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Research Article

IDENTIFICATION OF GROUNDWATER POTENTIAL ZONES USING GIS TECHNIQUE IN SOUTH BANGALORE METROPOLITAN REGION OF KARNATAKA, INDIA

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ABSTRACT
Ground water is the most Cherished natural resources which support all environmental issues. The present work carried out to assess and identification of groundwater potential zones using Geographic Information System (GIS). Different Thematic layers like Geology, Geomorphology, Land use land cover, Slope, Soil, Drainage Density and Lineament density are generated and used in the integration to identify the ground water potential zones. Weight and Rank were assigned according to their influence based on infiltration of ground water. Ground water potential zone are classified in to five Groups like Excellent, Good, Moderate, Poor and Very Poor. The present study reveals that there exists Good zone 33%, Excellent 27%, Moderate and Poor 18% and Very Poor 4% in the study area. In the overall area 70% has good potential zone and 30% of the area has poor to very poor zone are observed.

Keywords: *Ground Water Potential, Thematic Layers, Arc GIS, Weighted Overlay*

INTRODUCTION
Groundwater is a form of water occupying all the voids with in a geological stratum. Water bearing formations of the earth's crust act as conduits for transmission and as reservoirs for storing water. The groundwater occurrence in a geological formation and the scope for it exploitation primarily depends on the formation of porosity. High relief and steep slopes impart higher runoff, while topographical depressions increase infiltration. An area of high drainage density also increases surface runoff compared to allow drainage density area. Surface water bodies like rivers, ponds, etc., can act as recharge zones (Murugesan *et al.,* 2012). The groundwater occurrence in a geological formation and the scope for its exploitation primarily depends on the formation of porosity. High relief and steep slopes impart higher runoff, while topographical depressions increase infiltrations. An area of high drainage density also increases surface runoff compared to a low drainage density area. Surface water bodies like rivers, ponds, etc., can act as recharge zones, enhancing the groundwater potential in the neighborhood (Karanth, 1987; Hrkal, 1992, 2001; Sujatha and Rajeswara, 2003; Rai *et al.*, 2005; Subramani *et al.*, 2005; Mathes and Rasmussen, 2006; El-Hames *et al.,* 2011; Rekha *et al.,* 2011; Anithamary *et al.,* 2012; Magesh *et al.,* 2012; Venkatramanan *et al.,* 2012). The present study area, which is a hard rock terrain, having undulating topography though get sufficient rainfall, suffers from water scarcity for domestic, agricultural, and industrial purposes due to limited nature of aquifers (inadequate weathered and fissured zones). Also, sometimes presence of basic and meta-basic dykes and the quartz reefs in the area have acted as barriers for the flow of water (Singh *et al.*, 1997) Groundwater is attracting an ever increasing interest due to scarcity of good quality water and growing need for domestic, agricultural and industrial uses. It has become crucial not only for targeting the groundwater potential zones, but also monitoring and conserving this important resource (CGWB, 1985).

MATERIAL AND METHODS
Study Area
The study area is situated in the Southern part of Karnataka and lies between the Longitude 77°3'57.66" E to 77°50'39.85" E and Latitude 13°7'1.33"N to 12°14'23.53"N. Survey Of India (SOI) Toposheets numbers (57G/4,8,12,16,57H,1,2,3,5,6,7,9,10,11 and 13). The study area covers about 4,125Sqkms of Bangalore and Ramanagara district. Gneissic and Granite Rock are dominantly covers in the study area.

The Catchment of South Bangalore Metropolitan region Comprises parts of Cauvery, South Pennar and Palar basins. DoddaguliHalla, DoddaHalla, Rayatmala Hole, Antaragange Hole, Kutle hole, Suvarnamukhi River, Vrishabavati River, Kanva Hole, Arkavati River, Cauvery River, ChikkatoreHalla, Shimsha River, Edakolada Halla and Dakshina Pinakini River, these are the watershed cover in the study area (Figure 1).

