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IDENTIFICATION OF GROUNDWATER POTENTIAL ZONE USING REMOTE SENSING ANDGIS TECHNIQUES FOR MANDYA TALUK

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ABSTRACT

A remote sensing and geographic information system (GIS) approach was used to define favourable regions for the construction of artificial recharge structures in Mandya in order to increase the well's longevity and stop the decreasing groundwater level patterns. Eight layers, including geology, geomorphology, slope, and topography, were analysed using GIS overlay analysis. Groundwater is a vital source of drinking water and agricultural water for the rural population, so adequate groundwater development is critical. The AHP-analytical hierarchical methodwas used in conjunction with a geographic information system (GIS) to map and evaluate groundwater yield potential in the Mandya taluk in this study. AHP has been extensively studied and it represents an accurate approach to quantifying the weights of decision criteria. The groundwater potential zone map thus obtained was categorized into five classes-very high, high, moderate, low and very low.

I. INTRODUCTION

India is the world's largest consumer of groundwater. More than 60% of agricultural activities depend on groundwater, and more than 85% of people rely on it for drinking water [Mohanavelu Senthilkumar et.al, 2019].Groundwater depletion has caused water levels to rise and shallow groundwater abstraction systemsto dry out over time. Apart from demand side control, artificial recharge and rainwater harvesting may be used to solve the issues. The constant depletion of groundwater for different purposes (irrigation, domestic, and industrial) has resulted inlower groundwater levels, a long-term decline trend, and even the drying up of wells. Central and state agencies are successfully implementing various initiatives such as rainwater harvesting, artificial recharge, and water use quality. However,determining the best position and structure for artificial recharge schemes is critical to their success. To classify possible groundwater areas, several researchers used an integrated geographic information system (GIS) and remote sensing techniques. In order to determine areas of possible groundwater and locate sites for artificial recharge, remote sensing and GIS cover a large and inaccessible region of the earth's surface in a short amount of time.

Factors influencing ground water Porosity-One thing that affects how groundwater actions is the porosity of a soil. This is the quantity of water the soil can hold. You can think about porosity because the areas among debris, similar to the areas in a jar of jelly beans. All of these nooks and crannies in among the portions of sweet are the pores - the bigger the open areas, the greater porous it is. The length and form of the soil debris decide porosity on this equal way. When debris areapproximately the equal length and form, there have a tendency to be large open areas because the debris do not suit collectively very well. Clay and sand are each very porous substances for this reason. On the alternative hand, sediment like limestone is much less porous due to the fact the debris suit collectively like puzzle portions, ultimate up the ones pores. What does this need to do with groundwater? Well, the greater porous the sediment, the greater water it could hold. The greater water it could hold, the greater water can flow down into the ground.

Permeability-Porosity tells us how tons water the soil can take in, however now no longer how rapid it does so. We name the fee of water infiltration into the floor permeability. To higher apprehend this, think abouta sponge and a rock. A sponge may be very permeable as it absorbs water very quickly. A rock on the opposite hand, isn't very permeable as it virtually does not soak up water thoroughly at all. Soil is the identical way - a few sediments without difficulty soak up water, at the same time as others do now no longer. Turns out that despite the fact that it is able to maintain plenty of water, it is now no longer very permeable, so it takes a long term to soak up it. Sand, on the opposite hand, is each porous and permeable. **Drainage density** is taken into consideration to be an vital index; it's far a degree of the feel of the community, and shows the stability among the erosive strength of overland float and the resistance of floor soils and rocks. Drainage density performs a completely essential function in groundwater availability and contamination. The drainage community relies upon on lithology and it presents an vital index of infiltration rate.

