very good groundwater potential is in 13.22 per cent, good groundwater potential 32.18 per cent, moderate in 42.62 per cent and poor in 10.83 percent.

Conclusion

The study attempted to recognition of groundwater potential zones using RS and GIS technique. DEM derived from SRTM which is useful for slope map prepared. GSI resource map is used for preparing the various thematic maps. The study area divided into five groundwater potential zones. The greater part of the study area shows good to moderate range of groundwater potential. This technique was effectively used and verified for assessment of groundwater potentiality of the area.

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