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

Narasimharajapura Taluk, Chikmagalur District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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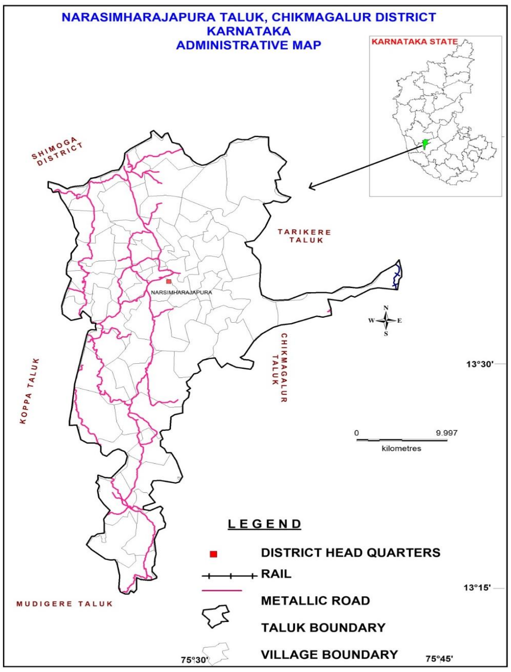
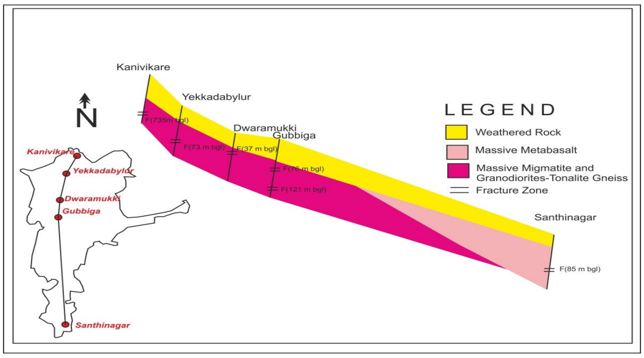
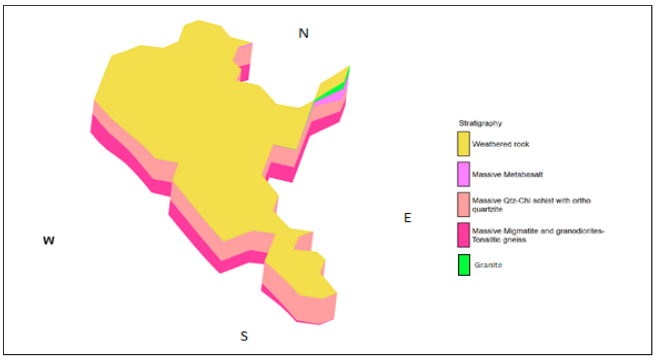
Aquifer Maps and Management Plan, Narasimharajapura Taluk, Chikmagalur District, Karnataka State

(AAP: – 2022-2023)







By

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APRIL 2023

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

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

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, Narasimharajapura (NR pura) Taluk of Chikmagalur district of Karnataka state covering a geographical area of 803sq.km.has been taken upduring 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 inthepreparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:

Compilation of existing data (Central & State Govt.)

↓

Generation of different thematic layers

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Identification of Primary Aquifer

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Identification of data gaps

↓

Data generation (water level, exploration, geophysical, hydrochemical, hydrogeological etc.)

↓

Robust Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

1.3 Study area

NR pura is one of the 7 talukas of Chikmagalur district of Karnataka state covering an area of 803Sq.km. and falls in Survey of India Toposheet number 48 O/5, O/6, O/7, O/9, O/10, O/11. The taluk is bounded by North latitudes 13°15’23” and13°46’9”and East longitudes 75°22’48” and 75° 44’ 42”. It is bounded by Shimoga district in the north, Mudigere taluk in the south, Chikmagalur and Tarikere taluk in the east and Koppa taluk in the west. According to 2011 Census data, the taluk has total population of 66090 persons with 32449 male and 33641 female population.

