केन्द्रीय भूमिजल बोर्ड

जल शक्ति मंत्रालय, जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

भारत सरकार

Central Ground Water Board

Ministry of Jal Shakti,
Department of Water Resources, River Development
and Ganga Rejuvenation
Government of India

Report on

AQUIFER MAPPING AND MANAGEMENT PLAN

Tarikere Taluk, Chikmagalur District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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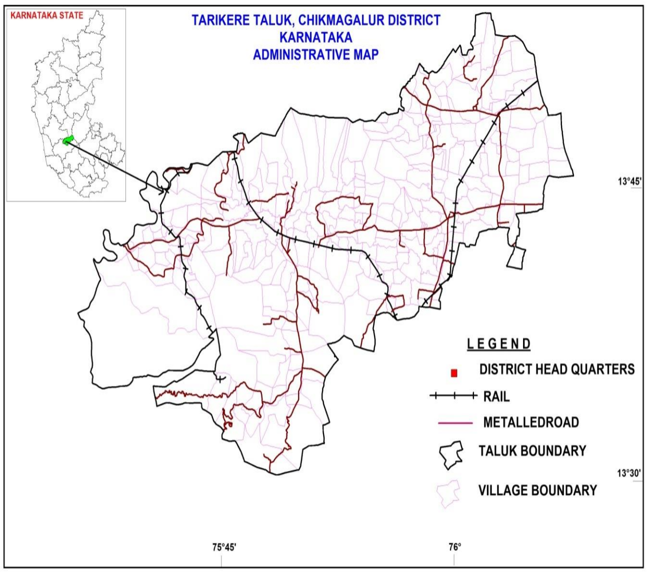
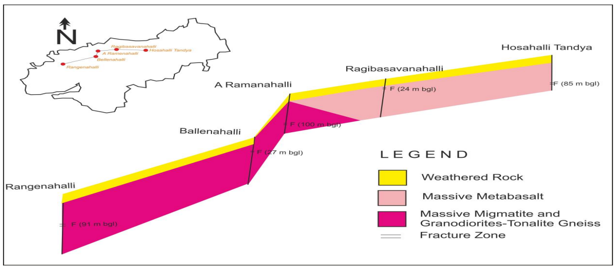
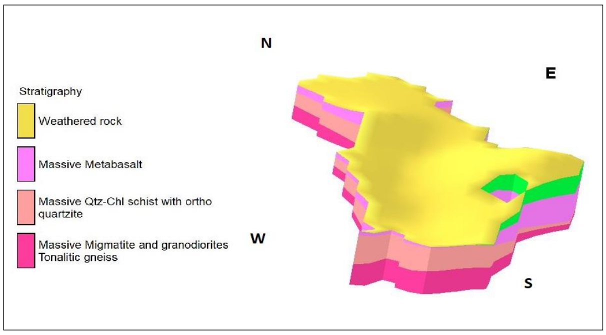
Aquifer Maps and Management Plan, Tarikere Taluk, Chikmagalur District, Karnataka State

(AAP: – 2022-2023)







By

Anisha.K, Sc-C, CGWB, KR, Trivendrum

APRIL 2023

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1. INTRODUCTION

In XII five-year plan, National Aquifer Mapping (NAQUIM) has been taken up by CGWB to carry out detailed hydrogeological investigation. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers.

Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at robust and implementable ground water management plans. By understanding the goals of NAQUIM, Tarikere Taluk of Chikmagalur district of Karnataka state covering a geographical area of 840 sq.km. has been taken up during the Annual Action Plan of 2022-23.

1.1 Objective and Scope

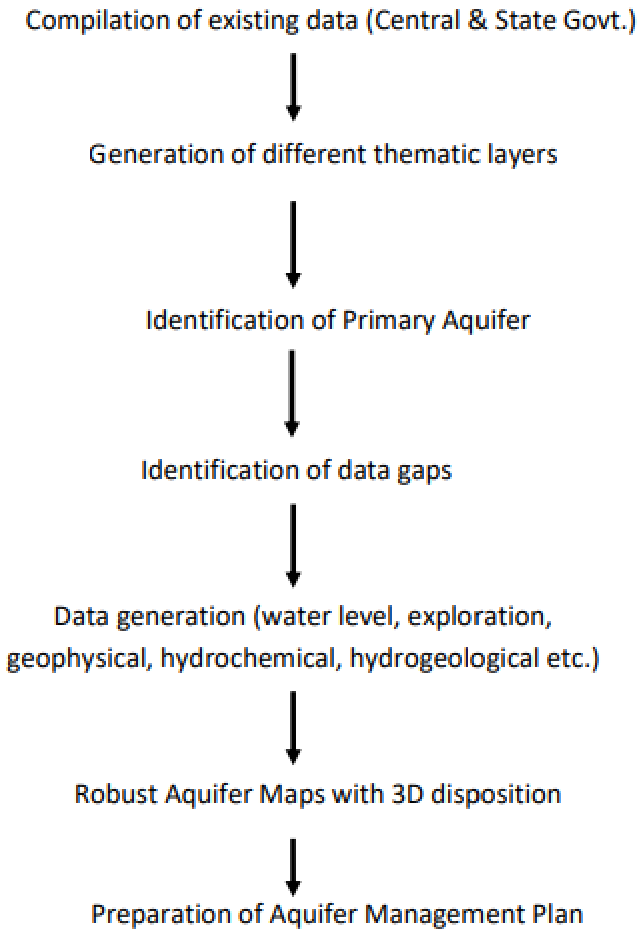
Aquifer mapping itself is an improved form of groundwater management – recharge, conservation, harvesting and protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e., the aquifer map and management plan. The activities under NAQUIM are aimed at:

- Identifying the aquifer geometry,
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths
- Aquifer-wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan.

This clear demarcation of aquifers and their potential will help the agencies involved in water sector to ascertain the volume of water available for various uses as well as the need of management measures implemented to achieve a sustainable development goal.

1.2. Approach and Methodology

The ongoing activities of NAQUIM include topographic sheet wise micro-level hydrogeological data acquisition, geophysical and hydro-chemical investigations, supplemented by ground water exploration down to the depth of 200/300 meters. The data on various components thus collected were brought on GIS platform by geo-referencing for its utilisation in the preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



1.3 Study area

Tarikere is one of the 7talukas of Chikmagalur district of Karnataka state covering an area of 1223 Sq.km. and falls in Survey of India Toposheet number 48 O/9, O/10, O/13, O/14, 57C/1& 57C/2. The taluk is bounded by North latitudes 13°30’18” and13°53’49.2”and East longitudes 75°36’10.8” and 76° 8’ 38.4”. It is bounded by Bhadravati and channagiri taluk in the north, Kadur taluk in the south, Holalkere and Hosdurga taluk in the east and NR pura and chikmagalur taluk in the west. According to 2011 Census data, the taluk has total population of 245960 persons with 123422 male and 122538 female population. Tarikere taluk has the highest rural population in the district.

Tarikere taluk is well connected to other parts of Karnataka by the National Highway-69 (NH-17) and rail network. Administratively, the district is divided into 51 Gram panchayaths, 280 villages, 1 Town Panchayath and 1 town municipal council.

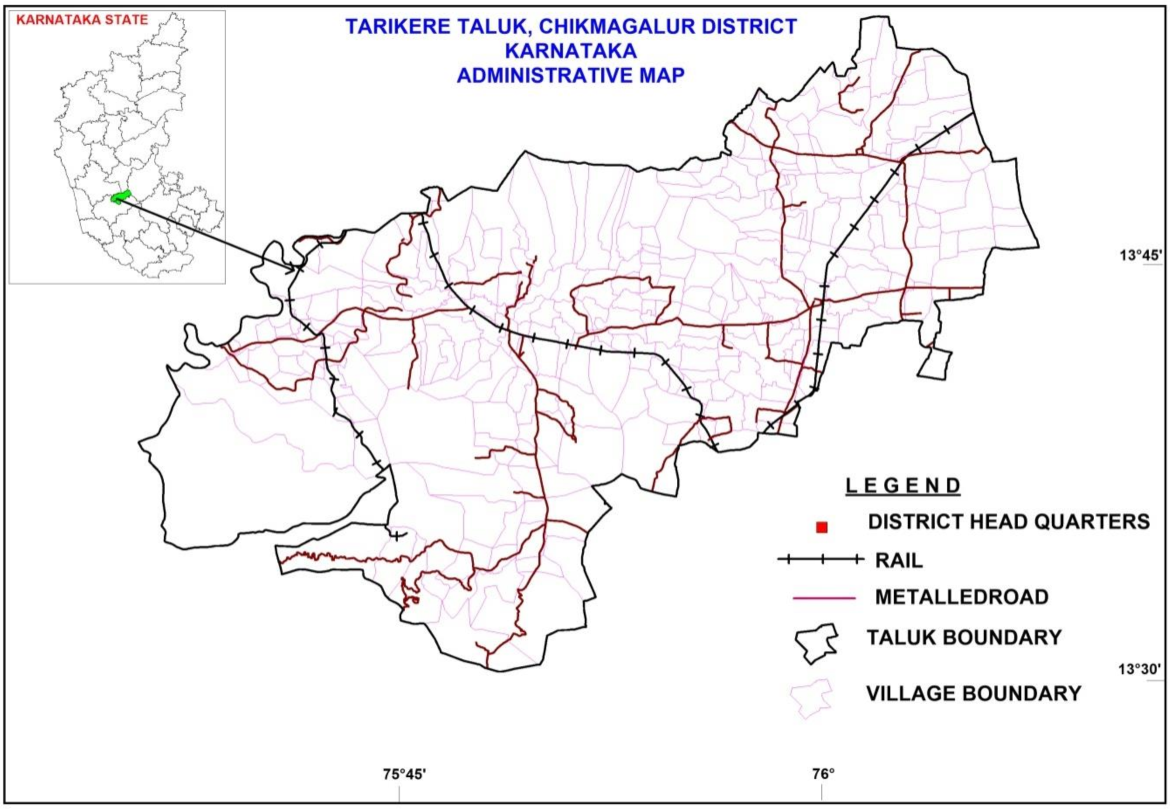


Figure 1. Administrative set-up, TarikereTaluk, Chikmagalur district

1.4 Data Adequacy and Data Gap Analysis and Data Generation:

The available data on Exploration activities, Geophysical Surveys, Ground water monitoring and ground water quality of Central Ground Water Board were compiled and analysed for aquifer mapping studies. In addition to these, data on ground water monitoring and ground water quality from State Department were also utilised. The data adequacy and data gap analysis were carried out for each quadrant of topographic sheet as per the criteria suggested in the manual of Aquifer Mapping in respect of the following primary and essential data requirements. viz.,

- Exploratory Wells
- Geophysical Surveys
- Ground Water Monitoring and
- Ground Water Quality

1.5 Rainfall and Climate

Tarikere taluk falls in the transition zone between the hilly zone and Central Dry zone and experiences a semi-arid climate. During the month of April and May, mean monthly temperature ranges up to 38°Cand during October to January the mean monthly temperature drops up to 8°C. The relative humidity varies between50to 84% and is highest during January and February months.

The rainfall and its distribution is highly erratic which increases from East to west. The average annual rainfall of Tarikere taluk is 1053 mm (2010 to 2019). The normal annual rainfall of Chikmagalur district is 946 mm with 68 rainy days. Based on Rainfall situation, year is broadly divided in to three seasons:

- Pre-monsoon (Jan to May)
- South west monsoon (June to September) and
- North east monsoon (Oct- Dec)

The south west monsoon contributes a major share (61%) of the rainfall whereas the northeast monsoon season accounts for about 23%. The balance 15% is contributed during the period from January to May. The monthly rainfall during the last ten years from 2010 to 2019 is given in table 1 and graphical representation of the same is given in figure 2.

Table 1. Monthly rainfall (2010-19)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
2010	4	0	15	121	89	109	227	327	220	121	303	0	1535
2011	0	0	0	101	68	119	212	133	74	168	31	0	906
2012	0	0	0	218	4	22	70	175	106	64	91	0	750
2013	0	3	5	35	0	22	70	175	106	64	91	0	571
2014	0	0	3	64	179	81	286	255	97	197	29	17	1208
2015	0	0	10	50	163	206	164	180	163	148	89	3	1176
2016	1	1	0	5	69	197	161	73	78	140	115	27	867
2017	0	0	0	13	39	89	153	206	205	129	0	0	834
2018	0	0	14	71	244	178	270	219	131	157	22	7	1313
2019	0	0	0	27	50	58	125	550	243	331	38	49	1471

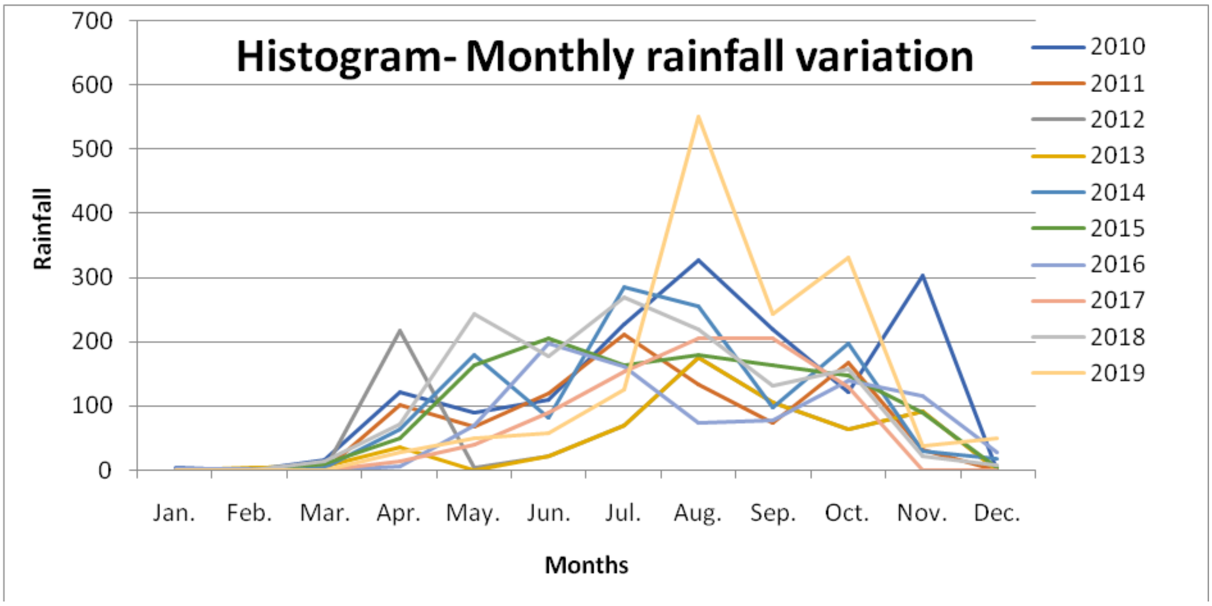


Figure 2. Monthly rainfall variation-Histogram (2010-19)

1.6 Physiography and Geomorphology

Physiographically Karnataka is divided into major three division namely Coastal region. Malnad Region and Maidan Region. In Tarikere, both Malnad and Maidan Region can be identified (Figure 3). Western part of Tarikere Taluk falls in Malnad region whereas the eastern part falls in the southern Maidan physiographic division. Plains, Hills, Plateaus, piedmont, pediplain and valleys are the main geomorphic units identified in Tarikere region. Both Malnad and Maidan are erosional surface. In ground water point of view, valleys and pediplain have moderate to good groundwater prospects whereas hills and plateaus have poor ground water prospects. The geomorphological map of the taluk is given in figure 4 and slope map in figure 5.