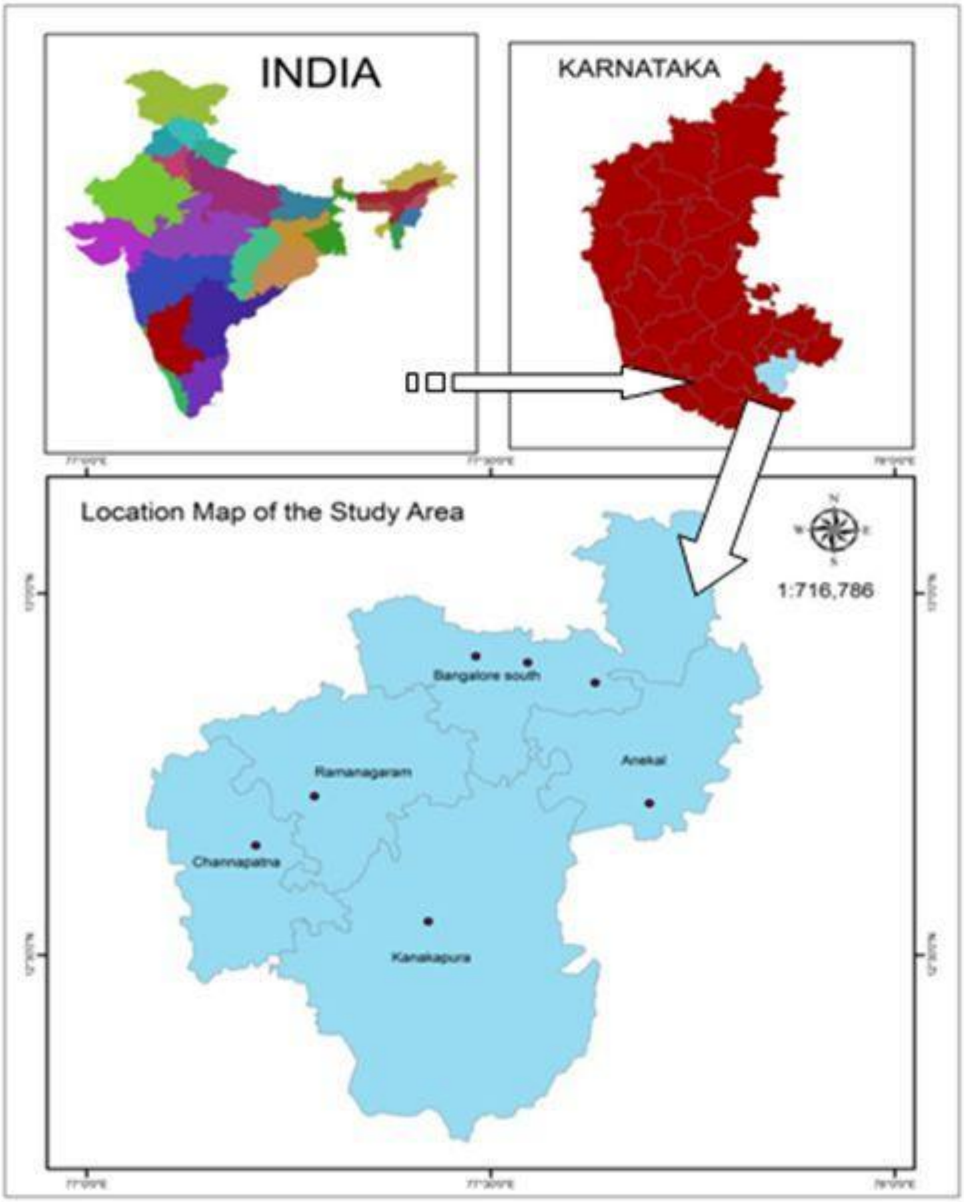
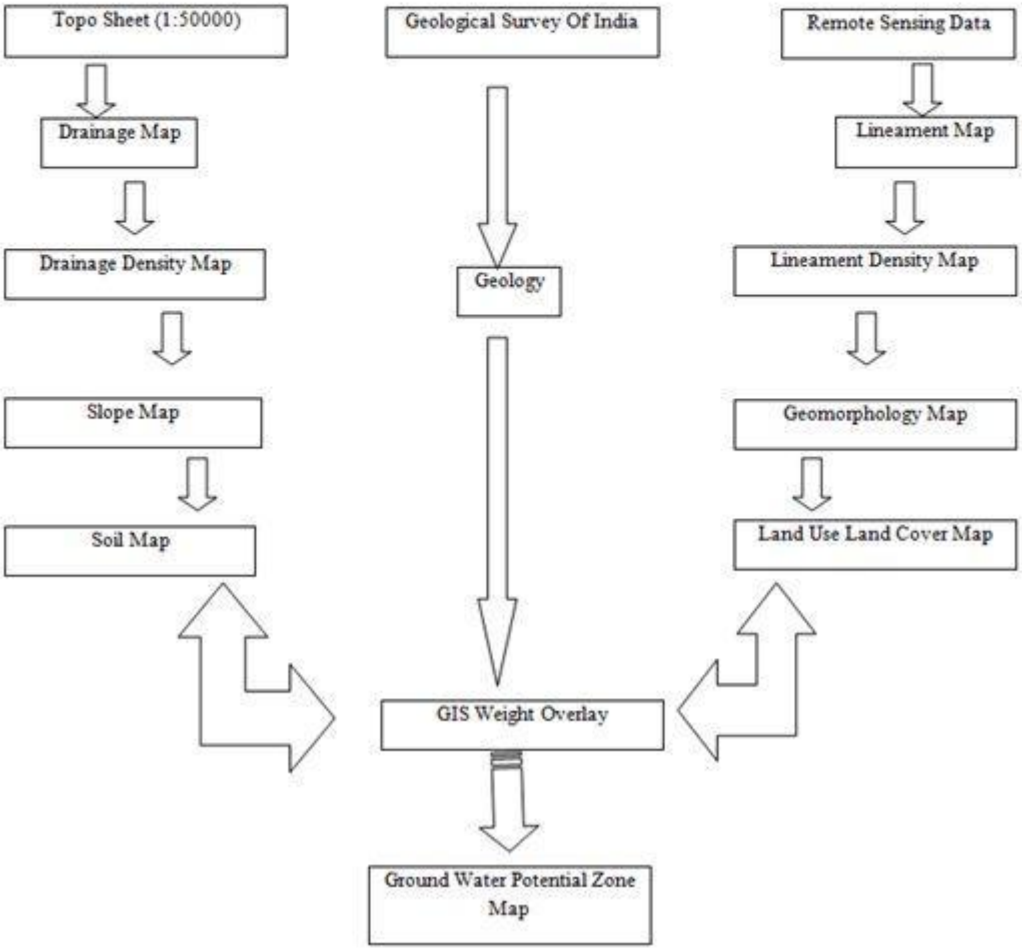