NR Pura taluk has no major road and railway network. It is well connected to nearby taluks through a network of metalled roadsAdministratively, the district is divided into 14 Gram panchayaths, 58villages and 1 Town Panchayath.

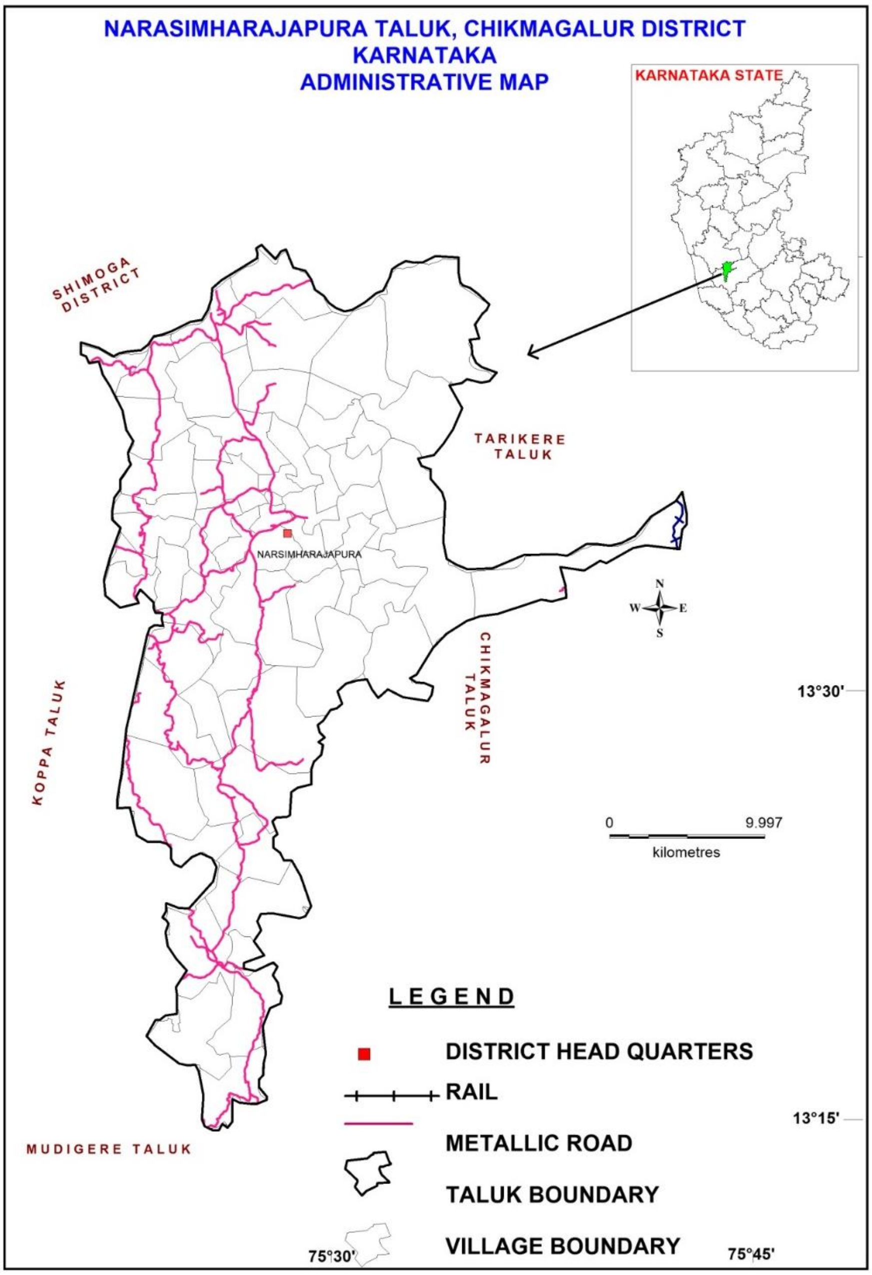

Figure 1: Administrative set-up, NR PuraTaluk, chikmagalur district

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

NR Purataluk falls in the hilly Agro–ecology zone and experience plenty of rainfall. During the month of April and May, mean monthly temperature ranges from 21°C to 36°Cand during October to January the mean monthly temperatureranges from 15°C to 32°C.During rainy season temperature ranges from 20 to 28°C.

