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SPATIAL DATA INTEGRATION OF LITHOLOGY, GEOMORPHOLOGY AND ITS IMPACT ON GROUNDWATER PROSPECT ZONES IN PRECAMBRIAN TERRAIN OF CHITRADURGA DISTRICT, KARNATAKA, INDIA USING GEOMATICS APPLICATION

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KEYWORDS: Lithology; Geomorphology; impact on Groundwater; Chitradurga; Geomatics.

ABSTRACT
Mapping of lithology and geomorphology are carried out in typical hard rock terrain of Chitradurga district, which belongs to Dharwar Craton, Southern India. Groundwater resources in hard rock terrain are limited which need proper management and developmental programme strategies in its sustainability. Efforts have been made to evaluate the lithological units and geomorphological landforms in Precambrian terrain using Visual Image Interpretation Techniques (VIIT) and Digital Image Processing (DIP) of Landsat-7 False Color Composite (FCC) through GIS software's. Different lithological formations and landforms under each geomorphic unit have been mapped. The present study aims to integrate the geomatics application in assessing the demarcation of groundwater prospecting zones of the study area using bore well data collected during the year 2010. The final results highlight the potentiality of geomatics application in mapping of lithology and geomorphological landforms for groundwater exploration in hard rock terrain of Chitradurga district, Karnataka.

INTRODUCTION
Groundwater being a dynamic resource, getting recharged annually, primarily from the rainfall, is vulnerable to various developmental activities and is prone to deterioration in quality and quantity (Basavarajappa and Manjunatha. 2015a). Groundwater targeting in hard rock terrain is a very difficult task due to typical hydrological properties of unconfined and fractured aquifers (CGWB., 2013). Sustainability of groundwater resource depends mainly on two factors viz. Annual groundwater recharge and annual groundwater draft. The annual groundwater recharge depends on the quantity and intensity of rain fall, the infiltration characteristics of the soil, the depth to groundwater level, the slope of the area and the geomorphology (CGWB., 2007). Fractures, rock cleavages & fault/thrust play a vital role in affecting the surface storage and groundwater recharge. The magnitude of the water table fluctuation depends on drainage, topography and geological conditions (Pushpavathi K.N., 2010). About 43 no' of groundwater levels have been encountered through observation well points (15-open wells; 28-dug wells) during the monsoon period of 2010 (Fig.2). The present study is undertaken to investigate the impact of groundwater prospects by assessing the lithology and geomorphology of the study area using advance techniques. Satellite data with its multi-spectral, temporal, spatial and synoptic view including limited Ground Truth Check (GTC) provide an edge to characterize the lithology and geomorphic features (Basavarajppa et al., 2014c). Thematic maps are integrated by overlay techniques using GIS to assess the lithology and geomorphological landforms and its effects on groundwater. Visual Image Interpretation Techniques (VIIT) of satellite imageries in pictorial format and computer processing of Remotely Sensed (RS) digital data are the two methods well utilized in the study area through geomatics technique (Basavarajappa and Manjunatha. 2014b). Thematic maps are prepared by VIIT & DIP (image restoration, image enhancement & image classification) on Landsat-7 ETM+ FCCs (Geo-coded) have been analyzed using ArcGIS v10 (Fig.3). Based on the image interpretation elements like shape, size, tone, texture, pattern, shadow, association etc., various geomorphological units & associated lithological formations are delineated and verified during field visits (Ground Truth Check - GTC).

STUDY AREA
It lies in between 13° 34' to 15° 02' N latitude and 76° 00' to 77° 01' E longitude with an aerial extent of 8,338 Km^2 (Fig.1). It includes six taluks namely Challakere, Chitradurga, Hiriyur, Holalkere, Hosadurga and Molakalmuru with general elevation of 732 m above MSL (Basavarajappa et al., 2014a). It receives low to moderate rainfall. The normal annual rainfall is 574 mm (1981-2010) recorded from last three decades.

