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Research Article

GIS TECHNIQUES IN WATER RESOURCES PLANNING AND MANAGEMENT IN CHAMARAJANAGAR TALUK, CHAMARAJANAGAR DISTRICT, KARNATAKA, INDIA

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ABSTRACT

The over-exploitation and contamination of groundwater continue to threaten the long-term sustainability of our precious water resources, in spite of the best efforts made by various agencies. This has many serious implications to the economic development of a country like India. Lack of judicious planning and integration of environmental consideration to ground water development projects are primarily responsible for such a state of affair in the ground water sector. Geographical Information Systems could be of immense help in planning sustainable ground water management strategies, especially in hard rock areas with limited ground water potential. Data collected from Satellite Imagery and through field investigations have been integrated, on a GIS platform, for demarcation and prioritization of areas suitable for ground water development and ground water augmentation. An attempt has also been made to assess the vulnerability of the area to ground water contamination. This paper demonstrates the utility of GIS in planning judicious management of ground water resources in a typical hard rock area of Chamarajanagar Taluk, Karnataka, state India.

INTRODUCTION

The increasing dependence, on groundwater resources as the principal source for irrigation, domestic and industrial sectors, has resulted in the overexploitation of this precious resource in many states of India. The contamination of surface and ground water resources, mainly from anthropogenetic contaminants, has also become fairly widespread. The combined effects of groundwater over-exploitation and contamination are now posing a serious threat to the long-term sustainability of these vital resources. These problems are especially acute in areas underlain by crystalline formations in which the quantative availability of the resource is limited to the weathered and fractured zones. Judicious planning, development and management of the available resources are the only option available to ensure the long-term sustainability of this resource. It is also equally necessary to protect the available resource in terms of quality in addition to quantity. The current study also involves strategies for development, augmentation and prevention of contamination of ground water and provides for optimum benefits when they are implemented Geographical Information Systems, Which have, of late, found application in various fields, can be of immense use in the formulation of strategies for sustainable ground water development and management. An attempt has been made to demonstrate the utility of GIS techniques in water resources planning and management of parts of a Chamarajanagar Taluk, Karnataka State, India.

Study area

Chamarajanagar taluk comes under the semi arid climatic region. It lies between $11^0\ 40^1$ to $12^0\ 10^1$ east latitude and $76^0\ 40^1$ to $77^0\ 15^1$ longitude with the geographical area extent of 1235.90 sq.kms. It covers 190 villages coming under survey of India toposheet Nos.57D/12, 57D/16, 57H/4, 58A/9, 58A/13, 58A/14, 58E/1, 58E/2,58E/5, on a scale of 1:50,000. The annual average rainfall on the taluk is around 696mm. Chamarajanagar Taluk enjoys a salubrious climate with a mean maximum temperature of 34°C and a mean minimum temperature of 16.4°C. There is no major river draining in this taluk. However, this region is drained by Suvarnvati and Chikkahole, which are the tributaries of Cauvery River bordering Kollegal taluk of Chamarajanagar District. The topography of the study area is an undulating plain, underlain by hard rock comprising mostly peninsular gneiss, and Charnockites. Charnockite is a wide spread formation in this taluk. The monsoon seasons are March to May and the summer months are June to September. October to December is the post

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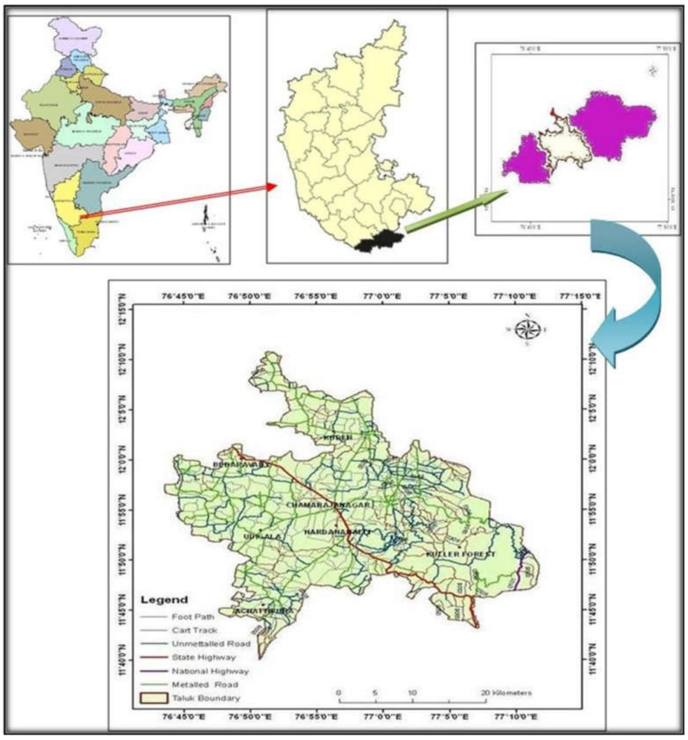
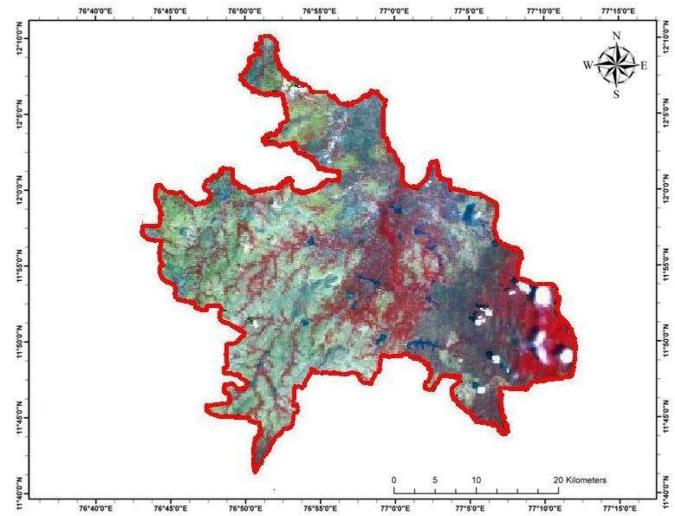
monsoon season as well as January to February are winter months/season. (Map.1)



