AN APPROCH TO DELINEATE ARTIFICIAL RECHARGE STRUCTURES FOR PIRIYAPATNA TALUK OF MYSURU DISTRICT, KARNATAKA, INDIA USING GEOINFORMATICS

[1]Manjunatha M.C, [2]Madhu S.P, [3]Sharath H.P, [3]Rakshitha J, [3]Inchara K, [3]Divya
[1]Assistant Professor, Department of Civil Engineering, Maharaja Institute of Technology, Thandavapura, Mysuru -571302
[2]Associate Professor, [3]B.E students, Department of Civil Engineering, Maharaja Institute of Technology, Mysuru -571 438

Abstract: Water is one of the main natural resources that essential for human's daily life, domestic, industrial and other various fields which need periodic assessing, monitoring for its sustainability. Major water sources are under serious threat due to gradual increase in population, climatic change, over withdrawal of groundwater, agriculture, deforestation and from other sources around the world. This study aims to recharge the groundwater resources using artificial storage techniques, modifying surface runoff through Geoinformatics technique. Survey of India (SoI) topomap, IRS-1D, PAN+LISS-III and ASTER G-DEM satellite images have been effectively utilized in the present study using GIS software's. Efforts have been made to evaluate the thematic layers of lithology, geomorphology, drainage & its density, lineament & its density, soil, slope, land use/ land cover using overlay weightage analysis. The derived thematic maps have been assigned suitable weightages using Analytical Hierarchy Process (AHP) depending on the features priority to derive suitable sites for Artificial Recharge Structures (ARS). The final results highlight the capability of Geoinformatics in deriving best sites for ARS decision making process which is suitable for similar geological terrain.

Keywords - Piriyapatna taluk, Saaty's AHP, ARS, Geoinformatics.

1. INTRODUCTION

Groundwater is the major sources of domestic and drinking purposes in the study area, which is depleting due to change in climatic conditions, low precipitation amount, rapid industrialization, urbanization and over withdrawal of groundwater for irrigation activities (CGWB, 2012). Groundwater is one of the most vital natural resources and the largest available source of fresh water (Kumar et al, 1999) in which more than 85% is required for India's rural domestic use, 50% for urban water requirements and more than 50% of irrigation activities (CGWB, 2012). Approximately, 48% of the urban water share in India is derived from groundwater (Centre for Science and Environment, 2012). Gradual increase in population, increasing urbanization, industrialization, over exploitation & large withdrawal of groundwater resources imposes stress on groundwater regime distorting the aquifer recharge-withdrawal equilibrium and majorly affecting the ecological imbalance (Garg, 1976). Rise in temperature increases the evaporation of surface water bodies & transpiration in wetlands resulting in low precipitation amounts, timings, intensity rate, long-term climatic variables such as air temperature and moisture content (Dinakar S, 2005). Rain is a main factor in water cycle that falls on earth's surface and fills all surface water bodies such as pool, pond, lakes, canals, channels, rivers, sea and oceans (Basavarajappa et al, 2015b). In India, even though the average rainfall is 1100 mm there is a scarcity of water that results in water crisis (Hajare et al, 2003). Higher run-off of rain water on hill slopes looses substantial quantity of water to other region without sufficient infiltration. Suitable ARS techniques on specific sites are very much important in order to balance the recharge-withdrawal equilibrium and store water to supply in sufficient amount especially during extreme summer seasons (Sivanappan, 2006). ARS especially in hard rock terrains requires thorough understanding of lithology, geomorphology and lineaments of an area, which are directly controlled by the terrain characteristics such as weathering grade, fracture extent, permeability, slope, drainage pattern, landforms, land use/land cover and climate (Dinakar S, 2005). Satellite images illustrates the real conditions of hydromorphology, tectonics (lineament, fracture, joints, faults), LU/LC which are indicative of groundwater movement and localization (Krishnamurthy et al, 1996). Geoinformatics tool come in handy (Drury, 1986) to select suitable sites for ARS by analyzing all thematic layers and overlay weightage analysis of Analytical Hierarchy Process (AHP) (Thomas Saaty, 1980).

2. STUDY AREA

It lies in between $12^0 12'$ to $12^0 34'$ N latitude and $75^0 55'$ to $76^0 15'$ E longitude with an aerial extent of 815 km^2 (Basavarajappa et al, 2012) (Fig.1). The general elevation is 1307mts above MSL falling in semi-arid region of southern dry – agro-climatic zone (VI). Piriyapatna taluk is moist during the winter and rainy season with the mean temperature ranges from 16^0C to 34^0C. The average annual rainfall ranges from 700 to 810mm (CGWB, 2012).

2.1 Crops & irrigation

The study area is dependent mainly on groundwater for agriculture practices; but the water scarcity arises due to erratic rainfall in the monsoon season (Koushari, 2017). Major crops grown are tobacco, ragi, paddy, maize, pulses, oilseeds & cereals, turmeric, vegetables & fruits, flowers, banana, coconut and areca nut plantation in which Ragi is the important crop grown in the study area (District at a Glance: 2012-13). Cauvery is the main perennial river flowing in the northern parts of the piriyapatna taluk and fulfilling the canal irrigation of 26.6 km^2, tank is 6.25 km^2, wells 7.2 km^2, tube wells 2.46 km^2 (District at a Glance: 2012-13).

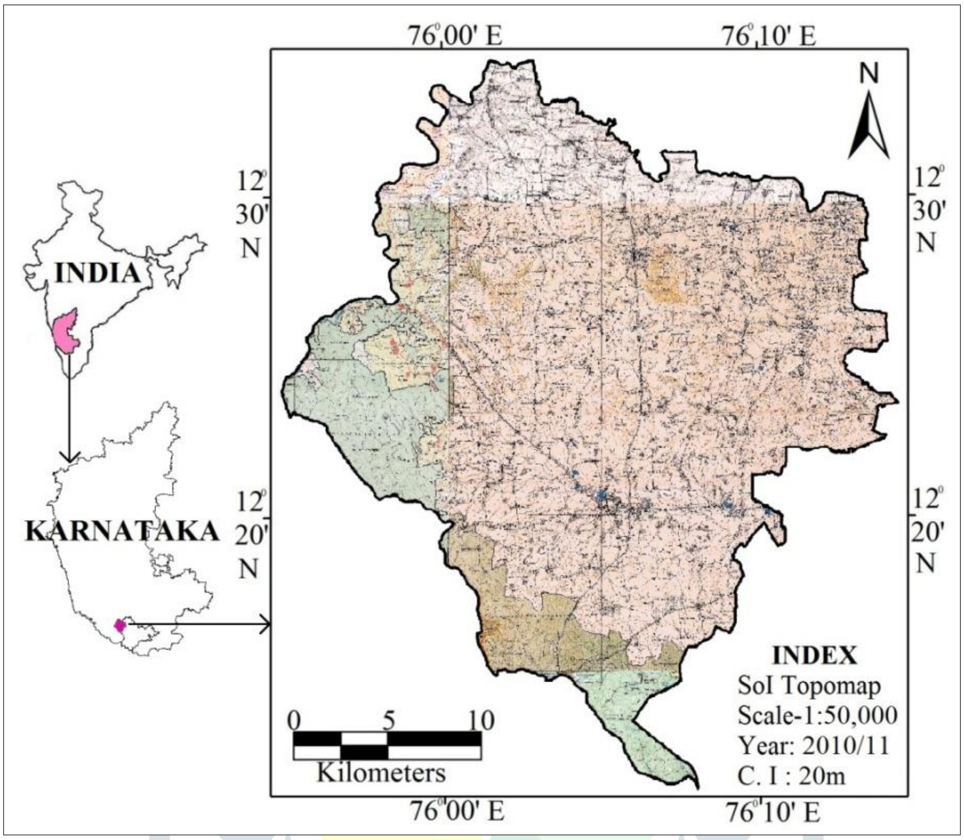

Fig.1. Topomap showing location of Piriyapatna taluk

3. METHODOLOGY

3.1 Methods

Survey of India toposheet of 1:50,000 scale, are effectively utilized in digitization and extraction of the base maps through Visual Image Interpretation Techniques (VIIT); whereas Digital Image Processing (DIP) have generated using PAN+LISS-III and ASTER G-DEM (Global Digital Elevation Model) satellite images through ArcGIS software (Manjunatha et al, 2015). The present study involves a systematic analysis of thematic layers of geological formations, geomorphological landforms, drainage patterns, lineament/ faults, soil types, slope categories and land use/ land cover patterns along with field survey (Love Kumar, 2017). Lithology map is derived from Quadrangle map of GSI number 48P and 57D of 1:250,000 scale; whereas geomorphology derived from geomorphological map of Karnataka of 1:250,000 scale (Basavarajappa et al, 2012). Drainage patterns are digitized from SoI topomap and overlaid on ASTER GDEM image of 30m resolution (Fig.3). Lineaments and LU/LC map are extracted from PAN+LISS-III image of 5.8m resolution (Fig.2) (Manjunatha and Basavarajappa, 2017); whereas slope map is derived digitally from ASTER GDEM image (Love Kumar., 2017). All the layers are then converted into raster format to determine best sites for Artificial Recharge Structures through overlay weightage analysis (Harish Chandra et al, 2014). Thomas Saaty's (1980) Analytical Hierarchy Process (AHP) has been adopted for assigning ranks to each class. All seven parameters have been overlaid using weighted overlay analysis and results have been schematically obtained (Dinakar S, 2005).

