Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 09, September-2023

Identification of Potential Groundwater Recharge Zone

Suma TN
Assistant professor, Department of civil engineering
GMIT, Bharathinagara
Mandya, India

Abstract - **Abstract: The study aims to use the timely and cost-effective remote sensing and geographical information system (GIS) method for identifying groundwater potential recharge zones in Jagalur Taluk, Davanagere district. Eight Groundwater influencing factors are used for this study viz, Rainfall, slope, geomorphology, geology, lineament density, drainage density, and land use and land cover and soil maps. The method to assess the groundwater potential zone was done using weighted overlay analysis and Analytical Hierarchy Process (AHP) algorithm. The slope map, LULC map, drainage density map was extracted from Liss III imagery, CartoDEM, using software such as ArcGIS 10.2, Erdas Imagine and Google Earth. The weight for each factor was assigned according to their relative importance based on Saatty's scale of AHP. The resulting groundwater potential map was classified into five zones such as very low, low, moderate, high and very high.**

Keywords: AHP, Groundwater Potential recharge Zone, GIS and Remote Sensing.

1. INTRODUCTION

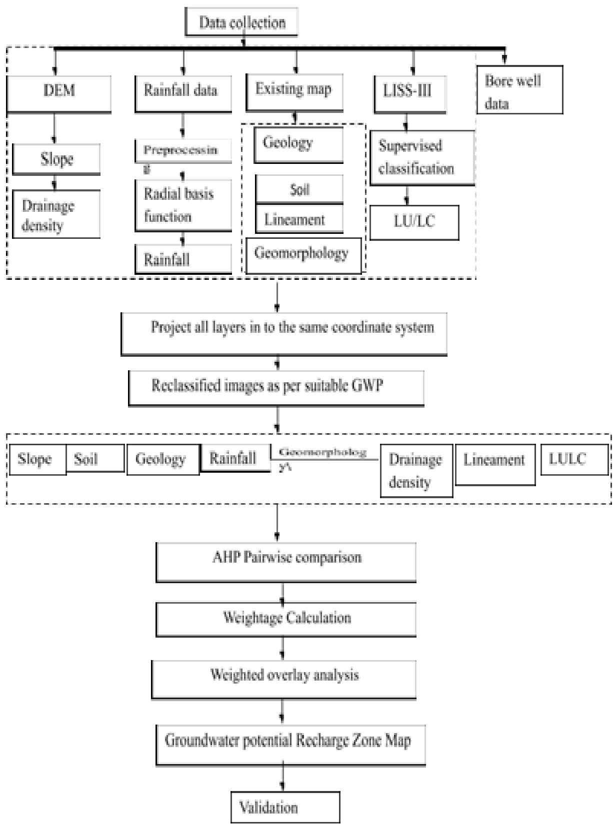
Groundwater is the most valuable resource on earth. Ground water contributes to about 80% of drinking water requirements in the rural areas, 50% of urban water necessities and greater than 50% of irrigation requirements of the nation. Thus, it plays a crucial role in Indian economy as agriculture is the major occupation. The main sources of groundwater recharge are rain, snow and to a small extent surface water. Groundwater may infiltrate by gravity of the earth and departing through on permeability of bed rocks. Hence groundwater of bed rock depends on porosity and permeability. On the bed rock, commonly sedimentary rocks have more groundwater potential, because it is more porous and permeable than other rocks. The study of groundwater has remained more risky, as there is no direct method to facilitate observation of water below the surface. Its presence or absence can only be inferred indirectly by considering the geological and surface Parameters.

2. OBJECTIVES OF THE PRESENT STUDY

- Identification of groundwater recharge potential zones in Jagalur Taluk, through integration of various thematic maps with GIS techniques.
- Validate the results using observed bore well data
- Maintaining the Integrity of the Specifications

3. METHODOLOGY

3.1 Study area: Jagalur Taluk is located in Davanagere district, the central part of northern Karnataka. It lies between 14 °24 ’ to 14 °42’ north latitudinal parallels and 76 °6’ and 76 °32’ east longitudinal parallel. Jagalur Taluk cover a total area of 971sq.km. and it includes 171 villages. Annual rainfall varies between 530 to 560 mm in Jagalur. In general, southwest monsoon contributes 58 % of total rainfall and northeast monsoon contributes 22 % rainfall. The remaining 20 % rainfall is received as sporadic rains in summer months. In the past 20 years the maximum and minimum rainfall is 704 mm and 380 mm respectively. It receives low to moderate rainfall. Jagalur summer highest day temperature is between 31° C to 40°C.