The average annual rainfall of NR Pura taluk is 1567 mm (2010 to 2019). The normal annual rainfall of Chikmagalur district is 1609mm with 94 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 (77%) of the rainfall whereas the northeast monsoon season accounts for about 11%. The balance 12% 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	3	0	0	82	77	238	446	345	256	232	134	0.0	1812
2011	18	33	11	32	82	273	320	360	164	226	10	0	1529
2012	0	0	0	122	129	128	248	476	132	42	104	0	1381
2013	0	77	10	13	0	128	248	476	132	42	104	0	1230
2014	0	0	8	102	122	95	805	504	222	139	4	12	2013
2015	0	0	15	60	120	274	251	201	135	85	53	0	1194
2016	0	0	28	45	119	338	360	263	96	108	47	1	1405
2017	0	0	0	25	95	172	326	293	170	37	0	0	1118
2018	0	0	23	99	245	510	550	519	88	54	27	0	2115
2019	0	0	0	12	17	155	336	752	319	254	10	14	1869

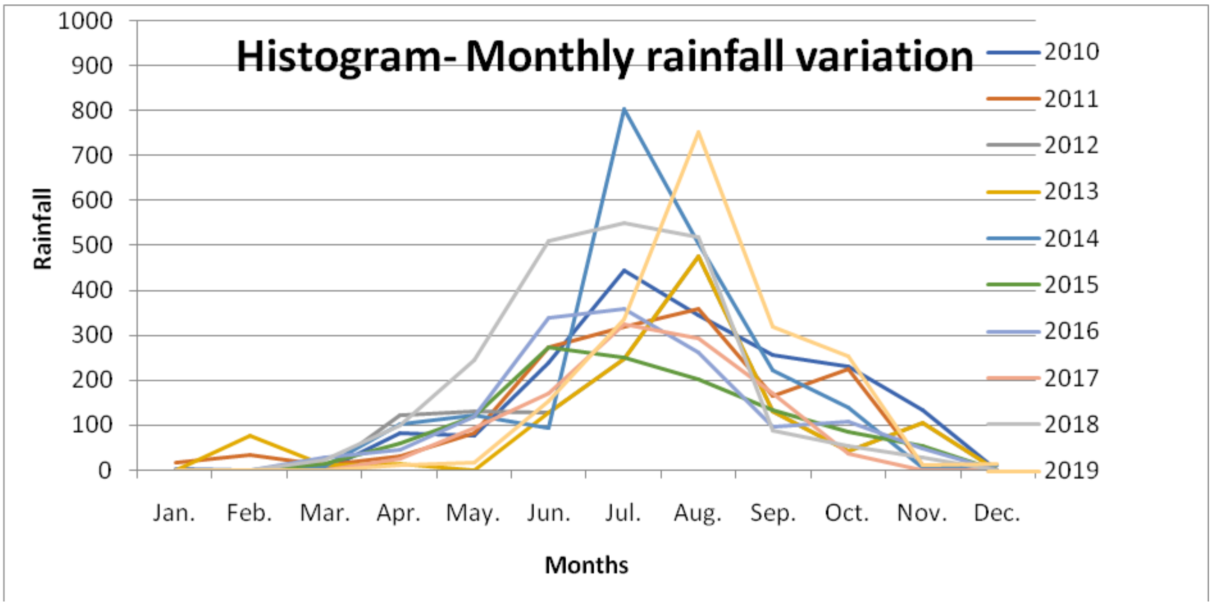

Figure 2. Monthly rainfall variation-Histogram (2010-19)