Map 1 Location of the study area

METHODOLOGY

Satellite data of IRS-ID, LISS-III +PAN merged was used to prepare the geomorphological map of the taluk (Map.2). The geomorphological map was generated in digital form and the each unit wise geographical area was computed using arc view GIS. Ground water resources were estimated for the each geomorphical units of the study area based on GEM-1997 (Groundwater estimation method) methodology. Data used for resource estimation were proportionally considered for each geomorphic unit.

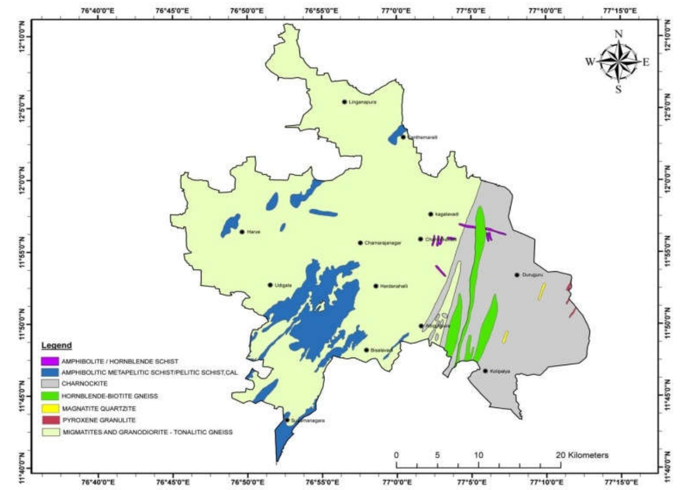


Map 2 Satellite Image of the Chamarajanagar taluk

The main occupation of the people of this taluk is farming and most of the lands are dry lands. Growing mulberry crop and rearing of silk worms are the main activities of people. Since the Irrigation facility is very sparse in district, the farmers dependent on seasonal rains to grow their crops. The district is predominantly agrarian, agriculture is the backbone of the economy. The net sown area is 1.75 lakh ha. with about 30% having irrigation facilities; croping intensity is 122%; 38507ha. Sown more than once. ragi, maize, jowar, paddy, horse gram, black gram, red gram, cowpea, groundnut, cotton and sunflower. The entire district has a semi arid climate, the mean minimum temperature is 13.80-27.70ºc, while the hot weather mean maximum temperature is 30-38ºc.The rainy season is from May to September with an average annual rainfall ranging from 620 to 1470mm. Based on the physiographical features, this area has undulating topography with sparse vegetation, wide valleys and plains.

Geology of the Area

Geographically this area comprises of Amphibolite, hornblende, and Charnockite, granitic gneisses of Proterozoic age of Southern Karnataka. Ultramafic rocks are found in the granite gneisses and are intruded by quartz and dolerite dykes. Granitic gneiss is the wide spread formation in the taluk (Map.3).

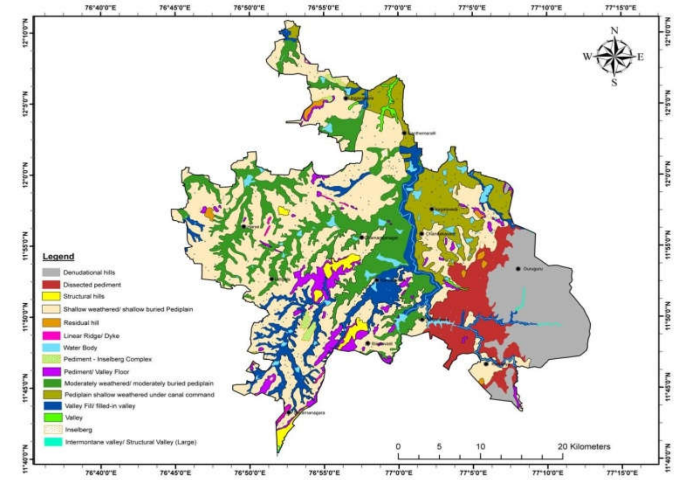


Map 3 Geology Map of the Chamarajanagar taluk

The district comprises of granitic gneisses having the strike along NNE and SSE direction with a general easterly dip 70ºto 80º, they are grayish to pink in colour. The gray gneisses are highly weathered, fractured and fissured up to an average depth of 8 to 10m. The pink colored gneisses are and do not suffer much tectonic disturbances. At some places the depth of weathering is more than 10m which is observed from well inventory and drilling records. The chief rock types of the area are gneisses, amphiblities, schist with intrusions of dykes covered by a mantle of different types of soils, which are the resultant products of weathering of the these rocks.