Figure 1: Location Map

Methodology

The base and drainage maps have been prepared using 1:50000 SOI topographical sheets. Drainage, Drainage Density and slope maps have been derived using topo sheet in GIS environments. Geology, Soil and Lineament maps of Geological Survey of India have been prepared using GIS. Remote Sensing Technique has been used to obtain Geomorphology, Land use land cover. All the thematic layers are integrated by intersect method using Arc GIS to identify the ground water potential zones. The details of methodology are shown in the flow chart.



Lineament Density

Lineaments area straight line is elements visible at the earth's surface as a significant "lines of landscape" (Hobbs, 1904). These are primarily are function of discontinuities on the earth surface caused by geological or geomorphic processes (Clark and Wilson, 1994). Geological features that give to lineaments include faults, shear zones, fractures, dykes and veins as wells bedding planes and Stratigraphic contacts. Geomorphic features, which appear as lineaments on the maps, aerial photographs and satellite images include streams line are valley sand ridgelines. In the present study area lineament area digitized form Geological survey of India maps. The majority of area covers dendritic drainage pattern, Major and Minor lineaments are observed, Very high Lineament density observed around 81% of the study area (Table 1). Its indicate that excellent ground water potential zone Figure (2).

Table 1: Lineament Density details

Lineament Density	Area in Sq.Km
Very High	3322.68
High	115.24
Moderate	468.11
Low	173.89
Very Low	41.99
Grand Total	4121.91

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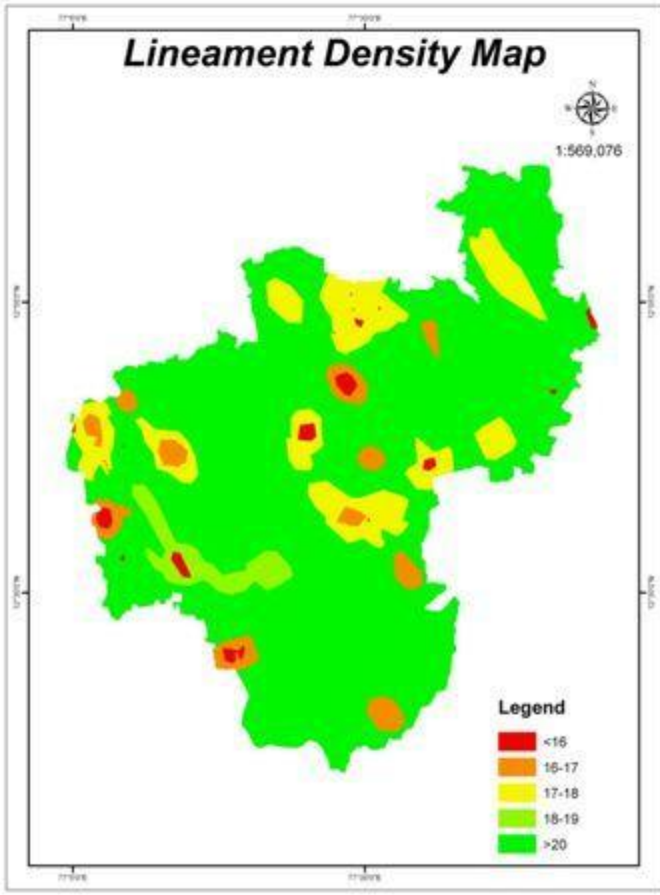


Figure 2: Lineament Density Map

Drainage Density

Drainage density is defined as the total length of streams of all orders per drainage area. Density factor is related to climate, type of rocks, relief, infiltration capacity, vegetation cover, surface roughness has no significant correlation with drainage density. The drainage density indicates the closeness of spacing of channels (Horton, 1932). According to Horton, Drainage Density is defined ratio of total length of all stream segments in a given drainage basin to the total area of that basin. It is expressed by a formula:

$DD = \sum L/A$ Where, $\sum L$ = Total length, A =Total area.

The drainage density is low in Shimsha River, Vrishabavati River & Antaragange Hole. High values observed in Kanva Hole Dodda Halla, Doddaguli Halla & Suvarnamukhi River Figure (3). In the study area, drainage density ranges between 1.942 to 136.57 Sq.Km (Table 2) (Krishna and Renuka, 2014).