4. RESULTS AND DISCUSSIONS

4.1 Rain fall map: The rainfall is not the same at all the places and its variation is based on the environment conditions of the place. Groundwater recharge potential is dependent on the rainfall, Since, the rainfall varies spatially and temporally, it is necessary to determine the influence of rainfall in any region over a period. Rainfall data collected from the statistical department were utilized to generate rainfall pattern map using ArcGIS software. The obtained rainfall map is classified into five classes varying from 350-460 mm/year, 460-480 mm/year, 480-510 mm/year, 510-570 mm/year and 570- 620 mm/year and is shown in Figure 5.1. Only 2.05% of total area covers low rainfall (350-460 mm/year) and 12.35% of total area covers heigh rainfall (570- 620 mm/year). It is observed that western part of the study area receives the largest amount of rainfall while the eastern part receives the lowest amount of rainfall. High rainfall is favorable for high groundwater potential.

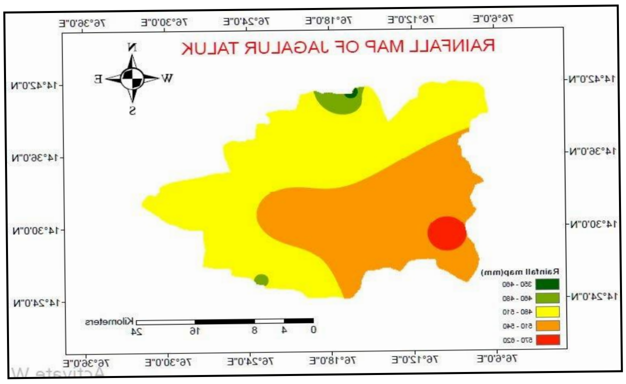


Figure.1. Rainfall map of Jagalur Taluk

4.2 Slope map: Slope map provide an idea about the gradient or steepness of the terrain. Slope is inversely proportional to the ground water recharge. 0°-1° slope is a very low gradient unit therefore the water will not flow under the action of gravity thereby increasing the chances of water penetrating into the underlying layers. Thus, when the slope increases the probability of water penetration into the ground gradually decreases. Higher Slopes permits easy flow of water and reduces the water infiltration. In this study, slope is classified into five classes as shown in Figure 3. The five classes represent the slope in degrees 0°-2°, 2°-5°, 5°-9°, 9° - 17° and 17°-41° respectively. 51.9% of total area covers low (0°-2°) slope and only 0.82% of total area covers high (17°-41°) slope. The areas having 0°-2°slope fall into the ideal category because of the nearly flat terrain and relatively high infiltration rate. The areas with 2°- 5° slope are considered as good for groundwater storage due to slightly undulating topography with some runoff. The areas having a slope of 5°-9° cause relatively high runoff and low infiltration, and hence are categorized as poor and the areas having a slope 9°-17° are considered as very poor due to higher slope and runoff. Whereas the area having slope 17°-41° are considered as extremely poor and unsuitable due to higher steep slope and does not favor direct percolation.