3.2 Materials used

I. **Survey of India toposheets:** 48P/14; 48P/15; 57D/2; 57D/3, 57D/4.
Source: Survey of India, Bangalore region, Bengaluru.

II. **Satellite Imagery:** IRS-1D, PAN+LISS-III image of 5.8m Resolution (dated: Nov 2008 & Dec 2009) and ASTER G-DEM with 30m resolution (dated: 17th Oct 2011).
Source: NRSC-ISRO, Hyderabad; USGS, Earth Explorer website.

III. **Thematic layers:** lithology, geomorphology, drainage, lineament, soil, slope, land use/ land cover and stream order.

IV. **GIS Software's:** ArcGIS v10 and PCI Geomatica v16.

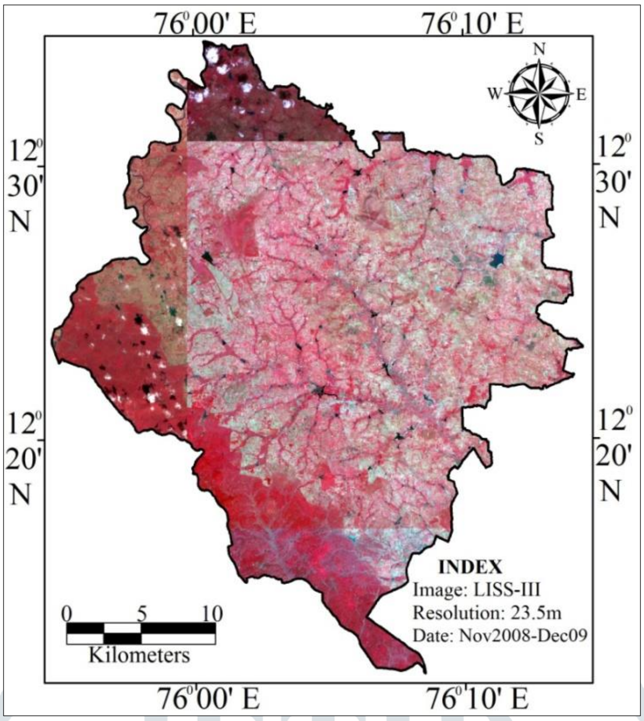

Fig.2. IRS-1D, PAN+LISS-III Satellite image of Piriyapatna taluk

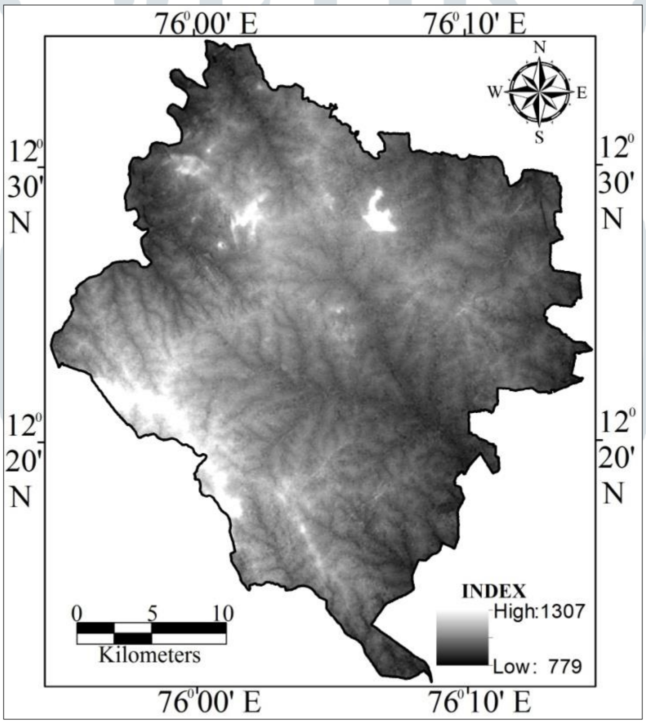

Fig.3. ASTER GDEM satellite image of Piriyapatna taluk

4. DIGITIZATION OF INDIVIDUAL THEMATIC LAYERS

4.1 Lithology

Groundwater recharge is controlled by the geological and hydrological characteristics of the aquifer system (CGWB, 2012). Precambrian age of igneous and metamorphic rocks are noticed to be exposed either at the surface or underlain by country rocks (CGWB, 2012). Archeaen and proterozoic age group of rocks are well exposed, underlain by hard rock terrain consisting of amphibolites, migmatites, ultramafics, hornblende-biotite geniss, charnockite and intruded by dolerite dykes of proterozoic era (Mahabaleswar et al, 1995) (Table.1; Fig.4). Migmatite, granodiorite, Tonalitic gneisses are wide spread and dolerite dykes are noticed rarely in the study area (Koushari, 2017). Charnockite rocks are noticed in south western part followed by amphibolites with pelitic/ metapelitic schist observed in NNW parts in the taluk (Srikantappa et al, 1992). During field investigations, naturally exposed weathering granitic gneisses noticed along discontinuities and causes complex weathering profiles. Basement rocks are observed at shallow depth with more intense of structural faults & joints resulting in rock weathering profiles (Dinakar S, 2005). Small scales of dyke quarries are also observed exploiting upto the depth of 20 to 25 mts and frequently blasting of rocks causes serious impact on groundwater conditions & its depletion (Basavarajappa et al, 2012). The hard rock terrain of the study area implies low infiltration of groundwater and its percolations; which may require ARS to store and for artificial infiltration of water (Dashora et al, 2019) (Table.3 & 4).

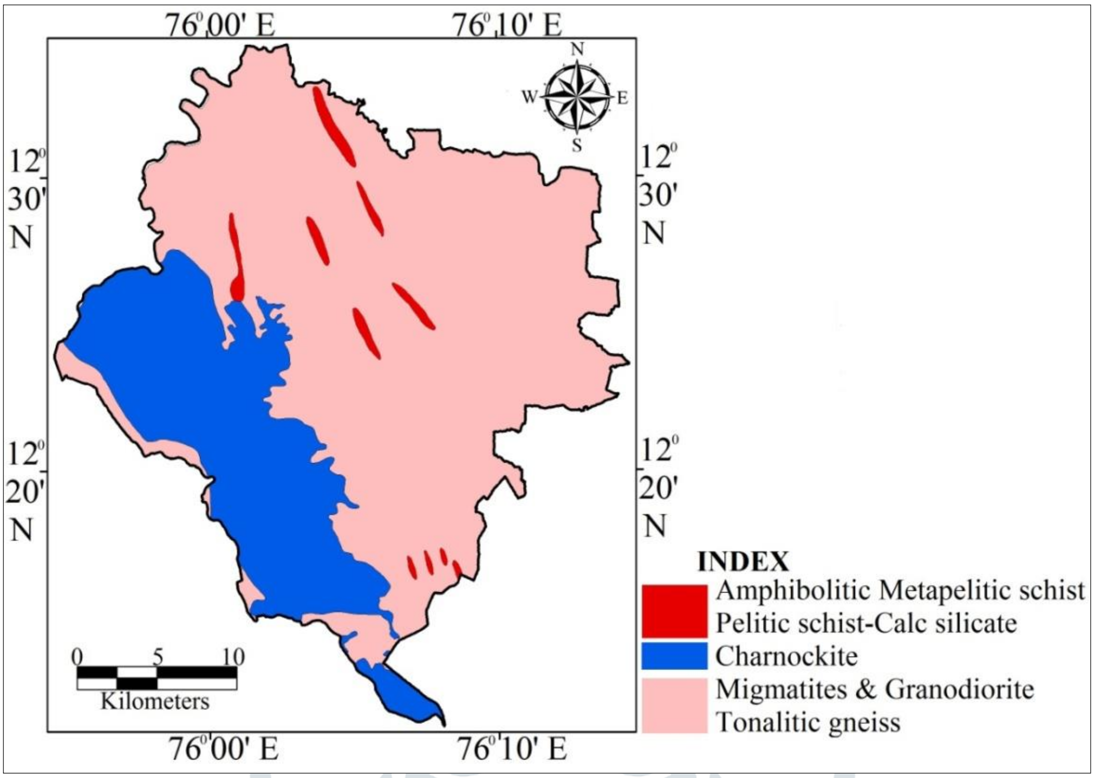

Fig.4. Lithology map of Piriyapatna taluk

Table.1. Lithostratigraphic succession (modified after Mahabaleswar and Peucat, 1988)