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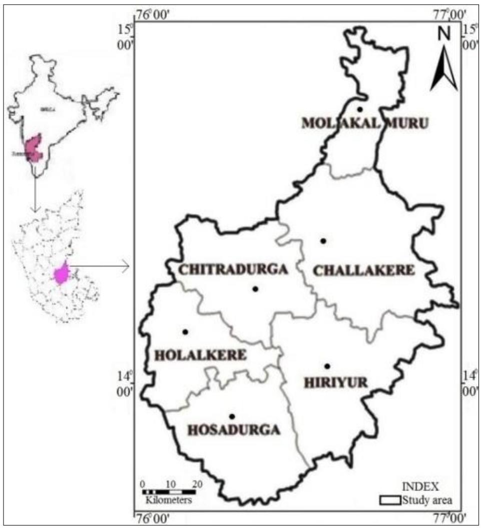
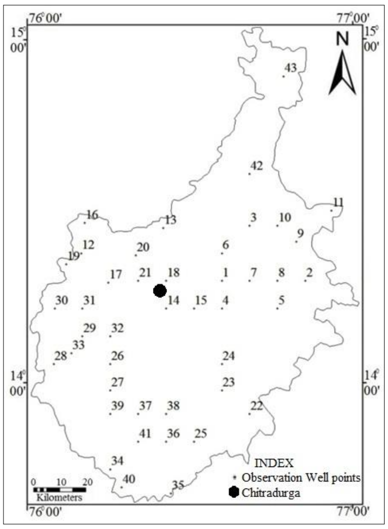
Figure: 1 & 2



Location map



Observation Well points map

The average annual rainfall is 744 mm (2011) (Manjunatha et al., 2015b). Soil types of the district comprise deep & shallow black soil, mixed red & black soil, red loamy & sandy soil (Basavarajappa and Manjunatha. 2014b). Vedavathi, Chikkahangari and Tungabhadra rivers drains major parts of the study area (CGWB. 2007).

MATERIALS AND METHODS

a. **Topomaps:** 57A/12; 57B/3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16; 57C/1, 2, 5, 6, 9, 10, 13.
Sources of data: Survey of India (SoI) of 1:50,000 scale, (year: 1975-2010).

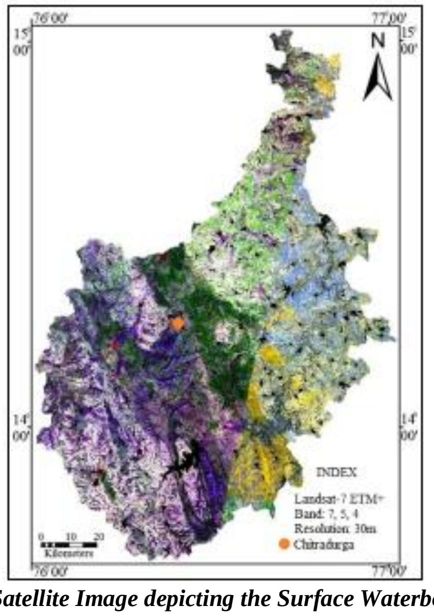
b. **Satellite Remote Sensing data:** Landsat-7 ETM+ of FCC Geocoded data with 30m Resolution of band 7,5,4 (year: April-May 2015). Sources of data: Open access from USGS (website), Earthexplorer.

c. **Thematic maps:** Observation well point map, Landsat-7 ETM+ map, Lithology, Geomorphology and Groundwater prospect map (2011).

d. **GIS software's:** Erdas Imagine v9.2 and ArcGIS v9.2.

e. **GPS:** Limited Ground Truth Check (GTC) has been done using GPS-Garmin 12.