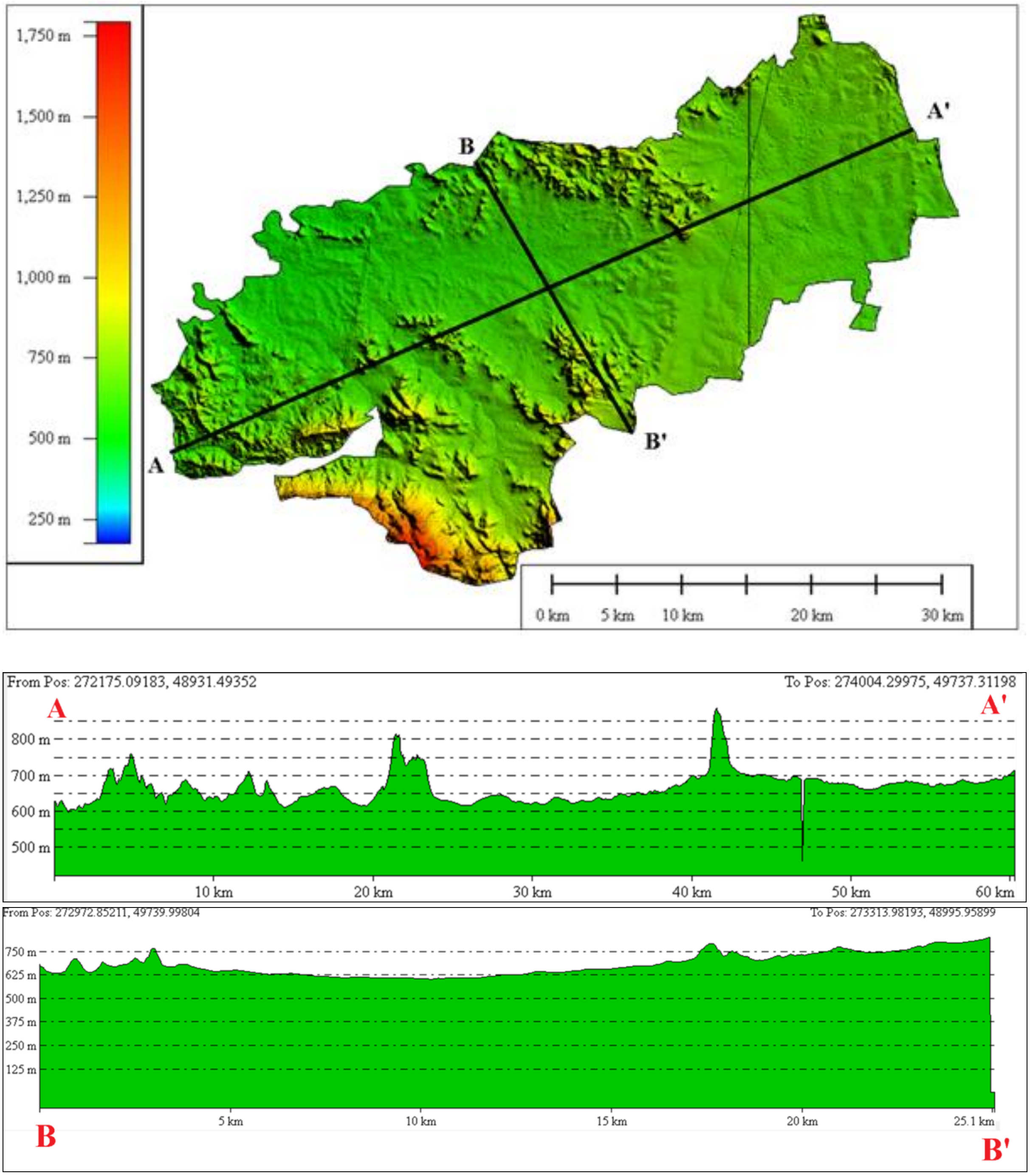


Figure 3.Digital Elevation Model of Tarikere taluk

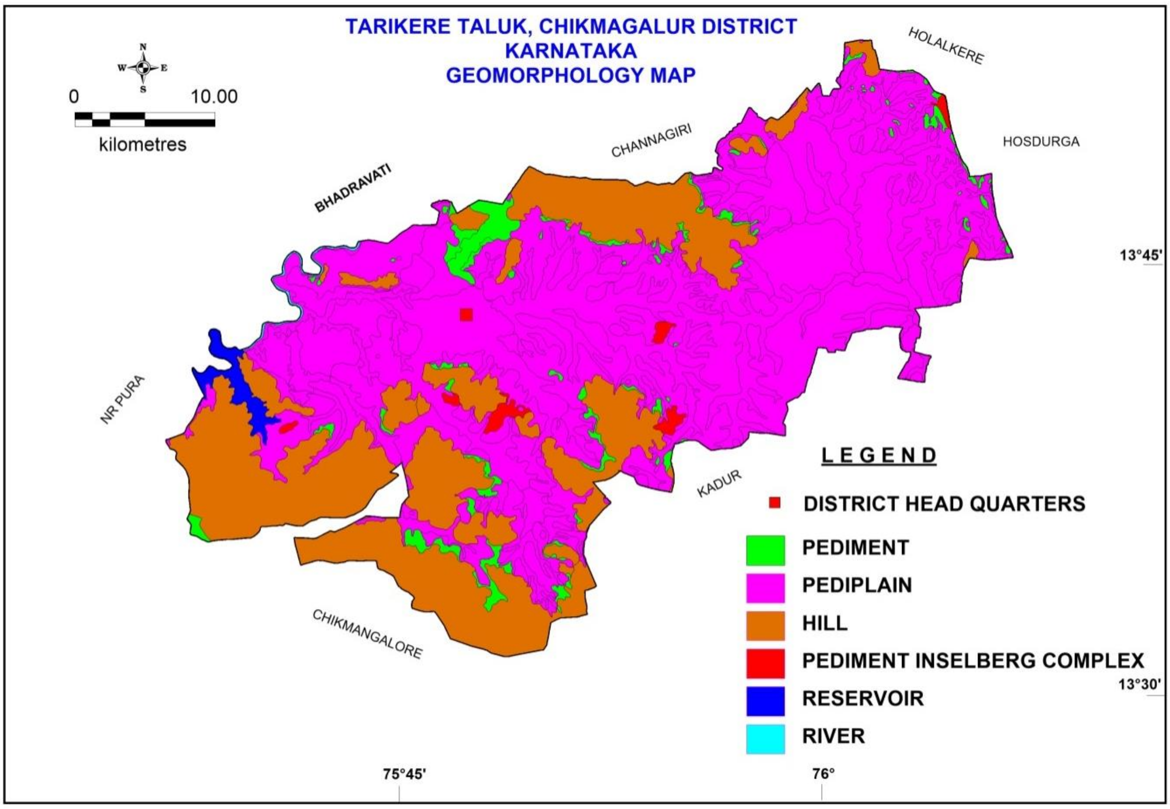


Figure 4. Geomorphology map

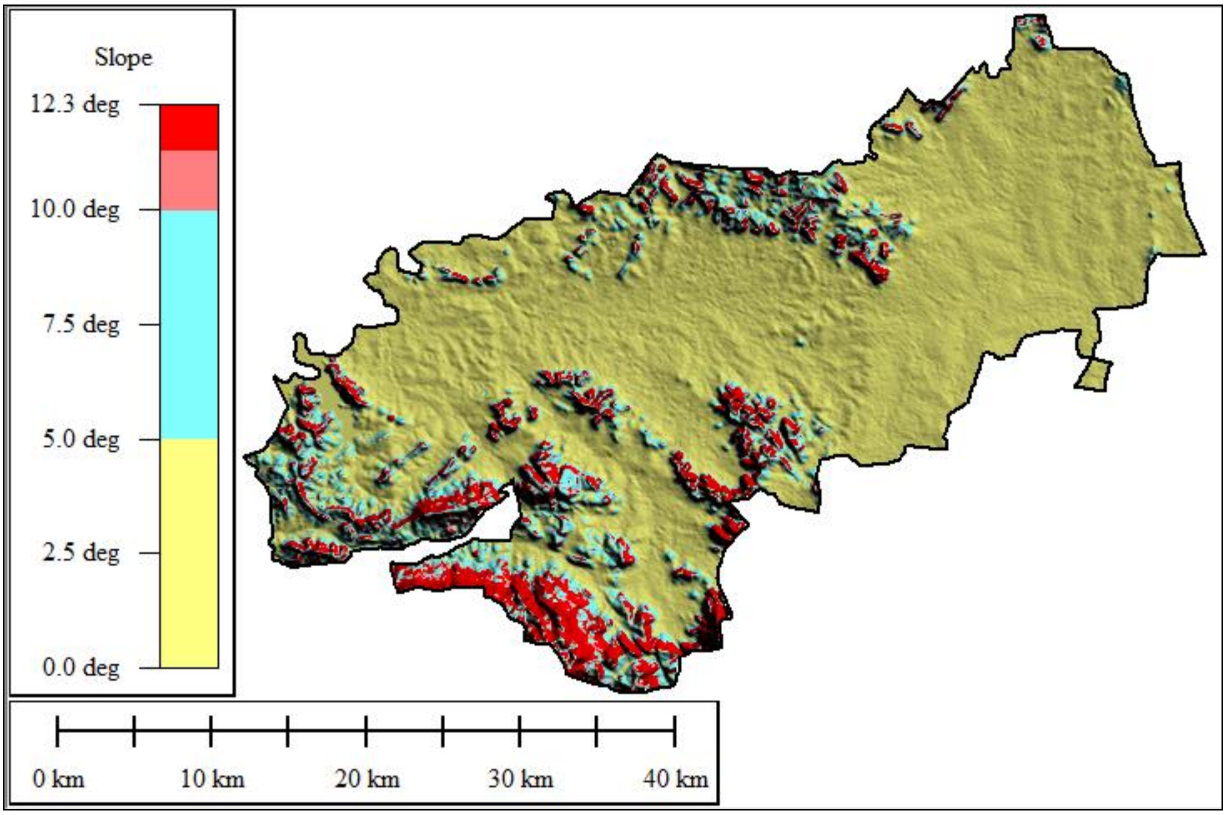


Figure 5: Slope Map of Tarikere Taluk.

1.7 Land Use, Soil, Agriculture, Irrigation and Cropping Pattern

Land use/ land cover pattern is one of the factors that determine the availability and utilisation of groundwater resources in an area. Further, it directly influences the surface runoff and ground water infiltration rate in a considerable manner. The information related to land use patterns for the present study area was referred from the District at a glance, Chikmagalur district- statistical report- FY 2019-20 published by the Directorate of Economics and statistics, Govt of Karnataka. Summarised land use pattern and cropped area of the district is given in table 2. The land use map of the district is shown in figure 6. The major crops raised in the taluk are Coconut, arecanut, pulses, cereals etc. The area under different crops is given in table 3.

Table 2. Land use pattern

Item	Area (Ha)
Forest	43448
Land put to non-agricultural use	5811
Barren and uncultivable land	3669
Permanent Pastures	7831
Cultivable waste land	790
Fallow other than current fallow	14590
Current fallow	3600
Net area sown	53848
Area sown more than once	38581

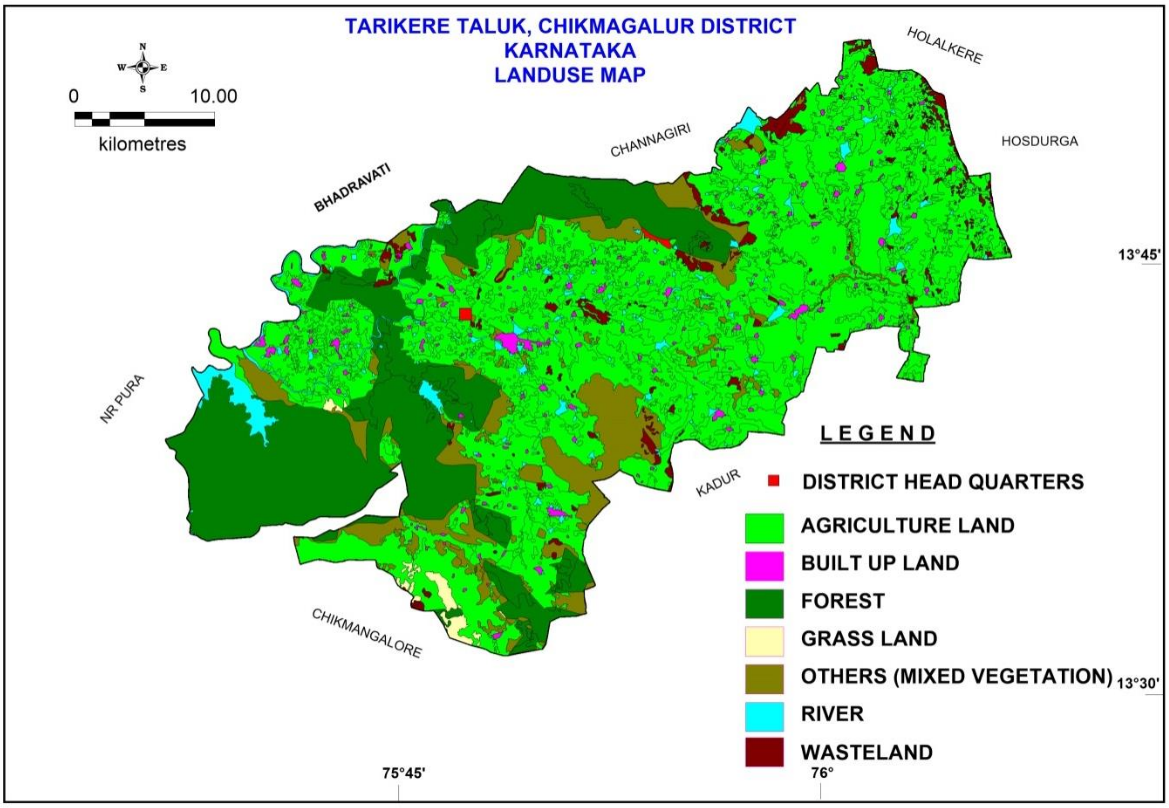


Figure 6. Land use/ Land cover – Tarikere taluk

Table 3. Area under different crops

(Source: District at a glance 2019-20)

Crop	**Area (Ha)**
Paddy	3732
Jowar	6364
Maize	6192
Ragi	5769
Total Pulses	12616
Ground nut	2615
Total fruits including banana	3058
Total vegetables	6748
Total plantation crops	2468
Total condiments and spices	464
Coconut	14957
Arecanut	25246

The source wise area irrigated as per District statistical report 2018-19 is given in table 4.

Table 4. Sources of Irrigation

(Source:District statistical report 2018-19)

Source	Gross Area irrigated (Ha)	Net irrigated area
Canal	9603	6573
Tank	5656(179 no)	5656
Open Well	34 no	
Bore well	18054	18032
Lift Irrigation	79 (127 no)	79
Total	33392	30340

There are mainly three types of soil observed in the taluk namely Clayey soil, Clayey mixed and Clayey skeletal based on the textural characteristics. Figure 7 shows the distribution of the soil over the region. The western parts of Tarikere taluk contain sandy to gravelly soil. Soil in the taluk is generally acidic with patches of alkaline soil.