Stratigraphic position	Rock type
Younger intrusive	Dyke rocks
Closepet granite	Coarse to medium and pink to grey color
Charnockites	Mainly basic granulite
Older gneissic	Grey gneisses predominant complex

4.2 Geomorphology

The land is plain to undulating region, partly southern maiden region with major Cauvery River flowing in northwestern border of the study area (Basavarajappa et al, 2012). Hydrogeomorphic units were identified and delineated based on NRIS classification system, such as channel island, curvilinear ridge, denudational hills, dissected pediment, dyke ridge, inselberg, pediment, pediment inselberg complex, pediplain moderate, pediplain shallow, residual hills, river/streams and valley fill shallow (Srinivasa et al, 2005) (Fig.5). Valley fill shallow and pediplain moderate are very good to good groundwater prospects zones and considered most favourable zones for groundwater prospects while pediplain shallow areas are good to moderate, pediment inselberg complex and pediment zones are moderate to poor and denudational hills, residual hills and inselbergs are considered as poor to very poor groundwater prospects in the study area (Manjunatha and Basavarajappa, 2015). The geomorphic units occupied by charnockite rocks and granitic gneisses occur as continuous range major hard surface and generally act as runoff (Pushpavathi K.N, 2010). Among delineated landforms, river/stream, reservoir, Reservoir Island and hills are not suitable for ARS. Ranks and weightages are assigned based on the priorities of the geomorphological parameters which may be suitable for recharge structures (Table.3 & 4).

4.3 Drainage

East flowing Cauvery river drains entire taluk showing dendritic type of drainage pattern (Koushari, 2017). Major River Cauvery flows in Northern border of the study area and is the only river which has been harnessed for irrigation from ancient times and it is estimated that as much as 95% of its surface flow is put to use before it enters into the Bay of Bengal (CGWB, 2012). The River water flow in high volume when heavy rainfall occurs during monsoon seasons at Tala-Cauvery channel bar /flood bar which fills the surface water bodies/ tanks. 53 major surface tanks were identified as per the District Statistics report (2012-13). All tanks are rain fed and interconnected by streams at many places exhibiting sub-dendritic to dendritic type of drainage patterns which are freely developed due to gneissic and granitic terrains topography (CGWB, 2012). The drainage pattern also reflects the influence of slope, lithology and structure in the study area. Water from these surface tanks is mainly utilized for agriculture purposes (District at a glance, 2012-13). About 15,440 tube wells are used by the farmers to irrigate the 16,718 hactares of land in the study area (Koushari, 2017). Maps of drainage and drainage density are generated from ASTER GDEM satellite image of 30m resolution using Hydrological tools of ArcGIS software (Seyed, 2011) (Fig.3 & 6). Ranks and weightages are assigned based on the priorities of rater resultant maps as shown in the Table.3 & 4.

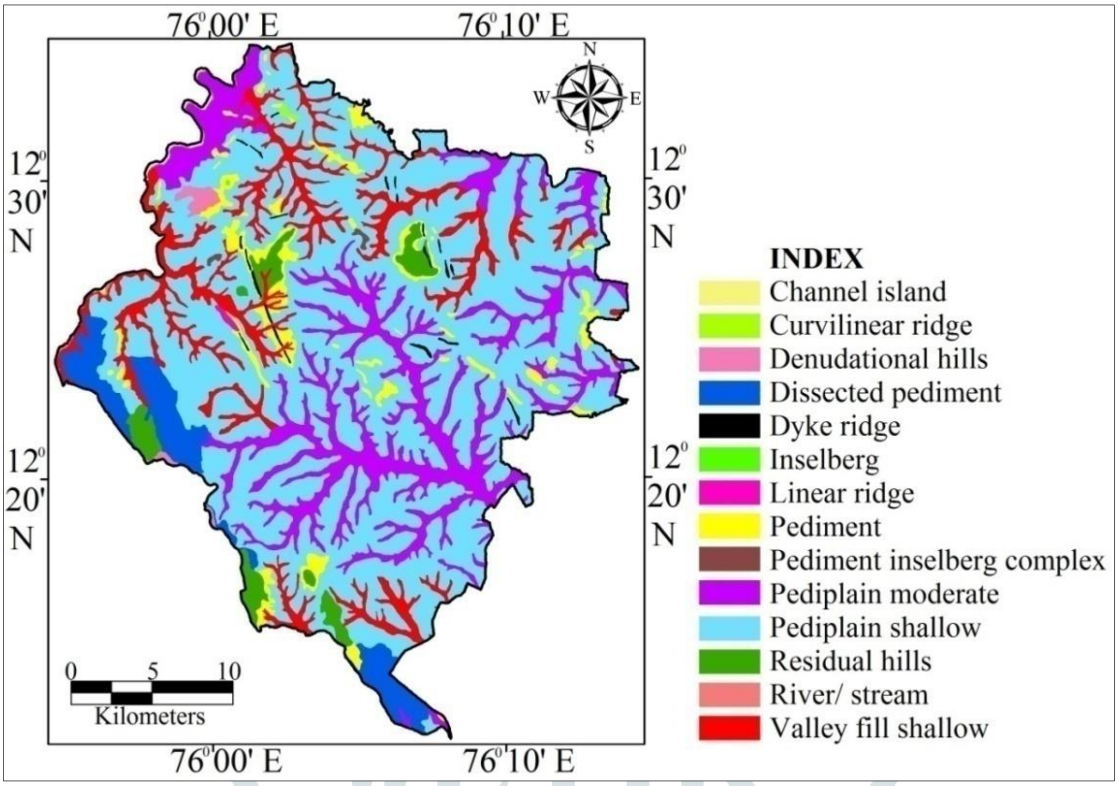

Fig.5. Geomorphology map of Piriyapatna taluk

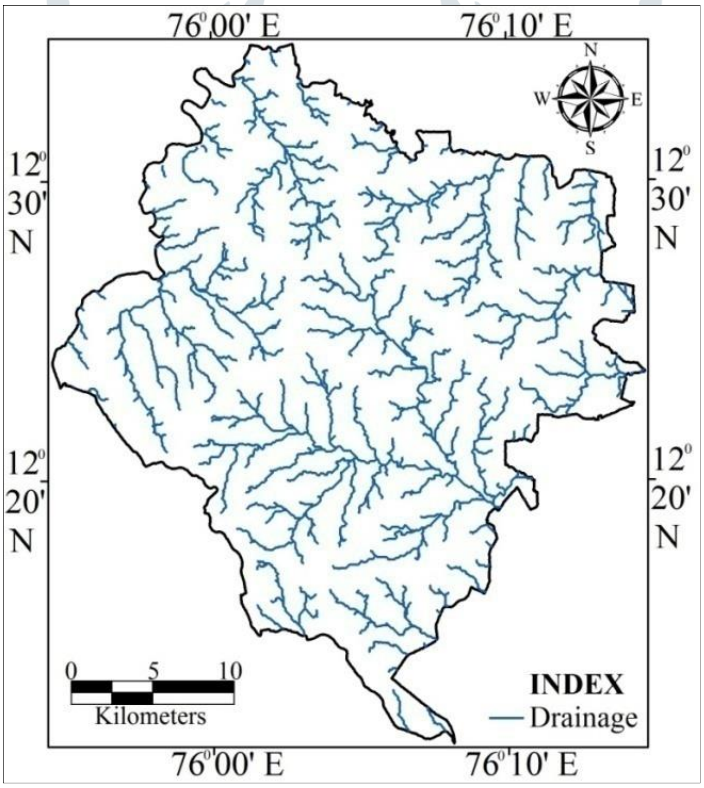

Fig.6. Drainage map of Piriyapatna taluk

4.3.1 Drainage density

Drainage density is one of the key factors for site suitability analysis of ARS. The high drainage density indicates the closeness of channels spacing; while low drainage density results in highly resistant or permissible sub soil materials, dense vegetation and low relief (Horton, 1932). High drainage density is the resultant of weak or impermeable subsurface material (Vipin Kumar, 2017). It is a measure of the total length of the stream segment of all order per unit area with main morphological factors of slope gradient and relative relief. Drainage density (Dd) is significant as a factor determining the time of travel by water in a terrain. Sparse vegetation, mountainous relief and low density lead to coarse drainage texture while high drainage density leads to fine drainage texture. Higher Dd implies higher surface water runoff which become difficulty in ARS; whereas low Dd implies less surface runoff and will be highly suitable (Fig.7). Drainage ordering represent the number of streams presents in each order denoted as 1st, 2nd, 3rd and 4th stream orders. 2nd, 3rd or 4th stream orders are suitable for Storage Tank and Percolation Tank type of ARS (Harish Chandra et al, 2014) (Table.3 & 4).

