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Research Paper

Identification of Groundwater Potential Zones Using Remote Sensing and GIS in Hanur Watershed Area, Kollegal Taluk, Chamarajanagar District, Karnataka State, India

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Groundwater is an important Natural source contributing significantly in total annual supply. However, overexploitation has depleted groundwater availability considerably and also led to land subsidence at some places. Assessing the potential zone of groundwater recharge is extremely important for the protection of water quality and the management of groundwater systems. Groundwater potential zones are demarked with the help of remote sensing (RS) and Geographic Information System (GIS) techniques. In this study a standard methodology is proposed to determine groundwater potential using integration of RS & GIS technique. The composite map is generated using GIS tools. The accurate information to obtain the parameters that can be considered for identifying the groundwater potential zone such as geology, slope, drainage density, geomorphic units and lineament density are generated using the satellite data and survey of India (SOI) toposheets of scale 1:50000. It is then integrated with weighted overlay in ArcGIS. Suitable ranks are assigned for each category of these parameters. For the various geomorphic units, weight factors are decided based on their capability to store groundwater. This procedure is repeated for all the other layers and resultant layers are reclassified. The groundwater potential zones are classified into seven categories namely poor to nil, poor, moderate to poor, moderate, good to moderate, good & very good to good. The use of suggested methodology is demonstrated for a selected study area in Hanur watershed area Kollegal Taluk of Chamarajnagar District in Karnataka state. This groundwater potential information will be useful for effective identification of suitable locations for extraction of ground water

Keywords: Remote sensing, GIS, Weighted overlay, Groundwater, Potential zone

Introduction

Groundwater is the one of the most natural resource that supports human health and ecological diversity (Waikar and Nilawar, 2014). Protecting it from contamination and carefully managing its use will ensure its future as an

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important part of ecosystems and human activity. The rate of groundwater flow is controlled by two properties of the rock: porosity and permeability. The main sources of groundwater recharge are precipitation or Rainfall and flow of discharge include effluent seepage into the streams and lakes, springs, evaporation and pumping. It is estimated that approximately one third of the world's population use groundwater for drinking (Jose, Jayasree, Kumar, andRajendran, 2012). Groundwater is the source for irrigation and domestic purpose. In which 80% of the rural areas are use groundwater for domestic purpose and 50% of the urban areas use the groundwater for domestic purpose. Due to more dependent on usage of groundwater for domestic purpose and irrigation and for other sectors may results in exploitation of groundwater resources (Shakak, 2015). Groundwater is dynamic and replenishable resource. The exploitation and exploration of groundwater resources needs to understanding geology, geomorphology of that area. The data and thematic maps such as satellite images, soil data, geology data, drainage data and rainfall data, are helpful for mapping of groundwater potential zones (Giri andBharadwaj, 2012).