RS and GIS are widely used to prepare and integrate different types of thematic layers. The combination of these dual methods has proven to be an effective means of harvesting GWP and different studies have been shown in different parts of the world proposed AHP as a method to resolve socio-economic issues in decision-making that were used to solve an extensive variety of difficulties (Jha et al. 2010; Krishnamurthy et al. 2000). AHP provides a technique for input the different issues to measurements to solve the decision-making problems when the dimensions are independently using to derive priority scales between the various thematic maps (Mundalik etal. 2018; Kadam et al. 2018). Saaty's (1999) states that AHP not only gives priority to the features but also to the groups of elements that are frequently needed. The AHP offers a method for multi-criteriaassessment of specific context with which a uniquealternative to common criteria can be measured(Kanagaraj et al. 2019).

Numerous researchers are utilized decision making approaches like MCDA, MIF and AHP for different applications rather than the above technique, for example, identification of artificial recharge structures (Rajasekhar et al. 2019) and locating recharge sites for different hydrological components, watershed characteristics and sustainable development and watershedmanagement (Mogaji 2016).

II. Study area

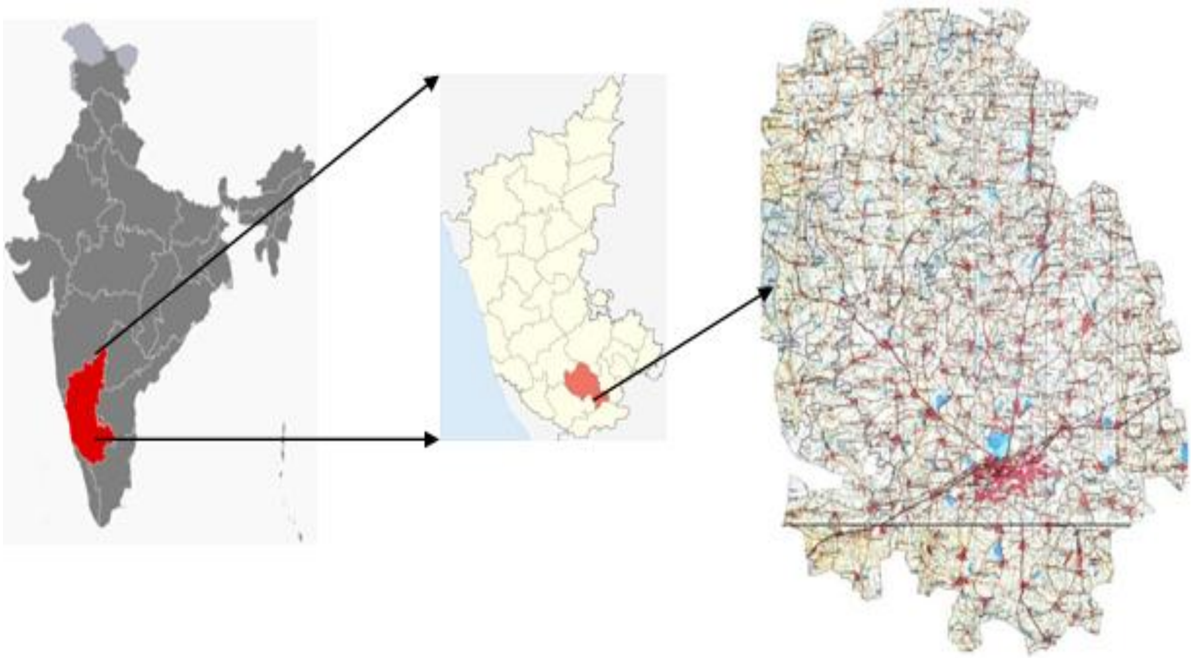


Figure 1: Study area.

Mandya taluk has an advantage of command areaof two canals/reservoir-krishnaraja sagara and Hemavathi. The average rainfall -795 mm with temperature variation 18 ºC -31ºC and Potentialevaporation – 1581 mm. MANDYA receives about80% of the annual rainfall during the South-West monsoon period (June to September), 12% during the post-monsoon period (October to December), 7% during the summer season (March to May) and only 1% rainfall is received during the winter season (January to February). Mandya experiences semi-arid type of climate. There are three seasons namely, summer, rainy and winter seasons, respectively. Summer season is hot and dry while, winter is cool and pleasant. From March to May it is summer in Mandya. Availability of canal water makes the district ever green. The district comes under Southern Dry zone (Zone-7). The maximum rainfall occurs in the months of May, September and October. Kharif season receives 38 per cent rainfall and 36 per cent of rainfall is received during Rabi season.