1.6 Physiography and Geomorphology

Physiographically Karnataka is divided into major three division namely Coastal region,Malnad Region and Maidan Region. NR Pura taluka falls in Malnad Region. A digital elevation model (Bhuvan) depicting the major physiographic features in the taluk is given in figure 3. Pediplains, Pediments, Denudation hills and structural hills are the major geomorphological features identified in the study area. In ground water point of view, valleys and pediplains have moderate to good groundwater prospects whereas hills have poor ground water prospects. The geomorphological map of the taluk is given in figure 4 and slope map in figure 5.

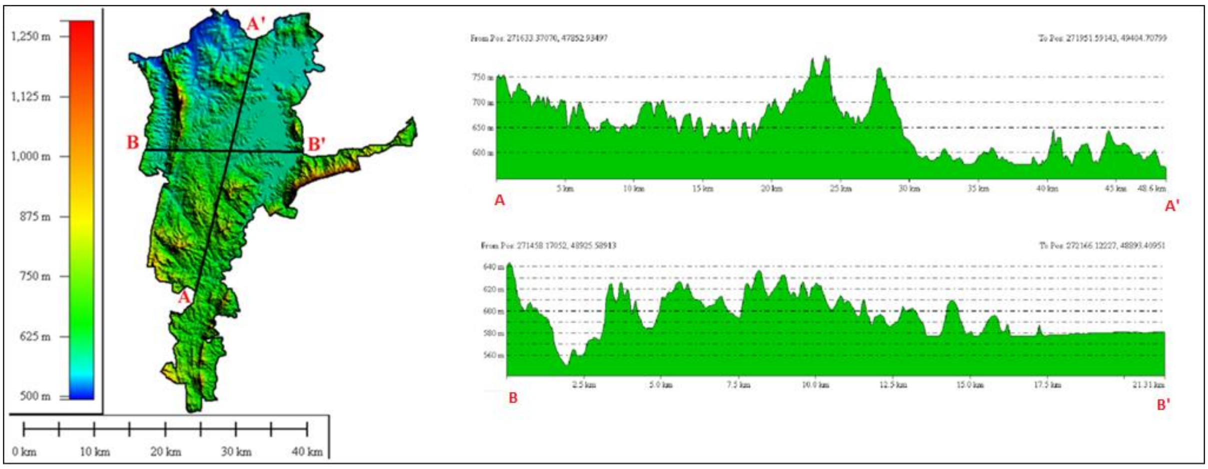

Figure 3. Digital Elevation Model of NR Pura taluk

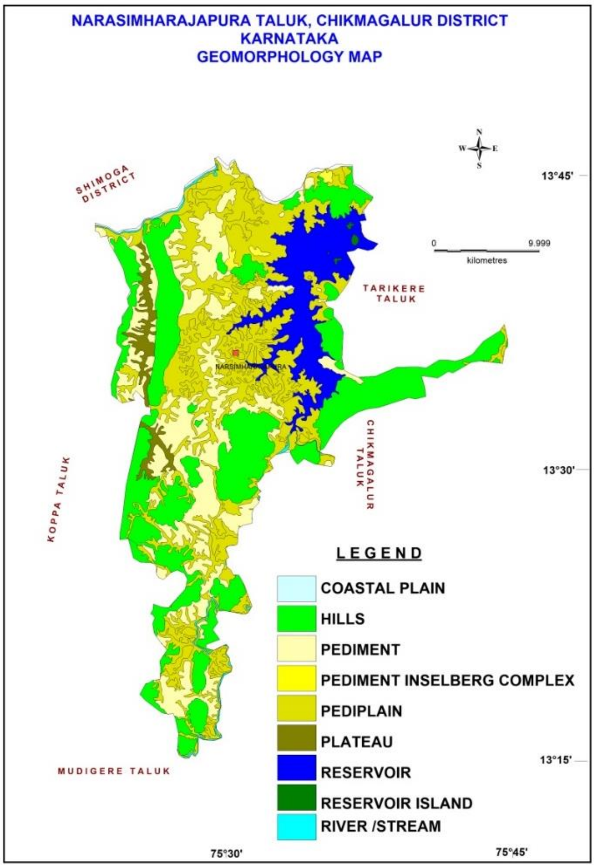

Figure 4. Geomorphology map

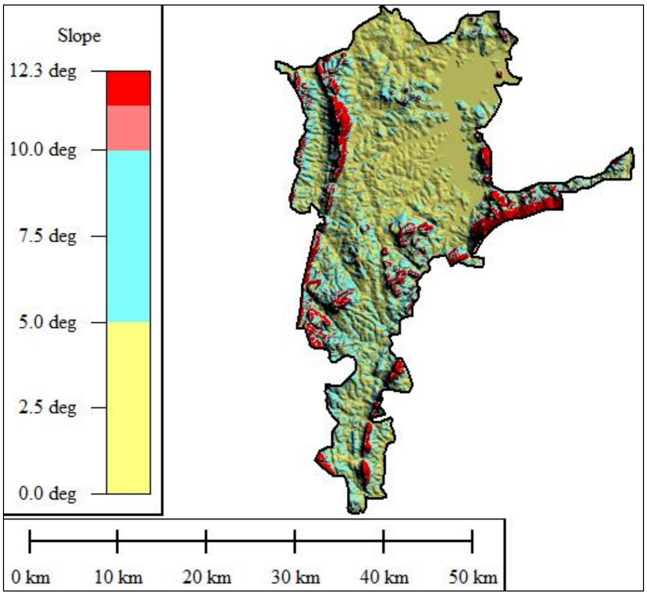

Figure 5: Slope Map of NR PuraTaluk.