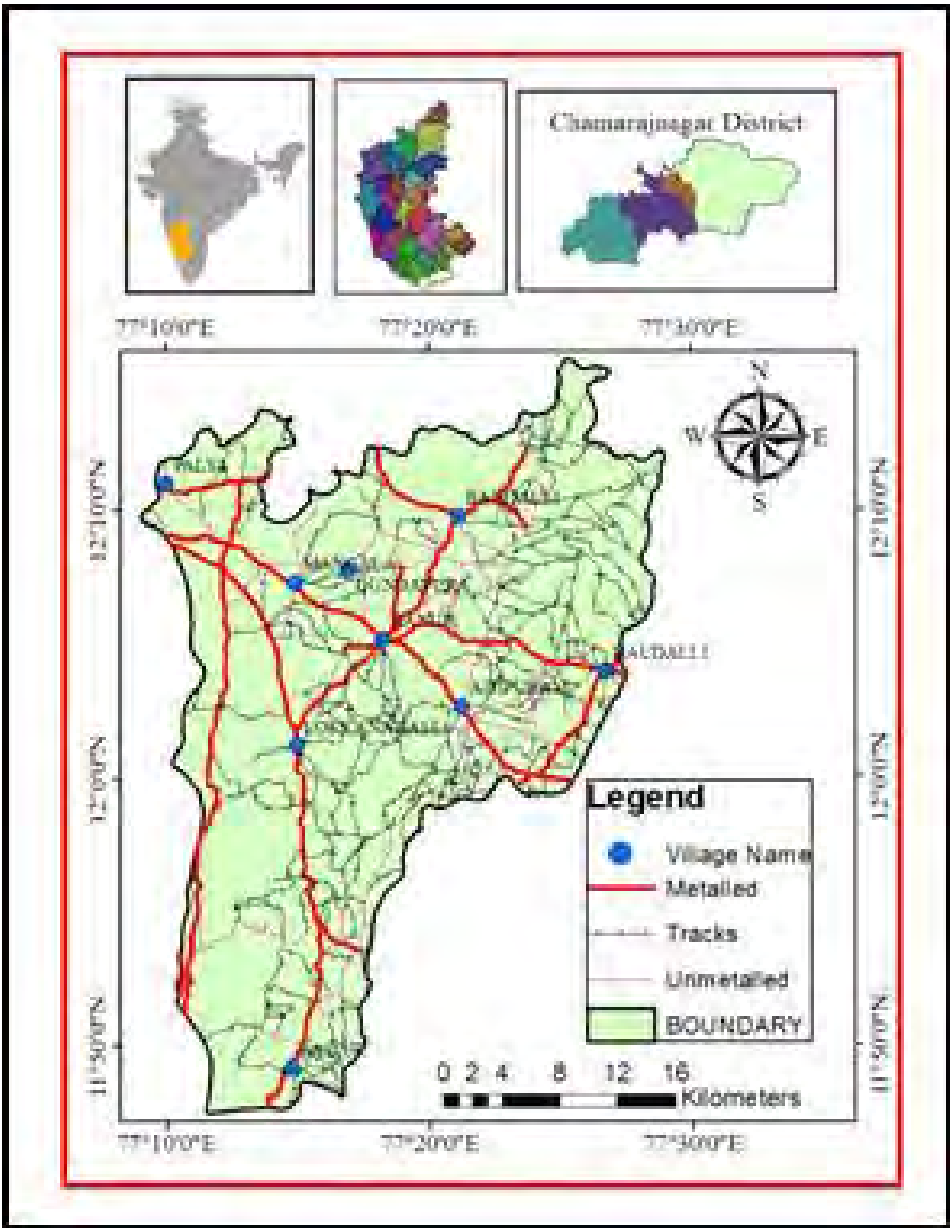
Remote sensing data combined with Geographical Information System (GIS) technique is very efficient in identification of groundwater potential of any region. The study results that the integration of thematic maps prepared from remote sensing techniques using GIS gives more and accurate results (Jose *et al.*, 2012). Groundwater is available when water infiltrates below the earth surface and soil beneath the earth surface is porous (Sayeed, Hasan, Hasnat, andKumar, 2017).

Identification of groundwater occurrence location using remote sensing data is based on indirect analysis of directly observable terrain features like geological structures, geomorphology, and their hydrologic characteristics. Also lineaments play significant role in Groundwater exploration in all type of terrain. Application of GIS and RS can also be considered for multi criteria analysis in resource evaluation and hydrogeomorphological mapping for water resource management. The use of remote sensing and GIS tools to extract detailed drainage, slope and geomorphic features in the study area suggests appropriate methods for groundwater potential zone studies.

2. Study Area

Kollegal is one of the Taluks in Chamarajanagar District. It lies to the East of Chamarajanagar. It is bounded by Yelandur and T. Narsipur Taluks and to the west Mandya and Bangalore to the North, East and South it is bounded Dharamapuri District of Tamil Nadu state. It Consists of 5 Hobli's named Kasaba, Ramapura, Hanur, Palya, Lokkanahalli. Kollagal taluk is one of the largest taluks in Chamarajnagar district and also largest taluk in Karnataka state. The study area (Hanur Watershed) lies between 77^0 5^1 to 77^0 30^1 East longitude 11^0 45^1 to 12^0 15^1 North latitude **(Map.1).**with total aerial extent of 1026 sq kms falls in the Survey of India (SOI) toposheets no 57H/4, 57H/7, 57H/8, 58E/1 and 58E/5. Kollegal is well known for its silk industry. It is also called as silk city which attracts traders from all over the state. The area is accessible by good road network. It is connected by two national highways NH 209 which starts from Bengaluru-Dindukal via Coimbatore, Kollegal and NH 212 which starts from Kollegal to Calicut/Kozhikode, via T.Narasipura, Mysuru the nearest railway station is Chamarjanagar.