Water availability-0.48768 BMC, the total water demand is 0.582 BMC. Gross irrigated area under canal/reservoir- 23268 hect. Irrigation through bore wells, tube wells, tanks is not popular.-Although taluk has tanks-95, bore well-2024, tube wells- 4180, the area irrigated by is substantially less.Agricultural area with one half having irrigated dominantly grows paddy and sugarcane. The other half depends on rainfall alone. There is **excellent slope** to strength the irrigation through tanks, bore well as well as through other water harvesting structure

A. METHOD

III. METHOD AND METHODOLOGY

ArcGIS is a geographic information system (**GIS**) for working with maps and geographic information maintained by the Environmental Systems Research Institute (ESRI). It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web**.** Landsat 8 is one of the Landsat series of NASA (National Aeronautics and Space Administration). The data of Landsat 8 is available in USGS (United States Geological Survey) Earth Explorer website at free of cost. Landsat 8 satellite images the entire earth once in 16 days. In

B. Methodology

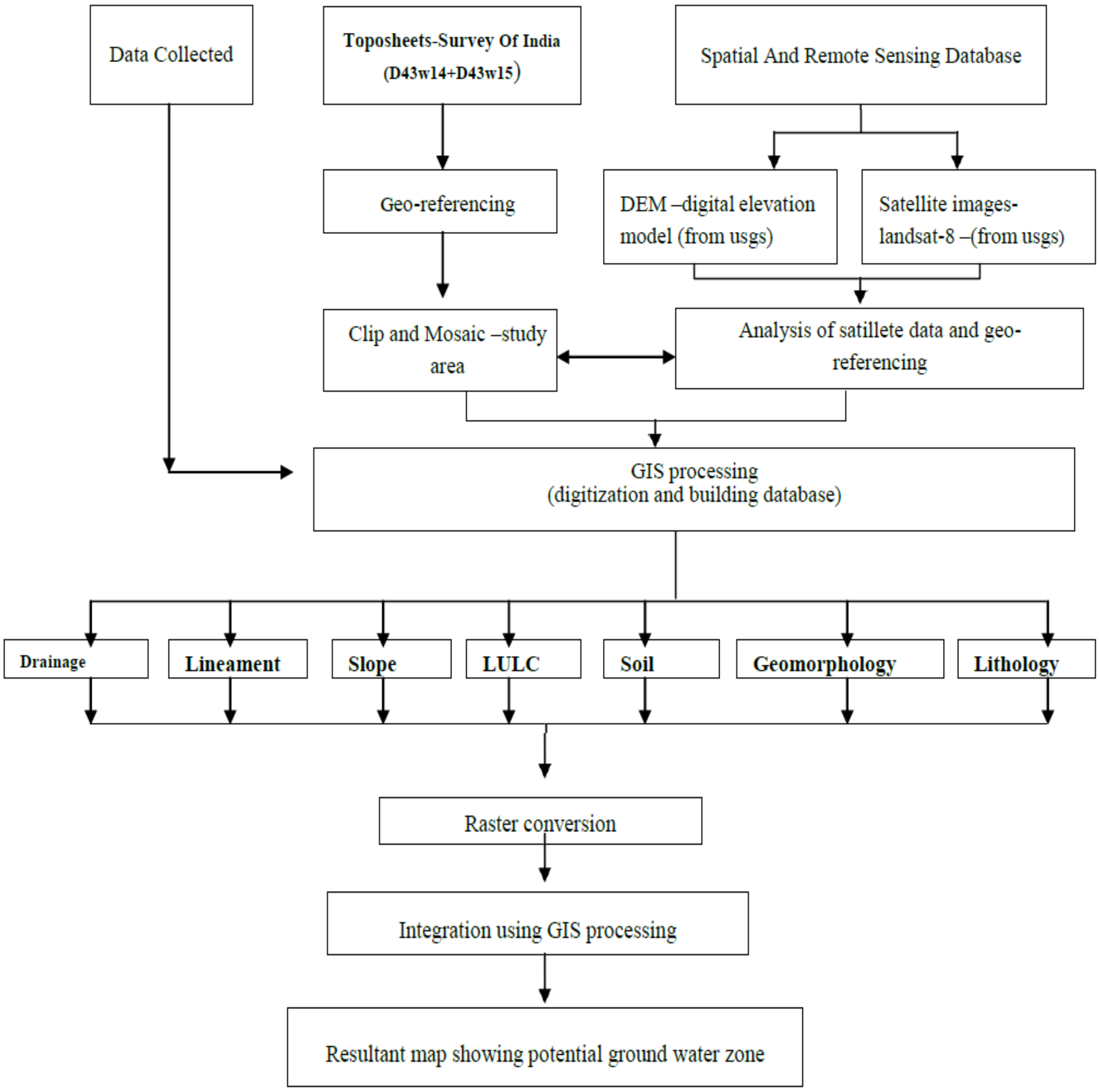


Figure 2: Methodology adopted in the study.

- This approach involves preparation of different thematic maps (resource maps) by using remote sensing data and/or by conventional sources.
- The critical analysis of thematic maps derived from satellite data interpretation and other collateral data leads to identification of problems and potentials of each of the thematic information in terms of its availability, sensitivity, severity and criticality of the resources for the optimum utilization of the resources.
- Combining these thematic layers under GISenvironment using a set of logical conditions

Analytical Hierarchical Process

The analytical hierarchy process (AHP) -. Thisapproach has four very important steps:

(1) Standardization of the assessment criteria,
(2) generation of a comparison matrix in pairs including all the thematic layers (weighting of the evaluation criteria),
(3) Verification of the incoherence of theelaborated matrix, and
(4) Aggregation of weighted decision criteria

IV. RESULT AND DISCUSSIONS

1. DRAINAGE MAP