Geomorphology

The physiographic conditions of the Taluk may be classified into partly maidan, general tableland with plain and undulating regions. The different landforms discernable on the imagery have been broadly classified into denudation and very less fluvial landforms. The landforms delineated are Pediment, pediplain, valley fills, residual and inselburg. The general elevation is 656 M AMSL (Map.4)



Map 4 Geomorphology map of Chamarajanagar taluk

Denudational hills

Denudational hills consist of highly fractured gneisses covered with big boulders and sparse vegetation occurring due to the accumulation of weathered material. These hills are marked by sharp to blunt crest lines, rugged tops and light grey in colour. These occur as a group of massive hills with resistant rock bodies that are formed due to differential erosion and weathering and observed only in south-eastern part of the study area. The geomorphic expression and shape of the denudational hills are controlled by lithology, and spacing of structural features like joints and fractures occurring in them. The denudational hill features are classified into a) denudational hills in granites, genisses and migmatites, b) denudational hills in schistose formations and c) denudational hills in basic intrusive (dykes).The denudational hills in granites, gneisses and migmatites are the most extensive and occur almost in the entire area. Denudational hills are characterized by horizonatal, curvilinear and vertical joints, which accelerated the process of weathering. These have given rise to the typical semi-arid type of tropical weathering geomorphic forms such as exfoliation domes, domed inselbergs and tors with steeper slopes along with the sliding of the bigger boulders.

Pediment & Pediplain

Pediment is gently sloping, or gently undulating, low relief bed rock erosional surface at the base of hills range. Pediments are formed on weather resistant rock and planation surfaces formed on less resistant bedrock in contact with steeper, more resistant bedrock., Gilbert [1877] and Miller [1950] explain that the "rock pediments" reflect the same lithology, typically granite, granodiorite, or quartz monzonite, migmatitic gneisses that of the adjacent hills range (Oberlander, 1972). Pediment zones permit poor infiltration and act as run-off zones; however the fractures, which traverse these zones, could act as limited recharge zones.

The pediplain is characterized by a gently undulating to flat topography, spreading over the grainites, gneisses and schistose formations. Pediplain occupies a small area and it is observed in north-east part of the study area, mostly covered reddish brown, medium to coarse gravel and at soil ranging in thickness from 10 to 35 m. and this zone act as good infiltration zones.

Residual hill

It is an isolated low relief hill formed due to differential erosion so that a more resistant formation and as a residue like small hills are formed. Residual hills are basically the hard rock zones left behind after erosion has occurred. These are the resistant isolated; steep sided, usually smoothened and rounded hill circumdenudation rising abruptly above the surroundings over the level plains in tropical regions (Gary *et al*., 1972). The lithology in residual hill area is dominant with granodiorite, tonalite and migmatitic gneiss. Residual hills are generally resulted from the end product of pediplanation, which reduces the original mountains into a series of scattered knolls standing on the pediplains (Thornbury 1990). These residual hills exhibit conical to rounded forms with steep to very steep slopes. King (1948) termed those residual hills as inselberg

Structural Hill

A complex erosional process, shapes the structural hills predominantly by erosion, circumdenudation, weathering and mass washing. The dip of the strata controls the rate of denudation processes in these structural hills. These hills are linear to arcuate exhibiting definite trends composed of varying lithology. Generally the groundwater potential is moderate to poor in structural hills.

Valley fills

Valley fills has been developed mainly in the valley portions over granitic gneiss due to deposition of unconsolidated materials by fluvial agencies. The materials are silt, fine sand and at some places pebbly. The thickness of fill and weathered zones are ranging from 1 to 15 m and it act as good recharge zone.

The taluk has been divided into five minutes square grids and systematic water levels of 12 villages wells have been subjected to the preparation of grid deviation water table. This table gives the areas of recharge in the upstream area of the catchments forms the positive zone and discharge areas of the catchments forms the negative zone. Where wider spacing of the contours and their disposition suggests a flat, gentle gradient of the water table with comparatively high permeability of the lithology when compared to the areas with close space contours. The water level data of select observation wells being monitored and further has been study for the behavior of ground water levels in the phreatic zone for the period of 2000-2016.