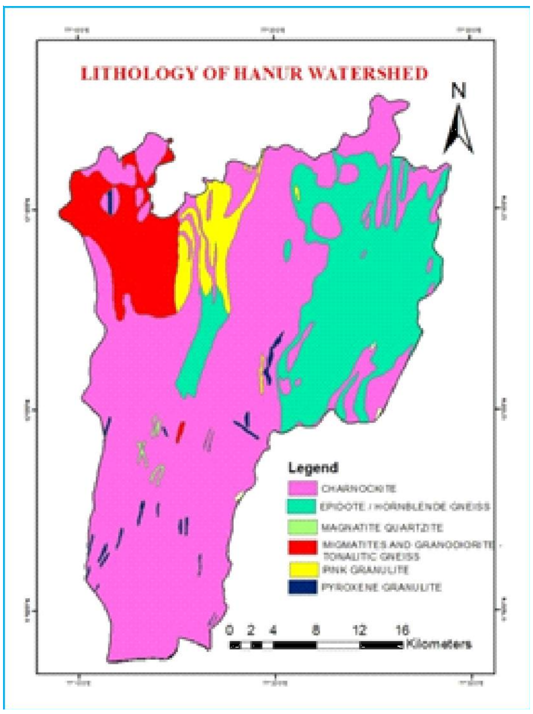
Map 1: Location of the Study Area



3. Data Used and Methodology

The survey of India toposheets 57H/4, 57H/7, 57H/8; 58E/1 and 58E/5 have been used as base maps. Digitized using satellite images of Indian Remote Sensing (IRS) 1C and 1D PAN+LISS merged data (26 mtrs), were overlaid on SOI toposheets, on 1:50,000 scale, constructed through visual interpretation using Arc Map (V 10.30) and Eradas Imagine 9.2, and association patterns. GIS and remote sensing technology is applied to prepare various thematic maps Preparation of digital elevation model (DEM) by interpolating contour map that is digitized from SOI toposheet. DEM is used to prepare slope, aspect, flow accumulation and stream order. Methodology is widely used for preparing runoff potential map for small to medium size engaged drainage basin. All the thematic layers will overlay by using GIS to find the final integrated output of groundwater potential zones in the present study, geomorphology, slope, drainage density, Land use/land cover, geology and lineament density are considered for the identification of groundwater potential.

Map 2: Lithology of Study area



4. Factors Influencing Groundwater

1. Geology of the Study Area

Geology of the study area is fall into Proterozoic basin of Southern Karnataka and comes under the semi-arid type and underlain by hard rock terrain consisting of Peninsular gneiss, Charnockite, Epidotite / Hornblende Gneiss, Magnatite quartzite, Migmatites and Granodiorite-Tonalitic gneiss (MGTG) and Pink/Pyroxene Granulite of Proterozoic era. Charnockites is widely spread in the study area (Map 2), (Table 1).

Table 1: Distribution of Lithology of Hanur Watershed in sq. km and Percentage

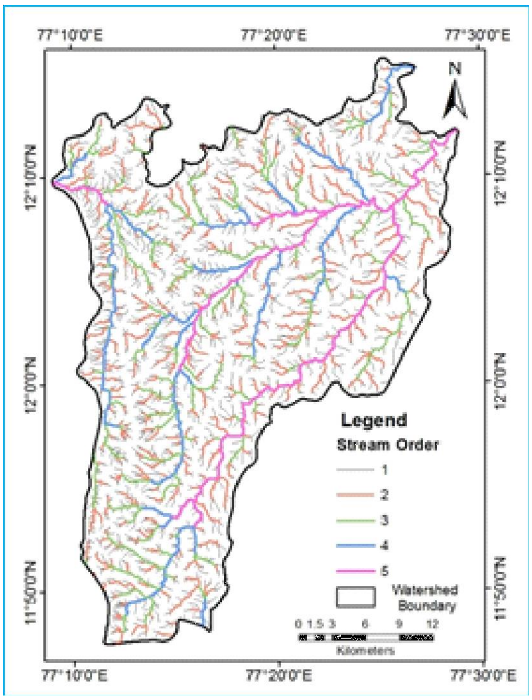
Lithology	Area in sq. km.	Area in %
Charnockite	646	62.96
Epidote / Hornblende gneiss	240	23.39
Magnatite quartzite	3	0.29
Migmatites and granodiorite - tonalitic gneiss	88	8.58
Pink granulite	41	4
Pyroxene granulite	8	0.78
Total	**1026**	**100**