In geomorphology, drainage systems, additionally referred to as river systems, arethe patterns formed through the streams, rivers, and lakes in a specific drainage basin. The number, size, and form of the drainage basins located in a place range andthe bigger the topographic map, the extra information on the drainage basin is available. Drainage density is taken into consideration to be an critical index; it's miles a degree of the texture of the network, and suggests the stability among the erosive strength of overland flow and the resistance of surface soils and rocks Drainage basins characterized via way of means of impermeable rock and soils have a tendency to have better drainage density because of the dearth of infiltration and percolation. Conversely, drainage basins with permeable rock and soil types have a tendency to have low drainage density.

2. Slope map

A map indicating the topography of a place in conjunction with an evaluation of topographic features as they've prompted and might preserve to persuade land development. Slope. The slope is asignificant terrain feature which explicit thesteepness of the ground surface. Slope gives vital information on the character of the geologic and geodynamic processes working at regional scale Surface run - off and rate of infiltration are stimulated basically through slope of the surface. Larger slopes produce smaller recharge due to the fact the water acquired from precipitation flows unexpectedly down asteep slope at some stage in rainfall.

3. Lineament map

A **lineament** is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault. Typically a lineament will appear as a fault-aligned valley, a series of fault orfold-aligned hills, a straight coastline orindeed a combination of these features.Fracture zones, shear zones and igneousintrusions such as dykes can also be expressed as geomorphic lineaments Lineaments could be mapped using satellite imagery by visually detecting contrasting color, tone and texture patterns in a volcanic region.

Applying these helpsto understandthe groundwater flow**Lineament Density.** Lineaments are structurally controlled linear or curvilinearfeatures. It can be identified from thesatellite imagery by their relatively linear alignments. Lineaments represent the zones of faulting and fracturing resulting inincreased secondary porosity andpermeability. Lineaments of the study area are extracted from IRS LISS-III satellite data using automatic lineament extractionmethod. The lineament density map wasthen prepared using line density in GIS software.