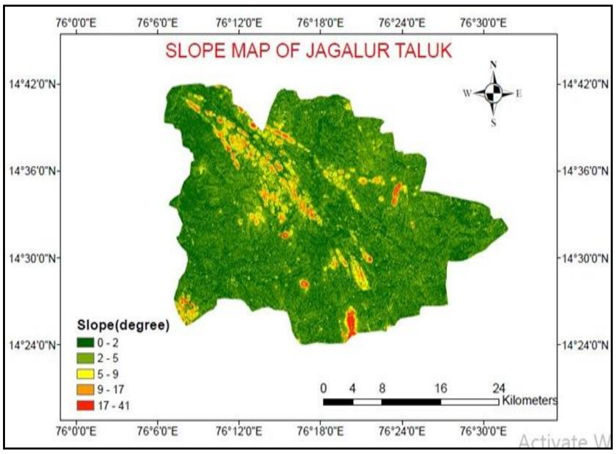


Figure.2. Slope map of Jagalur Taluk

4.3 Drainage density map: The drainage density means the whole length of drainage per unit area. The drainage density of an area and permeability are inversely associated. The less permeable rock, less infiltration of rainfall which tends to be concentrated in surface runoff, resulting a well-developed drainage system. In relation with surface runoff and permeability, the drainage density indicates the unsuitability of groundwater recharge of an area. The water runoff will be high if the density of drainage is high, thus infiltration of water into ground would be less, whereas low drainage density area's surface-water runoff will be less thus infiltration of surface water into the ground will be high. For the present study, stream data has been created from the carto DEM. Streams data have been used to find out the drainage density of study area. The drainage density map is classified into five classes as, 0-0.4 km/km^2, 0.4-0.8 km/km^2, 0.8-0.1.1 km/km^2, 1.1-1.5km/km^2 and 1.5-2.5 km/km^2 respectively as shown in Figure 4. 20.39% of total area covers low (0-0.4 km/km^2) drainage density and 25.5% of total area covers high (1.5-2.5 km/km^2) drainage density. The higher weight is assigned to low drainage density (0-0.4km/km^2), it is capable of high infiltration rate and low runoff. The lower weight is assigned to high drainage density (1.5-2.5 km/km^2), it is capable of low infiltration rate and high runoff.

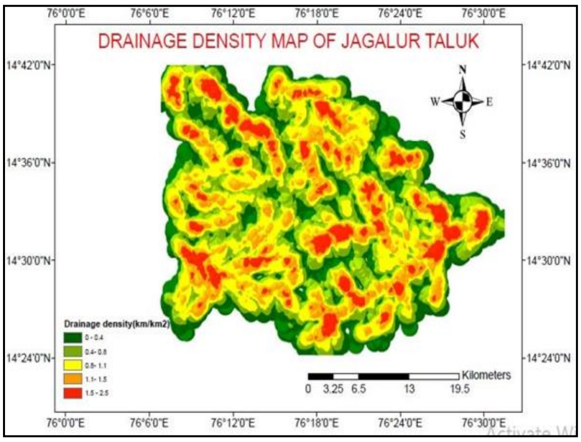


Figure.3. Drainage density map of Jagalur Taluk

4.4 Lineament map: Lineaments are structurally controlled linear or curvilinear features, which are identified from the satellite imagery by their relatively linear alignments. These

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 09, September-2023

features express the surface topography of the underlying structural features. Lineaments represent the zones of faulting and fracturing resulting in increased secondary porosity and permeability. These factors are hydro-geologically very important as they provide the path ways for groundwater movement.The lineament density map was generated based on collected lineament data using line density tool with spatial analyst in ArcGIS software. The lineament density map is classified into five classes, which are 0-0.3 km/km2, 0.3-0.6 km/km2, 0.6-0.9 km/km2, 0.9-1.2 km/km2 and 1.2-2.5 km/km2 respectively as shown in below Figure5.The higher weight is assigned to high lineament density (1.3-1.6km/km2), it is capable of high infiltration rate and low runoff. The lower weight is assigned to low lineament density (0-0.3 km/km2), it is capable of low infiltration rate and high runoff. 18.2% of total area covers low lineament density (0-0.3 km/km2) and 3.60% of total area covers high lineament density (1.2-2.5 km/km2).