5. Drainage and Drainage Density Map

Drainage map consists of water bodies, rivers, tributaries, perennial andephemeral streams, ponds. The study area is fifth order basin joining the rivers, tributaries based on topography

Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin Drainage density depends upon both climate and physical characteristics of the drainage basin. Low drainage density is more likely to occur in region and highly resistant of highly permeable subsoil material under dense vegetative cover and where relief is low. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. The drainage density characterizes the runoff in an area or in other words, the quantum of relative rainwater that could have infiltrated. Hence the lesser the drainage density, the higher is the probability of recharge or potential groundwater zone. The study area drainage map is divided in to 4 classes shown in (Table 2, Map 3 and 4).

Map 3: Drainage Map of the Study Area



Map 4: Drainage Density Map of Hanur Watershed

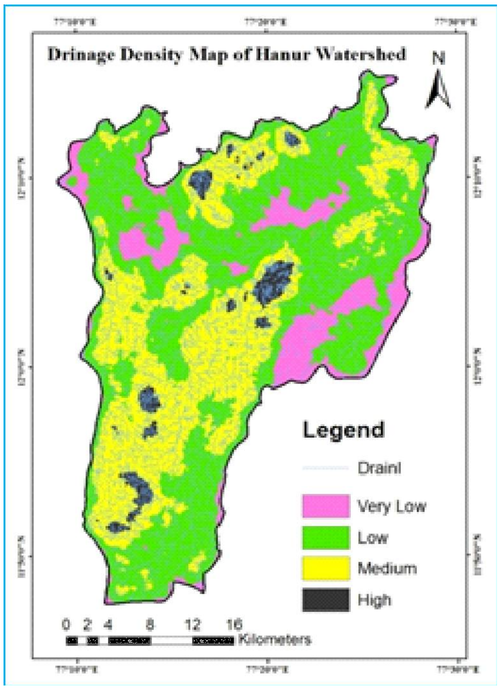


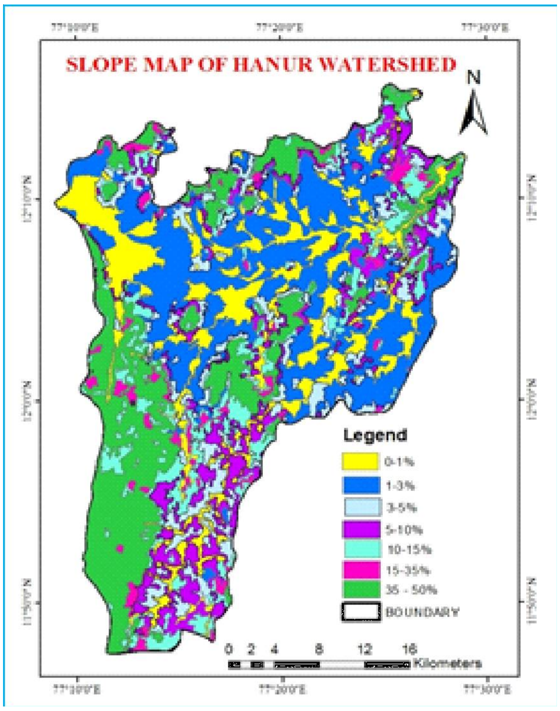
Table 2: Drainage Density Classes

Class	Km/Km^2	Drainage Density Classes
1	0-1.5	Very Low
2	1.5 - 3	Low
3	3 - 4.5	Medium
4	4.5 - 6	High

6. Slope Map

In the present study area, the slope map has been prepared from Survey of India (SOI) Toposheets on 1:50,000 scales based on the guidelines of All India Soil (AIS) and Land use Survey (LUS, 1995) slope percentage varies between 0-50 percent. On the basis of slope classes the present study area can be divided in to seven slope classes. (Table 3 and Map 5) namely 0-1%, 1-3%, 3-5%,

Map 5: Slope Map of Hanur Watershed



5-10%, 10-15%, 15-35% and more than 35 % In the nearly level slope area (0-1) degree, the surface runoff is slow allowing more time for rainwater to percolate and consider good groundwater potential zone, where as strong slope area (10-15) degree, facilitate high runoff allowing less residence time for rainwater hence comparatively less infiltration and poor groundwater potential. Most of the south western part of the study area occupies slope category of more than 15 % high degree of inclination represents steeply sloping land. Indicated by the closely spaced contour lines in this area, which is dominated by Charnockite terrain.