1. Comparing the pre-and post monsoon water levels during 2016 with the average water levels of the corresponding period for the previous decade (2000-2016)
2. Analysis of trends of ground water levels during pre- and post-monsoon periods for the Period 2000-2016

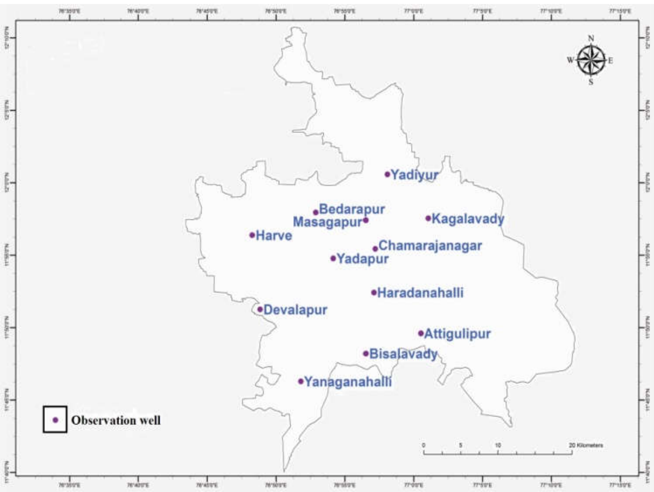
The results of the comparative analysis of pre- and post monsoon depth to water levels during 2001 with the average water levels of the previous decade (2000-2016) show that (Table.1) about 75 percent of observation wells showed deeper ground water levels during pre-monsoon period of 2001 in comparison with the average values for the corresponding period in the previous decade, indicating a progressive decline in ground water levels.

Table 1 2000-2016 Month wise details water level data of Chamarajanagar taluk

Sl no	Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1	Devalapura	64.13	64.09	64.07	64.10	64.09	64.10	64.10	64.10	64.10	64.20	64.20	64.17
2	Yadiyur	55.41	55.38	55.35	55.30	55.26	55.30	55.30	55.30	55.30	55.40	55.50	55.48
3	Bisalavadi	80.24	89.07	89.00	80.20	72.94	72.90	72.80	80.10	80.20	80.30	89.20	80.37
4	Yanaganahalli	64.18	64.15	69.54	69.50	75.75	69.50	69.40	69.40	75.80	83.30	64.20	69.28
5	Kagallvadi	50.69	50.51	50.57	50.40	54.71	54.70	50.30	54.90	54.80	54.80	50.70	50.71
6	Yedapura	55.74	55.68	55.61	55.60	55.49	55.50	55.50	55.50	55.40	55.70	55.90	55.86
7	Harve	104.3	60.74	60.65	91.10	60.89	60.40	60.70	60.40	60.50	60.80	60.90	60.87
8	Chamarajnagar	15.43	54.39	54.31	54.30	54.27	54.30	54.30	54.30	54.30	54.40	54.50	54.48
9	Masagapura	56.15	56.12	56.02	56.00	61.16	61.20	60.60	55.90	51.40	56.10	52.00	52.00
10	Bedarapur	64.33	64.36	78.44	78.40	78.35	70.30	60.00	63.80	64.00	70.30	64.10	58.92
11	Haradhanalli	73.20	73.20	89.60	101.0	89.47	101.0	101.0	101.0	89.50	67.00	67.00	61.89
12	Attigulipur	72.27	72.36	72.28	65.6	72.06	65.50	65.40	65.30	72.00	65.40	65.60	65.66

Similarly, about 65 percent of wells had deeper post-monsoon water levels during 2016 when compared with the decadal average values, indicating inadequate recharge into the ground water reservoirs. Observation wells falling in all the blocks forming part of the watershed show similar behavior of ground water levels. The trend of ground water levels in the observation wells has been computed using the method of simple linear regression in order to study the temporal variations of ground water levels. The trend analysis indicates a declining trend during post-monsoon period.

The groundwater in the area, in general, is suited for domestic and irrigation applications. Specific electrical conductance in the majority of samples analyzed is within 2000µS/cm at 25°C and the Sodium Adsorption Ratio (SAR) is below 10. Brackish ground water having Ec in excess of 3000 µS/cm at 25°C, observed in local patches is due to pollution or local recharge/discharge conditions.



Map 5 Observation well map of Chamarajnagar taluk

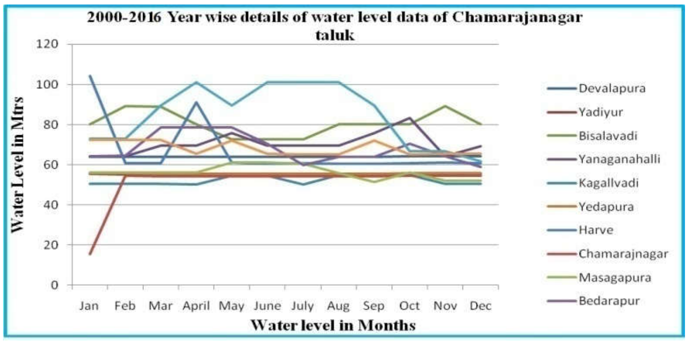
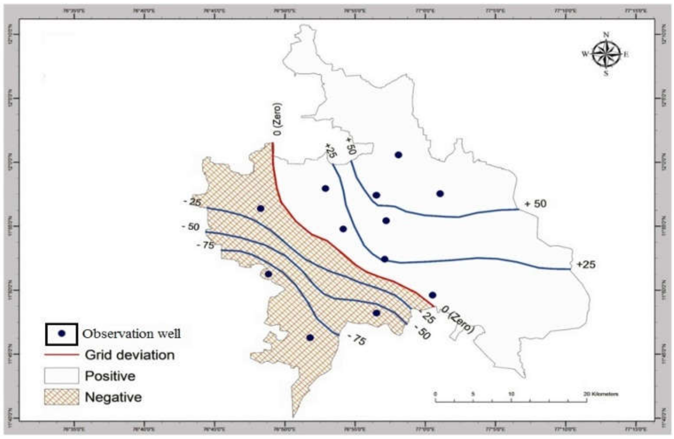