Table 2: Density Density details

Drainage Density	Area in Sq.Km
1.94-4.7	693.488
4.72-8.67	2149.292
8.67-136.57	1282.945

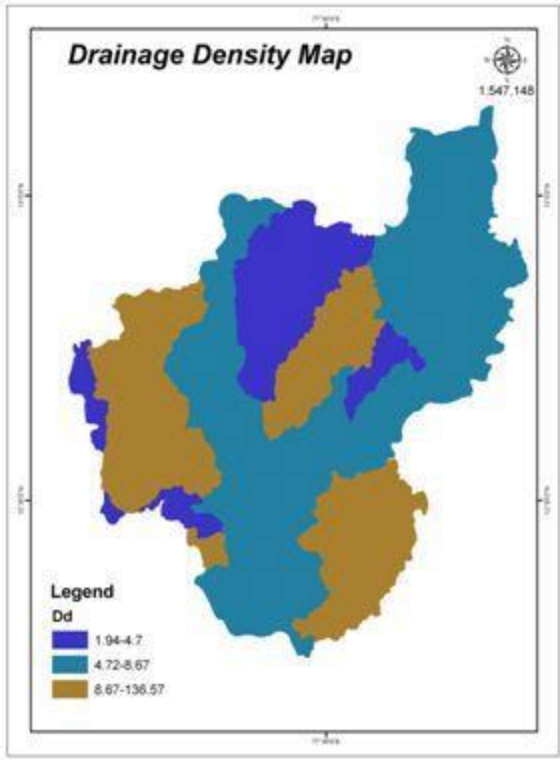


Figure 3: Drainage Density Map

E. Geology

Pitchamuthu (1969) made the area geologically famous by proposing Charnockitinsation of the Gneisses, the rock types exposed in the area belong to Sargur group, Peninsular gneissic complex (PGC), charnockits, Clospetgranite, basic and younger intrusives. Charnokite group is represented by Charnokite Sargur group comprises ultra mafic rocks, Amphibolite quartzite; banded magnetite quartzite occurring has small bands and lenses with in Migmatites and Gneisses. The PGC is the dominate unit and covers about one thirds of the area which includes granites, Gneisses and migmatietes occurs of the east and west of Closepet granite. The intrusive body trending nearly N-S within the Gneisses, it comprises grey and pink granite. The Closepet granite contains encloses of Migmatites, Gneisses, Quarzite and Amphibolite it is represented of variable composition. The basic intrusive are represented Dolerite, Gabbro occasionally Norite and Pyroxenite. Dolerite is the dominant basic dyke they occur in the prominent trends is N-S & E-W to ESE-WSW. Gneisses and migmatites of PGC (Archaean) which range from 2900 to 2500 million years closepet granite is intruded into the older rocks during the late Archaean period about 2500 million years. The lower Proterzonic basic dyke are dated 2400 million years and upper Proterozic dykes as felsite, felsite porphyry and lamprophyre are the youngest intrusive and dated at 800 million years.

In the study area laterite formation in Cainozoic age, quartz vein, felsites, felsites porphyry, Lamphrophyre and Potassic rock, these are the younger intrusive formation in upper Proterozoic age, Basic dyke are the basic intrusive. Pink and Grey granite are the Closepet granite its formation under Lower Proterozoic in age. Gneiss / Migmatite / Granite this are Peninsular Gneissic Complex, Quartzite, Amphibolite / Homblende schist formation are Sargur group of schist belt and Charnockite formation in Charnockite group Rock, these group under the age of Archaean. In the study area Gneiss (68%), Pink and Grey Granite (28%) rocks are dominantly spread in the study area (Table 3). Gneiss and Granite rock are more suitable for of Ground water accumulation Figure (4).

Table 3: Geology details

Geology	Area in Sq.Km
Quartzite	9.18
Gneiss	2812.691
Granite	47.27
Pink & Grey Granite	1131.971
Amphibolite / Homblende schist	2.217
Laterite /Migmatite/Falsite/Ultra Potassic Rock	9.944
Charnockite	114.683
Grand Total	4127.956

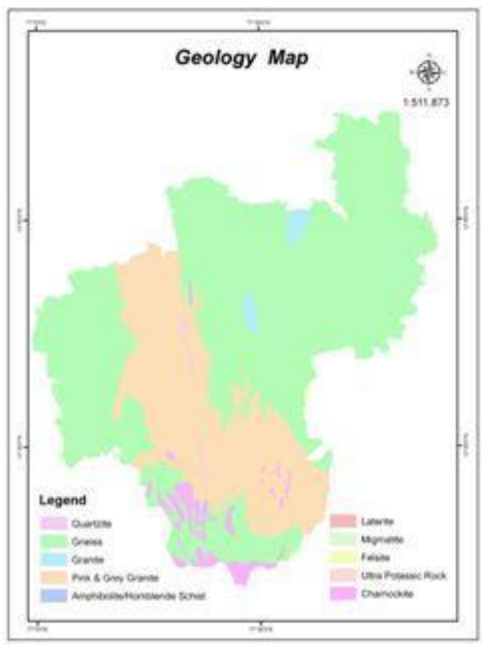


Figure 4: Geology Map

A. Geomorphology

Geomorphological area can be divided in to uplands plateaus and pediplanes. The region part of the area in covered by denudational plateaus and pediment – pediplanes complex covered by NNE- SSW trending hills of the intermittent plains, isolated granitic hills constitute hog-backs. Laterite covered flat topped hills in the northeastern part of plateaus. Bangalore situated on N-S trending highland with an average altitude of 930 meter above Mean Sea Level. It forms between the River Arkavatian in the west, Pinakini in the east, the ground water occurrence movement of recharge aquifers are controlled by the degree of weathered and fractured, as these hard cry stalling back primary porosity of the weathered. The fractured granite and gneisses constitute principal aquifers in the area, the chief source of recharges in seasonal rainfall and seepage from river, reservoirs and tanks.