7. Lineament and Lineament Density

Lineament can be defined as linear or curvilinear geomorphic and tectonic structural features

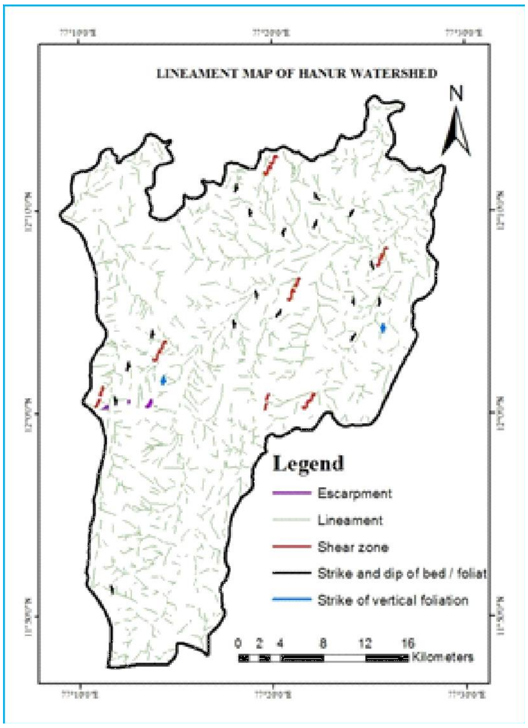
Table 3: Distribution of Slope of Study Srea in sq. km and Percentage

Slope Degree	Area in sq. km.	Area in %	Slope Category
0-1%	169	16.47	Nearly slope
1-3%	274	26.7	Slightly sloping
3-5%	103	10.03	Gently sloping
5-10%	118.4	11.54	Moderately sloping
10-15%	108.2	10.57	Strongly sloping
15-35%	36	3.5	Moderately steep to steep
35 - 50%	217.4	21.19	Precipitous sloping
Total	**1026**	**100**	

representing discontinuity of the area (El Hadani, D., 1997). Lineament is simple or complex linear marks of a surface, whose part are oriented in a curvilinear relationship and vary clearly from the pattern of neighbouring features and most probably reflect some sub surface event (O'Leary *et al*., 1976). Faults, fractures, lithologic contact can be evaluated through lineament analysis. Lineaments are the result of topographic depression, subsurface anomaly, anomalies of vegetation and hydro-system (Kassou at al., 2012). Although all linear features of naturally or anthropogenic origin are termed as lineament but 'Geological lineament' can be refers as linear features of geologic origin detected from satellite images (Arcasoy *et al*., 2004). Hobbs (1904)

Lineament density map is a measure of quantitative length of linear feature expressed in (Km/Km2). Lineament density of an area has direct influence on groundwater prospectiveness of that area. In present study area with high lineament density (1.6-2.4) having good groundwater potential where as area with very low lineament density (0-0.8) having poor groundwater potential. The entire map classified in three categories (Table 4, Maps 6 and 7).

Map 6: Lineament Map of Hanur Watershed



Map 7: Lineament Density Map of Hanur

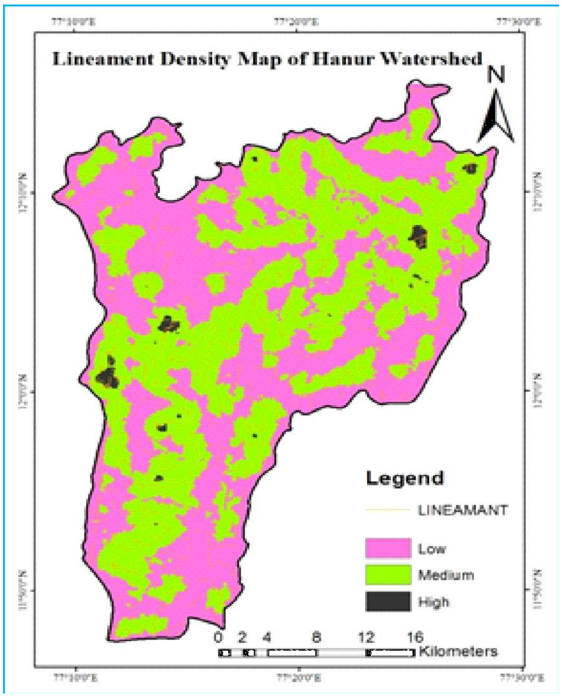


Table 4: Lineament Density Category

Class	Km/Km^2	Lineament Density Category
1	0-0.8	Low
2	0.8- 1.6	Medium
3	1.6- 2.4	High