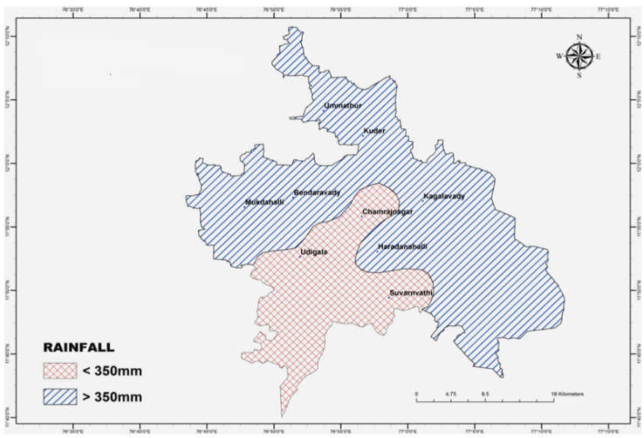
Fig 1 Water level data of Chamarajanagar taluk

Table 2 Grid deviation water table values of Chamarajanagar taluk

Sl.No.	Observation well in village	Topographic height in mtr	W.L (BGL) in mtr	W.L (AMSL) in mtr	Deviation from average Di=X-Xi
1	Devalapur	860	23.28	836.72	-84.18
2	Yadapur	755	24.36	730.64	21.90
3	Bisalavady	869	50.00	819.00	-66.46
4	Yanagalli	889	45.54	843.46	-90.92
5	Kagalavady	728	49.96	678.04	74.50
6	Yedayur	722	33.00	689.02	63.52
7	Harve	803	46.00	757.38	-4.84
8	Chamarajanagar	752	30.00	722.21	30.33
9	Masagapur	732	33.50	698.56	53.98
10	Bedarapur	795	55.00	740.16	12.38
11	Bisalavady	825	14.70	810.97	-58.43
12	Attigulipur	800	60.00	740.64	11.90
13	Hardanahalli	801	85.00	716.24	36.30
Grid averge water level (AMSL)X=752.54mt					



Map 6 Chamarajanagar taluk grid deviation water table



Map 7 Chamarajanagar Taluk Rainfall

Table 3 Rainfall data of the Chamarajanagar taluk

Name of the Station	Years	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total Annual
Udigala	2000-016	0.00	10.00	18.52	26.52	47.63	14.16	37.28	24.46	36.56	54.60	27.63	16.10	313.46
Haradanahalli	2000-016	19.90	20.23	34.46	70.45	82.46	34.67	69.70	70.56	107.39	171.26	56.67	24.21	761.96
Ummathur	2000-016	0.00	0.00	71.16	89.71	80.70	67.43	54.30	77.34	130.15	107.07	50.78	19.48	748.12
Chamarajanagar	2000-016	3.77	5.44	16.60	27.86	42.38	12.20	24.52	24.06	36.76	65.23	26.73	17.52	303.07
Suvarnavathi	2000-016	12.63	9.04	6.09	22.71	27.44	25.73	21.90	22.32	35.52	74.67	30.40	11.40	299.85
Bendaravadi	2000-016	9.20	12.52	73.58	64.55	120.18	110.16	125.26	63.77	82.27	88.96	42.61	14.65	807.71
Mukdahalli	2000-016	17.20	6.53	29.26	64.75	88.75	58.35	66.05	81.00	61.76	133.46	89.15	38.76	735.02
Kagalavady	2000-016	5.00	4.30	30.12	68.30	79.55	58.30	57.57	77.11	122.12	199.50	69.30	24.64	795.86
Kuder	2000-016	0.00	2.00	40.00	78.90	78.26	58.00	63.99	99.52	113.93	175.94	58.74	14.12	783.4

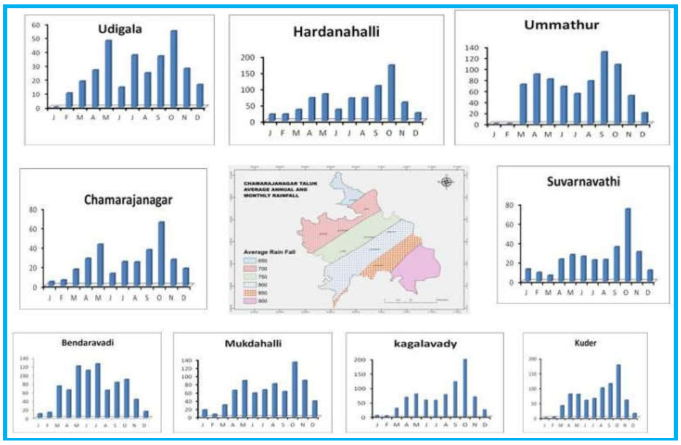


Fig 2 Average annual and Monthly Rainfall (in mm)