The Various Types of Geomorphological features were found pediments and Pediplain, Valley flat, Hills valleys Denudational Plateaus and Denudational Hills. Hills / Valleys (31%), Pediplain and Pediments (28%), Denudational Plateaus (28%) dominantly spreads in the study area (Table 4). Pediplain and pediments are flat surface with good weathered profile covering thick vegetation. These types of thick vegetation are very helpful and acts as important role for ground water infiltration Figure (5).

Table 4: Geomorphology Classes details

Geomorphology	Area in Sq.Km
Pediments/Pediplain	1169.42
Valley Flat	231.225
Hills Valleys	1285.258
Denudational Plateaus	1150.331
Denudational Hills	288.637

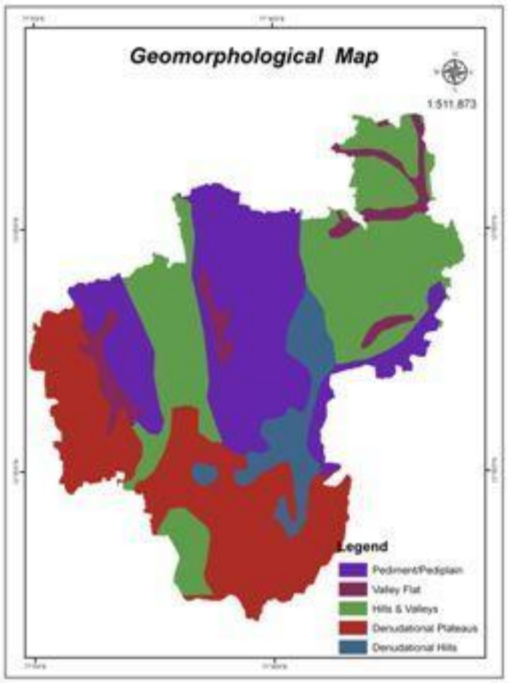


Figure 5: Geomorphological Map

B. Land Use Land Cover (LuLc):

Land use land cover features are dominant in the development of ground water resources, it control hydrological activity like infiltration Evapotranspiration and Runoff. Agricultural lands are reducing and discharge thereby increase in the infiltration. In the forest area infiltration is more and run off will be less. Agricultural Land (59%), water bodies / Wetlands (16%), Forest (15%) and Built-up land (10%) are showing the percentage of area covering in the study area (Table 5) Figure (6).

Table 5: Land use Land Cover details

LuLc	Area in Sq.Km
Agricultural Land	2448.8
Forest	617.41
Grassland/Grazing land	7.038
water bodies / Wetlands/others	653.017
wastelands/Build up land	398.507

Grand total	4124.772

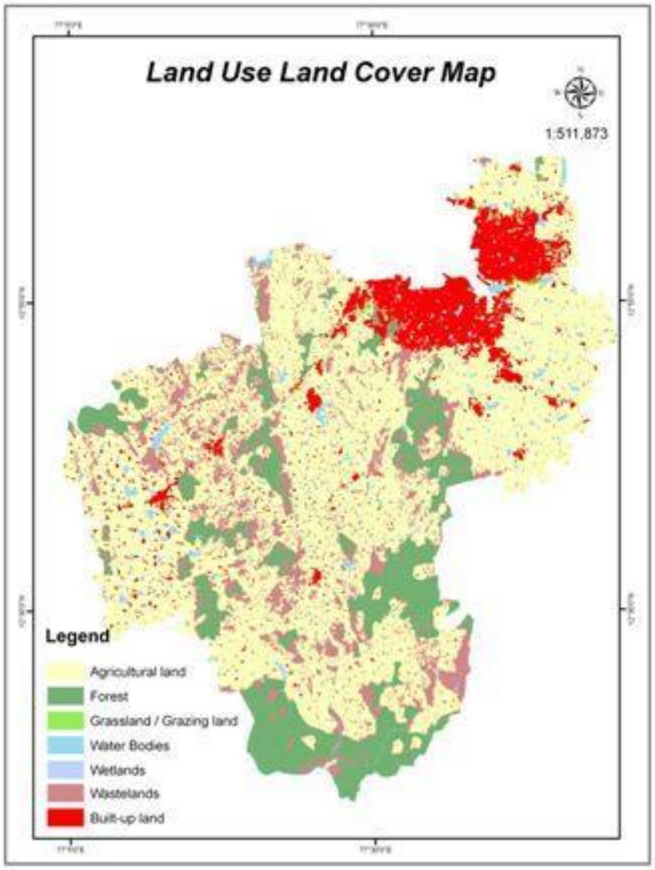


Figure 6: Land Use Land Cover Map

C. Slope

Slope may be defined has the concept of the terrain parameters which is explained by horizontal spacing of the contour in the study area, there are five groups depending upon terrain, the lower slope values indicates the flatter terrain (Gently slope between 0-5 %) and higher slope values (steeper slope between 15-35%). Slope is measured by identification of maximum rate of changing value for each cell to neighboring cells vise percentage nearly too very gently slope. In the gently slope area the surface runoff less and rain water to percolate and consider as recharge and good ground water potential zone. Whereas steeper slop facilitate high runoff and less infiltration. Nearly too very gently slope 0-5 (73%), gently to Moderate Slope 5-10 (10%), Strong Slope 10-15(9%) covers in the study area (Table 6) Figure (7).