4. Map

Lithology describes the geochemical, mineralogical, and physical properties of rocks. It plays a key role in many processes at the Earth surface, especially the fluxes of matter to soils, ecosystems, rivers, and oceans.

5. Geomorphology map

Mapping is regarded as a essential approachof the field generating treasured base records for geomorphologic and environmental studies and practice. Geomorphologic maps may be taken into consideration graphical inventories of a panorama depicting landforms and floor in addition to subsurface materials. Geomorphology. Geomorphology represents the landform and topography of an place, and is one of the fundamental elements used broadly for the delineation ofgroundwater capability zones. It offers statistics approximately the distribution of numerous landform functions in addition to tactics like temperature changes, geo - chemical reactions, motion of water,freezing and thawing etc. The highland place of the take a look at place includes hilly terrain and undulating surfaces. However, the lowland place consistsusually of lightly undulating surfaces. The fundamental geomorphic functions of the take a look at place are the decrease lateritic plateau, denudation hills, valleys and water bodies. The dissemination and variety of the morphological functions are especially adaptable with respect to.

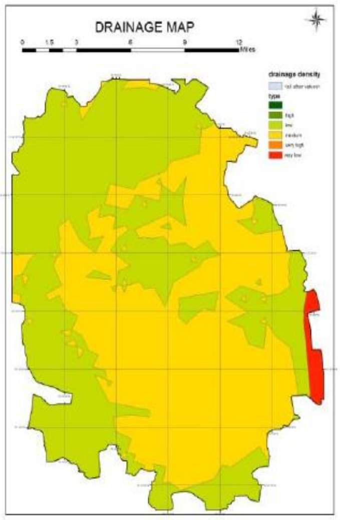
6. Soil Map

Soil. Soil types play an important role on the amount of water that can infiltrate into the subsurface formations and hence influence groundwater recharge. The soil texture and hydraulic characteristics are the main factors considered for estimation of rate of infiltration.. The details of the soil categories identified in the basin as per the scheme of National Bureau of Soil Survey (NBSS) and Land Use Planning (LUP), India.

7. Land use land cover

The land use and soil provides information on infiltration, soil moisture and vegetation. Remote sensing and GIS offer dependable and more precise baseline information for LULC mapping. Landsat & Operational Land Imager images of 2020 were used for Land use land cover mapping. Predominantly the area is characterised by the wet crop (water intensive crops like paddy, sugarcane & banana), plantation and dry crop (agricultural field) and accountsfor 80% of the total area of the aquifer system. This area is highly suitable for water conservation and recharge. The ranks were devised to the individual LULC type, according to its individual features influencing the groundwater recharge,holding and its occurrence.

(a)



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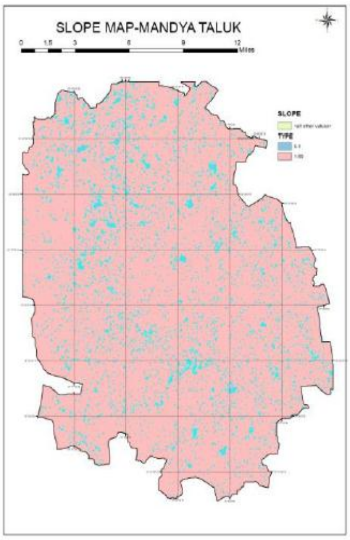

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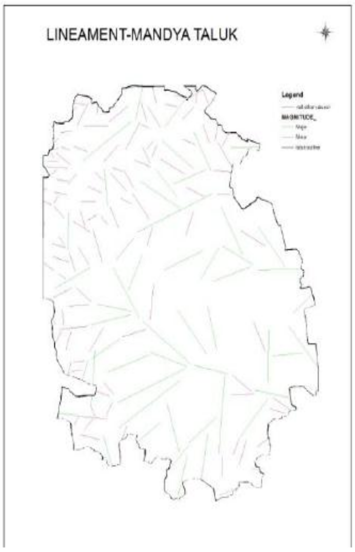