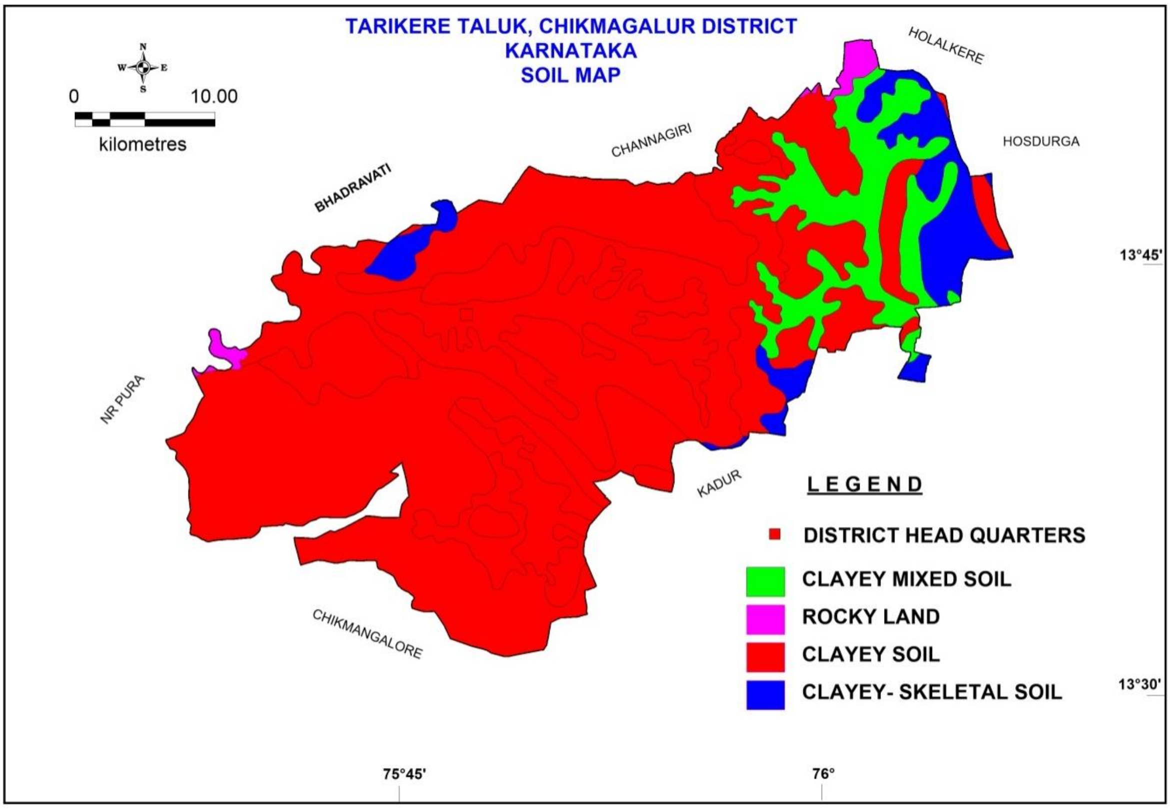


Figure 7. Textural classification of soils – Tarikere Taluk

1.8 Hydrology and Drainage

Even though the Chikmagalur district is blessed with seven rivers, no major river is flowing through Tarikere taluk except Veda which flows about 40 km length. However, the Bhadra River has been harnessed for irrigation and power generation near Lakkavalii village, Tarikere Taluk. The tributeries of this river exhibit dendritic drainage pattern. Drainage map of the district is given in figure 8.

Bhadra Dam is constructed across Bhadrariver near Lakkavalli village, Tarikeretaluk, Chikkamagaluru district of Karnataka state at an elevation of 601.00 m above MSL. The dam is located at a latitude 13º 42’ 00” N and a longitude 75º 38’ 20” E. The Bhadrariver rises from Varaha hills “Gangamoola” in the Western Ghats about 24 km west of Kalasa in Chikkamagaluru district. After flowing for about 190 kms, it joins the river Tunga at Kudli, 14.40 kms east of Shivamogga city and becomes Tungabhadra River, which is a major tributary of Krishna river. The right bank canal irrigates about 4785.89 Ha of land in Tarikere taluk. Tarikere has highest irrigated area and the taluk is getting advantage of Command Area development projects of Bhadra River. Tarikere also has an area of about 6000 hectares under assured irrigation with channels that are 50 kilometers in length. The Jambadahalla Reservoir is constructed across Jambadahalla stream near Duglapura in Tarikere talukis an earthen dam with masonry spillway.

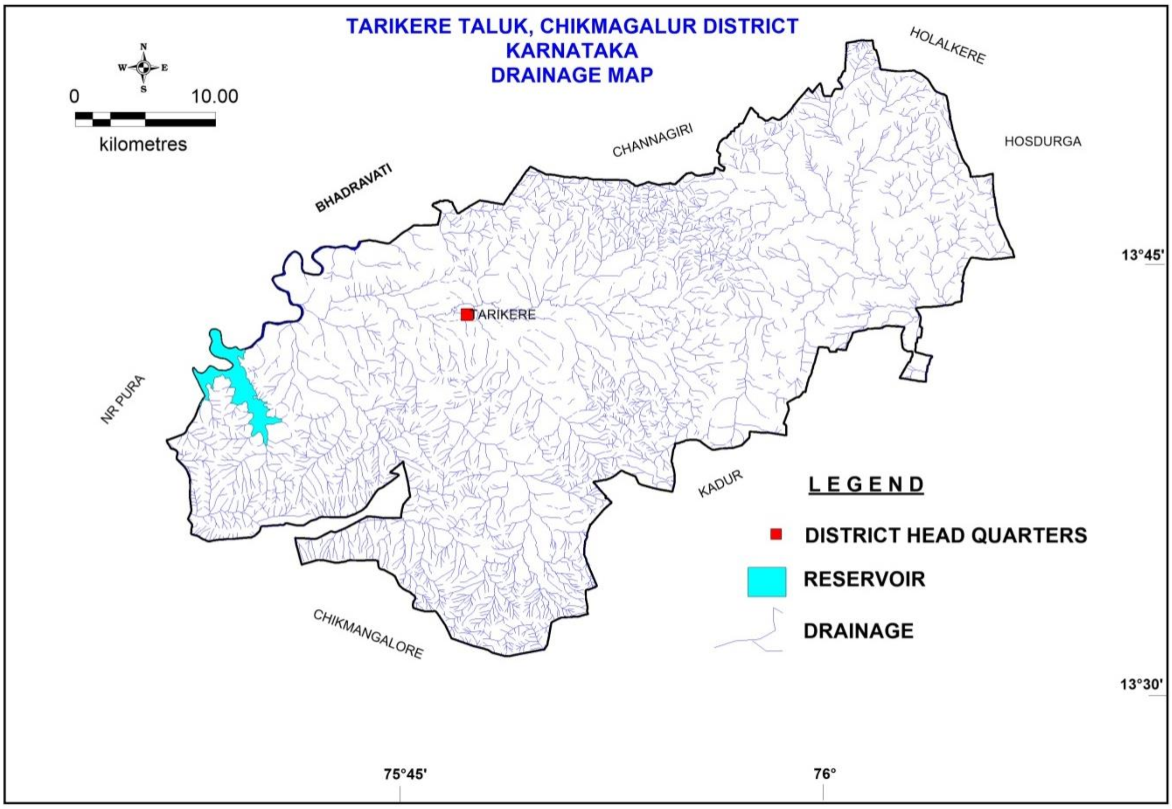


Figure 8. Drainage map

1.9 Prevailing Water Conservation and Recharge Practices

The State Ground Water department, Department of agriculture, Department of irrigation, Forest department etc. are carrying out extensive water conservation and artificial recharge activities in the district. Tarikere taluk presents ample scope under Command area development as well as dry land development. A drive for afforestation is also implemented in the transitional Tarikere taluk.

2 DATA COLLECTION AND GENERATION

The primary data such as water levels, quality, and lithological inputs available with CGWB has been collected and utilised as baseline data. However, ancillary data such as numbers of agriculture details, irrigation facilities, rainfall, etc. have been collected from the various State/Central govt. departments and compiled.

2.1 Data Collection and Compilation and Generation

The data collection and compilation for various components were carried out as given below.

- **i.** Hydrogeological Data – Current and historical water level data from 10 Dug wells (DW) and 1 piezometers (PZ)) monitoring wells in Tarikere taluk representing Aquifer-I (Weathered crystallines). were also collected and compiled.
- **ii.** Hydrochemical Data - Ground water quality data from 10 existing Ground Water Monitoring Stations of CGWB representing Aquifer-I and data of 5 Bore wells in the taluk representing Aquifer-II were also collected and compiled.
- **iii.** Exploratory Drilling – Five exploratory wells were drilled in the study area during by CGWB were compiled.
- **iv.** Geophysical Data – Data of11 no of Vertical Electric Sounding (VES) conducted in Tarikere is compiled.
- **v.** Hydrology Data – Data on various irrigation projects, their utilisation status, number of ground water abstraction structures, and area irrigated from irrigation department were compiled.
- **vi.** Hydrometeorological Data – Long-term rainfall data of all rain gauge stations in the taluk were collected and compiled.
- **vii.** Cropping Pattern Data – Data on prevailing cropping pattern from Agriculture Dept. were complied.

2.2 Data Generation

After taking into consideration, the data available with CGWB on Ground Water Exploration, Geophysical survey, Ground Water Monitoring Wells (GWMW) and Ground Water Quality, the data adequacy were compiled. Based on gap analysis additional data were generated and discussed below:

2.2.1 Ground Water Exploration

Historic data compilation indicates that 5numbers of exploratory wells were drilled by CGWB in the taluk and its depth varies from 41.4 to 231 m. Except one well at Sivane, all others are drilled during 1999-2000. Figure 9 represents the location of the exploratory wells.

2.2.2 Ground Water Monitoring Wells

Data gap analysis revealed the existence of 11 GWMWs (10DW+1PZ) in the Tarikere taluk. Additional 12 KOWs wells were fixed for regime monitoring and micro-level data acquisition pertaining to Aquifer-1. The details of GWMWs are given figure 10.

2.2.3 Ground Water Quality

As stated in table 1 already there existed 10 water quality data for Aquifer-1. Additionally, 33 samples were collected from KOWs for major element analysis of which 10 are from DW and balances 23 are from BW. The details of quality monitoring stations are given in figure 11.

2.2.4 Geophysical data

Data gap analysis revealed the existence of 11 geophysical data in the taluk. Details are given in figure 12. Additional 8 sites were proposed for data generation.

2.2.5 Thematic Layers

The following thematic layers were also generated on the GIS platform, which supported the primary database and provided precise information to assess the present ground water scenario and also to propose the future management plan.