8. Geomorphology

Geomorphology is the scientific study of landforms and landscapes. It is closely related to soil science, hydrology, geology and environmental science, Geomorphology of an area depends upon the structural evolution of geological formation. Geomorphology reflects various land form and structural features. Many of the features are favourable for the occurrence of groundwater and classified in terms of groundwater potentiality. The geomorphic units

Map 8: Geomorphology of Hanur Watershed

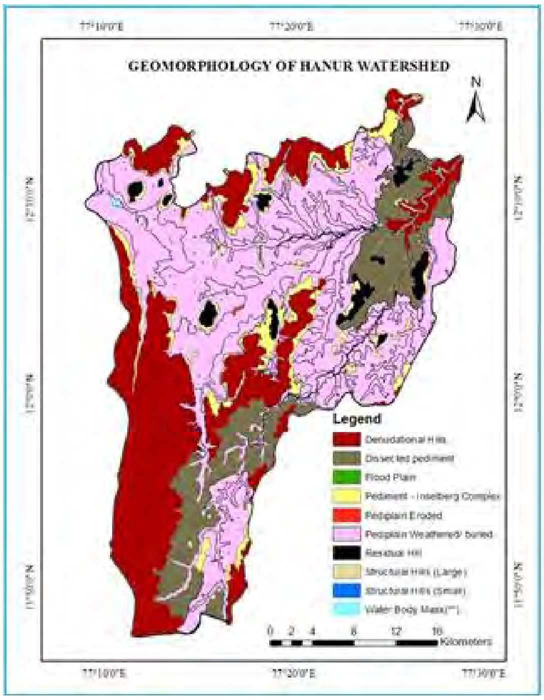


Table 5: Distribution of Geomorphological Features of Study Area in sq. km and Percentage

Landforms	Area in sq. km.	Area in %
Denudational Hills	300.00	29.23
Dissected pediment	142.73	13.91
Flood Plain	0.800	0.08
Pediment - Inselberg Complex	62.08	6.05
Pediplain Eroded	0.500	0.05
Pediplain Weathered/ buried	484.42	47.24
Residual Hill	25.00	2.43
Structural Hills (Large)	5.00	0.48
Water Body Mask(**)	5.47	0.53
Total	**1026**	**100**

of the basin can be divided into nine categories namely denudational hills, Dissected Pediment, Flood Plain, Pediment, Pediment- Inselberg complex, Pediplain, Residual Hills, Structural hills and water bodies. (Map 8, Table 5).

9. Land Use / Land Cover

Land use/land cover mapping is one of the important applications of remote sensing. Land use plays a significant role in the development of groundwater resources. It controls many hydrgeological processes in the water cycle viz., infiltration, evapotranspiration, surface runoff etc. surface cover provides roughness to the surface, reduce discharge thereby increases the infiltration. In the forest areas, infiltration will be more and runoff will be less whereas in urban areas rate of infiltration may decrease. The study area covering an area of 436.3 sq kms agricultural land, 9.88 sq kms built up land, 514.97 sq kms forest, 6.01 sq kms grass land, others 8.78 sq kms, waste land 43.5 sq kms and water bodies 7.01 sq kms (Map 9, Table 6).