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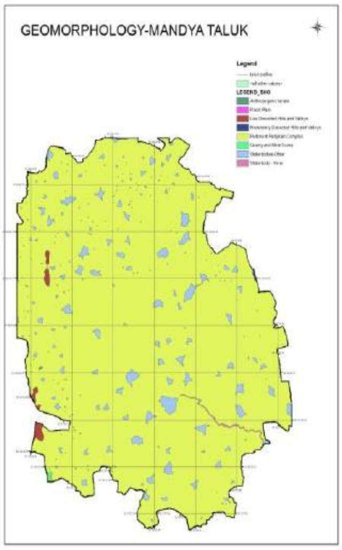

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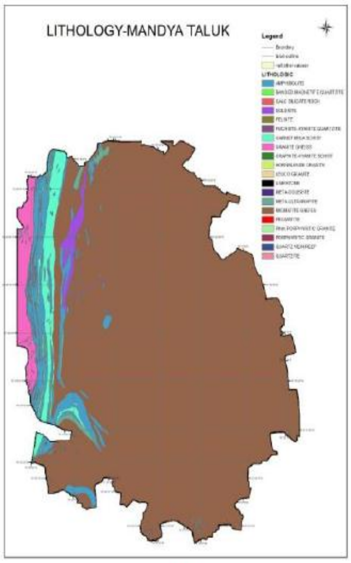

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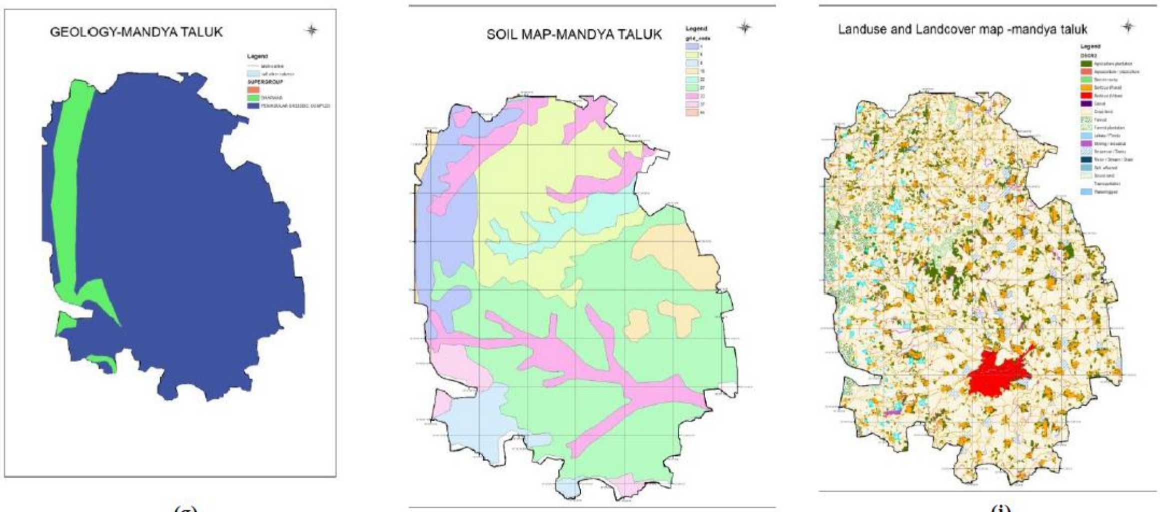


(g) (h) (j)

Figure 4: Thematic maps /layers generated in ArcGIS-(a) drainage map. (b) drainage density map, (c) slope map, (d) lineament map, (e) geomorphologic map, (f) lithology map, (g) geology map, (h) soil map (j) Landuse and land cover map of Mandya taluk.