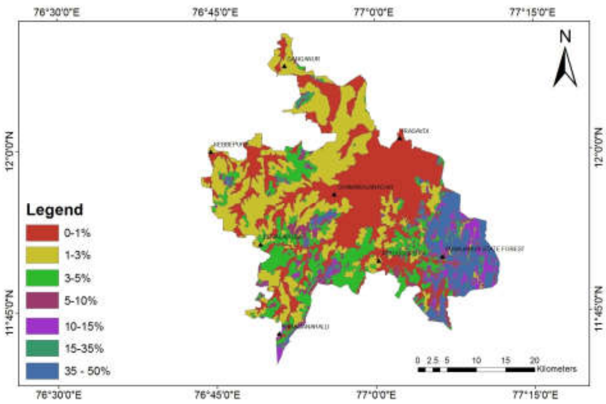
Rainfall and return seepage from irrigated fields constitute the major components of recharge, whereas extraction of ground water through various abstraction structures constitute to be the major component of draft in the area. The ground water resources available in the area have been computed as per the norms prescribed by the Ground Water Estimation Committee (1997) constituted by the Government of India. The estimation of resources has been carried out block-wise due to the non-availability of data pertaining to area.

Slope Analysis of Chamarajanaga taluk

The slope percentage in the area varies from 0 to 50%. On the basis of the slope, the study area can be divided into seven slope classes. The areas having 0 to 1% slope fall into the ‘very good’ category because of the nearly flat terrain and relatively high infiltration rate. The areas with 1 to 3% slope are considered as ‘good’ for groundwater storage due to slightly undulating topography with some runoff. The areas having a slope of 3 to 5% cause relatively high runoff and low infiltration, and hence are categorized as ‘moderate.’ The fourth (5–10%) slope are consider as moderate to steep (poor)and fifth (10–15%) slopes are considered as moderate to very steep (poor) and (15-35%) slopes are steep , 35-50% slopes are considered very steep slope categories are considered as ‘poor’ due to higher slope and higher runoff (Map.8). In the present study area, slope map has been prepared on 1:50,000 scale.

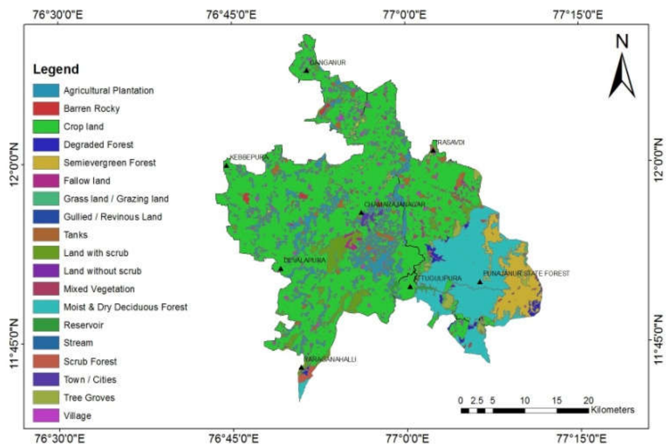
Land Use/Land Cover

(Map .9) the Land use/ Land cover classes like dense and hill vegetation land, rock out crops land settlement and barren land, water bodies land (rivers, streams, ponds etc.) and agricultural land was delineated based on the image characteristics like tone, texture, shape, association, background, etc.



Map 8 Slope of Chamarajnagar taluk

Forest area occupies the hilly terrain of southeastern part, while agriculture land occupies the northeastern part of low lying areas. Land use describes as the land is used for the different purpose such as agriculture, settlements or industry, whereas land cover refers to the material such as vegetation, rocks and water bodies that are present on the surface (Anderson *et al*., 1976; Sankar *et al*. 2002) among these terms, land use is more common. The land use map of the area has been prepared by using satellite imagery and are classified as water body, agriculture, forest, waste land and built up land.