Map 9: Land Use Land Cover of Hanur Watershed

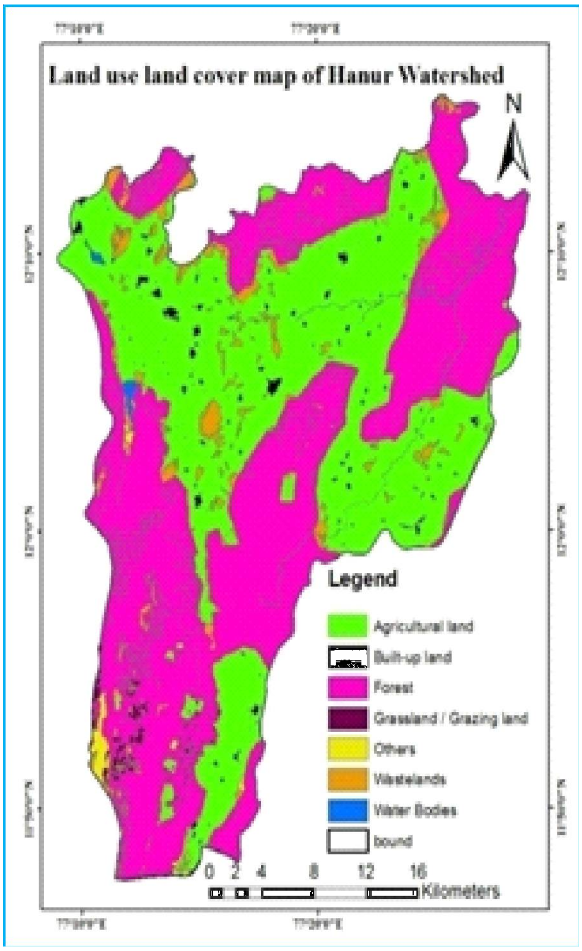


Table 6: Land Use Land Cover Details in Hanur Watershed

Description	Area in Sq kms
Agricultural land	436.3
Built-up land	9.88
Forest	514.97
grass/ grazing land	6.01
others	8.78
waste land	43.05
water bodies	7.01
Total	**1026**

10. Weightage Over Analysis

The groundwater potential zones are obtained by overlaying all the thematic maps in terms of weighted overlay method using the spatial analysis tool in ArcGIS 10.30. During the weighted overlay analysis, the ranks have been given for each individual parameter of each thematic map and the weight is assigned according to the influence of the different parameters. The weights and rank have been taken considering the works carried out by researchers such as (Krishnamurthy *et al* 1996, Saraf andChowdhary 1998).

All the thematic maps are converted into raster format and superimposed by weighted overlay method (rank and weight wise thematic maps and integrated with one another through GIS (Arc/Info grid environment).For assigning the weight, the slope and geomorphology were assigned higher weight, whereas the lineament density and drainage density were assigned lower weight. After assigning weights to different parameters, individual ranks are given for sub variable. In this process, the GIS layer on lineament density, geomorphology, and slope and drainage density were analyzed carefully and ranks are assigned to their sub variable (Butler *et al*., 2002, Asadi *et al*., 2007, Yammani, 2007).

The maximum value is given to the feature with highest groundwater potentiality and the minimum value given to the lowest potential feature. The landforms such as pediplain given highest rank and lower value are assigned for denudational hill. As far as slope is concerned, the highest rank value is assigned for nearly slope and low rank value is assigned to Precipitous slope. The higher rank factors are assigned to low drainage density because the low drainage density factor favours more infiltration than surface runoff. Lower value followed by higher drainage density. Among the various lineament density classes the very high lineament density category is assigned higher rank value as this category has greater chance for groundwater infiltration. Lower value is assigned for very low lineament density. In LuLc high rank is assigned to crop land and low value is assigned to waste land.

Table 7: Rank and Weight for Different Parameter of Groundwater Potential Zone

Parameter	Classes	Groundwater Prospect	Weight (%)	Rank
Geomorphology	Denudational Hills	Nil	30	1
	Dissected pediment	Moderate		3
	Flood plain	Good		4
	Pediment inselberg complex	Moderate		3
	Pediplain eroded	Good		4
	Pediplain weathered / buried	Very good		5
	Residual hill	Poor		2
	Structural hill	Poor		2

Table 7 (Cont.)