1. Drainage
2. Physiography/Dem
3. Geomorphology
4. Slope
5. Soil
6. Land Use – Land Cover
7. Geology and Structure

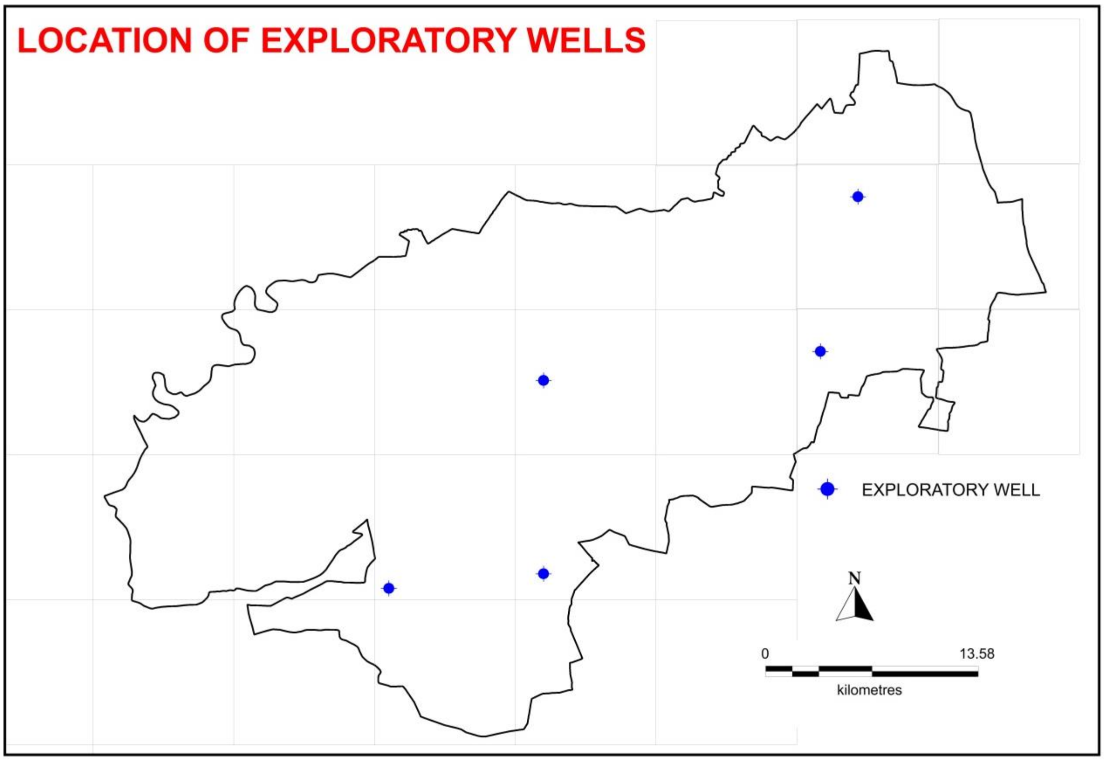


Figure **9. Location of EWs drilled in the study area**

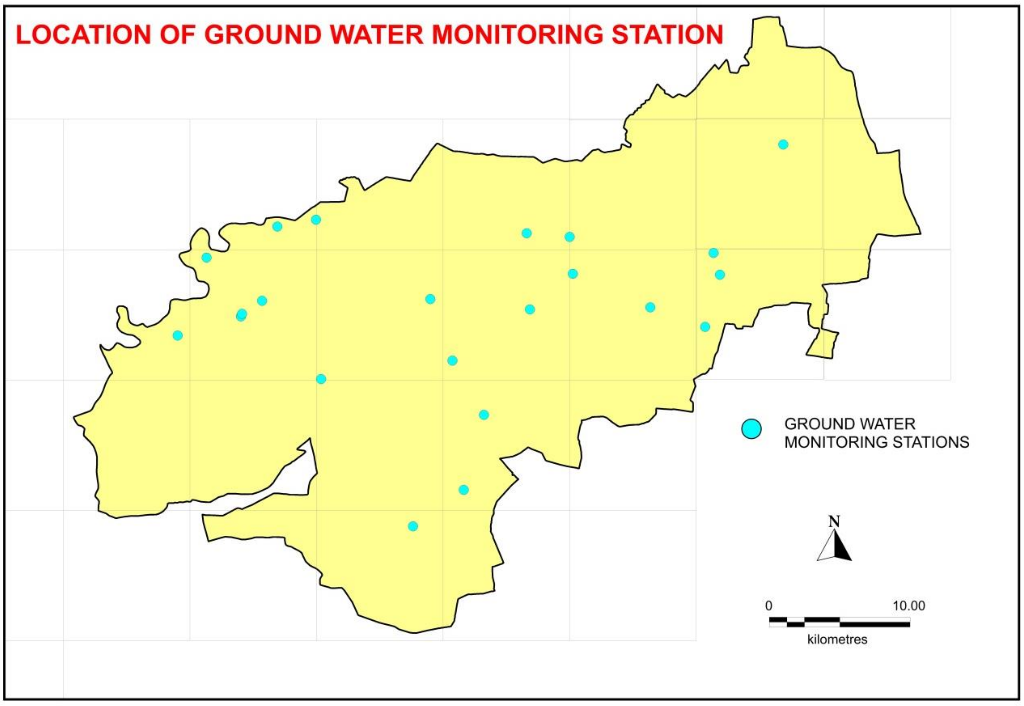


Figure 10. Location of water level monitoring stations (DWs) in the study area

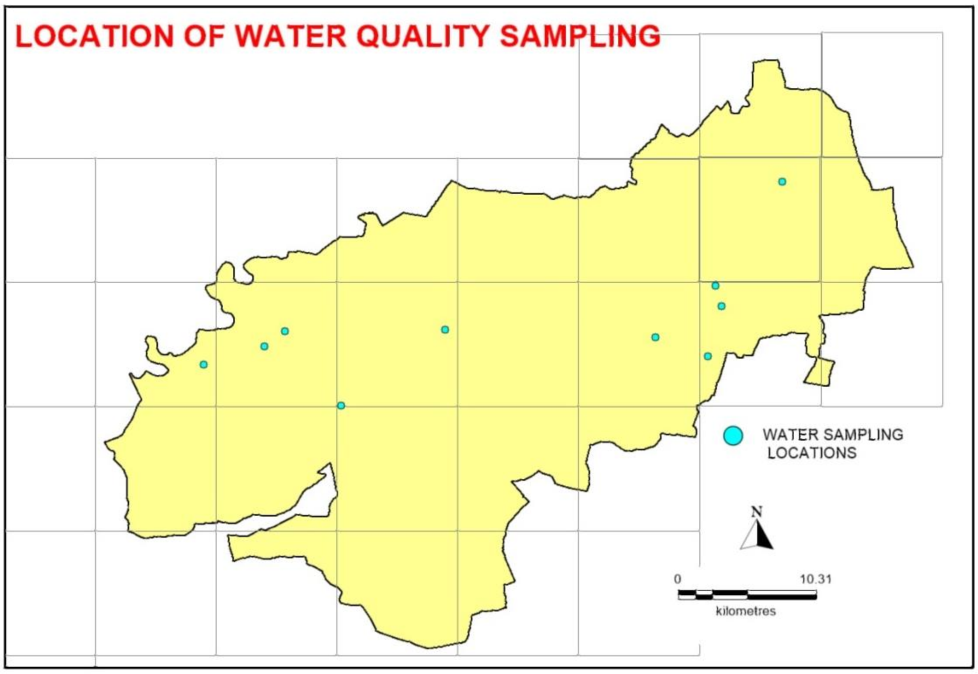


Figure 11. Location of water quality sampling stations

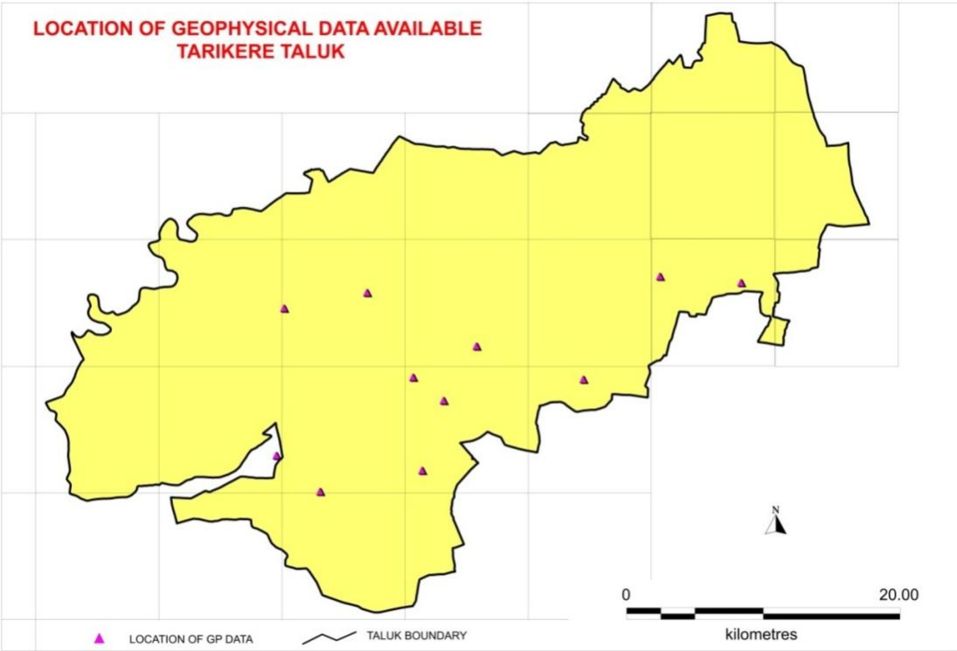


Figure 12. Location of geophysical survey conducted.

3 Data Interpretation, Integration and Aquifer Mapping

Various data pertaining to hydrogeology, geophysics and exploratory drilling were collected and validated. Using these data maps of ground water level scenario, quality aspects, 2-D and 3-D sub-surface aquifers disposition, yield potential etc. were prepared. Finally, aquifer maps were generated and their characteristics are discussed in detail below.

3.1 Geology

The study area comes under Bababudan belt of Dharwar super group. The major lithology identified in the taluk area is Migmatites and granodiorite and Schists. Near Tarikere the gneissic exposure transects the structural trend lines of the schist belts. Quartzite, conglomerate and phyllites are also found in the area.

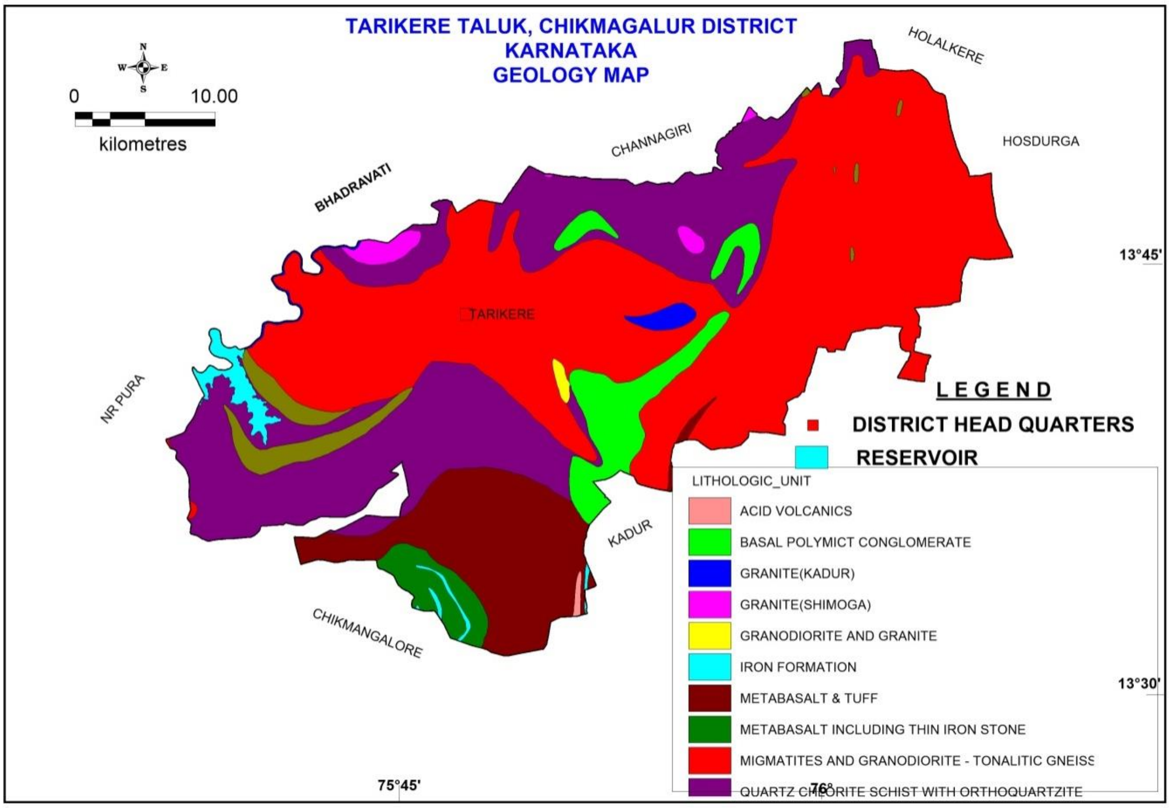


Figure 13.Geology-Tarikere taluk.

3.2 Hydrogeological data interpretation

The Aquifer Systems exists in the taluk is broadly categorized into weathered/shallow (phreatic) aquifer and deeper crystalline(fractured) aquifers. Ground water occurs in weathered and associated fractures in water table condition whereas in fractured aquifer system groundwater occurs in semi-confined condition. The hydrological data generated during the Aquifer mapping study were utilized to depict the Aquifer properties and its behaviour during various seasons.

3.2.1. Phreatic Aquifer – I

It comprises weathered/partially weathered crystalline rocks. The depth of weathering considerably varies because of mineralogical composition of the rock types. Water level is a direct indicator of the availability of groundwater resources in an area. Measurements of water levels in wells are necessary for the evaluation of the quantity of ground water and its interaction with surface water and rainfall. The water levels in the phreatic aquifer were analysed for pre-monsoon and post monsoon. Shallow water level are observed in the western part of the taluk near the reservoir during pre-monsoon season and during post monsoon 67% the wells are showing rise in water level. Depth of Dug wells analysed generally ranges from 6.9 to 20.7 m bgl and depth to water level generally ranges from 0.6 to 8.4m bgl during pre-monsoon and from 0.48 to 8.5 during post-monsoon. During pre-monsoon major part of the districthave water level in the range of 5-10 m bgl.The depth to water level map of Tarikere taluk for pre- monsoon season (May 2022) is shown in figure 14 and for post monsoon season (Nov 2022) in figure 15.

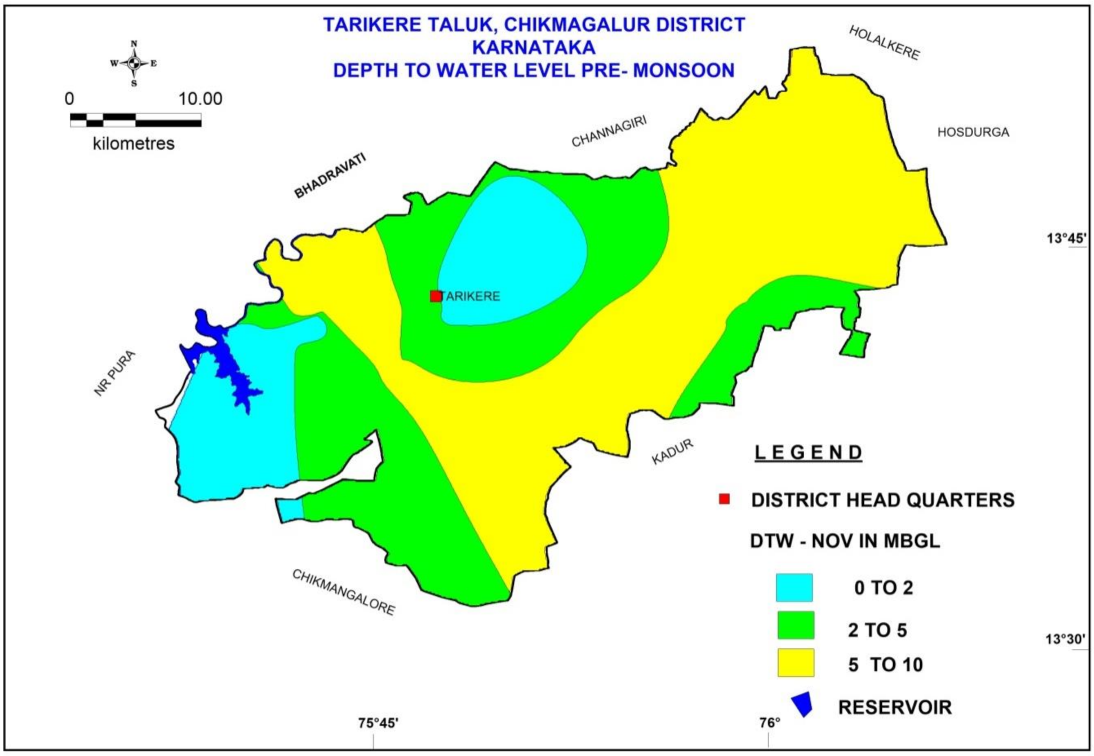


Figure 14.Depth to water level Map pre-monsoon (May 2022)

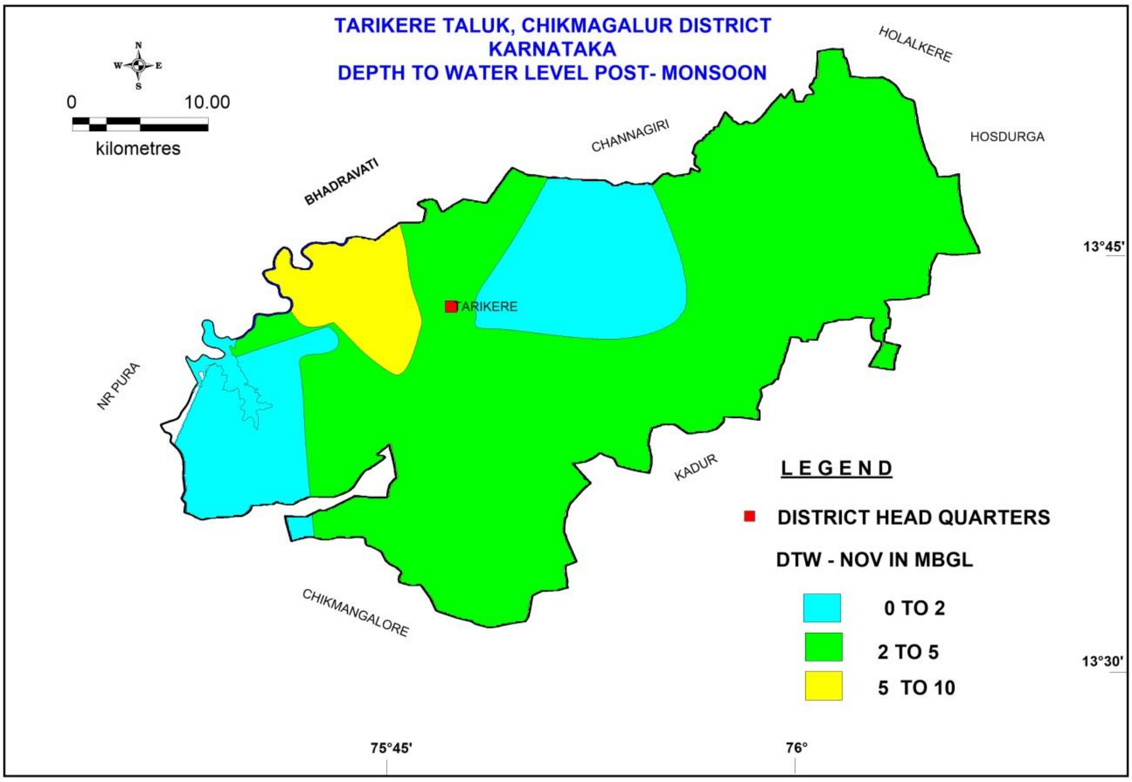


Figure 15. Depth to water level Map post-monsoon (November 2022)

Water level fluctuation in the wells in an area between pre and post-monsoon period is indicative of the net changes in the groundwater storage in response to the recharge and discharge components and is an important parameter for planning sustainable groundwater development and management. The 67 % of the wells analysed is showing rise in water level during post monsoon season and remaining 33% is showing fall in water level during the period of analysis. Major part of the taluk is showing rise in the range of 0-4 m bgl. Fall in water level is noticed in the north western part of the taluk. The fluctuation map as well as water table contour map with direction of flow of taluk is depicted in figure 16 and 17 respectively.