Figure: 3



Landsat-7 ETM+ Satellite Image depicting the Surface Waterbodies in black tone

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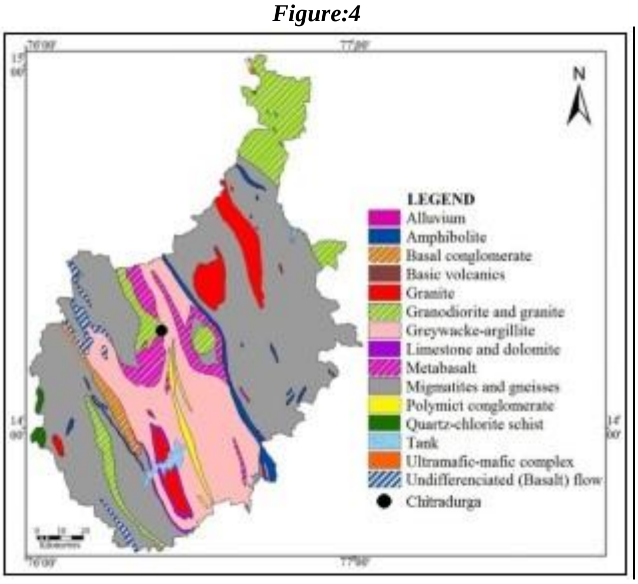
GEOLOGY

Chitradurga group of rock formations shows the evidences of deposition in the interior parts of basins and have the stamp of deep water facies (Radhakrishna and Vaidyanadhan., 2011). Geologically, the study area confirms Archaeans and Dharwars as basement complex. The study area represents mainly of gneisses, patches of Closepet granite, granitoids and schistose formations and act as crystalline formations in groundwater movement and storage (GSI-Memoir., 1981). Fracture/ fissure system developed along with joints and faults facilitates the groundwater circulation and hold moderate quantity of water (CGWB., 2007). Different forms of granites, gneisses, schists, quartzites, undifferenciated flow etc. Major litho-units encountered during field visits are conglomerate, orthoquartzite/ quartz chlorite schist, greywacke, metavolcanics, laterite, talc, sericite schist, shale, basic volcanic rocks, gneissic, phyllite and numerous bands of iron formations (Fig.4) (Basavarajappa and Manjunatha., 2014b). The schistose rocks even with well-developed schistosity are relatively impermeable, but yield very less quantity of water. Groundwater availability is encountered in weathered, decomposed rock formations in deeper zones. At many locations, various important rock formations are intruded by dolerite dykes which acts as barrier of groundwater movement. There are many parallel hill ranges noticed as schistose rocks. The general strike of the belt is N 20^0 W and S 20^0 E and dipping both in East and West directions varying from 55^0 to 85^0 providing better idea in groundwater movement with respect to a specific direction (Basavarajappa et al., 2014d). The nature of the rock types not only influences the tectonics but also have direct effect on topography, drainage pattern, soil types and other factors of tectonics with reference to groundwater conditions.

Figure:4



Lithology map of the study area

GEOMORPHOLOGY

The Karnataka Plateau which has undergone various stages of erosion-deposition processes as a result of upliftment of Western Ghats (Radhakrishna and Vaidyanadhan., 2011). Granitic/gneissic landscape and schistose landscape are the major plan surfaces that have been subdivided into various landform units such as hills, pediments, plains and valleys. These landscapes are rugged noticed with number of hill ranges with elevation ranging between from 550 to 1200 m above MSL (NBSS & LUP., 2013; Manjunatha et al., 2015a). The study highlights the use of satellite Remote Sensing techniques in mapping of geomorphological landforms classification system on 1:50,000 scale. The landforms observed in the study area are Channel island, Denudational hills, dyke ridge, inselberg, linear ridge, pediment, pediment inselberg complex, pediplain moderate, pediplain shallow, reservoir, reservoir island, residual hills, river/stream, structural hills, valley and valley fill shallow (Fig.5). Physiographically the district comprises of undulating plains, interspersed with sporadic ranges and isolated low ranges of rocky hills. The study area forms part of the Southern maiden region, has extensively undulating plateau (CGWB., 2013).