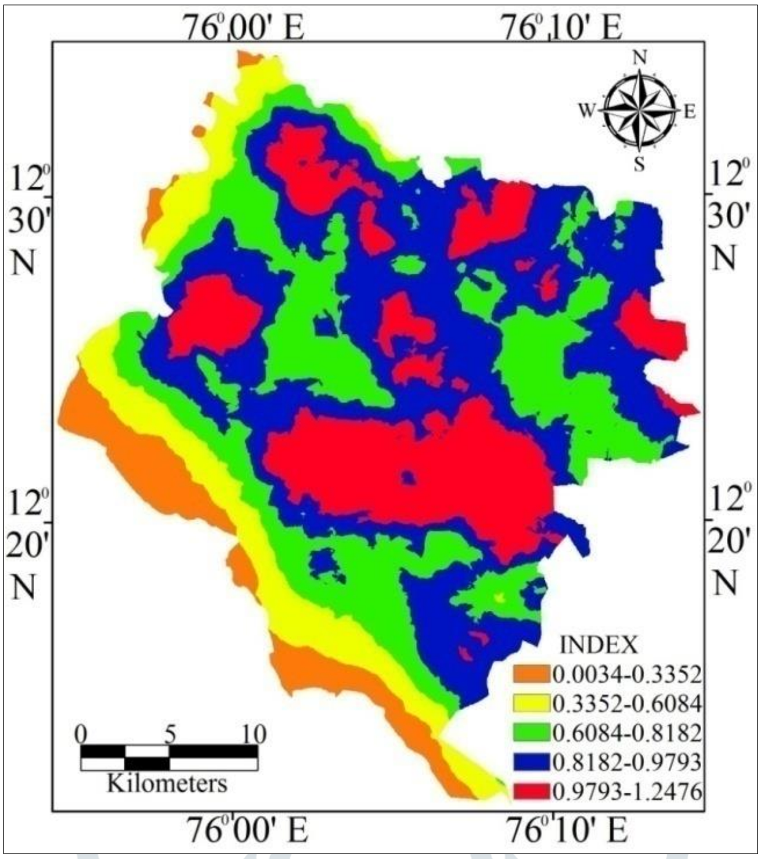

Fig.7. Drainage density map of Piriyapatna taluk

4.4 Lineament

A lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as subsurface faults and factures which influences the groundwater occurrence (Manjunatha and Basavarajappa, 2017). Lineaments are digitally extracted on LISS-III image using PCI Geomatica and ArcGIS software's. Faults/lineaments act as conduits and very good aquifers, on other hand faults act as drains, lowering the water table and thus affecting the distribution of groundwater resources (Mulwa et al, 2005). Faults act as barriers to the groundwater flow, if filled with impermeable material such as silts and clays (Abdul Rahiman et al, 2015). Direction of lineaments, joints, fractures are controls the movement & accumulation of groundwater and bore wells located on this high yield of water. Prominent lineaments are trending towards NNE-SSW, N-S, NW-SE and E-W to NW-SE directions (CGWB, 2012) (Fig.8). The central and southern parts represent shallow groundwater levels; whereas northern parts shows deeper groundwater levels due to the flowing direction of streams and sub-streams (Koushari, 2017) (Table.3 & 4). These factors have a strong influence on the good aquifers, yields of boreholes data, static water levels, water flow and distribution of groundwater. This highly influences the amount of water available in a faulted region (Koushari, 2017).

4.4.1 Lineament Density

Lineament density (Ld) are generated digitally on LISS-III satellite image using Line Density tool of ArcGIS software (Basavarajappa et al, 2016). The output raster map has been classified into five categories of very low, low, moderate, high and very high (Fig.9). Low Ld indicates the more suitability; whereas very high Ld indicates less suitability for ARS (Manjunatha and Basavarajappa, 2015). Ranks and weightages for five categories are given based on the suitability of ARS priorities as shown in the Table.4. The major structural features that are impacting on the groundwater are fractures which are subdivided into joints, fissures and faults, which are formed by brittle fracturing of rocks (Roberts, 1982). These structures are of great influence on groundwater flow patterns in the aquifer observed in the study area (Senthil Kumar et al, 2015). The rocks in these units are hard & compact acting as run-off zones and limited infiltrations are noticed along the weak planes of joints, faults, fractures, folds and dykes (Singhal and Gupta, 1999) (Table.3 & 4).

4.5 Soil

Soil is one of the important parameter for site suitability analysis in ARS which highly influences the groundwater infiltration (Basavarajappa et al, 2015a). The soils of entire Piriyapatna taluk are derived from granitic-gneisses and charnockite rocks (Koushari, 2017) (Fig.10). Red soils are observed in upland areas and at the contacts of granites and schist representing the admixture of sand and silt (Basavarajappa et al, 2012). Black soils are of clay type and dark black in color. Mixed types of soils also found in localized manner at some places along the contact of schist and other basic intrusions (Koushari, 2017). Porosity and permeability of the soils impact the movement of groundwater and infiltration of surface water into the ground (Manjunatha and Basavarajappa, 2015). The infiltration rate of the soil determines the type of artificial recharge structure to be located and surface run-off potential determines the soil texture of the study area (Siddan, 2005). Ranks and weightages have been assigned (Table.3 & 4) based on soils infiltration capacity in the study area.