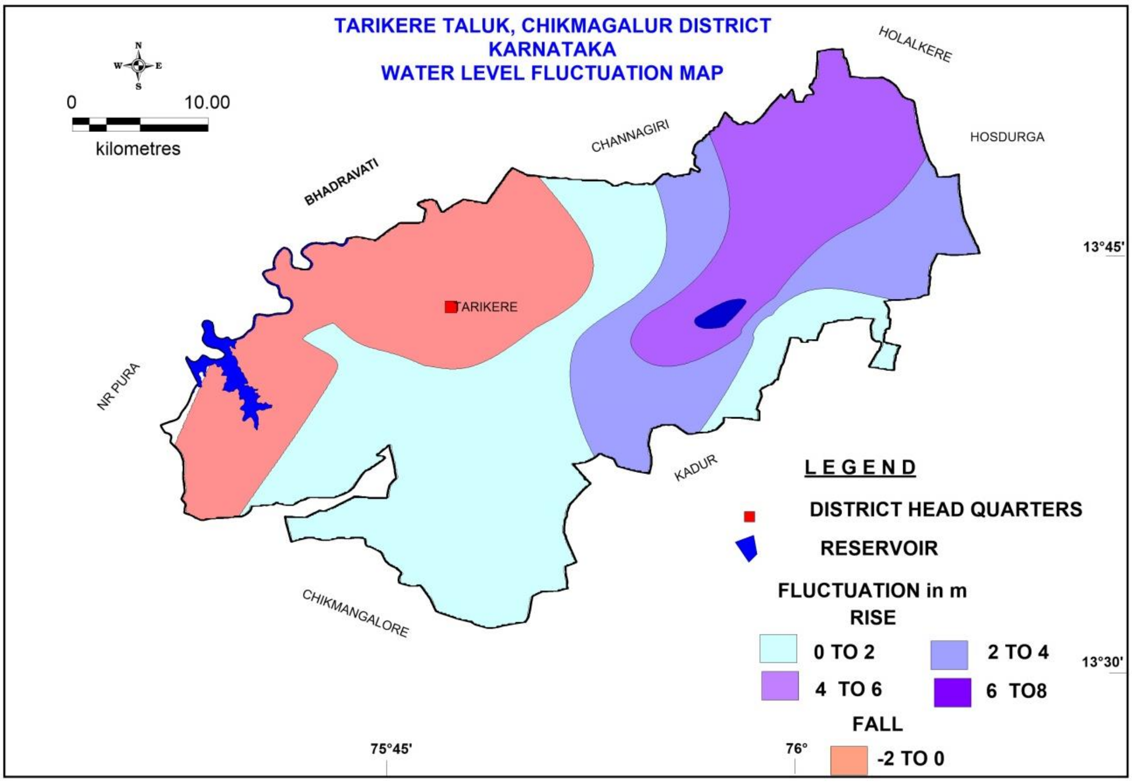


Figure 16: Water level Fluctuation Map

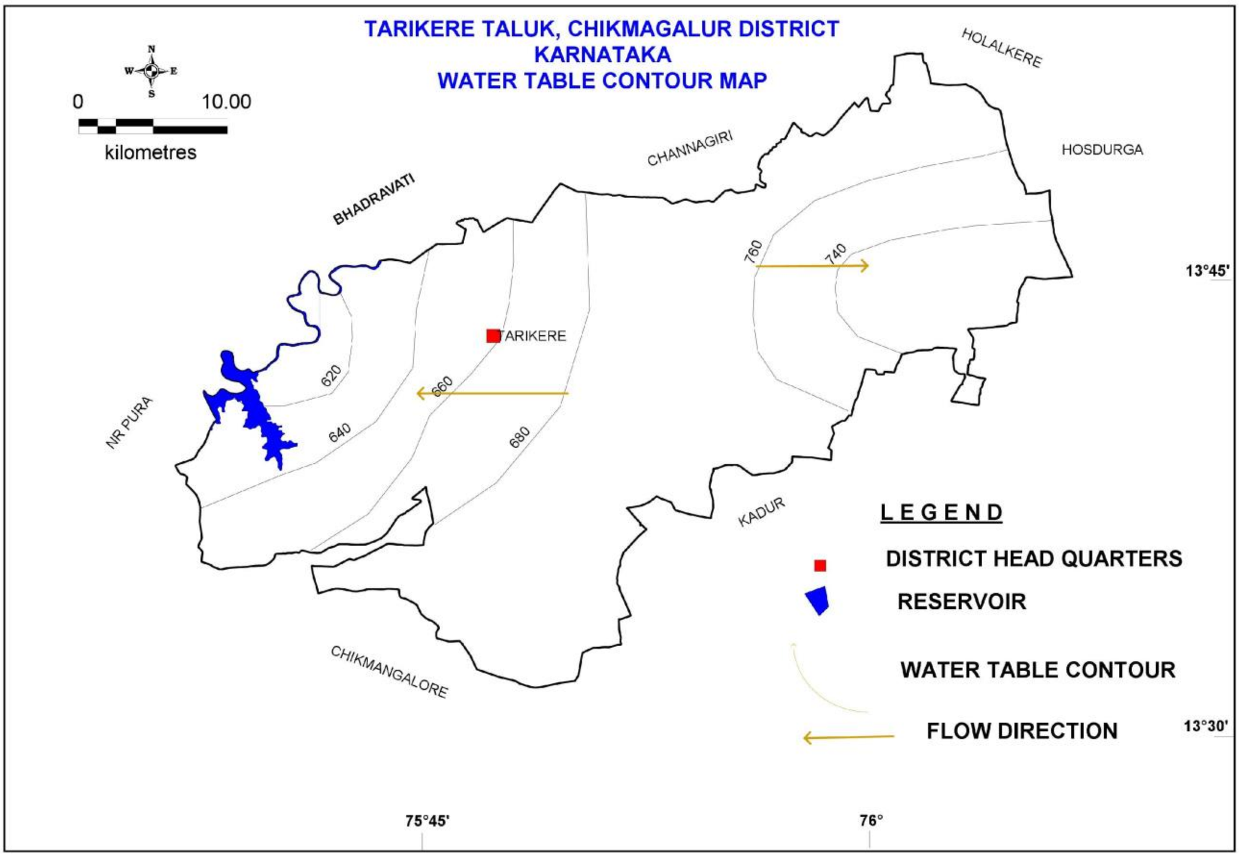


Figure 17: Water table contour map

3.2.2. Weathered thickness

From the exploratory drilling data and field studies two aquifer zones were identified viz. the weathered zone (aquifer - I) and the fracture zone (Aquifer-II) below it. Weathered zone includes the weathered formation and the underlying shallow fractures and its thickness varies in the range of 6.1 to 24.4 m. The weathered thickness in the area varies highly and the data have been used to elucidate the lateral and vertical changes in weathered zone. The information from bore wells has been analysed for understanding the spatial variations in the thickness of weathered zone. The thickness of the weathered zone generally decreases towards the north western part and increases as moving towards the south western part of the district. The Spatial variations of weathered zone thickness in the area are given in Fig 18.

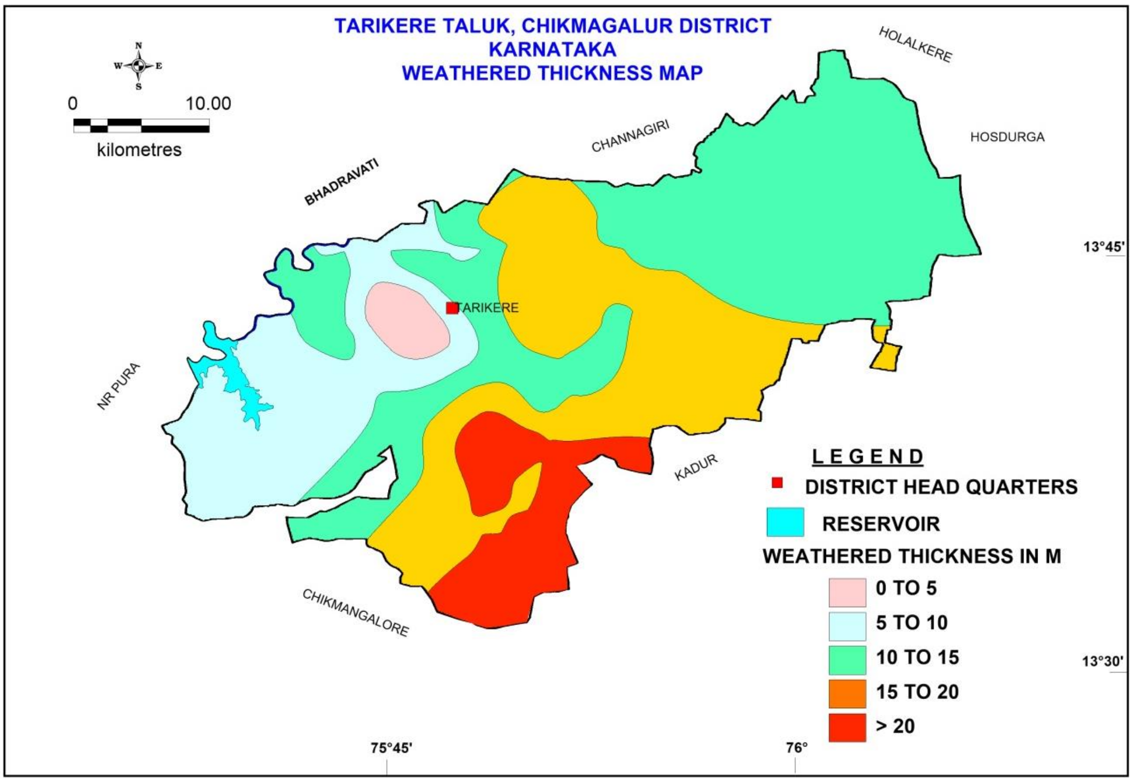


Figure 18 Map showing the spatial variation of weathered thickness.

3.2.3 Chemical quality of phreatic aquifer

In a groundwater flow regime water chemistry constantly undergoes modification due to various processes such as dissolution of minerals, precipitation of dissolved ions under unstable conditions, cation exchange and anthropogenic addition etc. The chemical composition of subsurface water is controlled by various factors such as the amount of dissolved CO_2 in rain water and soil, the composition of the rocks through which the water percolates and the duration of contact between the water and the soil/rock. The chemical analysis results of dug wells tapping the phreatic aquifer system are given in table 5.

Table 5: Water Quality of Dug wells

Sl no	Location	Latitude	Longitude	pH	EC in mS/cm	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	SiO2	PO4	F	U (30 ppb)	TDS	TA
						----------mg/l----------															
1	Bettathavarakare	13.7112	75.8875	7.82	1560	510	132.3	43.7	116.4	24.0	0.0	414.8	198.5	8.0	200.7	36.0	0.8	0.5	NA	1013.0	340.0
2	Hosahalli Tandya	13.7575	75.9136	7.88	1430	610	96.2	89.9	61.2	4.8	0.0	329.4	177.3	6.0	223.8	39.6	0.1	0.3	NA	900.0	270.0
3	Vittalapura	13.7599	75.8854	8.68	1180	300	64.1	34.0	55.2	141.9	24.0	323.3	134.7	6.0	127.3	22.6	2.7	0.3	NA	797.0	305.0
4	MC halli	13.7686	75.7467	7.35	1480	600	160.3	48.6	65.3	4.2	0.0	305.0	148.9	12.0	348.1	31.7	0.1	0.2	NA	1005.0	250.0
5	Nandi	13.6438	75.8571	8.13	1690	540	128.3	53.5	116.0	30.5	0.0	317.2	170.2	5.0	413.6	29.1	0.1	0.2	NA	1140.0	260.0
6	Linkadahalli	13.5957	75.8439	7.53	2220	1000	128.3	165.2	48.3	2.3	0.0	372.1	301.3	6.0	469.4	40.7	0.1	0.2	NA	1389.0	305.0
7	Gopalacolony	13.7641	75.7212	7.71	700	275	80.2	18.2	34.5	1.2	0.0	329.4	46.1	3.0	7.8	31.1	0.0	0.3	NA	423.0	270.0
8	Karkuchi	13.7443	75.6746	7.32	1060	400	102.2	35.2	52.9	19.6	0.0	250.1	148.9	9.0	145.3	37.0	0.1	0.1	NA	703.0	205.0
9	Gonagilkatte(Krishnapura)	13.5725	75.8105	7.31	460	130	34.1	10.9	48.3	0.8	0.0	152.5	39.0	12.0	49.1	21.8	0.0	0.0	NA	309.0	125.0
10	Rangenahalli	13.7083	75.6980	7.45	870	270	62.1	27.9	60.5	15.4	0.0	244.0	127.6	45.0	1.6	24.6	0.1	0.1	NA	514.0	200.0

- The parameter above permissible range is highlighted with red colour.

The ground water quality data of 10 dug wells were analysed and the results shows that quality of ground water in the phreatic aquifer in the region is generally good for drinking purpose except in pockets were Nitrate is above permissible limit. The electrical conductivity (in µS/cm at 25^{o} C) of groundwater in phreatic zone is in the range of 460 to 2220 and Chloride in the range of 39 to 198.5 mg/l. Fluoride content in the observation wells monitored is in the range of 0.0 to 0.5 mg/l in the study area. Nitrate above permissible limit is observed80% of the analysed wells.

The percentage of the epm values of cations and anions in the samples from phreatic zone were plotted in Hill- Piper diagram (Fig. 19) for classifying the water types and most of the samples fall in Calcium Bicarbonate type. Also the results of chemical analysis are plotted in Wilcox diagram to evaluate the suitability of water for irrigation purpose (Fig 20) and the samples are falling in low Sodium hazard zone and medium to high salinity zone. 8 samples are falling in high salinity zone.

There exists a good positive correlation (R2 = 0.62) (Figure 21) exists between Chloride and Nitrate which indicates agriculture influence and animal waste in ground water.

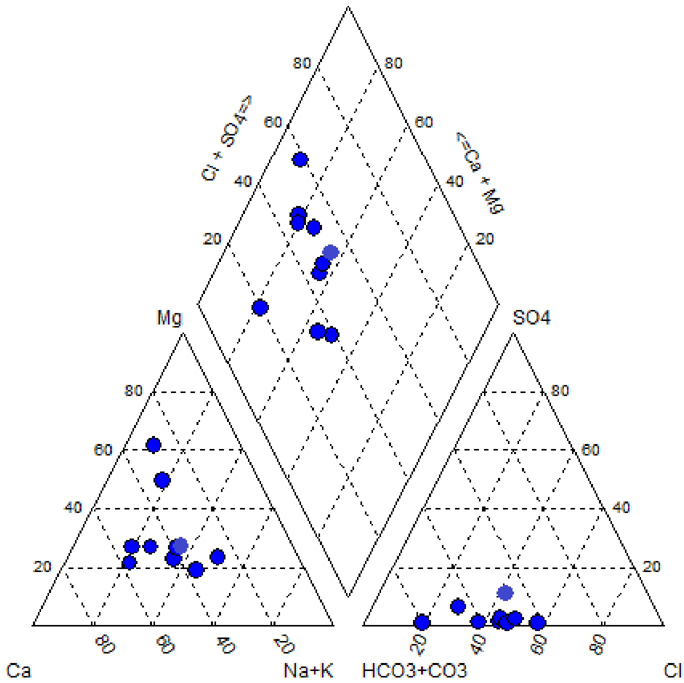


Figure 19. Hill –Piper diagram of phreatic aquifer

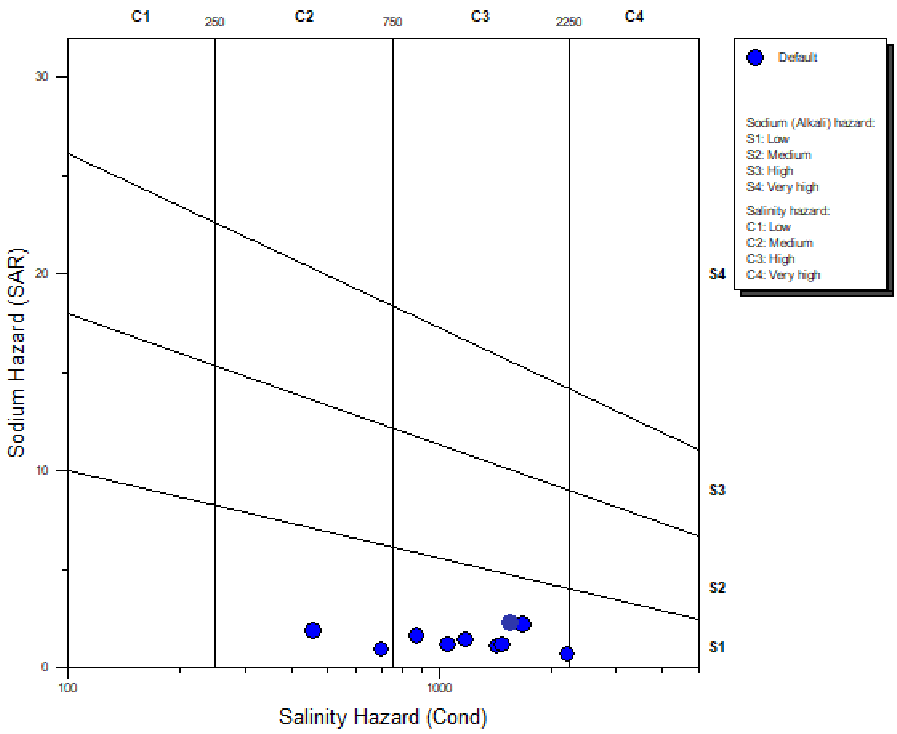


Figure 20. Showing Wilcox diagram of phreatic aquifer.