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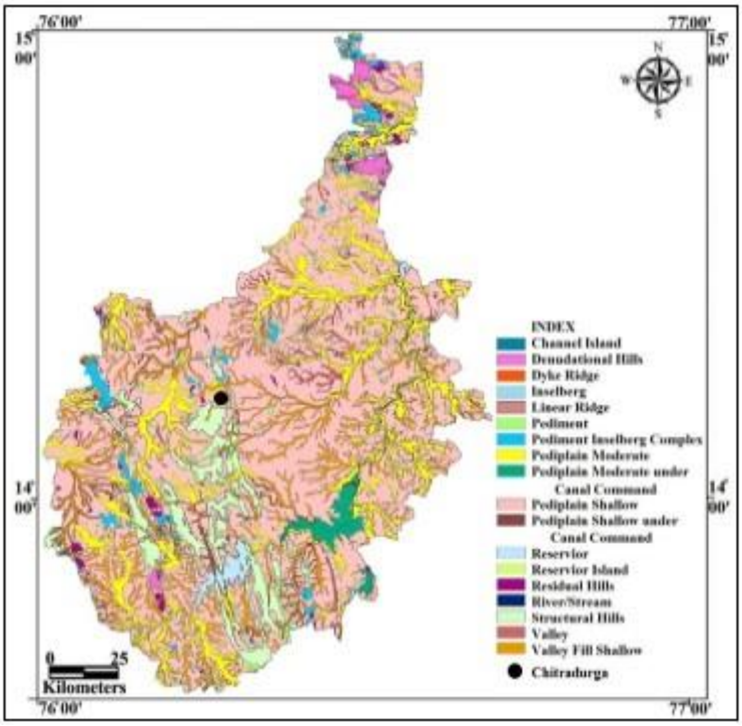
Figure: 5



Geomorphological landforms of the study area

GROUNDWATER RECHARGE, DISCHARGE AND IMPACT

Groundwater occurs under phreatic conditions in the weathered rock of Peninsular Gneissic complex comprising of gneisses, granites, quartzites and schistose formations. At depth, the groundwater occurs in the fractures and fault zone of these crystalline rocks under semi-confined to confined conditions. The thickness of weathered zone varies from less than a 1.6 m near hill slopes and higher altitudes to about 30.3m BGL (Below Ground Level) in valleys and topographic low areas (CGWB., 2013). Geomorphic conditions play a significant role in controlling the surface as well as groundwater horizons (Basavarajappa et al., 2013). Denudational hills are noticed in Molkalmuru taluk with the presence of few joints, fractures and shear zones representing poor groundwater prospect zones. Residual hills are observed in western and northern parts of the study area with steep gradient representing very poor groundwater prospect zones due to immediate rainwater runoff without much infiltration (Kamal Raj and Pramod Chandra Sahu., 2006; Tiwari., 1996). Pediments represent poor groundwater conditions due to the type of underlying folded structures, fracture system and degree of weathering (Girish Gopinath and Seralathan P., 2004). Linear ridges occur as linear to curvilinear, narrow, low-lying relief and barren lands represents the poor groundwater prospects. The water table depths are relatively shallow near perennial surface water bodies and topographically low areas (Basavarajappa et al., 2014c). It represents moderate to good groundwater prospects when associated with fractures/ lineaments. Structural hills are composed of gneiss and schistose rocks and acts as runoff zone with poor recharge conditions. Valley fills are highly favorable for groundwater occurrences and acts both as recharge & discharge areas for groundwater. Secondary porosity such as lithological contacts, unconformities, folds, faults, bedding plains, fractures, joints, shear zones provides pathway in occurrence & movement of groundwater through granite, quartzites and schistose rock formations (Basavarajappa et al., 2014c). Gneissic rocks are highly weathered & slope varies from nearly level to very gentle slope especially observed in Molkalmuru taluk; while weathered granitic hills are noticed in Hosadurga and Chitradurga taluks. Shallow groundwater levels are noticed at Narasipura (Chitradurga taluk) observation well is 0.73 m; while deeper groundwater levels are noticed at Chitrahalli (Holalkere taluk) observation well is 31.50 during monsoon season (Fig.6; Table.1). Weathered/ fractured granitic-gneisses, schists, amphibolites, greywacke, hornblend schists are the major water bearing rock formations with the thickness ranging from 1 to 200m bgl (CGWB., 2013). Dug wells are the ideal structures in weathered rocks. Artificial Recharge Structures (ARS) such as check dams and nalla bunds are better option to mitigate the water scarcity issues during extreme summer conditions. Subsurface dykes acts as arresting the groundwater movement along river courses (CGWB.,