Table 6: Slope details

Slope %	**Area in Sq.Km**
0-5	3003.693
5-10	432.017
10-15	349.652
15-35	163.319
>35	176.098

Grand Total	4124.779

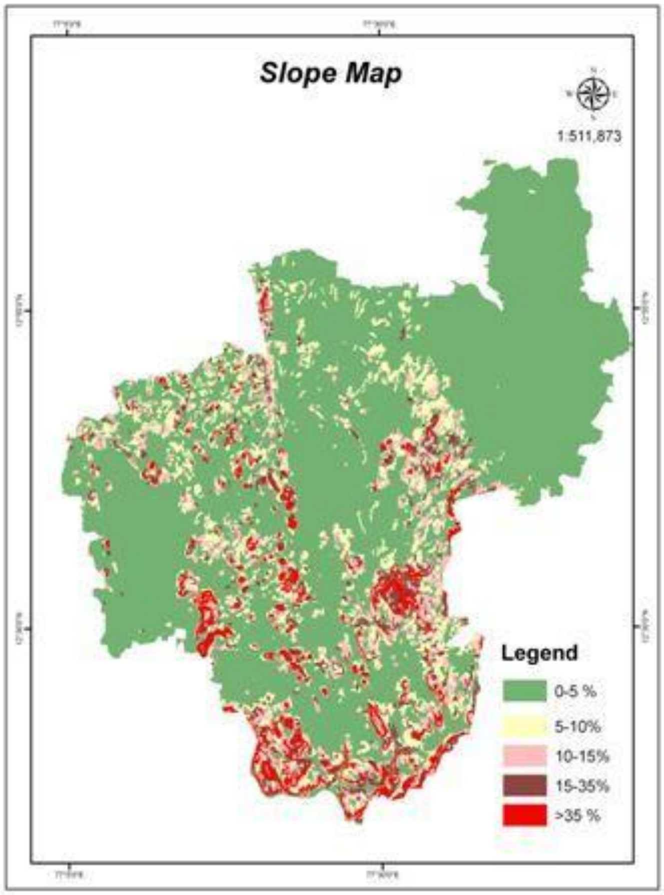


Figure 7: Slope Map

D. Soil

Hydraulic properties of soil play an important role in movement of soil moisture form ground surface to water table through unsaturated zone. Different types of soil layers are present in the study area they are Red sandy soil, Red Loamy soil and Lateritic soil. For the ground water movements Red sandy and red loamy soil is very helpful. Red Sandy Soil (50%), Red Loamy Soil (20%) and Laterite Soil (30%) cover in the area (Table 7) Figure (8).

Table 7: Soil and Area

Soil	**Area in Sq.Km**
Red Sandy	2060.575
Red Loamy	836.443
Laterite	1228.192
Grand Total	4125.21

E. Ground Water Potential Zone

Table 8: Rank and weight for different Thematic Maps

Sl.No	Thematic Layers	Classes	Rank	Weight age
1	Geomorphology	Pediments/Padiplain	5	25
		valley Flat	4	
		Hills Valleys	3	
		Denudational Plateaus	2	
		Denudational Hills	1	
2	Slope %	0-5	5	20
		5-10	4	
		10-15	3	
		15-35	2	
		>35	1	
3	LULC	Agricultural Land	5	15
		Forest	4	
		Grassland/Grazing land	3	
		water bodies / Wetlands/others	2	
		wastelands/Build up land	1	
4	Structural	<16	5	15
		16-17	4	
		17-18	3	
		18-19	2	
		>20	1	
5	Soil	Red Sandy	5	10
		Red Loamy	4	
		Laterite	3	
6	Drainage density	1.94-4.7	5	10
		4.72-8.67	4	
		8.67-136.57	3	
7	Geology	Quartzite	5	5
		Gneiss	5	
		Granite	4	
		Pink & Grey Granite	4	
		Amphibolite/Homblende schist	3	
		Laterite /Migmatite/Falsite/Ultra Potassic Rock	2	