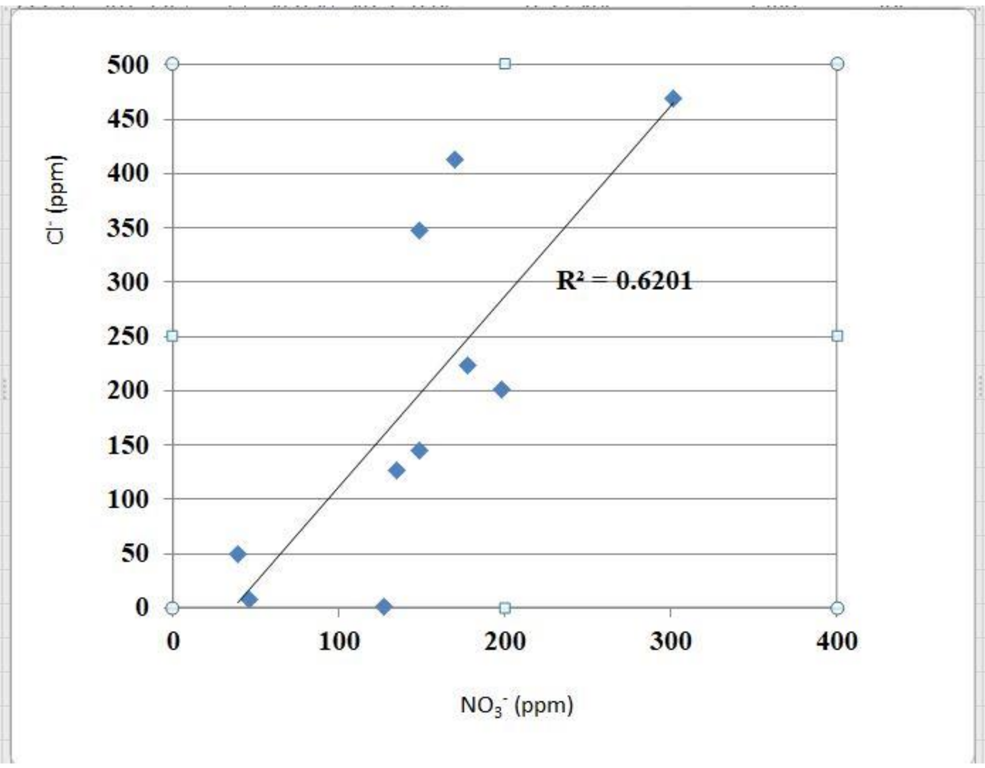


Figure 21: Graph showing correlation between Cl^- and NO_3^-

3.2.4. Fractured aquifer II

The geology of the area in conjunction with lithological log of bore wells has been used to study the disposition of fracture aquifer system. In hard rocks groundwater potential is controlled by lineaments and fractures. The availability of water in the fracture zones depends on presence of secondary porosity (interconnected fracture zones or lineaments). The information on weathered thickness and fracture zones from 4 exploratory wells and from data collected in the field have been used for the preparation of various diagrams like fence, 3D model etc., to represent the sub-surface aquifer disposition of the area.

The depth of the bore wells drilled by CGWB in the area ranges from 41.4 m to 231.11 mbgl. Groundwater in the deeper fractured aquifer system exists under semi confined state, in general. Weathered zone includes the weathered formation and the underlying shallow fractures and its thickness varies in the range of 6.1 to 24.4 m. The weathered thickness in the area varies highly and its thickness generally decreases towards the north western part and increases as moving towards the south western part of the district. Moving towards east the Massive Migmatites and granodiorites- Tonalite Gneiss are overlain by Massive Metabasalt. The static depth to water level ranges from 3.66 to 16.25 mbgl. Most of the bore wells in the area tap the fracture zones within the depth range of 19.19 to 95.59 m bgl and rarely extend up to 128m bgl. In order to understand the aquifer disposition 2D (Figure 22), fence diagram (Figure 23) and 3D view models were created using Rock Works software (Figure 24) of the area were prepared using details of bore well of depth greater than 100 m depth.

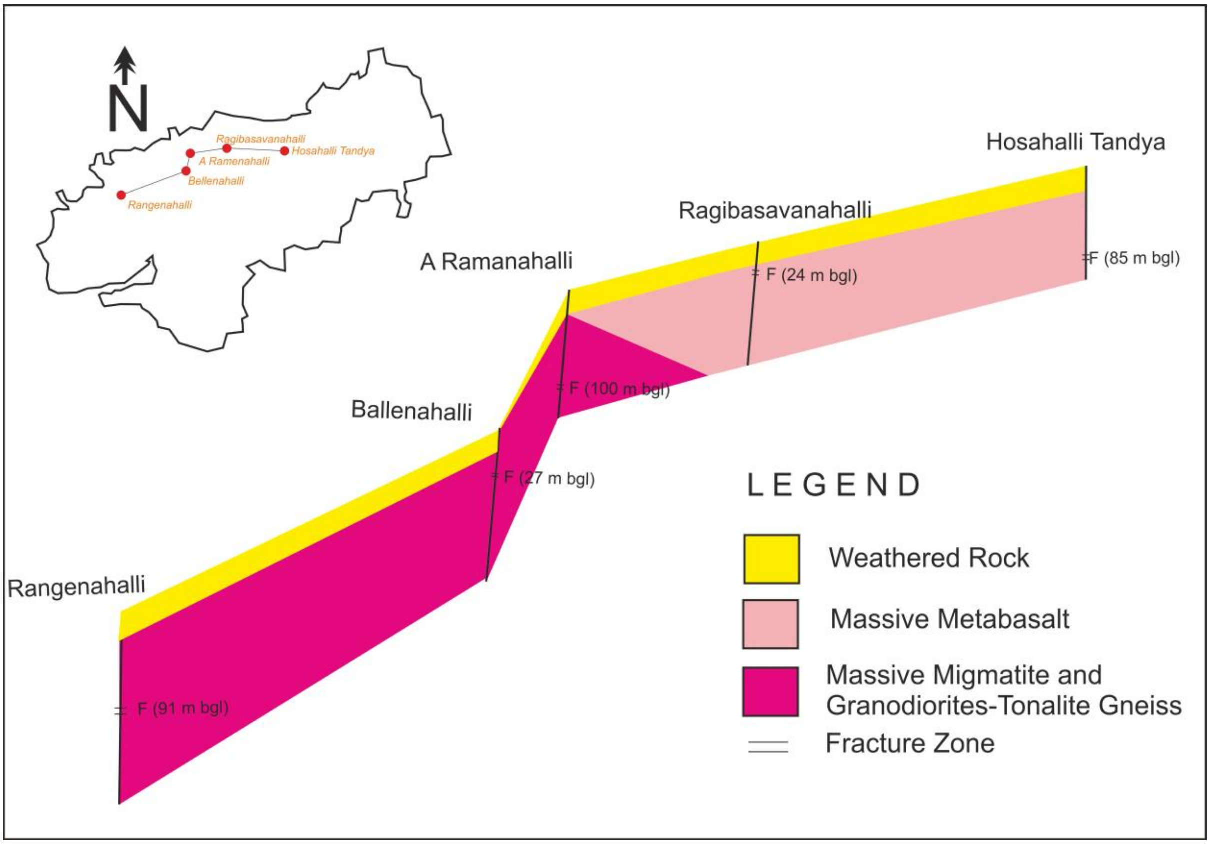


Figure 22: Cross section along Ranganahalli- Hosahalli Tandya.

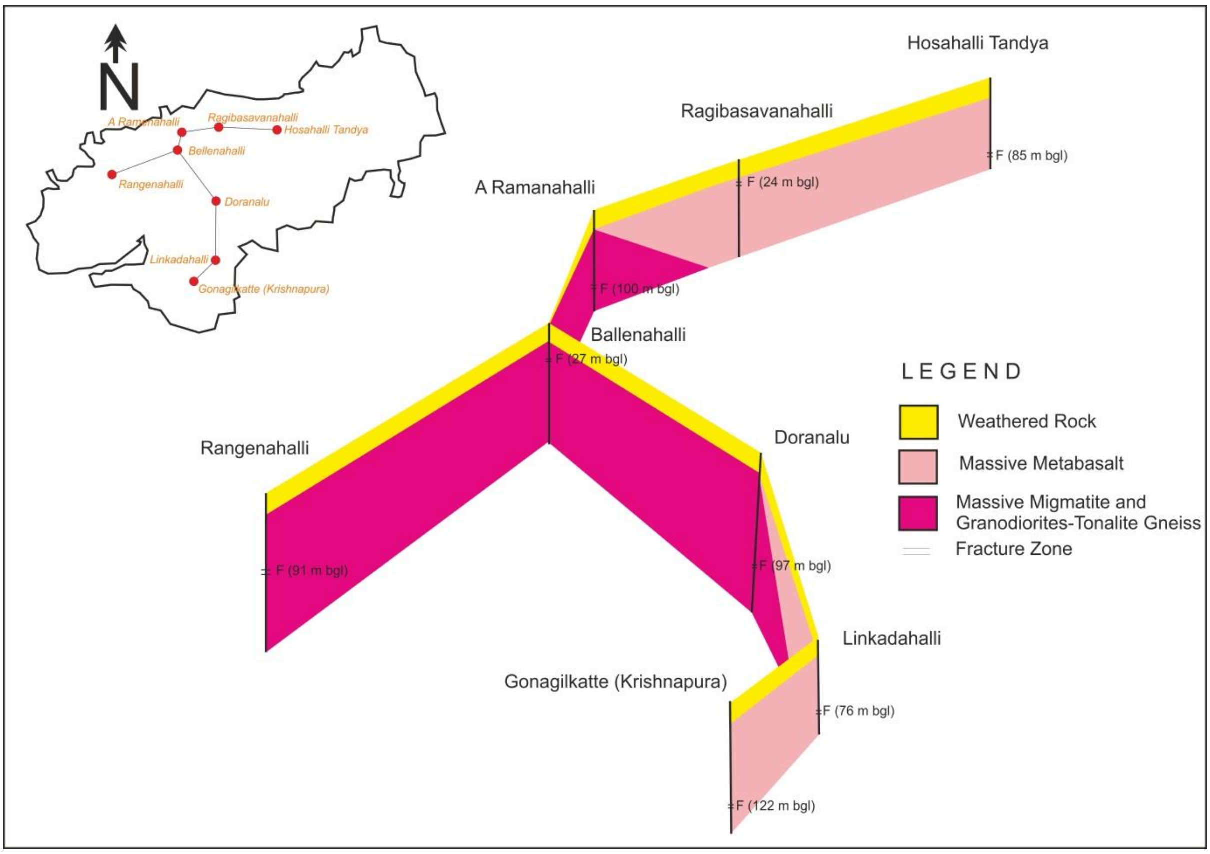


Fig. 23 Fence diagram showing aquifer disposition in tarikere taluk.

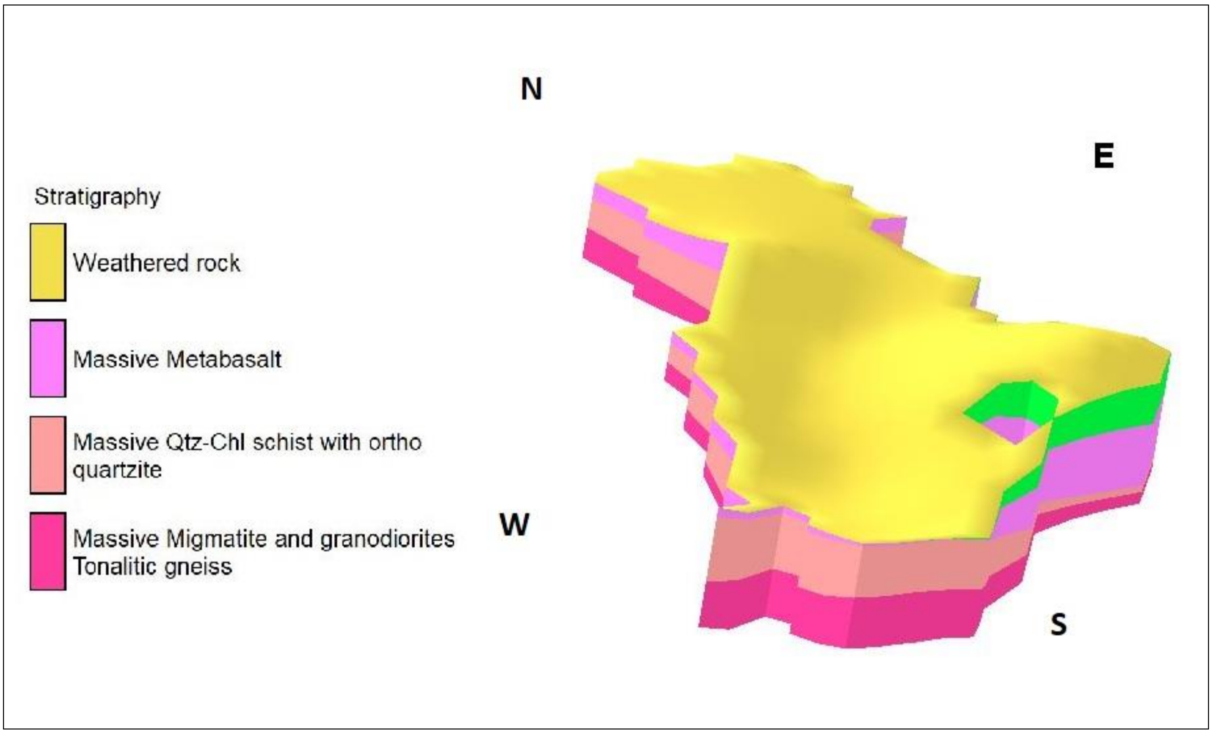


Fig. 24. 3D model showing aquifer disposition in tarikere taluk.

3.2.5 Aquifer characteristics

The hydraulic properties of fracture systems are evaluated from pumping tests. The Transmissivity value obtained for a bore well 13.96 m^2/day and the specific capacity of the wells ranges from 12 to 119 lpm/m dd.

3.2.6 Water level in fractured aquifer

The water level of 14 piezometers of depth ranging from 65 to 117 are analysed for both pre and post monsoon season. The water level is found to be ranging between 3.3 to 20.3 mbgl during pre-monsoon and ranging in between 1.25and 14.6 mbgl during post monsoon season. The wells analysed shows no fluctuation to rise in water level upto 3.35 m.

3.2.7 Water Quality of fractured aquifer

The ground water quality data of 23 bore wells were analysed (Table 6) and the results shows that quality of ground water in the fractured zone in the region is generally good except Nitrate contamination. The electrical conductivity (in µS/cm at 25° C) of groundwater is in the range of 450 to 1710 and Chloride in the range of 37 to 177.29 mg/l. Fluoride content in the wells monitored range between 0.06 to 1.5mg/l.

The percentage of the epm values of cations and anions in the samples from fractures were plotted in Hill- Piper diagram (Fig. 25) for classifying the water types and the water samples fall in Ca-HCO_3 type and mixed type. Also the quality is plotted in Wilcox diagram to evaluate the suitability of water for irrigation purpose (Fig 26) and the samples are falling in low Sodium hazard zone and medium to high salinity zone indicating the suitability of water for irrigation use.