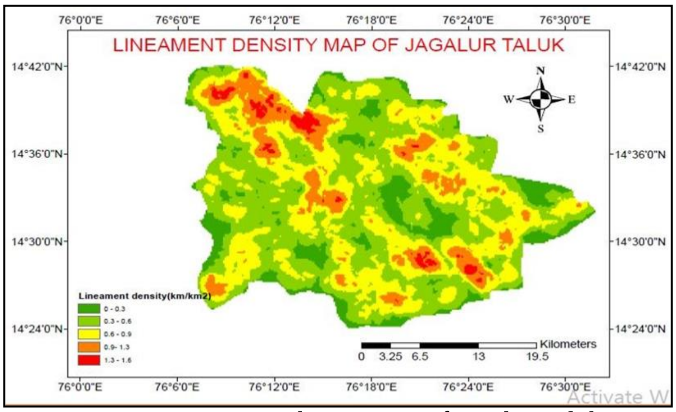


Figure.4.Lineament density map of Jagalur Taluk

4.5 LULCmap:Supervised classification is one of the commonly used classification methods for creating the land use and land cover maps, vegetation type maps, soil type maps etc., by using the GIS software. This method was used for creating the land use and land cover map of the study area. LISS-III data was used for supervised classification with Maximum Likelihood algorithm, by using ERDAS Imagine 2014 software. LULC map covers a total geographical area of 971Sq.km. of which the five classes have been considered as given in Table 1. The LULC map shows that, 65.4% of total area cover agricultural land, 31.2% of total area cover barren land, 20.6% of total area cover water body, 1.32% of total area cover built up land and only 0.3% of total area cover forest. Agricultural land covers major part of the Jagalur Taluk.

Table 1: Classes of LU LC map

Classes	Area in sq.km
Built-up	11
Forest	3
Barren land	302
Agricultural land	635
Water body	20
Total	= 971 sq km

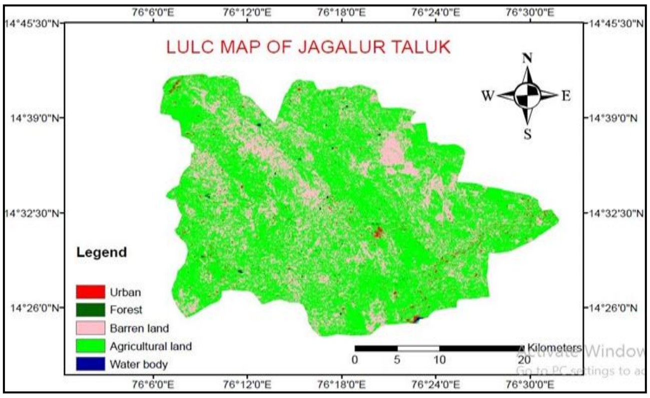


Figure .5. LULC map of Jagalur Taluk

4.6 Geomorphology map: Geomorphology is a study related to earth structures and also depicts the various landforms relating to the groundwater potential zones and also structural features.Geomorphology of an rea depends upon the structural evolution of geological formation. The study area shows various landforms like denudational hills, pediplains, structural hills and water body mask shown in Figure 6.The geomorphology map of the Jagalur Taluk shows that, 5% of area cover denudational hills, 2.7% of area cover water body, 4.2% of area cover structural hills and major part of the study area occupy pediplains is about 92.2% of the total study area.

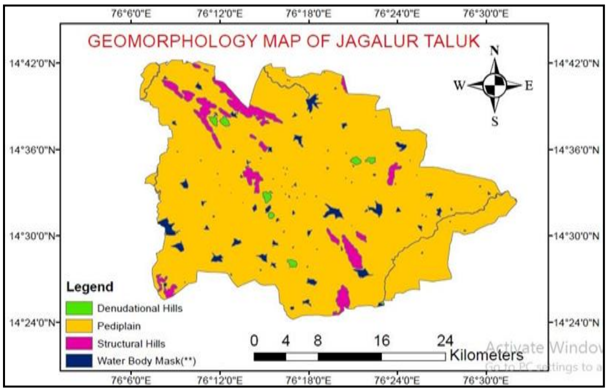


Fig.6. Geomorphology map of Jagalur Taluk

4.7 Soil map: Soil is an important factor for delineating the groundwater potential zones. The analysis of the soil type reveals that the study area is predominantly covered by fine, clayey and loamy soil as shown in Figure 7. The soil map of Jagalur Taluk shows that 47.8% of total area covers fine soil, 36.56% of total area covers loamy soil and 15.5% of total area covers clayey soil.