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 2019-20published 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 can be categorised as agriculture land, Forest, Water bodies, Wasteland and others based in the land use map of the taluk. The land use map of the district is shown in figure 6. The major crops raised in the taluk are Arecanut, fruits, cereals, condiments and spicesetc. The area under different crops is given in table 3.

Table 2:Land use pattern

Item	Area (Ha)
Forest	31944
Land put to non-agricultural use	9480
Barren and uncultivable land	4708
Permanent Pastures	14443
Cultivable waste land	3894
Fallow other than current fallow	162
Current fallow	698
Net area sown	14166
Area sown more than once	4089
Total Area Cropped	

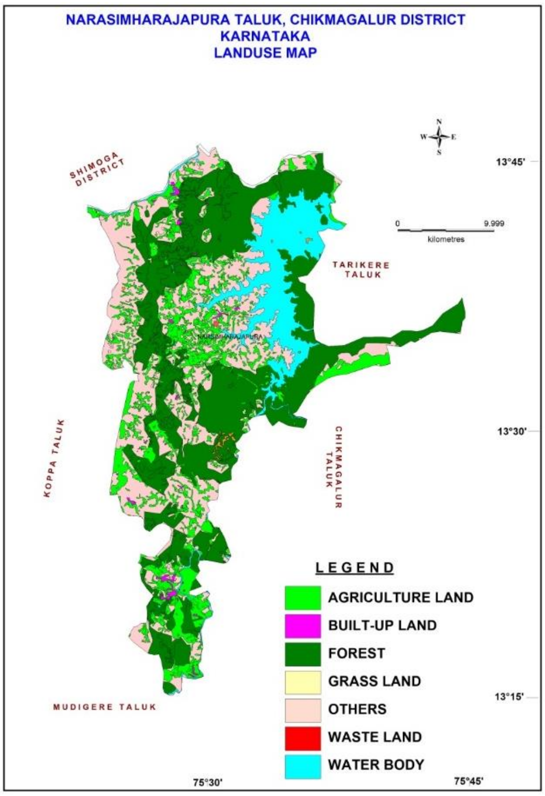

Figure 6. Land use/ Land cover – NR Pura taluk

Table 3:Area under different crops

(Source: District at a glance 2019-20)