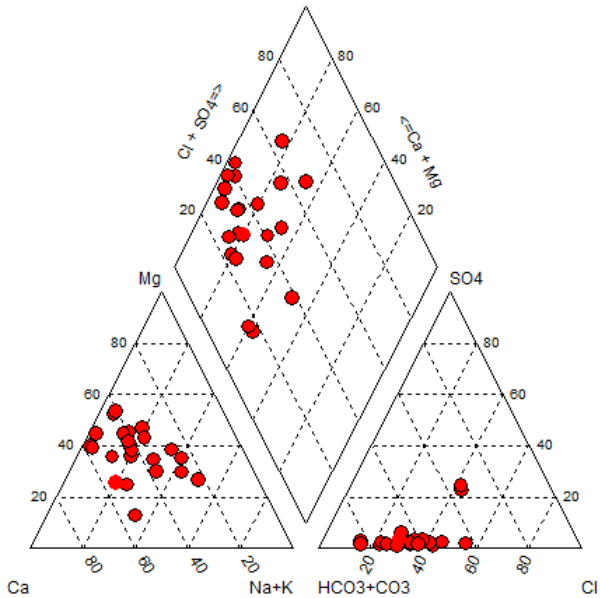


Figure 25. Piper Diagram of samples from fractured aquifer

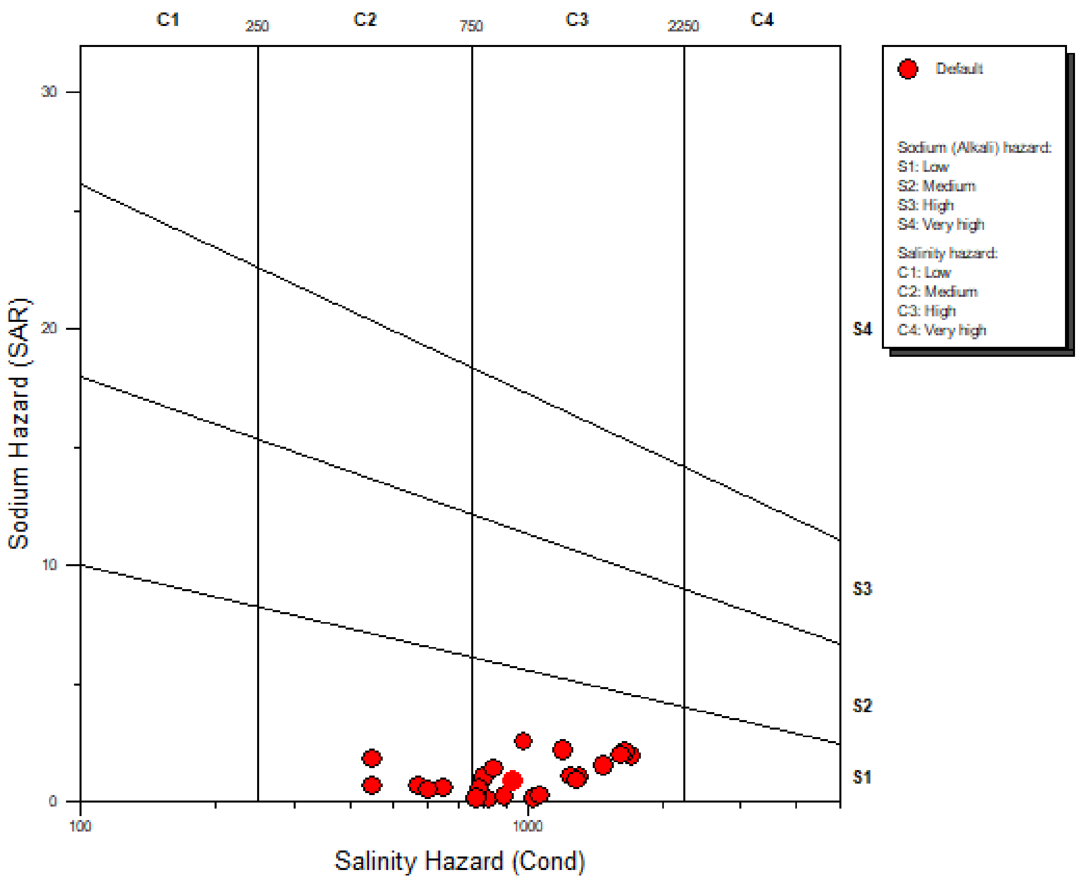


Figure 26: Wilcox diagram of fractured aquifer

3.2.8. Result of geophysical survey carried out in the region

A total of 14 VES were conducted in Tarikere taluk, Chikmagalur district under NAQUIM studies. The survey was carried out by using schlumberger configuration with maximum spread of (AB/2) up to 250m.

The interpreted results reveals that the first layer have the resistivity in the range of 25 to 286 Ohm.m except at one site, where it is 1303 Ohm.m. the first layer with a thickness in the range of 0.5 to 2.3m. is considered as top soil. This is followed by a resistivity in the range of 15.9 to 121 Ohm.m except at one site where it is less than 10 Ohm.m. This second layer extends to a depth of 25m is considered as weathered formation. The third layer is showing a resisitivity in the range of 30.4 to 376 Ohm.m and extended to a depth of 80 m which is fractured in nature. The same layer is showing a resistivity of 1890 Ohm.m at one site (A. Ramanahalli) which can be considered as massive. The fourth and fifith layer is showing a resisitivity in the range of high to very high and considered as massive formation except at one site (Jaladihalli) which is showing a resistivity of 207 Ohm.m and the same layer extended with depth at few sites.

The salient characteristics of the 2 aquifer systems mapped in the taluk are given in table 6.

Table 6. Salient aquifer characteristics of aquifer systems in the study area

Type of aquifer	Phreatic aquifer (Aq. I)	Fractured Zone (Aq.-II)
Formation	Weathered Crystallines	Fractured Crystallines.
SWL	Range between 0.6 to 8.4 mbgl	Range between 3.3 to 16.25 mbgl.
Weathered/Fractured zones encountered	Mostly weathered formations up to 25mbgl	Down to 128 mbgl
Yield	Negligible to $15m^3$/day	1.5 to 6.6lps
Aquifer Parameter (Transmissivity-m^2/day)	-	13.96 m^2 /day
Specific Capacity	-	12 to 119 lpm/m dd
Suitability for drinking & irrigation	Nitrate contamination	Nitrate contamination

Table 7. Water Quality of bore well

Sl no	Location	pH	EC	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO4	NO_3	Sio_2	PO_4	F	U	TDS	TA
1	K hosur	7.5	930	365	80.16	40.10	38.40	8.22	0	335.50	88.63	7	58.85	32.58	0.07	0.70	NA	559.00	275.00
2	Bettathavarakare	7.66	980	290	56.11	36.45	98.90	1.59	0	439.20	46.09	10	81.40	40.60	0.04	0.83	NA	639.00	360.00
3	Hunsaghatta	7.68	1310	550	112.22	65.61	55.20	1.19	0	457.50	113.44	7	151.10	31.67	0.06	0.34	NA	817.00	375.00
4	Hosahalli Tandya	7.6	450	190	32.06	26.73	20.70	0.49	0	225.70	39.00	3	3.10	25.09	0.04	1.00	NA	288.00	185.00
5	Vittalapura	7.36	800	335	60.12	44.96	42.50	2.08	0	341.60	60.27	8	45.55	33.92	0.04	0.35	NA	506.00	280.00
6	Ragibasavanahalli	7.72	650	300	56.11	38.88	23.10	2.77	0	213.50	42.54	3	149.85	34.35	0.10	0.12	NA	481.00	175.00
7	A ramanahalli	7.59	570	205	56.11	15.80	22.30	2.47	0	170.80	42.54	7	75.75	30.10	0.03	0.22	NA	356.00	140.00
8	Bellanahalli	7.78	600	255	60.12	25.52	18.40	0.00	0	183.00	56.72	3	70.65	31.17	0.01	0.22	NA	377.00	150.00
9	Gantekanavu	7.42	1200	340	56.11	48.60	92.00	23.85	0	402.60	42.54	6	224.10	45.22	0.08	0.16	NA	784.00	330.00
10	Doranalu	7.67	1250	485	102.20	55.89	53.80	2.28	0	317.20	141.80	3	198.65	30.10	0.07	0.29	NA	781.00	260.00
11	Sunnadahalli	7.79	1710	570	116.23	68.04	105.80	8.21	0	402.60	155.98	13	312.40	33.82	0.10	0.24	NA	1059.00	330.00
12	Nandi	8.13	1650	560	124.25	60.75	115.00	24.94	0	427.00	219.79	15	177.60	33.09	0.05	0.18	NA	1031.00	350.00
13	Linkadahalli	7.65	1030	510	120.24	51.03	6.90	1.96	0	250.10	106.35	7	189.10	29.90	0.01	0.17	NA	665.00	205.00
14	Udevu	7.43	1070	505	90.18	68.04	13.80	1.17	0	256.20	95.72	10	216.95	30.29	0.08	0.20	NA	682.00	210.00
15	Hulithimmapura	7.62	820	380	82.16	42.53	4.60	1.17	0	268.40	88.63	10	24.75	30.29	0.05	0.17	NA	448.00	220.00
16	Dodalingadahalli	7.68	780	340	66.13	42.53	23.00	1.96	0	244.00	70.90	7	118.00	49.70	0.04	0.07	NA	528.00	200.00
17	Gopala Colony	7.88	890	415	72.14	57.11	11.50	0.78	0	372.10	92.17	4	6.75	45.52	0.26	0.08	NA	517.00	305.00
18	Boosenahalli	8.02	840	255	42.08	36.45	51.70	18.21	0	298.90	92.17	8	0.00	28.59	0.34	0.16	NA	460.00	245.00
19	Karkuchi	9.62	450	120	22.04	15.80	45.20	20.79	30	109.80	60.27	3	15.75	0.00	0.33	0.06	NA	268.00	140.00
20	Bellavara	7.56	1480	550	148.30	43.74	82.20	0.59	0	213.50	159.53	7	437.20	30.57	0.08	0.13	NA	1039.00	175.00
21	Siddarahalli	7.44	1290	520	104.21	63.18	48.30	0.20	0	195.20	141.80	100	183.70	29.23	0.10	0.13	NA	790.00	160.00
22	Rangenahalli	7.46	1620	520	168.34	24.30	103.50	31.28	0	244.00	177.25	140	224.70	34.61	0.11	0.12	NA	1053.00	200.00
23	Lakkavalli	7.9	770	380	90.18	37.67	6.90	1.96	0	280.60	70.90	20	50.85	40.25	0.08	1.50	NA	490.00	230.00

Aquifer Map

Aquifer map for phreatic as well as fractured aquifer is evolved out of the studies. Aquifer Map of phreatic aquifer is shown in figure 27 and fractured aquifer is shown in figure 28.

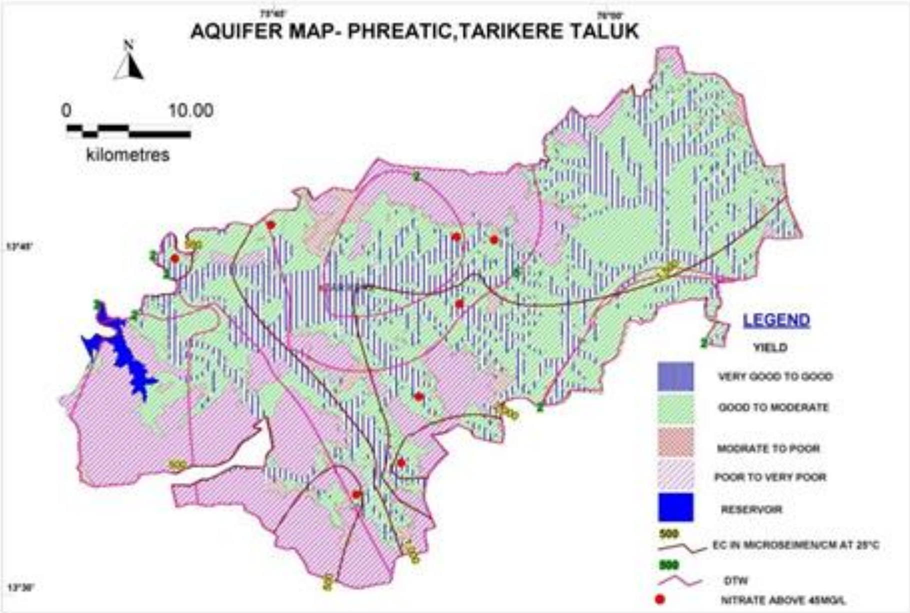


Figure 27: Aquifer Map of Phreatic Aquifer

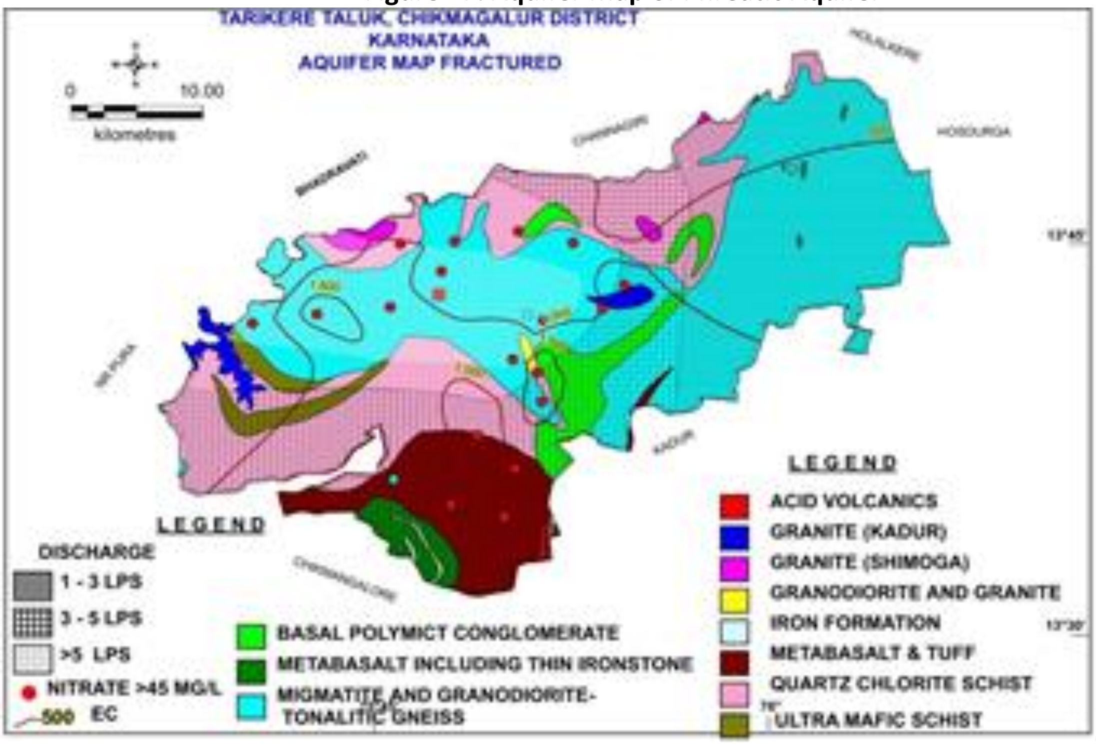


Figure 28: Aquifer Map of Fractured Aquifer

3.2.9 Ground water Resource Assessment

The occurrence of groundwater availability varies from place to place. Increasing population, rapid urbanization and industrialization has resulted in increasing use of groundwater resources. Judicious and planned development of groundwater and its scientific have become necessary to ensure long-term sustainability of this precious natural resource. Phreatic aquifers are the major source of groundwater. Any decision about future utilizations should be made after having a clear understanding of the status of the resource, the amount that has already been extracted, the amount remaining, and the impact of further depletion. The groundwater resources in the area are estimated based on the Groundwater Estimation Methodology (GEC) 2015. The salient features Groundwater Resource assessed in the area is detailed below.

An area of 143.56 Sq km, in the north eastern part of the taluk falls in canal command area. The annual extractable groundwater recharge to unconfined aquifer is 138.54 MCM and the stage of groundwater extraction is 92 %. Groundwater extraction for irrigation is on higher side (122.25 MCM) compared to the extraction for domestic as well as for industry. The total Ground water extraction of the area accounts to 127.44 MCM.The area under consideration falls under " Critical" category.

The availability and extraction of ground water is not uniform in the study area. Towards east the ground water extraction is more compared to the western part.