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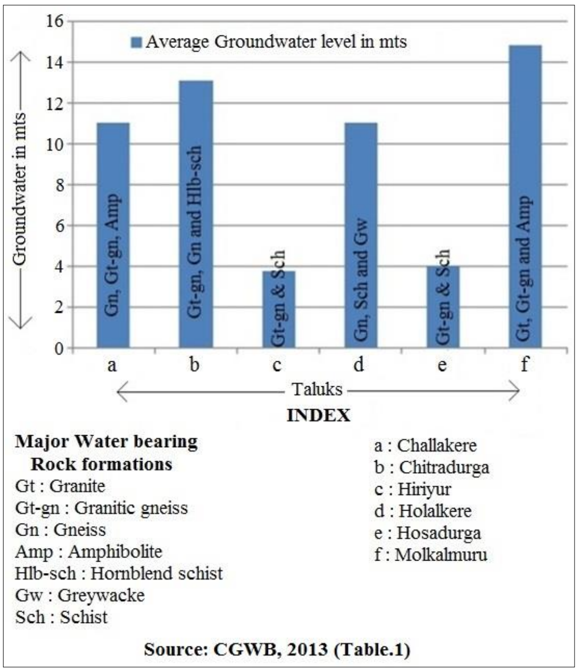
2007). The final composite map reveals four major groundwater prospect zones based on assigned weightages from 1 to 4 (1-represents very good; 2-good; 3-moderate and 4-poor groundwater prospects) (Fig.7).

Table.1. Average Annual Groundwater level data in meters (2010)

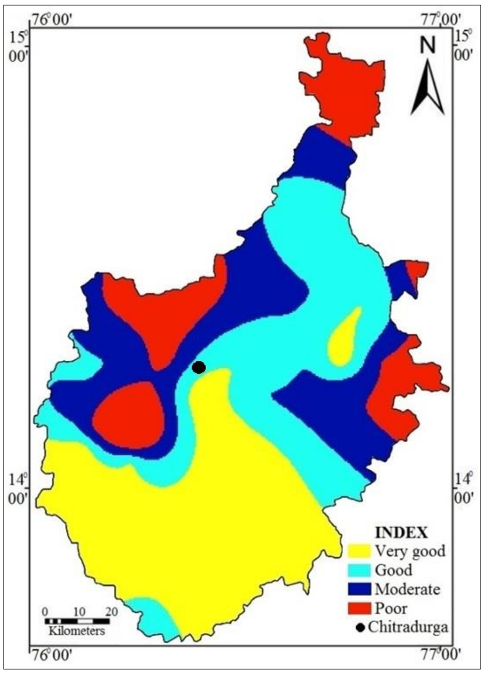
Sl. No	Observation Well	Latitude	Longitude	Groundwater level (m)
Challakere taluk				
1	Challakere	14.2555	76.5944	7.36
2	Parasurampura	14.2555	76.8486	16.59
3	Talaku	14.4250	76.6791	11.85
4	Kammathmari kunte	14.1708	76.5944	11.55
5	Thimmannanaikana Kote	14.1708	76.7638	15.73
6	Budnahatti	14.3402	76.5944	10.85
7	Dodderi	14.2555	76.6791	11.00
8	Purlehalli	14.2555	76.7638	3.72
9	Nagagondahalli	14.3755	76.8215	6.26
10	Mylanahalli	14.4250	76.7638	8.67
11	Obalapura	14.4702	76.9270	18.04
Chitradurga taluk				
12	Bharamasagara	14.3402	76.1666	14.91
13	Turuvanur	14.4166	76.4166	20.97
14	Medakaripura	14.1708	76.4250	2.68
15	Kallahalli	14.1708	76.5097	8.35
16	Bhahadurgatta	14.4334	76.1779	16.91
17	Vijapura	14.2500	76.2500	12.44
18	Belagatta	14.2555	76.4250	10.41
19	Bommakkanahalli	14.3402	76.0097	5.33
20	Chikkagondanahalli	14.3333	76.3333	20.20
21	Guddarangavvanahalli	14.2555	76.3402	19.20
Hiriyur taluk				
22	Bagganadu	13.8486	76.6791	4.34
23	Hiriyur	13.9205	76.5944	3.50
24	Balenahally	14.0013	76.5944	4.20
25	Yelladakere	13.7638	76.5097	2.93
Holalkere taluk				
26	Horakedevapura	14.0013	76.2555	5.18
27	Kummanaghatta	13.9205	76.2555	2.75
28	Arehallihatti	14.0013	76.0833	2.61
29	Amruthapura	14.0861	76.1708	17.97
30	Sasauhala	14.1708	76.0861	12.60
31	Hirekandavadi	14.1708	76.1708	13.66
32	Chitrahalli	14.0861	76.2555	31.50
33	Arehallihatti	14.0345	76.1373	2.16
Hosadurga taluk				
34	Kalkere	13.6791	76.2555	5.99
35	Heggere	13.6048	76.4393	4.47
36	G.Nerlakere	13.7638	76.4250	2.74
37	Madadakere	13.8486	76.3402	3.68
38	Seeranakatte	13.8486	76.4250	2.54
39	Narasipura	13.8486	76.2555	0.73
40	Belagur	13.6235	76.2902	8.01
41	Ajjakammasagara	13.7638	76.3402	4.11
Molakalmuru taluk				
42	B.G.Kere	14.5833	76.6791	7.52
43	Rampura	14.8817	76.7827	22.20