Crop	Area (Ha)
Total Cereals	3172
Total fruits including banana	510
Total vegetables	81
Total condiments and spices	1768
Coconut	141
Arecanut	5360

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	-	-
Tank	326(281 no)	326
Open Well	15 (17 no)	15
Bore well	1016(680no)	1016
Lift Irrigation	6 (830 no)	0
Total	4374	4349

There are mainly three types of soil observed in the taluk namely Clayey soil, Clayey skeletal and rocky land based on the textural characteristics. Figure 7 shows the distribution of the soil over the region. The clayey skeletal soil is found in the central part whereas clayey soil is found in the west and east of clayey skeletal soil. Rockyland is found in the northern part of the taluk bordering the Shimoga district.

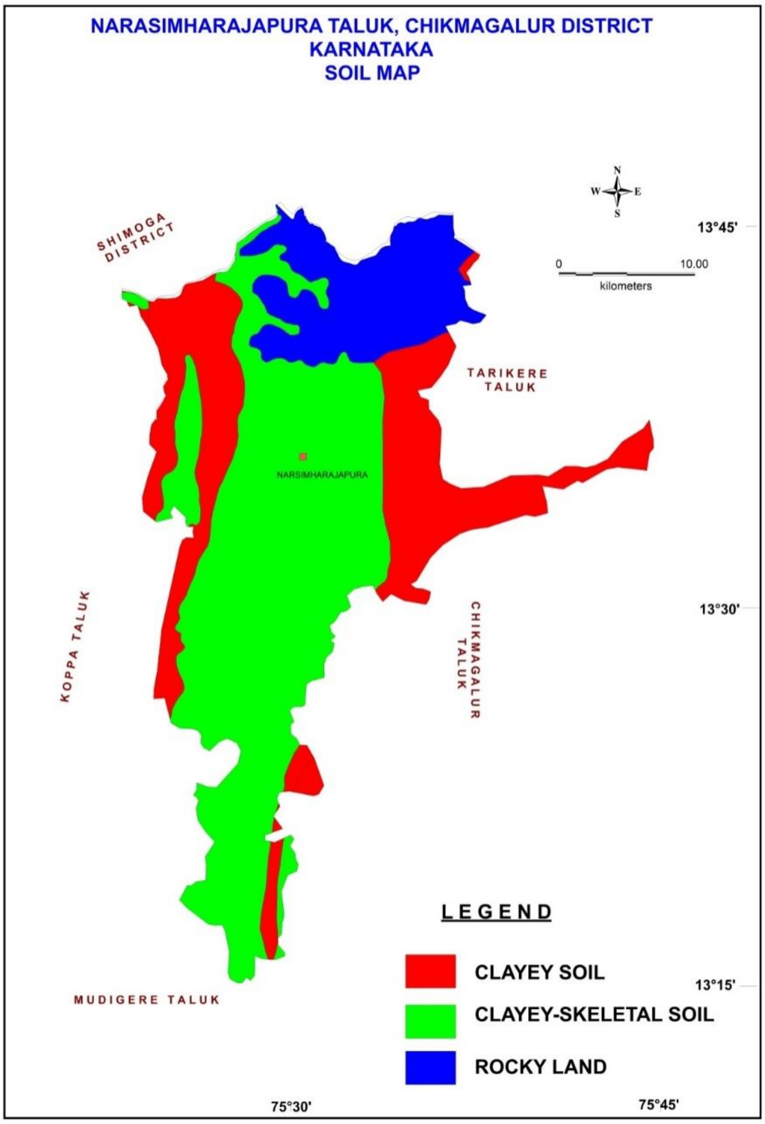

Figure 7. Textural classification of soils – NR puraTaluk

1.9 Hydrology and Drainage

Chikmagalur district is blessed with seven rivers, of which Bhadra river flows through NR Purataluk. However the Bhadra river has been harnessed for irrigation and power generation near Lakkavalii village. The tributaries of this river exhibit dendritic drainage pattern. Drainage map of the district is given in figure 8.