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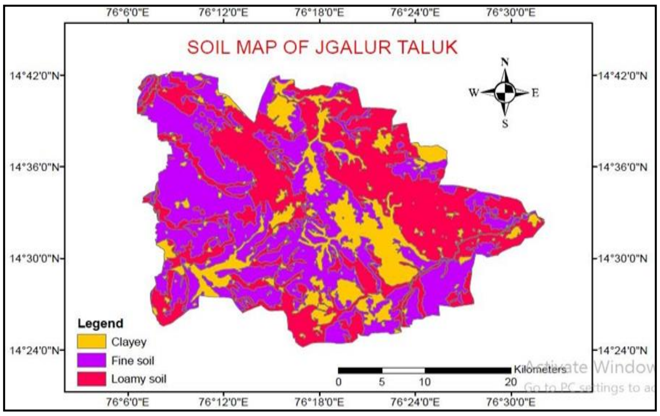

Figure.7. Soil map of Jagalur Taluk.

4.8 Geology map: Geology is the scientific study of the earth including its composition, structure and physical properties. The type of geology that exposed to the surface influence groundwater recharge by controlling the percolation and flow of water to the ground and geology plays a great role in the occurrence and distribution of groundwater potentials zone. In the study area there are 3 types of rocks as shown in Figure 8. In that 39.54% of total area covers metamorphic rocks, 46.96% of total area covers plutonic rocks and only 12.56% of total area covers volcanic rock.

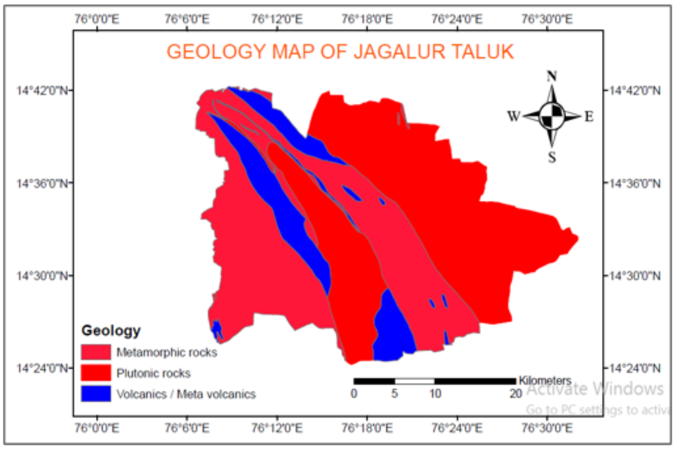

Figure.8. Geology map of Jagalur Taluk.

4.9 Groundwater potential map: The groundwater potential zones were identified by overlaying all the thematic maps in terms of weighted overlay analysis method using the spatial analysis tool in ArcGIS 10.3 are shown in Fig. During the weighted overlay analysis, the ranks have been given for each individual parameter of each thematic map and the weight are assigned according to the influence of the different parameters.

The derived groundwater potential map is classified into five categories namely very low, low, moderate, high and very high groundwater potential zones based on standard deviation References as shown in table below. The result of the groundwater potential zones shows that the very high groundwater potential zones constitute 10.7 % of the total study area. Moderate groundwater potential zones occupy the largest area of about 37.31% of the total study area and scattered all over the groundwater potential map. High groundwater potential zones constitute 29.24% of the total study area. The low and very low groundwater potential zones constitute about 6.17 and 16.58 % of the total study area, most of them are along hills with steep slope that are associated with high drainage density.

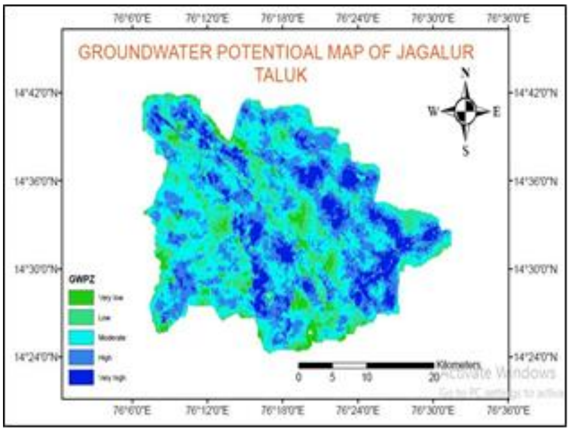

Figure 9: Groundwater potential map of Jagalur Taluk

Table.2. Weightage for different parameter of ground water potential zone.