Source: *NRDMS, Zilla Panchayat, Chitradurga*

Figure: 6 & 7



Taluk-wise Average Annual Groundwater level in mts



Groundwater prospect zones of the study area

CONCLUSION

The groundwater discharge is faster through artificial withdrawal from bore wells than its naturally replenished in Chitradurga district. The excellent groundwater prospect zones are noticed in and along the major parts of river basin; good prospect zones are noticed adjacent to the major rivers and sub-basins; moderate prospect zones occupies the weathered & fractured zones of granites, gneisses and schistose rock formations whereas poor prospect zones occupies rocky slopes and hilly mountains. Environmental services include Artificial Recharge Structures (ARS), increasing rain water percolation, increasing the area irrigated, reducing soil erosion, increasing soil fertility by double crop methods, conserving biodiversity and reclaiming degraded crop provide sustain crop rotation process and proper quantity of water supply will mitigate the water scarcity problems especially during extreme summer seasons. Groundwater occurs under phreatic condition in the weathered rock formations of the 'Peninsular Gneissic Group' of rocks comprising of weathered & fractured granites, gneisses, quartzites, horblend schist, amphibolite, greywacke and schistose rock formations. The main source of ground water occurring in the district is through precipitation and return flow from applied irrigation which will get recharged through phreatic zones. Lineament represents the faults/ joints/ fracture system, litho contacts and dykes are the tectonic elements especially useful in ground water studies. These linear structures represent both recharging phreatic zones and shallow groundwater table in specific bore well point application for maximum yield. Geomatics application provides data bank information in sub-surface water resources using collateral data, Remote Sensing Satellite Images and GIS tools.

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REFERENCES

1. Basavarajappa H.T, Dinakar S, Satish M.V, Nagesh D, Balasubramanian A and Manjunatha M.C, "Delineation of Groundwater Potential Zones in Hard Rock terrain of Kollegal Shear Zone (KSZ), South India using Remote Sensing and GIS", International Journal of Earth Sciences and Engineering (IJEE), Cafetinnova, Vol.6, No.5, Pp: 1185-1194, 2013.