Overlay analysis

Overlay analysis is a multi-criterion study wherein investigations is carried out with multifaceted things for determining certain themes with the aid of assigning rank to the respective features andthen assign weight age to the respective features depending upon the weightage of the theme on the objective. In this model, seven layers were integrated by assigning weightage for the theme having scale of 1–100 and ranks of the features between 1 to 10 scales. Overlay analysis was carried out for individual firkas (total 115) in the GIS environment using ArcGIS software 10.4 so asto have better Control over the layers and at a larger scale.

The set of criteria used in this study was measured on divergent scales. For this reason, it needed to be standardized in a common interval which varied in our case from 1-5. The highest values thus express the greatest suitability for the most favourable sites for the implantation of water points.

Table 6: Theme wise features, ranking & weightage.

Si.No	Factor	Geomorphology	Lineament Density	Lithology	Slope	Soil	Land Use Land Cover	Drainage Density	Weight
1	**Geomorphology**	7	6	5	4	3	2	1	0.38
2	**Lineament Density**	3.5	3	2.5	2	1.5	1	0.5	0.19
3	**Lithology**	2.33	2	1.67	1.3	1	0.67	0.33	0.12
4	**Slope**	1.75	1.5	1.25	1	0.75	0.5	0.25	0.10
5	**Soil**	1.4	1.2	1	0.8	0.6	0.4	0.2	0.08
6	**Land Use Land Cover**	1.167	1	0.83	0.67	0.5	0.33	0.167	0.066
7	**Drainage Density**	1	0.85	0.714	0.571	0.428	0.285	1/7	0.064
		18.147	15.55	12.964	10.341	7.778	5.185	2.589	1

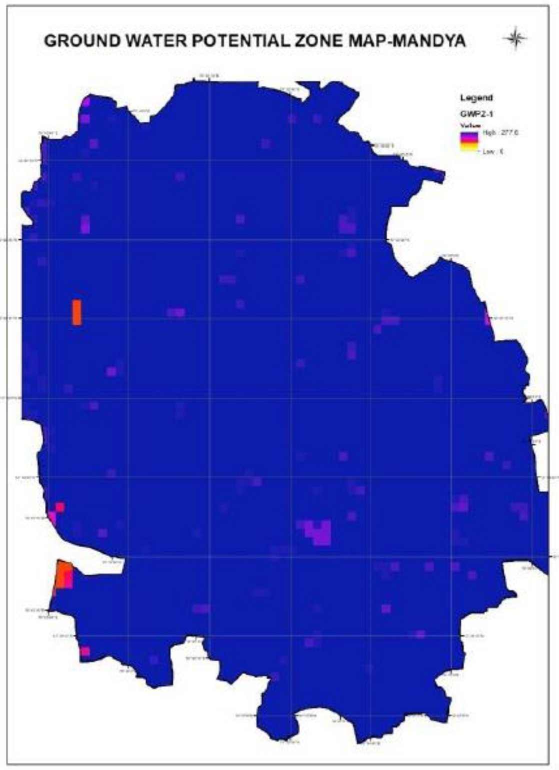
$$Normalized\ weight = \frac{Assigned\ weight\ of\ individual\ parameter\ feature\ class}{Geometric\ mean}$$

Further, the raster layers were reclassified based on the normalized weight range of sub-feature class of each thematic layer. The reclassified layers were multiplied by normalized weight value of individual thematic layer using the raster calculator in the GIS system. The normalized weight of each feature class was utilized to detect the groundwater potential zone (GWPZ) by incorporating thematic layers from the derived.

SI.NO	FACTOR	WEIGHT	RANK	OVERALL
I. GEOMORPHOLOGY				
1	Anthropogenic Terrain	**38**	2	76
2	Flood Plain		3	114
3	Low Dissected Hills And Valleys		1	38
4	Moderate Dissected Hills And Valleys		2	76
5	Pediment Pedipain Complex		4	152
6	Quarry And Mine Dump		1	38
7	Water Bodies-Others		3	114
8	Water Bodies-River		3	114
II. LINEAMENT DENSITY				
1	Major	**19**	5	95
2	Minor		1	19
III. LITHOLOGY				
1	Amphibolites	**12**	2	24
2	Banded Magnetite Quartzite		3	36
3	Calc Silicate Rock		3	36