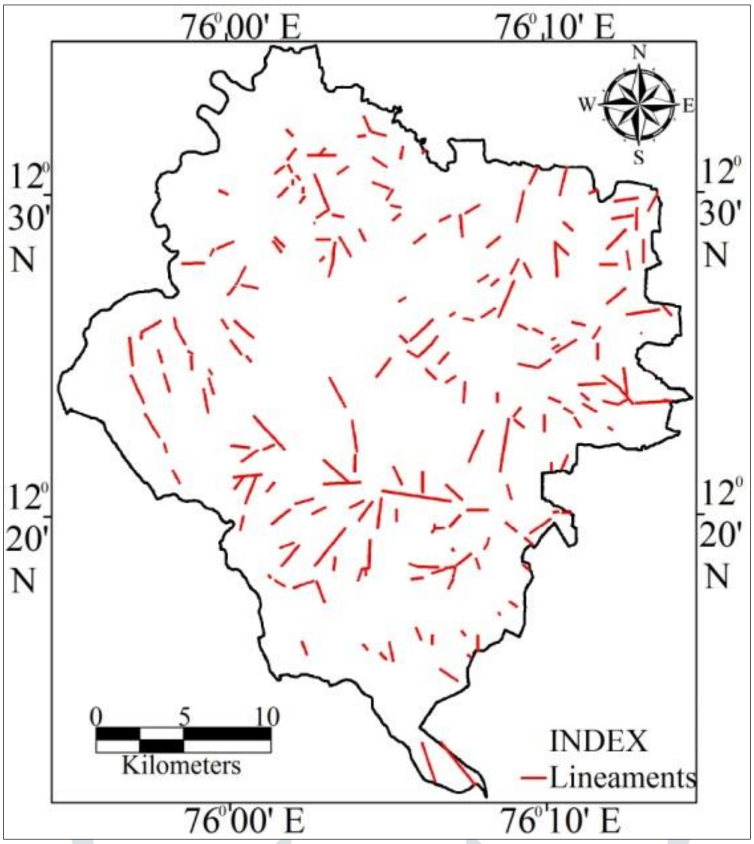

Fig.8. Lineament map of Piriyapatna taluk

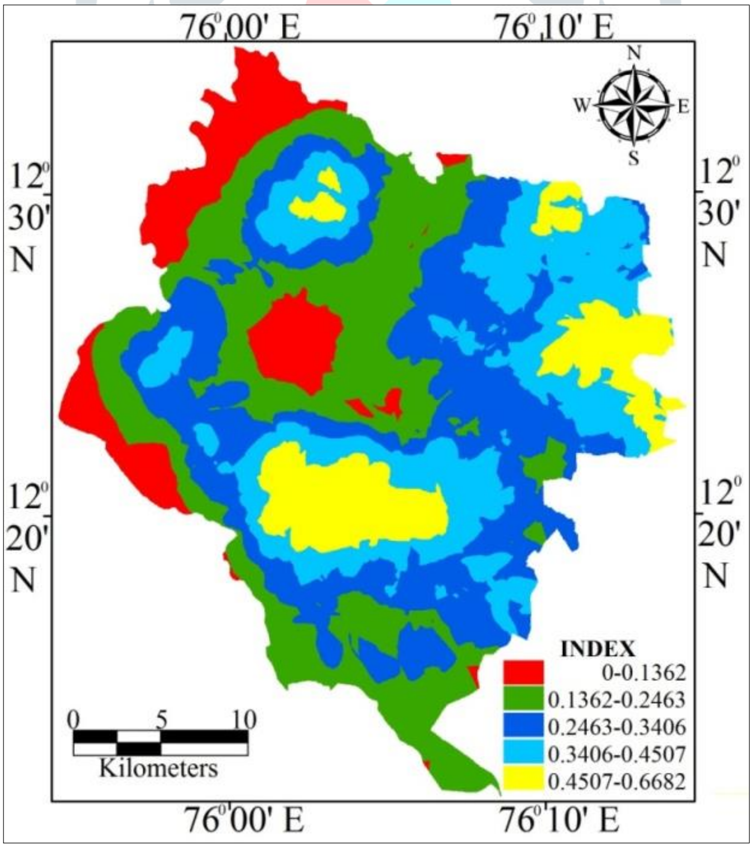

Fig.9. Lineament density map of Piriyapatna taluk

4.6 Slope

The taluk has classified as Southern Karnataka plateau representing partly plain ground, table land with plains, undulating and mountainous regions with general slope trending from Northern to Southern parts (CGWB, 2012). Slope map has been prepared by using ASTER GDEM of 30m resolution based on the guidelines of All India Soil and Land Use Survey (AIS & LUS, 1990) to determine the slope categories. These categories have been divided into five classes and ranks and weightages are assigned as shown in the Figure.11 and Table.3 & 4. Slope determines the rate of infiltration and run-off of surface water (Nassif and Wilson, 1975). Flat surface lands are highly suitable for ARS, since it implies lower surface run-off; while higher slope increases the run-off which makes the site not suitable for ARS (Yuguo et al, 2018). 'Very Good' ARS category falls under the range of 0^0 to 3^0 which is a nearly flat terrain having high infiltration rate. 'Good' ARS category ranges from 3^0 to 7^0 representing slightly undulating and some amount of runoff. 'Moderate' ARS category ranges from 7^0 to 11^0 which imply high runoff and low infiltration. 'Poor' ARS category ranges from 11^0 to 18^0 representing a moderate to steep slopes; whereas 'Very Poor' ARS category ranges from 18^0 to 53^0 representing higher slope and higher runoff (Basavarajappa et al, 2014b).

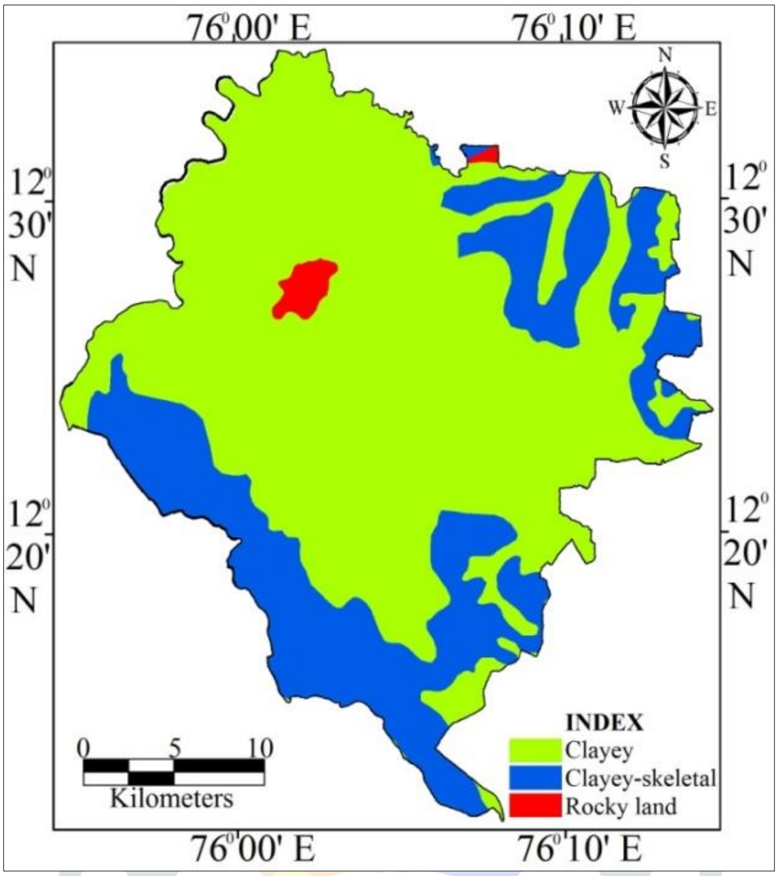

Fig.10. Soil map of Piriyapatna taluk

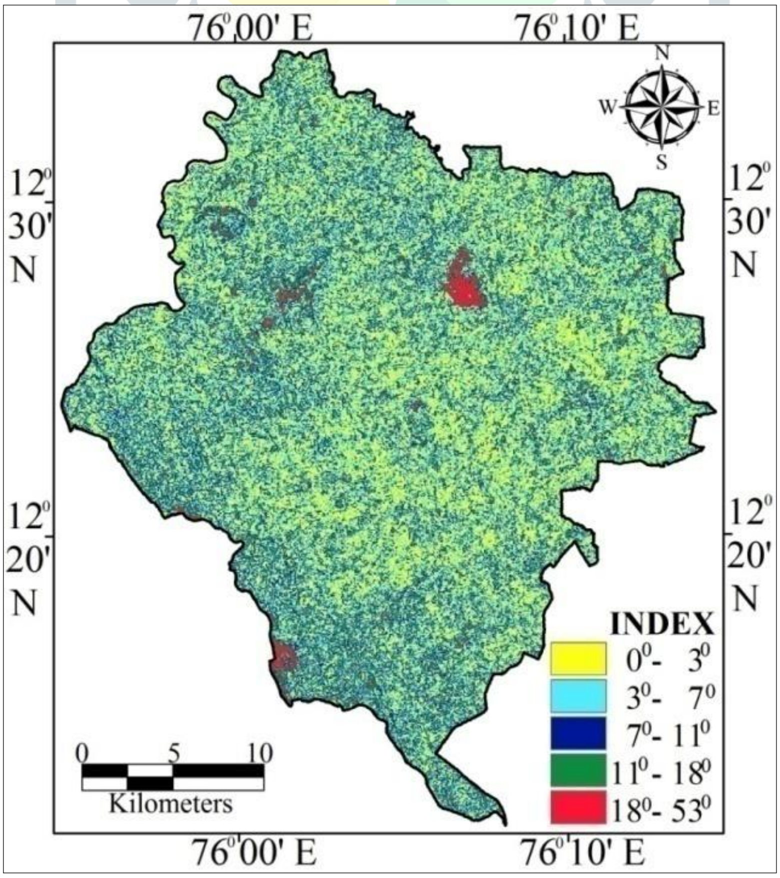

Fig.11. Slope map of Piriyapatna taluk

4.7 Land Use/ Land Cover (LU/LC)

LU/LC is also an important parameter in site suitability analysis of ARS which have higher impacts due to climatic changes, rapid increase in population and over demand of growing economic mineral deposits (Manjunatha et al, 2015). The land use pattern for human beings shows a reciprocal relationship between man and the ecological conditions of a region (Mandal, 1990). Sharma (1991) Opines that land use is a function of four factors namely land, water, air and man. Hence land use pattern in a region is governed in a large measure by physical controls and thereafter modified by socio-economic and technical organization variants. LU/LC exposes considerable influence on the various hydrological aspects such as interception, infiltration, catchment area, evaporation and surface flow (Sreenivasalu and Vijay Kumar, 2000). The impact of land use and land cover over the surface and sub-surface hydrologic condition is observed to be remarkably high on agricultural practices (Saraf and Choudhary, 1998). The LU/LC map is generated on LISS-III satellite image of 5.8m resolution using Supervised classification analysis in ArcGIS (Manjunatha et al, 2015) (Fig.12). Site suitability analysis on priority based LU/LC patterns influences the assigned ranks and weightages as shown in the Table 3 & 4.