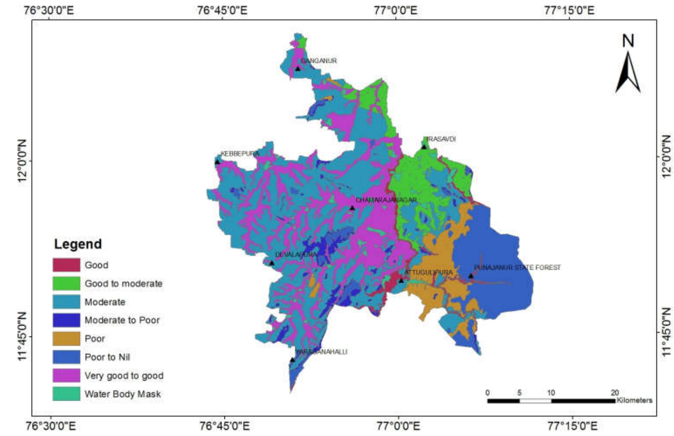


Map 9 Land use Land cover

Groundwater Prospects

It has been reported that there is a good interrelationship among the geomorphic units, geological characteristics, lineaments, drainage and their density and groundwater conditions in an area. It has also been noticed, the drainage density has negative correlation with the groundwater conditions in an aquifer (Pratap *et al*., 2000; Obi Reddy *et al*, 2000; Srivastava and

Bhattacharya, 2000) in the study area also, the geomorphology, Lineaments, intersection of lineaments, drainage density, type of lithology and surface water bodies are directly influencing the pattern of groundwater table. The drainage density in the area is relatively low in the valley region, moderate in plains and high in hills and pediments. Remotely sensed data and field investigations have clearly shown, the groundwater conditions in VSF and PPM is very good to good, in PPS; good to moderate, in pediments; moderate to poor and in hills; very poor. It could be attributed due to low drainage density and also most of the lineaments are confined to the valley regions and these lineaments are acting as pathways for groundwater movements. Hence the groundwater level in the area, along and in the regions near to lineaments at shallow depths and yield is relatively high. It is also noticed that the groundwater table increases considerably during the monsoon season.



Map 10 Groundwater prospects

RESULTS AND DISCUSSION

Based on the hydrological and hydrogeological investigations and the compilation and analysis of data pertaining to the occurrence, development and quality of ground water in the watershed, it is clear that the following factors should be taken into account for formulating any strategy for sustainable management of ground water resources in the watershed

1. The stage of development of ground water in the major part of the watershed is quite high.
2. The availability of surface water resources for future development is minimal.
3. There is considerable de-saturation of aquifers in the phreatic zone, as shown by the deep water levels in a major part of the watershed.
4. There is a general long-term decline of ground water levels in the area due to a combination of over-exploitation of available resources and the non-availability of sufficient rainfall to compensate ground water extraction.
5. Limited availability and presence of lithogenic fluoride and antrhopogenetic nitrate in excess of permissible limits recommended for drinking is a major constraint in the development of ground water for drinking purposes in parts of the watershed.
6. Pollution of water from industrial effluents is not yet a major concern in the area

In view of the above, any viable ground water management strategy for the taluk has to be two-pronged, aimed at extraction of ground water from suitable locations to satisfy the increasing demands of a growing population, with concurrent augmentation of groundwater resources through suitable means of artificial recharge. Identification of areas vulnerable to ground water contamination will also help in ensuring long-term sustainability of the limited resources available by ensuring that no industrial infrastructure development takes place in such areas in the future. The capabilities of Geographic Information Systems have been made use of for identification of priority areas for ground water resource augmentation and for assessing the vulnerability of ground water to contamination in the watershed.

The analysis attempted in the case study described above shows the use of Geographic Information System as a decision making tool in hydrogeology. It can also be made use of for various hydrological studies such as demarcation of areas suitable for ground water augmentation or development by incorporating relevant parameters. The vulnerability analysis attempted for Vaniar watershed indicate that a major part of the watershed have medium to high vulnerability to ground water contamination. Localized patches of very high vulnerability have also been demarcated clearly. The results are extremely useful in the context of watershed development, especially for selection of sites for establishment of industrial units, which are likely to contaminate the ground water in the watershed. In the absence of data pertaining to pollution of ground water in the watershed, field checks for validation of the vulnerability map of the watershed has not been attempted.

References

Agrwal.C.S Study of drainage pattern through aerial data in naugarh area of Varanasi district, U.P. *Jour. India Soc. Remote Sensing*, 26(4):169-185, 1998.

Amit Kumar Ray, Remote Sensing Studies in the Narmada-Tapti Linear zone in Gujarat and part of Madhya Pradesh. Abstract volume, National Symposium on GIS and Geological Remote Sensing, (NAGRES-97), 1997

Anderson, J.R., 1976, A land use and land cover Classification System for use with Remotesensor Data. U S Government prints office.

Balakrishnan, P., Tech Report on Issue in Water Resources Development and Management and Role of Remote Sensing. Publi. ISRO-Bangalore, p. 194, 1986

Balakrishnan, P., Remote Sensing Application in Water Resources in India, Proceedings, 8th ACRS, Jakarta, Indonesia.1987

Black, J.H., and Kipp, K.L., Observation well response time and its effect upon aquifer test results, *Jour. Hydrol*., 34, pp. 297-306. 1977

Central groundwater board, groundwater information booklet, Chamararajanagar District, Govt.of Karnataka, Bangalore, August 2012.

Gary 1972. Geomorphological studies for groundwater targeting in hard rock terrain of kadiri schist belt, Ananthapur District, Andrapradesh, India. *International journal of Earth Sciences and Engineering* vol. 04, No.05, oct 2011 pp 838-844.