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2. Basavarajappa H.T, Manjunatha M.C and Jeevan L, "Application of Geoinformatics on Delineation of Groundwater Potential Zones of Chitradurga district, Karnataka, India"., International Journal of Computer Engineering and Technology (IJCIET), Vol.5, Issue.5, May, Pp: 94-108, 2014a.
3. Basavarajappa H.T and Manjunatha M.C, "Geomatics Technique on Mapping and Reclamation of wastelands in Chitradurga District, Karnataka, India"., International Journal of Computer Engineering and Technology (IJCET), Vol.5, Issue.7, Pp: 99-110, 2014b.
4. Basavarajappa H.T, Pushpavathi K.N and Manjunatha M.C, "Spatial data integration of lithology, geomorphology and its impact on groundwater prospecting zones in Gundlupet taluk, Chamarajanagar district, Karnataka, India through Geomatics technique"., Journal of Environmental Geochemistry., Vol.17, No.1 & 2, Pp: 73-82, 2014c.
5. Basavarajappa H.T, Jeevan L and Manjunatha M.C, "Delineation of Groundwater Potential Zones in Precambrian Hard Rock Terrain of Tumakuru District, Karnataka, India using Geomatics Application" International Journal of Civil Engineering and Technology (IJCIET), Vol.5, Issue.12, Pp: 305-315, 2014d.
6. Basavarajappa H.T and Manjunatha M.C, "Groundwater Quality Analysis in Precambrian rocks of Chitradurga district, Karnataka, India using Geo-informatics Technique", Elsevier, Science Direct, Aquatic Procedia, Vol.4, Pp: 1354-1365, 2015a.
7. Basavarajappa H.T, Manjunatha M.C and Basavaraj Hutti, "Spatial data integration and mapping of groundwater potential zones on Precambrian terrain of Hassan district, Karnataka, India using Geomatics application", International Journal of Civil Engineering and Technology (IJCIET), Vol.6, Issue.5, Pp: 123-134, 2015c.
8. CGWB, Central Groundwater Board, Groundwater information booklet, Chamarajanagar District, Karnataka south western region, Bangalore, Pp: 1-21, 2007.
9. CGWB, Central Groundwater Board, Groundwater information booklet, Chamarajanagar District, Karnataka south western region, Bangalore, Pp: 1-31, 2013.
10. GSI, Memoir, "Early Precambrian Supracrustals of Southern Karnataka., Swaminath J and Ramakrishnan M, A Geological Survey of India, Govt. of India, Vol-112, 1981.
11. GSI, "Geological and Mineral Map of Karnataka", Geological Survey of India, Bangalore, 1981.
12. Girish Gopinath and Seralathan P, "Identification of Groundwater Prospective Zones using LISS III and Pumping test methods", Photonirvachak, J.Indian Soc. Remote Sensing, Vol.32, No.4, Pp: 329-342, 2004.
13. Kamal Raj and Pramod Chandra Sahu., "Targeting groundwater water in tribal dominated bonai area of Drought-Prone Sundargarh district, Orissa, India-A combined Geophysical and Remote Sensing Approach", J.Hum. Ecol., Vol.20, No.2, Pp: 109-115, 2006.
14. Manjunatha M.C, Basavarajappa H.T and Jeevan L, "Geomatics analysis on Land use land cover classification system in Precambrian terrain of Chitradurga district, Karnataka, India", International Journal of Civil Engineering and Technology (IJCIET), Vol.6, Issue.2, Pp: 46-60, 2015b.
15. Manjunatha M.C, Basavarajappa H.T and Jeevan L, "Climate change and its impact on Groundwater table fluctuation in Precambrian terrain of Chitradurga district, Karnataka, India using Geomatics application", International Journal of Civil Engineering and Technology (IJCIET), Vol.6, Issue.3, Pp: 83-96, 2015c.
16. NBSS & LUP., National Bureau of Soil Survey & Land Use Planning, Soil Resources Based Land Use of Hassan District, Indian Council of Agricultural Research, Govt. of Maharashtra, India, Pp: 1-21, 2013.
17. Pushpavathi K.N., "Integrated, Geomorphological study using Remote Sensing and GIS for Development of Wastelands in Chamarajanagar district, Karnataka, India", Unpub., PhD thesis, Univ. of Mysore, Pp.105-126, 2010.
18. Radhakrishna B.P and Vaidyanadhan R, "Geology of Karnataka", A Geological Society of India, Publications, 2011.
19. Tiwari A and Rai B., "Hydromorphological mapping for groundwater prospecting using landsat e MSS images da case study of part of Dhanbad district, Bihar", Journal of Indian Society of Remote Sensing, Vol.24, Pp: 281-285, 1996.