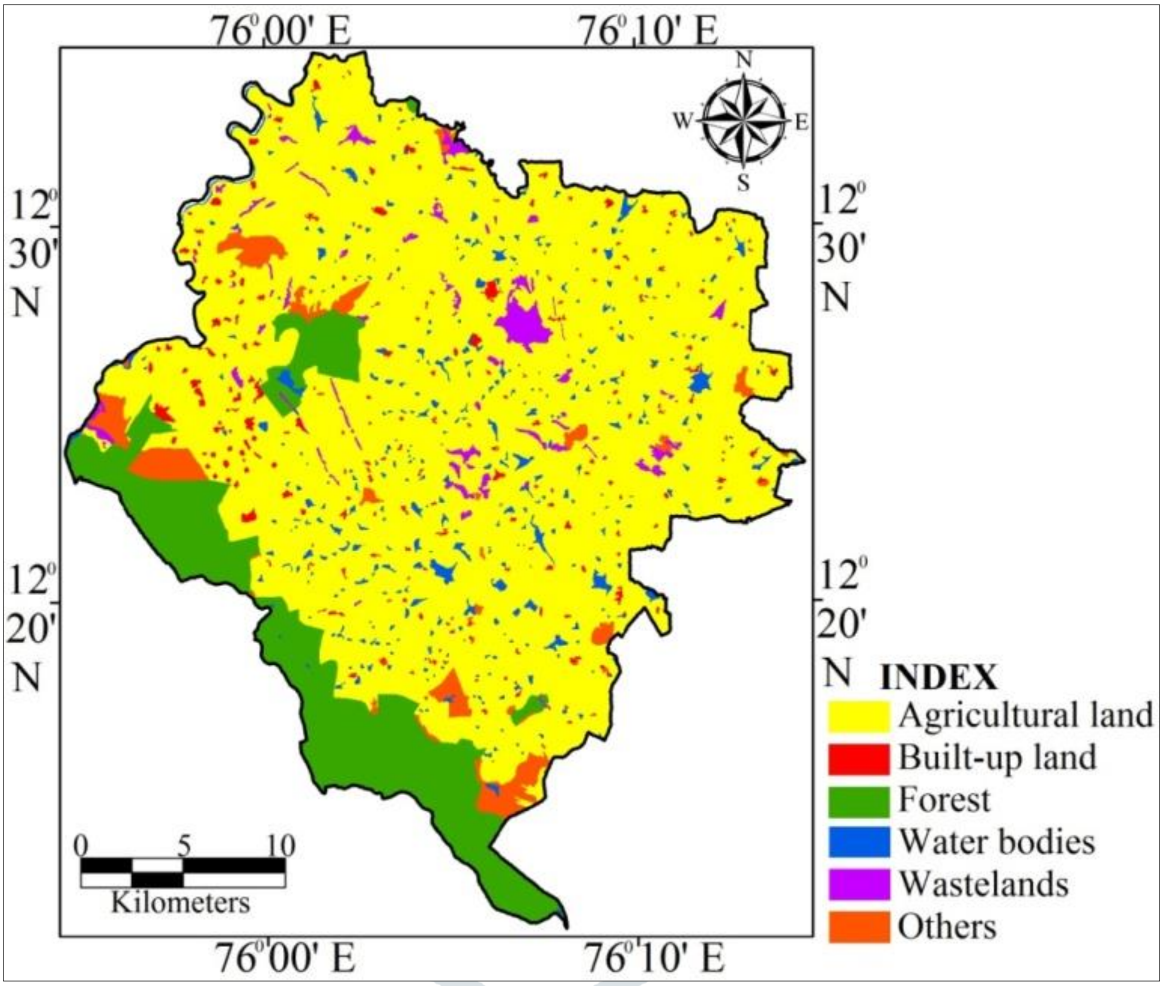

Fig.12. LU/LC map of Piriyapatna taluk

4.8 Stream Order (Sμ)

The stream order is the first step in any drainage basin analysis (Strahler, 1964). The variation in the total number and total length of the streams are due of precipitation, morphology and lithology of the terrain (Basavarajappa et al, 2014a). The terrain is characterized by flat land to steep slope and medium precipitation. Higher stream order is associated with greater discharge (Pushpavathi K.N, 2010) (Fig.13). The trunk stream, through which all discharge of water and sediment passes is therefore the stream segment of highest order (Rafiq, 2013). The basin order goes up to fourth in the given study area**.**

5. HYDROGEOLOGY

Hydrogeologically, the area forms a part of hard rock terrain comprising of granites, gneisses, charnockites and amphibolites (CGWB, 2012). Pegmatite veins and dolerite dykes are common intrusive in the area. The flat and low-lying areas are covered by a thick mantle of fertile soil (CGWB, 2012) (Fig.14). The groundwater occurrence and movement depends on the secondary porosities like weathering, fracturing, faulting, lineaments representing a tectonic history of the area as well (Manjunatha and Basavarajappa, 2015). Prominent lineaments are noticed to be trending towards NNE –SSW, N-S, NW-SE, E-W, NE–SW to NNW-SSE direction (Basavarajappa et al, 2012). The foliation in the granitic gneiss is trending with an easterly dip of 40^0 to 80^0 (CGWB, 2012). Hard rock's do not posses primary porosity and groundwater occurs under phreatic conditions in weathered zones of granites and gneiss (Bhagyashri et al, 2011). Water is under semi-confined to confined conditions in joints and fractures of these rocks at deeper levels (Manjunatha and Basavarajappa, 2015).

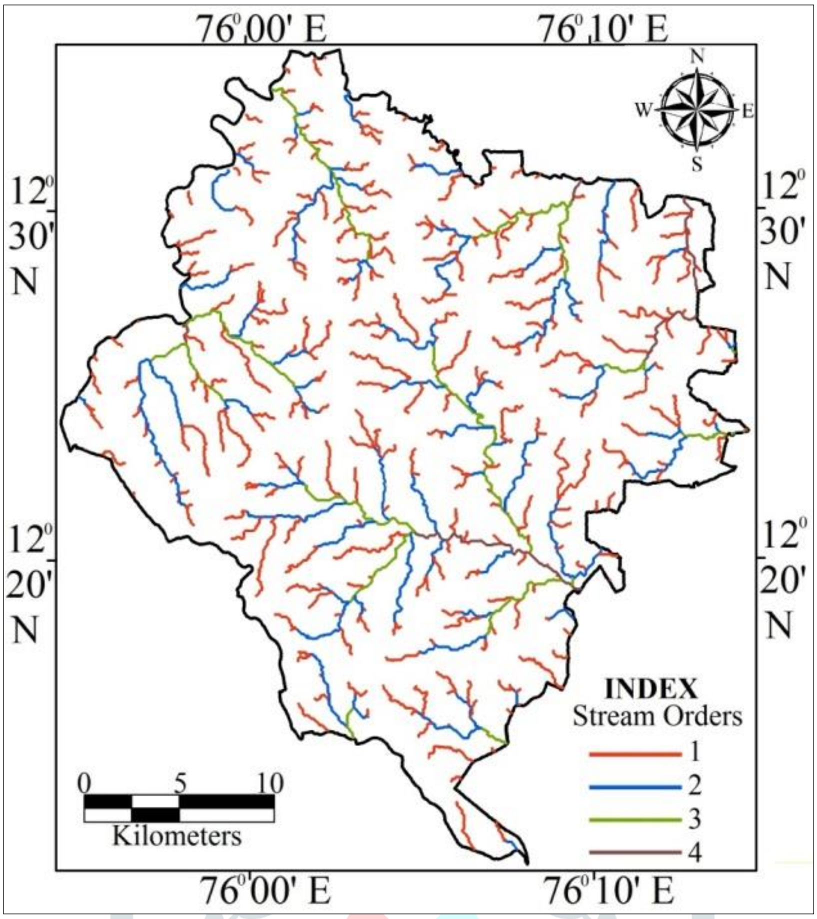

Fig.13. Stream Order map of the study area

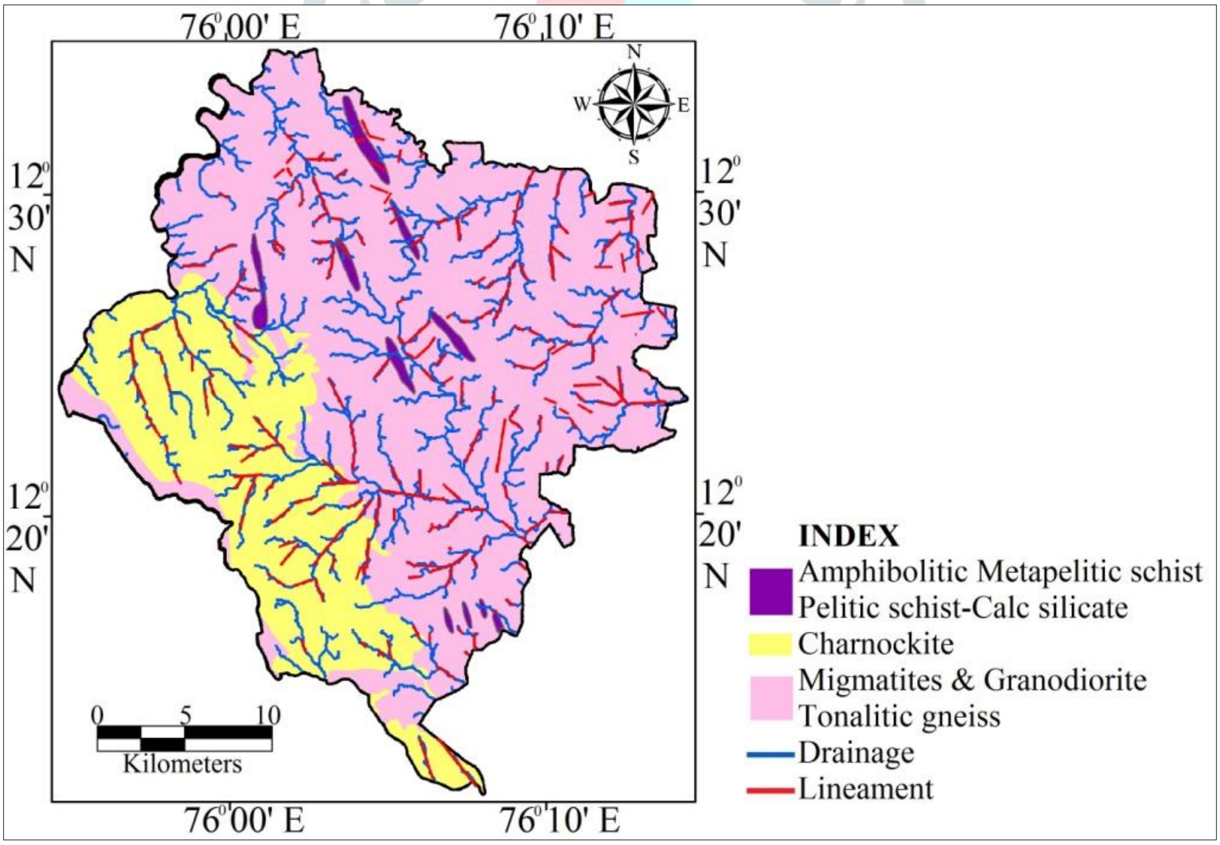

Fig.14. Hydrogeology map of Piriyapatna taluk

6. ANALYTICAL HIERARCHY PROCESS

One of the most important tools is the combination of an Analytical Hierarchy Process (AHP) method (Saaty, 1980) with GIS platform. This method has received considerable attention among multidisciplinary decision makers and has demonstrated its value in various studies (Sameh Kachouri, 2014). Thomas Saaty (1980) introduced Analytical Hierarchy Process (AHP) which is an effective tool in dealing the complex decision making, and may aid the decision maker to set priorities for best output results