Sl No	Influencing Factor	Class Intervals Or features	Ground water availability	Satty's Scale (in fraction)	Satty's Scale (in Decimal)	% influence = (Satty's scale /sum)*100	Relative Influencing Factor
1	Slope (in degrees)	0 – 2	Very high	1	1	56.17	56
		2 – 5	High	1/3	0.33	18.54	19
		5 – 9	Moderate	1/5	0.2	11.23	11
		9- 17	Low	1/7	0.14	7.86	8
		17 – 41	Very low	1/9	0.11	6.18	6
					Sum = 1.78		
2	Geology	Volcanic rock	Very High	1	1	65.35	65
		Plutonic rock	Moderate	1/3	0.33	21.56	22
		Metamorphic rock	Low	1/5	0.2	13.07	13
					1.53		
3	Geomorphology	Pedi plain	Very high	1	1	57.803	58
		Water body	Medium	1/3	0.33	19.26	20
		Structural Hills	Low	1/5	0.2	11.56	11
		Denudational Hill	Low	1/5	0.2	11.56	11
					Sum = 1.73		
4	Land use and Land cover	Forest	Very high	1	1	56.19	56
		Agricultural Land	High	1/3	0.33	18.539	19
		Water bodies	Moderate	1/5	0.2	11.23	11
		Built up	Low	1/7	0.14	8.025	8
		Barren Land	Very low	1/9	0.11	6.179	6
					Sum = 1.78		
5	Soil Texture	Loamy soil	High	1/2	0.5	48.543	49
		Fine soil	Medium	1/3	0.33	32.038	32
		Soil	Clayey	1/5	0.2	19.417	19
					Sum = 1.03		
6	Drainage Density (km/km^2)	0 - 0.4	Very high	1	1	56.17	56
		0.4 - 0.8	High	1/3	0.33	18.54	19
		0.8 -1.1	Moderate	1/5	0.2	11.23	11
		1.1 -1.5	Very low	1/7	0.14	7.86	8
		1.5 - 2.5	Low	1/9	0.11	6.18	6
					Sum = 1.78		
7	Lineament Density (km/km^2)	0 -0.3	Very low	1/9	0.11	6.18	6
		0.3-0.6	Low	1/7	0.14	7.86	8
		0.6-0.9	Moderate	1/5	0.2	11.23	11
		0.9-1.3	High	1/3	0.33	18.45	19
		1.3-1.6	Very high	1	1	56.17	56
					Sum = 1.78		
8	Rainfall in (mm/year)	350– 460	Very low	1/9	0.11	6.18	6
		460 – 480	Low	1/7	0.14	7.86	8
		480 – 510	Moderate	1/5	0.2	11.23	11
		510 – 540	High	1/3	0.33	18.45	19
		540 – 620	Very high	1	1	56.17	56
					Sum = 1.78		

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CONCLUSION:

In the total extent of 971 Sq.km of the Jagalur Taluk, 60 Sq.km (6.17%) of area has very low groundwater potential, 161 Sq.km (16.58%) of area has low groundwater potential, 362 Sq.km (37.31%) of area has moderate groundwater potential, 284 Sq.km (29.24%) of area has high groundwater potential and 104 Sq.km (10.4%) of area has very high groundwater potential. The moderate groundwater potential zone covers major part of study area. The result of consistency ratio in this study is 0.065 for groundwater potential. If the result of consistency ratio is greater than 0.1, the value is unaccepted and it must be re-evaluated. In this case, the consistency ratio for groundwater potential recharge zone was less than 0.1 and the value was accepted for further analysis.AHP is one of the appropriate methods for assigning the weightage for the groundwater study. The multi-parameter approach carried out by means of GIS and AHP technique is economical and not laborious.

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