4. GROUND WATER RELATED ISSUES

Both ground water quality and quantity problem exists in the taluk. The rainfall pattern is not unifrom in the taluk, the westernpart of the taluk receives fairly high rainfall compared to the eastern Ajjampur area. Fairly good area in the north western part of Tarikere taluk falls under canal command area. The ground water extraction is also not uniform, the extraction is on higher side in the eastern part compared to the western part. The main ground water issues identified are

1. As per the ground water assessment,the taluk falls under Critical catergory.
2. Limited Ground Water Potential and low Sustainability of wells.
3. Most of the dugwells tapping phreatic aquifer are dry.
4. Poor maintenance of dug wells.
5. Lack of awareness among people to maintain hygienic conditions around drinking water sources.
6. Comparitively high Electrical conductivity.
7. Nitrate contamination.

5.MANAGEMENT STRATEGIES & AQUIFER MANAGEMENT PLAN

The groundwater management strategies are inevitable for the sustainable development of the resources. Hence, it is the necessary to formulate a rational and scientific management plan suiting the area. In the present study sustainable management plan for groundwater resources is being proposed after a detailed understanding of the aquifer disposition.

An effective groundwater management practice must be preceded by an accurate account of the total available resources. From the resource estimation, tarikere taluk falls under Critical category. The ground water development should be coupled with management of water resources through rainwater harvesting and artificial recharge schemes. Farmers may be encouraged to change the cropping pattern and adopt modern irrigation techniques like drip and micro irrigation to have optimal use of the available resources.

5.1 Supply side management plan

Augmentation of groundwater resource can be achieved through construction of recharge structures. Topography, slope and soil thickness of the area plays a significant role in the selection of suitable structures for artificial recharge such as check dams, Vented cross bar, percolation pond etc.

1.Considering the long-term water level trend and seasonal water level fluctuation and declining trend of annual rainfall, it is proposed to construct artificial recharge (AR) structures to enhance the ground water resources and to arrest the decline in long term ground water level. The details of recharge structures proposed in the taluk as well as expected benefits are given below (Table 8):

Table 8. Details of recharge structures proposed in the taluk as well as expected benefits.

Total Geographic area(Sq km)	1223
Area Feasible for AR (Sq km)	559
Number of proposed recharge structures	
Check dam	54
Availability of surface non committed monsoon runoff (MCM)	14.119
Total Recharge capacity	14.119
Expected benefit of artificial recharge & RWH	
Volume of water likely to be recharged	10.560 MCM
Additional irrigation potential	0.013 Lakh Hectare

Note: The numbers proposed are tentative and actual feasibility studies are required in field to finalize the actual locations for the construction of AR structures.

2.In addition to the construction of new recharge structures regular desilting (once in three years) and maintenance of available ponds(about 61ponds are recommended), tanks and recharge structures in the taluk is also recommended.

3.The ground water worthy areas like topographic lows, valley portions should be developed through adequate soil conservation measures.

Map showing tentative locations feasible for the construction of AR structures is given in figure 29 and the details are given in Annexure 1.

5.2 Demand side management plan

1.Roof top rain water harvesting with storage: The region receives sufficient rainfall during monsoon hence Roof Top Rain water harvesting with storage and its direct usage is the most economical way to tackle the water scarcity during summer. The filter medium must be cleaned yearly before the onset of the monsoon.

2.Change in cropping pattern: The taluk falls under Critical category with stage of Ground Water extraction at 92% hence change in the crops cultivated i.e shfting from high water consuming crops to low water consuming one is recommended. It is recommended to change the crop in atleast 30% of paddy cultivated area inorder to save 25.58 MCM of water. By adopting water use efficiency method in this area 17.74 MCM of additional water can be saved. Thus bringing the stage of extraction to 51 %

3.Water Use Efficiency (WUE) practices: In order to reduce water consumption through flood irrigation and wastage of water, it is recommended to encourage the farmers to adopt Drip/sprinkler irrigation in about 4600 Ha of land.

4. Conjunctive use of both surface and groundwater is recommended in the canal command area. This would improve the quality of groundwater, prevent water logging condition and leads to availability of canal water upto the tail end.

5. Nitrate contamination is reported in the study area can be cured by improving the water and fertilizer management in the agroecosysytem.While soil, climatic, and geologic characteristics of the site strongly influence leaching potential, management practices finally determine the amount and extent of Nitrate leaching into groundwater systems.

Proper nutrient management includes:

- Correct accounting for crop nitrogen needs according to a realistic yield goal and
- Applying Nitrate fertilizers when (right time) and where (right place) it can be used most efficiently by the crop.

Also Multiple, small applications of Nitrate fertilizers through sprinkler/drip irrigation systems can increase fertilizer efficiency and reduce nitrate leaching into ground water. Proper training should be given to the people on water and waste management.

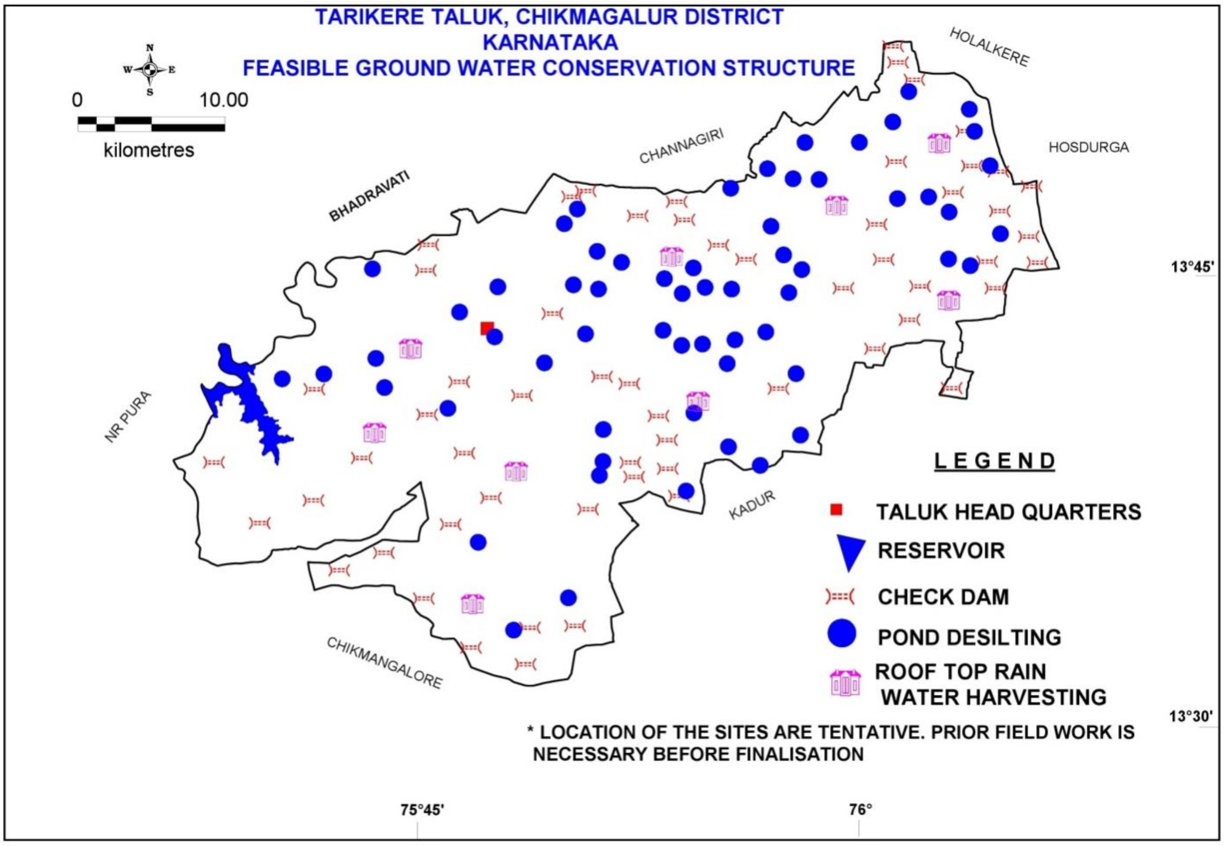


Figure 29: Map showing tentative location of feasible water conservation structure

6. SUMMARY

An area of 143.56 Sq km, in the north eastern part of the taluk falls in canal command area. The annual extractable groundwater recharge to unconfined aquifer is 138.54 MCM and the stage of groundwater extraction is 92 %. Groundwater extraction for irrigation is on higher side (122.25 MCM) compared to the extraction for domestic as well as for industry. The total Ground water extraction of the area accounts to 127.44 MCM.The area under consideration falls under " Critical" category.

Both ground water quality and quantity problem exists in the taluk. The rainfall pattern is not unifrom in the taluk, the westernpart of the taluk receives fairly high rainfall compared to the eastern Ajjampur area. Fairly good area in the north western part of Tarikere taluk falls under canal command area. The ground water extraction is also not uniform, the extraction is on higher side in the eastern part compared to the western part.

Supply side management plan: Augmentation of groundwater resource can be achieved through construction of recharge structures. Topography, slope and soil thickness of the area plays a significant role in the selection of suitable structures for artificial recharge such as check dams, Vented cross bar, percolation pond etc.

Demand side management plan: The region receives sufficient rainfall during monsoon hence Roof Top Rain water harvesting with storage and its direct usage is the most economical way to tackle the water scarcity during summer. The filter medium must be cleaned yearly before the onset of the monsoon. The taluk falls under Critical category with stage of Ground Water extraction at 92% hence change in the crops cultivated i.e shfting from high water consuming crops to low water consuming one is recommended. It is recommended to change the crop in atleast 30% of paddy cultivated area inorder to save 25.58 MCM of water. By adopting water use efficiency method in this area 17.74 MCM of additional water can be saved. Thus bringing the stage of extraction to 51 %. In order to reduce water consumption through flood irrigation and wastage of water, it is recommended to encourage the farmers to adopt Drip/sprinkler irrigation in about 4600 Ha of land. Conjunctive use of both surface and groundwater is recommended in the canal command area. This would improve the quality of groundwater, prevent water logging condition and leads to availability of canal water upto the tail end. Nitrate contamination is reported in the study area can be cured by improving the water and fertilizer management in the agroecosysytem.While soil, climatic, and geologic characteristics of the site strongly influence leaching potential, management practices finally determine the amount and extent of Nitrate leaching into groundwater systems.

Proper nutrient management includes:

- Correct accounting for crop nitrogen needs according to a realistic yield goal and
- Applying Nitrate fertilizers when (right time) and where (right place) it can be used most efficiently by the crop.

Also Multiple, small applications of Nitrate fertilizers through sprinkler/drip irrigation systems can increase fertilizer efficiency and reduce nitrate leaching into ground water. Proper training should be given to the people on water and waste management.

Annexure 1:

Details of tentative location of ground water conservation structures

Sl no	Longitude	Latitude	Structure
1	75.67523	13.61728	Check Dam
2	75.61252	13.64061	Check Dam
3	75.64142	13.60343	Check Dam
4	75.71951	13.58522	Check Dam
5	75.69139	13.5746	Check Dam
6	75.67578	13.68537	Check Dam
7	75.74473	13.55732	Check Dam
8	75.74755	13.77367	Check Dam
9	75.74598	13.75811	Check Dam
10	75.74675	13.66976	Check Dam
11	75.76159	13.60261	Check Dam
12	75.70566	13.64331	Check Dam
13	75.87475	13.64044	Check Dam
14	75.77027	13.6463	Check Dam
15	75.78697	13.61892	Check Dam
16	75.80877	13.51709	Check Dam
17	75.77441	13.52734	Check Dam
18	75.84	13.54062	Check Dam
19	75.8115	13.53948	Check Dam
20	75.8482	13.61197	Check Dam
21	75.8771	13.63171	Check Dam
22	75.89826	13.63672	Check Dam
23	75.90529	13.62002	Check Dam
24	75.89787	13.65417	Check Dam
25	75.767	13.68982	Check Dam
26	75.87935	13.79135	Check Dam
27	75.8924	13.66896	Check Dam
28	75.87405	13.68869	Check Dam
29	75.8065	13.68148	Check Dam
30	75.83811	13.8031	Check Dam
31	75.84664	13.80655	Check Dam
32	75.90388	13.79999	Check Dam
33	75.90886	13.78894	Check Dam
34	75.82566	13.73161	Check Dam
35	75.85695	13.69293	Check Dam
36	75.93019	13.7734	Check Dam
37	76.09942	13.76335	Check Dam
38	75.94761	13.76476	Check Dam
39	76.02986	13.78614	Check Dam
40	76.10732	13.79435	Check Dam
41	76.1256	13.77872	Check Dam

42	76.13105	13.76282	Check Dam
43	76.05059	13.72785	Check Dam
44	76.00886	13.74719	Check Dam
45	76.02877	13.7101	Check Dam
46	76.05714	13.74825	Check Dam
47	76.03423	13.76468	Check Dam
48	76.10461	13.74719	Check Dam
49	76.07706	13.68599	Check Dam
50	75.96795	13.68572	Check Dam
51	76.07787	13.80574	Check Dam
52	76.08987	13.82191	Check Dam
53	76.04023	13.89503	Check Dam
54	76.04323	13.88523	Check Dam
55	76.05359	13.87463	Check Dam
56	76.08632	13.8431	Check Dam
57	76.1065	13.81846	Check Dam
58	76.04214	13.82456	Check Dam
59	76.12751	13.80945	Check Dam

Sl no	Longitude	Latitude	Structure
1	75.76719	13.73262	Pond De-silting
2	75.75983	13.6738	Pond De-silting
3	75.78929	13.71752	Pond De-silting
4	75.68182	13.69473	Pond De-silting
5	75.65563	13.69182	Pond De-silting
6	75.71237	13.75911	Pond De-silting
7	75.71455	13.70427	Pond De-silting
8	75.72001	13.68652	Pond De-silting
9	75.79128	13.74809	Pond De-silting
10	75.93576	13.70109	Pond De-silting
11	75.82066	13.70162	Pond De-silting
12	75.85775	13.66082	Pond De-silting
13	75.85748	13.64121	Pond De-silting
14	75.8553	13.63273	Pond De-silting
15	75.90985	13.6232	Pond De-silting
16	75.95649	13.63883	Pond De-silting
17	75.98186	13.65737	Pond De-silting
18	75.93658	13.65022	Pond De-silting
19	75.97913	13.695	Pond De-silting
20	75.77898	13.59184	Pond De-silting
21	75.83574	13.55783	Pond De-silting
22	75.80121	13.53807	Pond De-silting
23	75.96004	13.72043	Pond De-silting

24	75.96331	13.78508	Pond De-silting
25	75.83893	13.74931	Pond De-silting
26	75.84657	13.71937	Pond De-silting
27	75.85475	13.74666	Pond De-silting
28	75.86921	13.76309	Pond De-silting
29	75.89539	13.72149	Pond De-silting
30	75.93849	13.74666	Pond De-silting
31	75.94067	13.71566	Pond De-silting
32	75.90712	13.71222	Pond De-silting
33	75.92185	13.74772	Pond De-silting
34	75.89621	13.75302	Pond De-silting
35	75.9074	13.74401	Pond De-silting
36	75.91449	13.75964	Pond De-silting
37	75.92022	13.71301	Pond De-silting
38	75.84139	13.79568	Pond De-silting
39	75.85393	13.76971	Pond De-silting
40	75.8332	13.78667	Pond De-silting
41	75.98474	13.83632	Pond De-silting
42	75.97122	13.76759	Pond De-silting
43	75.9745	13.74454	Pond De-silting
44	76.01896	13.83648	Pond De-silting
45	75.99359	13.81369	Pond De-silting
46	75.96113	13.82032	Pond De-silting
47	75.97722	13.81422	Pond De-silting
48	75.98268	13.75858	Pond De-silting
49	75.93795	13.80839	Pond De-silting
50	76.08824	13.85661	Pond De-silting
51	76.07542	13.79382	Pond De-silting
52	76.0626	13.80309	Pond De-silting
53	76.10133	13.82217	Pond De-silting
54	76.09151	13.8431	Pond De-silting
55	76.10788	13.78057	Pond De-silting
56	76.03996	13.84893	Pond De-silting
57	76.05005	13.86748	Pond De-silting
58	76.04296	13.80204	Pond De-silting
59	76.07509	13.76509	Pond De-silting
60	76.08881	13.76095	Pond De-silting