(Table.1). The AHP considers a set of evaluation criteria and a set of alternative options among which the best decision is to be made (Table.2). Multi criteria decision analysis using (AHP) is the most common and well known GIS based method for delineating best ARS sites (Arulbalaji et al, 2019) (Table.5). The weights of criteria in Saaty's technique are computed by applying the main eigen vector of the square reciprocal matrix of pair-wise comparison between the two factors. The priorities are interpreted with respect to the goal at the top of the hierarchy, and then elements at upper levels such as criteria, sub-criteria, etc (Jaroslav Ramik, 2017). Continuous rating scale of Saaty's analytical hierarchy process was used for assigning weights for pair-wise comparison (Sameh Kachouri, 2014) (Table.2).

6.1 Weighted Overlay Method

Weighted Overlay Method (WOM) along with the AHP & GIS provides a very assuring outcome for the site suitability assessment in solving complex problems (Malay Kumar, 2016) (Table.3). It has steps to analyze the relative influence of weights on each parameter, before obtaining the final score (Boroushaki and Malczewski, 2008). Analytical hierarchy process is one of the auspicious methods utilized for agricultural land suitability assessment based on individual parameters through quantitative assessment (Khahro et al, 2014). Pair-wise comparison is also used to calculate the overall score of individual elements or criteria. Integration of GIS and analytical hierarchy process helps to decision support system by the generation of suitability maps (Khahro et al, 2014). In this method the individual thematic layers and their relative attributes are assigned suitable weightages on the basis of their relative contribution towards the output (Malay Kumar, 2016). The analysis was performed with seven parameters such as lithology, geomorphology, drainage density, lineament density, soil, slope and land use/ land cover. Output results have been classified into five categories of very poor, poor, moderate, suitable and highly suitable based on standard deviation classification scheme (Malay Kumar, 2016). Pair-wise comparison and assessment of weightages are prepared for all seven parameters using Raster overlay analysis tool in ArcGIS software and given in Table.3. The results show that 9.16 Km^2 of area having very poor suitable sites, 257.66 Km^2 of poor suitable sites, 306.06 Km^2 moderately suitable sites, 97.43 Km^2 suitable sites and 105.22 Km^2 of highly suitable sites for Artificial Recharge Structure implementation in Piriyapatna taluk (Fig.15). Taluk & State roads, Power lines, Telephone lines, Temples, Settlements, and other land features are excluded during the process the Site Suitability map.

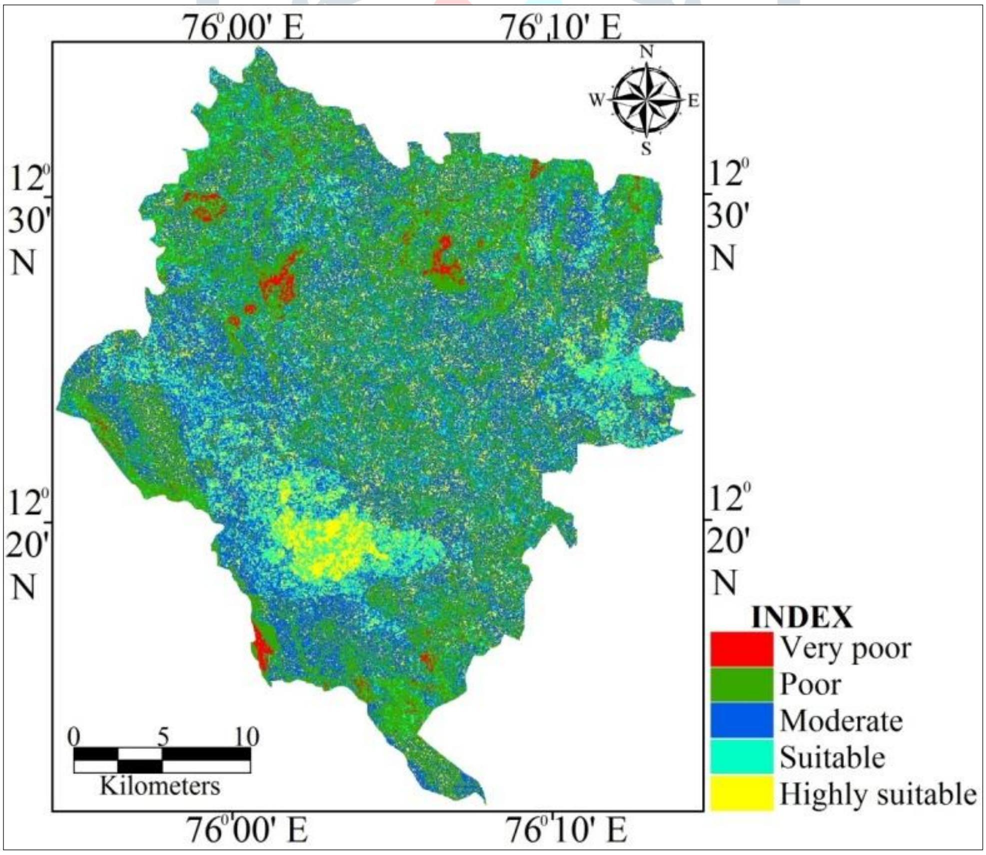

Fig.15. Overlay weightage map for ARS site suitability

Table.2. Continuous rating scale of Saaty's Analytical Hierarchy process

1/9	1/7	1/5	1/3	1	3	5	7	9
Extremely	Very strongly	Strongly	Moderately	Equally	Moderately	Strong	Very strongly	Extremely
Less important<----------------				Equal	---------------->More important			
Source: Saaty (1980) Note: 1/8, 1/6, 1/2, 2, 4, 6, 8 can also be used if more number of classes exists								

Table.3. Different weightages assigned to layers through Analytical Hierarchy process

Sl. No	Weightage analysis	Lithology	Geomorphology	Drainage density	Lineament density	Soil	Slope	LU/ LC
1.	Lithology	1	1	4	2	3	1	5
2.	Geomorphology	1	1	4	2	3	1	5
3.	Drainage density	0.25	0.25	1	0.333	0.5	0.25	3
4.	Lineament density	0.5	0.5	3	1	3	0.5	1
5.	Soil	0.333	0.333	2	0.333	1	0.333	3
6.	Slope	1	1	4	2	3	1	5
7.	LU/LC	0.2	0.2	0.333	1	0.333	0.2	1
	Column sum	**4.283**	**4.283**	**18.333**	**8.666**	**13.833**	**4.283**	**23**
	Consistency ratio (CR) = 0.05 < 1							

Table.4. Percentage of Influencing factor based on Saaty's Analytical Hierarchy Process (AHP)

Sl No	Influencing factor	Saaty's scale (in fraction)	Saaty's scale (in decimal)	Percentage influence = (Saaty's Scale/sum) * 100	Relative influencing Factor
1.	Lithology	1	1.00	23.36	23
2.	Geomorphology	1	1.00	23.36	23
3.	Drainage Density (m/m^2)	1/4	0.25	5.84	6
4.	Lineament Density (m/m^2)	1/2	0.50	11.68	12
5.	Soil types	1/3	0.33	7.71	8
6.	Slope (in degrees)	1	1.00	23.36	23
7.	LU/LC	1/5	0.20	4.67	5
			Sum=4.28		