Charnockite	1

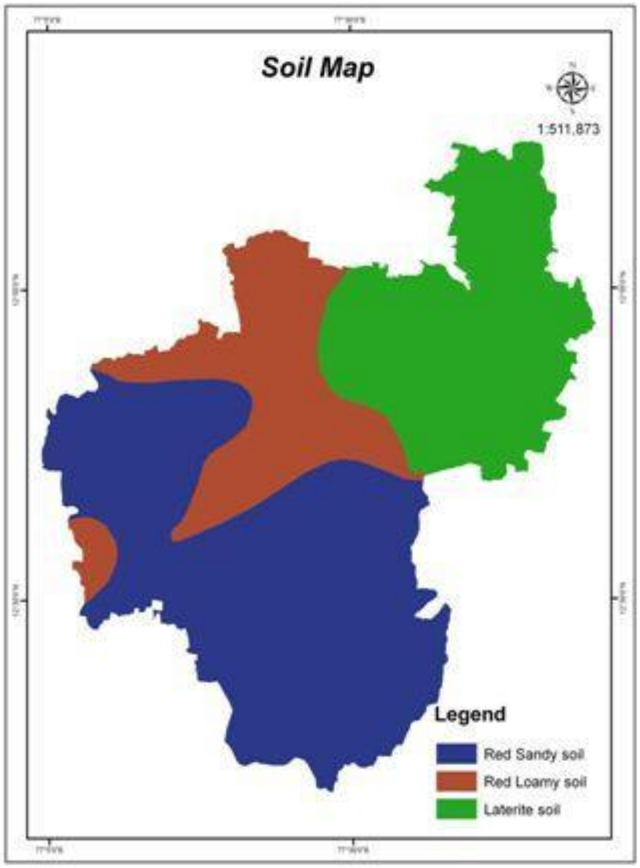
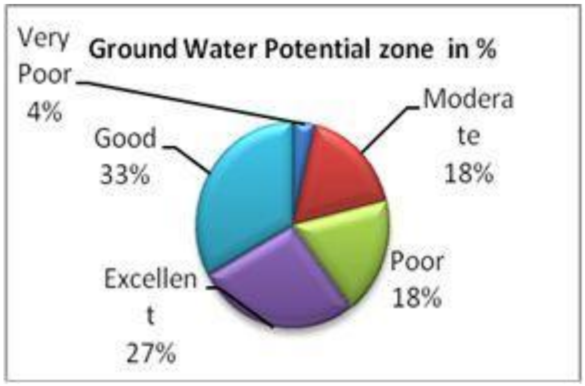


Figure 8: Soil Map

Table 8: Ground water Potential zone and Pie chart details:

Ground water Potential zone	Area Sq.Km
Excellent	1128.714
Good	1362.319
Moderate	718.033
Poor	756.8026
Very Poor	156.531
Grand Total	4122.3996