Parameter	Classes	Groundwater Prospect	Weight (%)	Rank
Slope Classes	Nearly slope 0-1%	Very Good	20	5
	Slightly sloping 1-3%	Good		4
	Gently Sloping 3-5%	Moderate		3
	Moderately Sloping 5-10%	Moderate to poor		2
	Strong Sloping 10-15%	Poor		1
	Moderately steep to steep 15-35%	Poor		1
	Precipitous sloping > 35%	Nil		0
Drainage density	0-1.5	Very Good	10	5
(Km/Km2)	1.5- 3	Good		4
	3-4.5	Moderate		3
	4.5- 6	Poor		1
Lineament density	0-0.8	Poor	15	1
(Km/Km2)	0.8-1.6	Good		4
	1.6-2.4	Very Good		5
Land use/ land cover	Agricultural land	Very Good	15	5
	Built-up land	Poor		1
	Forest	Moderate		3
	grass/ grazing land	Poor		1
	others	Poor		1
	waste land	Poor		1
	water bodies	Good		4
Geology	Charnockite	Moderate	10	3
	Epidote / Hornblende gneiss	Moderate		3
	Magnatite quartzite	Moderate		3
	Migmatites and granodiorite - tonalitic gneiss	Moderate		3
	Pink granulite	Moderate		3
	Pyroxene granulite	Moderate		3
		Moderate		3

Map 10: Groundwater Prospects Map of Hanur Watershed

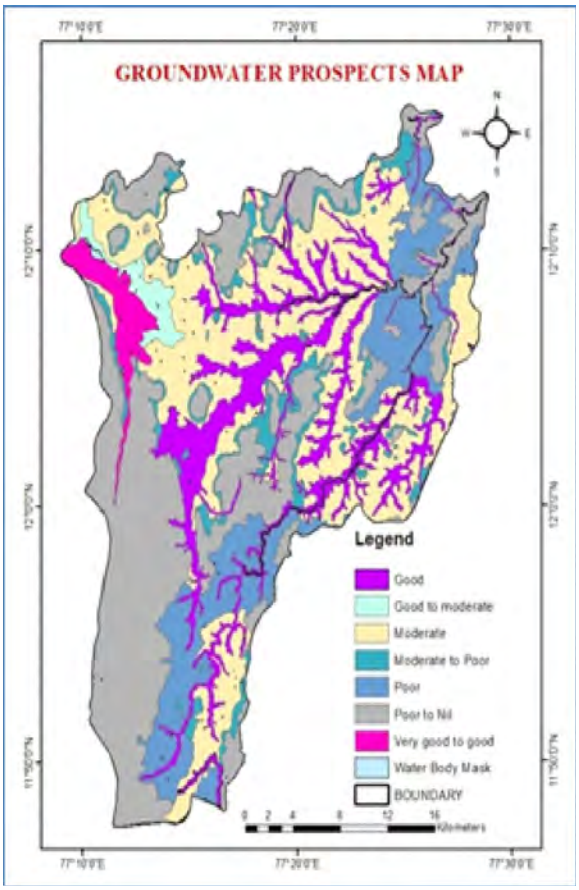


Table 8: Distribution of Groundwater Prospects Area in sq. km and Percentage

Groundwater Prospects	Area in sq. km.	Area in %
Very good to good	27.48	2.67
Good	153	14.91
Good to moderate	18	1.75
Moderate	291.85	28.44
Moderate to Poor	61.8	6.02
Poor	143	13.93
Poor to Nil	324.87	31.7
Water Body Mask	6	0.58
Total	**1026**	**100**

Conclusion

Remote sensing and Geographic Information System (GIS) approach is very constructive because this integrates various geospatial information especially for groundwater potential zone mapping. Study has focused on the effectiveness of remote sensing and GIS in the identification of groundwater potential zones of study area. The study reveals that integration of six thematic maps such as drainage density, slope, geology, geomorphology, lineament density and land use/land cover gives first hand information to local authorities and planners about the areas suitable for identification of groundwater potential zone. The present study area is classified in to Very Good to Good, Good, Good to Moderate, Moderate, and Moderate to Poor, Poor and Poor to Nil groundwater potential zones Map.10 As per Table 7 and 8, it can be seen that the Area having slope 0-10%, lineament density 1.6 to 2.4, drainage density 0 to 1.5 under Pediment- pediplain and cover with agricultural land is observed as Very good to Good groundwater potential zone and covers an area of 27.48 sq kms. The area having slope 10 to 15, lineament density 0.8 to 1.6, drainage density 1.5 to 3 under Pediment-pediplain, water body and cover with fallow land and crop land is observed as good The area covering 18 sq kms good to moderate, 291.8 5 sq kms moderate, 61.8 sq kms moderate to poor, 143 sq kms poor and 324.87 sq kms poor nil.

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