Table.5. Assigned weight according to Saaty's Analytical Hierarchy process

Sl. No	Influencing Factor	Class Intervals or features	Saaty's Scale (Fraction)	Saaty's Scale (Decimal)	Percentage Influence = (Saaty's Scale/Sum) * 100	Relative Influencing Factor
1.	Lithology	Amphibolite Metepelitic Schist	1/2	0.5	10.141	10
		Charnockite	1	1.0	20.980	20
		Migmatite and Granodiorite	1/2	0.5	10.141	10
				Sum =2.0		
2.	Geomorphology	Chanel island	1/4	0.25	2.765	2
		Curvilinear ridge	1/2	0.50	5.530	6
		Denudational hills	1/4	0.25	2.765	2
		Dissected pediment	1/2	0.50	5.530	6
		Dyke ridge	1/2	0.50	5.530	6
		Inselberg	1/3	0.33	3.650	4
		Linear ridge	1/2	0.50	5.530	6
		Pediment	1	1.00	11.060	11
		Pediment inselberg complex	1	1.00	11.061	11
		Pediplain moderate	1	1.00	11.060	11
		Pediplain shallow	1	1.00	11.060	11
		Residual hills	1/4	0.25	2.765	3
		River/stream	1/5	0.20	2.210	2
		Valley fill shallow	1/4	0.25	2.765	3
				Sum =7.53		
3.	Drainage Density (m/m^2)	0.0 - 0.342	1	1.00	43.86	44
		0.342 - 0.615	1/2	0.50	21.93	22
		0.615 - 0.824	1/3	0.33	14.47	14
		0.824 - 0.984	1/4	0.25	10.96	11
		0.984 - 1.247	1/5	0.20	8.77	9
				Sum =2.28		

4.	Lineament Density (m/m^2)	0.0 - 0.220	1/5	0.20	8.77	9
		0.220 - 0.338	1/4	0.25	10.96	11
		0.338 - 0.401	1/3	0.33	14.47	14
		0.401 - 0.519	1/2	0.50	21.93	22
		0.519 - 0.739	1	1.00	43.86	44
				Sum =2.28		
5.	Soil Types	Clayey	1/2	0.50	15.24	15
		Clayey Skeletal	1/4	0.25	7.62	8
		Rocky Land	1/5	0.20	6.01	6
				Sum =0.95		
6.	Slope (In Degrees)	0-3	1	1.00	43.86	44
		3-6	1/2	0.50	21.93	22
		6-9	1/3	0.33	14.47	14
		9-12	1/4	0.25	10.96	11
		12-53	1/5	0.20	8.77	9
				Sum =2.28		
7.	Land Use/ Land Cover	Agricultural Land	1/2	0.50	21.92	22
		Built Up	1/4	0.25	10.96	11
		Forest	1/3	0.33	14.47	14
		Wastelands	1	1.00	43.85	44
		Water Bodies	1/5	0.20	8.77	9
				Sum =2.28		

7. IMSD GUIDELINES ADOPTED FOR ARS

Integrated Mission for Sustainable Development [IMSD-1995] guidelines are effectively utilized in determining the best sites for Artificial Recharge Structures (ARS) such as Nala bunds, Percolation Tanks and Farm pond (Fig.16). In order to identify the exact location of a structure, different thematic layers such as lithology, geomorphology, drainage & lineament density, soil, slope and land use/cover were integrated under GIS environment (Table.5). Subsequently, different thematic layers are fulfilled with specific locations for suitable type of ARS (Mythili et al, 2009).

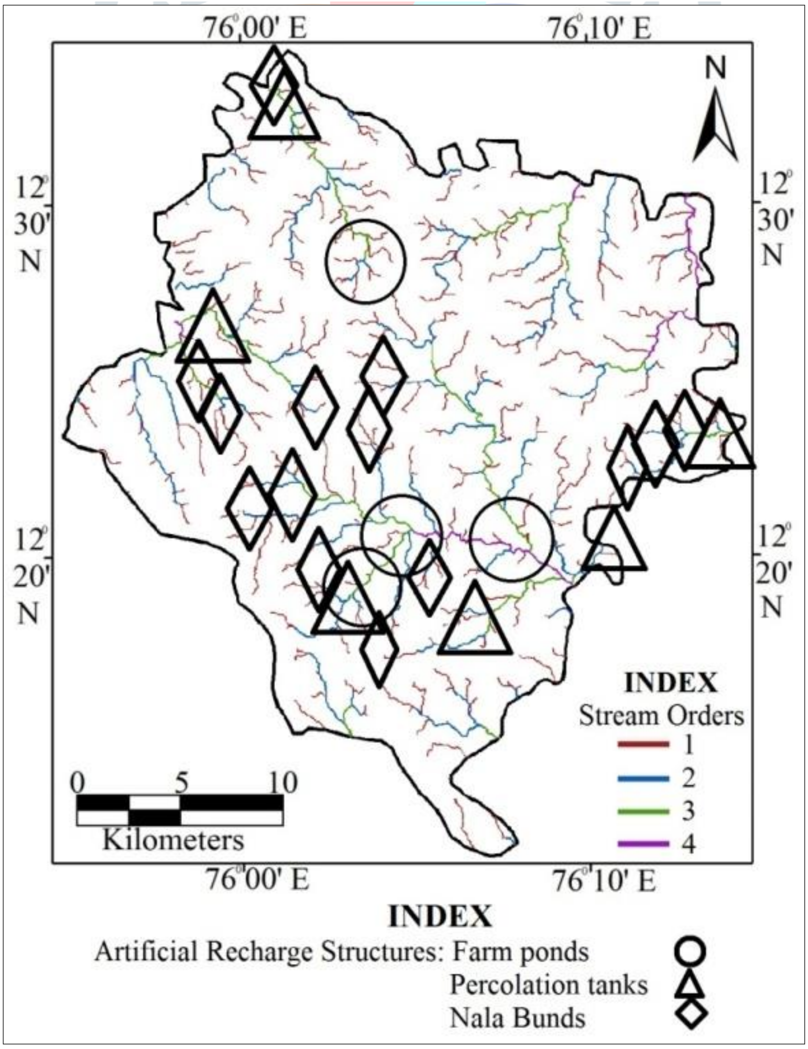

Fig.16. Final Output map for ARS implementation

7.1 Nala bunds

These structures are best suited across bigger streams of 2nd order having gentle slopes. The rainfall conditions should be less than 1000mm annually in the catchment areas and the soil in bund downstream should prone to water logging (Fig.16).

7.2 Percolation tanks

These structures are built mainly to impound monsoon runoff over a large area to augment groundwater recharge. Moderate to high porosity of soil and/ or underlying rocky strata is the main criteria for the choice of percolation tanks. These tanks are more suited across the small streams of lower elevations of 3^0-7^0. Soils available in catchment area should be of light sandy type to avoid silting up of the tanks bed (Fig.16).

7.3 Farm Ponds

These are ideal for the locations of narrow streams with ground on either side with less than 10% of ground slope. The infiltration rate of the soil should be moderate with either barren or shrub type of land use pattern. The pond should be located above the irrigated fields where it could serve major purposes for irrigation. Junction of the two drainage channels or large natural depression is preferred to control the sediments inflow. This is one of the particular structures that facilitate the recharge of groundwater even after the monsoon season (Fig.16).

8. RESULTS AND DISCUSSION

The groundwater levels in the study area rises during monsoon seasons and increases the reservoir storage capacity. But in non-monsoon periods, the groundwater level gets depleted due to gradual increase in population, rapid urbanization, industrialization, over-withdrawal and global warming (?) recorded from December to May (Manjunatha and Basavarajappa, 2017). The groundwater levels in Piriyapatna taluk is fully dependent on monsoon rainfall conditions and partially on the River Cauvery flowing in the Northern most boundaries. Hence, rainfall is an important part of the hydrologic cycle and is important in sustaining streams, wetlands, ponds and aquatic communities of the study area. Site suitability analysis is derived through AHP and WOM from important thematic layers in ArcGIS environment and the following conclusions have been drawn. The groundwater is over-exploited in Mysuru taluk since from 2008-09 due to rapid increase in industrialization, Urbanization, over-withdrawal of water and irrigation (Manjunatha and Basavarajappa, 2017). Artificial Recharge Structures (ARS) are the effective and efficient techniques to overcome critical and over-groundwater exploited areas to augment the groundwater system. These structures will significantly enhance the irrigation potential and agricultural productivity which fulfills the needs of growing population, demand and sustainability.

9. CONCLUSION

The Western parts shows hilly and rugged topography where Artificial Recharge Structures like nala bunds may be constructed; whereas percolation tanks may be practiced in comparatively plain areas. 4 Farm ponds, 6 Percolation tanks and 14 Nala bunds are identified as best sites ARS implementation in Piriyapatna taluk of Mysuru district generated using AHP and Geoinformatics. Due to overdependence on the river Cauvery and rapid urbanization in the study area, the water resources have been decreasing gradually. Statistics on water availability has shown that the KRS Dam will prone to drought in coming year with low rainfall conditions. Geoinformatics comes in handy for Decision Support System (DSS) to control the excess runoff to recharge the deep aquifer through innovative and cost effective manner. Since the Piriyapatna taluk is noticed at higher level by MSL with that of Mysuru taluk, the stored water can be supplied to KRS dam during extreme summer conditions to fulfill the needs of Mysuru region.

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