4	Dolerite			
5	Felsites		1	12
6	Fuchsite-Kyanite Schist		4	48
7	Granite Mica Schist		1	12
8	Granite Gneiss		1	12
9	Graphite Kyanite Schist		1	12
10	Hornblende Graphite		1	12
11	Leuco Granite		1	12
12	Limestone		5	60
13	Meta-Dolerite		1	12
14	Meta- Ultramafite		1	12
15	Migmatite Gneiss		2	24
16	Pegmatite		1	12
17	Pink Porphyritic Granite		1	12
18	Porphyritic Granite		1	12
19	Quartz Vein		3	36
20	Quartzite		3	36
IV. SLOPE				
1	0	**10**	5	50
2	>80		1	10
V. SOIL				
1	4	**8**	4	32
2	6		3	24
3	8		3	24
4	16		1	8
5	27		4	32
6	33		3	28
7	37		3	28
8	55		1	8
VI. LAND USE AND LAND COVER				
1	Agricultural plantation	**6.6**	3	19.8
2	Aquaculture		1	6.6
3	Barren rocky		2	13.2
4	Built-up(rural)		2	13.2
5	Built-up(urban)		1	6.6
6	Canal		5	33
7	Cropland		3	19.8
8	Forest		3	19.8
9	Forest plantation		3	19.8
10	Lakes/ponds		5	33
11	Mining/ industries		1	6.6
12	Tanks		5	33
13	River/streams		5	33
14	Salt affected		1	6.6
15	Scrub land		2	13.2

16	Transportation		1	6.6
17	Water logged		5	33
VII.	**DRAINAGE DENSITY**			
1	High		2	12.8
2	Low		4	25.6
3	Medium	**6.4**	3	19.2
4	Very High		1	6.4
5	Very Low		5	32



$$GWPZ = G_wG_{wt} + GM_wGM_{wt} + DD_wDD_{wt} + LD_wLD_{wt} + SL_wSL_{wt} + ST_wST_{wt} + LU_wLU_{wt}$$

According to the Eq., G = geology, GM= geomorphology, DD = drainage density, LD = lineament density, SL = slope, ST = soil texture, LU = land use/land cover, . Further, 'w' indicates the normalized weights of a thematic layer, and 'wt' indicates normalized weights of individual feature class of a thematic layer

Figure 5: Ground water potential zone.

The resultant map has been reclassified into four classes (very high, high, moderate and poor categories of the integrated values) indicating the suitable area for artificial recharge.

Table 4.5: Ground Water Potential Zone map value, zone and its description.

VALUE	ZONE	DESCRIPTION
0-40	VERY LOW	not suitable
40-74	LOW	not suitable
74-122	MEDIUM	Suitable for all recharge structures like earthen check dam, boulder check dam and nala bund, etc
122-164	HIGH	Suitable for all recharge structures like stop dam, check dam, etc.
164-229	VERY HIGH	Suitable for all recharge structures like percolation pond and stop dam, check dam, etc.

V. CONCLUSION

Geospatial technology has the advantage of covering vast regions of spatial, spectral and temporal availability of Earth surface. It covers inaccessible areas too within short time for identification of favourable zones for artificial recharge. Geospatial technology was applied in Mandya taluk which has an area of 71512ha. for identification of artificial recharge structures by interpreting eight thematic layers. Integration of geomorphology, geology, drainage/water bodies, LULC, soil, and slope. Resultant map shows fourcategories (very high, high, moderate and poor regions) for locating artificial recharge structures. The groundwater potential zonation map wasgenerated using remote sensing and GIStechnologies by assigning proper ranks and weightages to ten themes such as geology, drainagedensity, soil, lineament density, geomorphology, land use/land cover, slope, topographic position index, rainfall occurrence and groundwater level. The zonation map has four categories such as'low', 'moderate', 'high' and 'very high'

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