Gilbert G K 1877 Geomorphology of Desert environment 2nd edn, Springervol. Champan and hall 1994, pp 1389,123,119.

Greenbaum, D., Remote Sensing for hydrogeological mapping in semi-arid basement terrains. *British Geological Survey Techn*. Rep., WC/92/28, 1992

Hadani, H., Liman, D.N. and El Meslouhi, R., 1993, Remote Sensing application to groundwater resources, In: Proc. Int. Symp. Operationalization of Remote Sens. 9., Earth Science Application, ITC, Enschede, the Netherlands, pp 93-103.

Harish M Centre for infrastructure, sustainable Transportation and Urban Planning, Indian Institute of Science, Bangalore-12 *International Journal of Research in Pharmaceutical and Biomedical Science* Vol. 2 (3) pp 1281-1284 Jul - Sep 2011.

Kruck, W., Application of Remote sensing for groundwater prospection in the third world. In: Int. Symp. Remote Sens. and water Resources, IAH/Neth. Soc. Remote Sens, Enschede, The Netherlands., pp. 445-463,1990

Krupanidhi, K.V.J.R., Venkataraman, S., Mathuria D.P., and Murthy, K.N., Studies of specific capacities of wells in hard rocks and alluvial formations and Mysore State. Int. Nat. Symp. Procd. Development of Groundwater resources, Madras, India, Vol I, PP. IIa 61-74.1973

Marianthi Stefouli, Application of Remote Sensing Techniques to the hydrology of the mediteranian region, with special reference to Crete. Current Topics in Remote Sensing Vol. 1, pp 215-241.1990.

Miller 1950 Geological Society of America Bulletin, Nov 2010, Vol.122 No. 11-12, P 1815-1829, first published on Aug 11,2010.

Obi Reddy, G.P., Chandra Moulik., Srivastavs, K., Srinivasa, C.V and Maji,A.K., 2000. Evalution of Groundwater Potential zones using Remote Sensing Data-A case study of Gaimukh watershed, Bhaandara District, Maharastra. *Jour. Remote Sensing*, vol 28, No.1.pp.19-32.

Pratap, K., Ravindran, K, V. and Prabhakaran, B. (2000). Groundwater prospecting zones using Remote Sensing and Geographical Information System; A case Study in Dala-Renukoot Area, Sonbhadra District Uttar Pradesh. *J.Indian Soc. Remote Sensing*, 28(4); 249-263.

Sankar K.2002. Evaluation of groundwater potential zone using Remote Sensing data in upper vaigai river basin, T.N, India, *J Indian soc Remote sense* 30 (3) pp.119-129.

Srivastava, P. K. & Bhattacharya, A. K. (2000). Delineation of groundwater potential zones in a hard rock terrain of Bargarh district, Orissa using IRS data. *Jourl. Indian Soc. Remote Sensing*, v.28 (2&3), pp.129-140.

Thornbury, W.D. (1990). Principles of Geomorphology. Wiley Eastern Limited, New Delhi, 594P.

Aller, Linda, Bennett, Truman, Lehr, J.H., and Petty, J.P., 1985, DRASTIC: A standardized system for evaluating ground-water pollution potential using hydrogeologic settings: U.S. *Environmental Protection Agency publication* 600/2-85/018.

Oberlander T.M 1977 Slope and Pediment systems

Mohammad subhan lone., D. Nagaraju., Siddalingamurthy. S., Mahadevaswamy. G., Lakshmamma and Pankaja. G. 2012 Evaluation of Groundwater Potential Zones in H. D. Kote Taluk, Mysore District, Karnataka, India using Remote Sensing and GIS Techniques. *International Journal of Earth Sciences and Engineering* ISSN 0974-5904, Vol. 05, No. 03 (01), June 2012, pp. 611-617

Siddalingamurthy.S., D.Nagaraju., Sumithra S., Mohammad Subhan Lone., Ramakrishna and Lakshmamma Evaluation of Groundwater resources Studies of Chamarajanagar Taluk, Chamarajanagar District, Karnataka, India, using Remote Sensing and GIS Techniques. *International Journal of Remote Sensing & Geoscience* Volume 2, Issue 4, July 2013

Siddaraju, K., Nagaraju, D., Bhanuprakash, H.M., Shivaswamy, H.M., Balasubramanian, A. Morphometric Evaluation and Sub Basin Analysis in Hanur Watershed, Kollegal Taluk, Chamarajanagar District, Karnataka, India, using Remote Sensing and GIS Techniques. *International Journal of Advanced Remote Sensing and* GIS 2017, Volume 6, Issue 1, pp. 2178-2191

Siddalingamurthy., D. Nagaraju, G. Mahadevaswamy., Mohammad subhan lone., Lakshamma and G. V. Pankaja Evaluation of Morphometric Parameters Studies in Chamarajanagar Taluk, Chamarajanagar District, Karnataka, India, using Remote Sensing and GIS Techniques S. 2 *International Journal of Earth Sciences and Engineering* ISSN 0974-5904, Vol. 05, No. 03 (01), June 2012, pp. 524-531

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