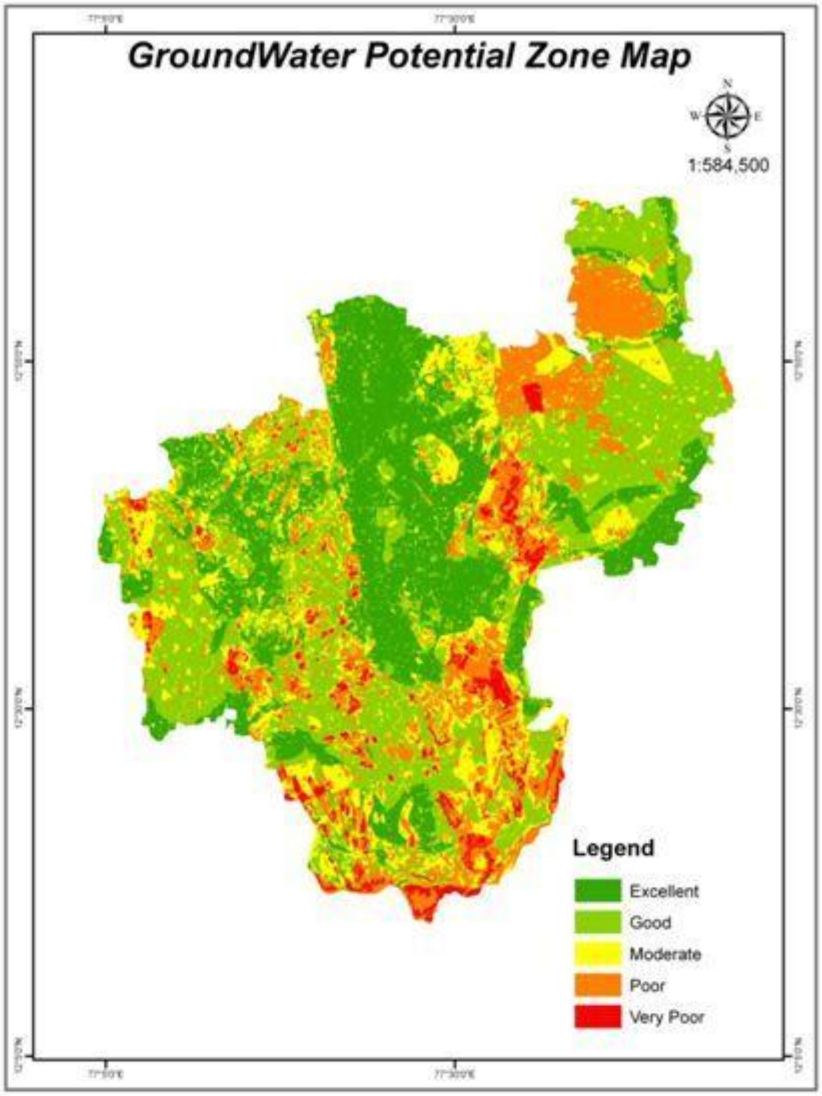


Figure 9: Groundwater Potential Zone Map

The ground water potential zones are obtained by overlaying all the thematic maps in terms of weighted overlay method using the spatial analysis tool in Arc GIS 10.1. During the weighted overlay analysis, the ranks have been given for each individual parameter of the each thematic map and the weight is assigned according to 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 (Krishnamurthy *et al.,* 1996, Saraf and Chowdhary, 1998) to the influence of the different parameters. The weights and rank have been taken considering the works carried out by researchers such as all the thematic maps are converted in to raster format and superimposed by weighted overlay method (rank and weight wise thematic maps were integrated with one another through GIS ArcInfo grid environment). For assigning the weight, the slope and geomorphology were assigned higher weight, where as 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 of lineament density, geomorphology, slope and drainage density were analyzed carefully and ranks are assigned to their sub variable (Butler *et al*., 2002, Asadietal, 2007, Yammani, 2007).

Application in Ground water Studies, Identification of ground water potential zones in Cauvery sub water shed, Karnataka, India. Thematic layers of Geology, Geomorphology, and Land use land cover, Slope, Soil, Drainage Density and Lineament density. These standard thematic layers are proposed to determine the ground water potential zone Using RS and GIS Technique. These thematic layers integrated with one layers to another layer by overlay method in Arc GIS. Suitable weights and ranks for each class. Weight and Rank are given based on infiltration of ground water. Ground water potential zone are classified in to five Groups like Excellent, Good, Moderate, Poor and Very Poor. In the ground water potential zone map. In the present study area for ground water potential zone grouped in to five classes those are Good 33%, Excellent 27%, Moderate and Poor 18%, Very Poor 4%. In the overall area 70 % good potential zone and 30 % of the area poor to very poor zone are observed (Table 8) Figure (9).

Conclusion

Geographical information system and remote sensing applications are power full tools and cost effective method for identification of ground potential zone. In the study area we assigned rank and Weightage for individual layers of features depending upon different grade of infiltration. Integration method are used for the seven layers like Soil, Slope, Geology, Geomorphology, Land use Land Cover, Drainage density and Lineament density, these thematic layers are very help full to identify the ground water potential zone. Major and Minor lineaments are observed in the study area. Very high Lineament density observed around 81% of the study area, its indicate that excellent ground water potential zone in the area. The drainage density has been calculated and ranges between 1.942 to 136.57 Sq,Km. Gneiss (68%), Pink and Gray Granit (28%) rocks are dominantly spread in the area. Gneiss and Granite rock are more suitable for identification of Ground water potential zone. Pediplain and Pediments (28%), Denudational Plateaus (28%) dominantly spreads. Agricultural lands are reduce discharge thereby increases the infiltration of ground water. In the forest area infiltration more and run off will be less. In the gently slope area (0-5) degree, the surface runoff less and rain water to percolate and consider for good ground water potential zone. Whereas steeper slop area (15-35) degree, facilitate high runoff and less infiltration. For the ground water movements Red sandy and red loamy soil is very helpful to identify the ground water potential zone.

Identification of ground water potential zones in Cauvery sub water shed, Thematic layers of Geology, Geomorphology, Land use land cover, Slope, Soil, Drainage and Lineament density. These standard thematic layers are proposed to determine and identify the ground water potential zone using Remote Sensing and GIS Technique. These thematic layers integrated with one layers to another layer by overlay method in Arc GIS. Suitable weights and ranks for each class are given based on infiltration of ground water. In the present study area for ground water potential zone grouped in to five classes they are Good 33%, Excellent 27%, Moderate & Poor 18% and Very Poor 4%. In the overall area 70% has good potential zone and 30% of the area has poor to very poor zone are observed by overlay method to delineate the groundwater potential zones. Ground water potential zone are classified in to five groups they are Excellent, Good, Moderate, Poor and Very Poor. The final Groundwater Potential zone map (figure 9), Red colour indicate Very Poor Zone and Green colour Indicate excellent zone in the study area. Moderate to poor zones in the study area has to be improved. The ground water potential information will be useful in hard rock terrain for ground water recharge in different technique they are Surface spread techniques like Flooding; Ditch and furrows; Recharge basin. Run-off conservation structures like Gully plugs; Bench terracing; Contour bund; Nala bund; Percolation tank ; Individual well recharge, Stream modification; Surface irrigation. Sub-surface techniques are Injection wells; Gravity head recharge wells; Aquifer Storage and Retrieval (ASR); Soil Aquifer Treatment (SAT); Indirect methods are Induced Recharge Pumping wells; Collector wells; Infiltration gallery, Aquifer Modification like Bore blasting; Hydrofracturing and Combination methods like Groundwater conservation, Structures, Groundwater dams, underground bandharas; Fracture sealing cementation techniques (FSC).

Hence the present approach was built with logical conditions; this approach can be successfully used elsewhere with appropriate modifications. Thus, the above study has clearly demonstrated the capabilities of remote sensing technique and GIS in demarcation of the different ground water potential zones (Figure 9).

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