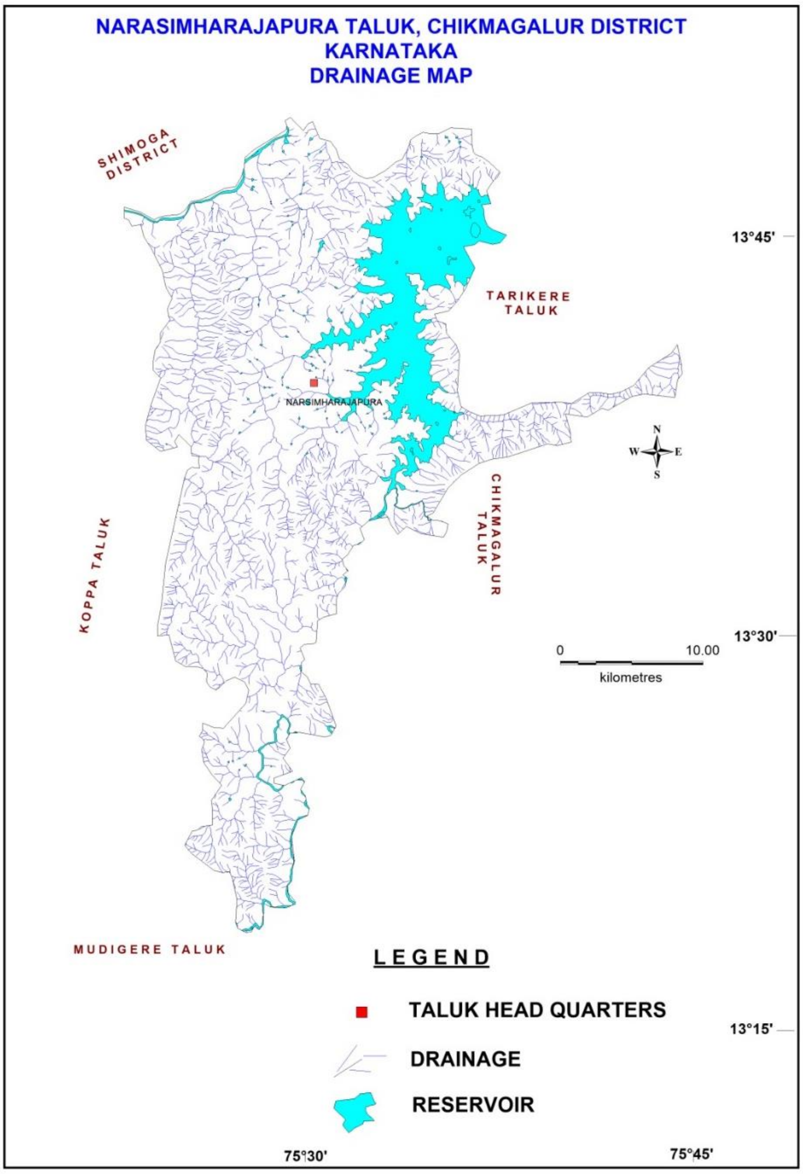

Figure 8. Drainage map

1.8 Prevailing Water Conservation and Recharge Practices

The State Ground Water department, Department of agriculture, Horticulture department, MGNRGS schemes, Department of irrigation, Forest department etc are carrying out extensive water conservation and artificial recharge activities in the district.

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 13 Dug wells (DW) and 1 piezometers (PZ)) monitoring wells in NR Pura taluk representing Aquifer-I (Weathered crystallines). were also collected and compiled.
- **ii.** Hydrochemical Data - Ground water quality data from 11existing Ground Water Monitoring Stations of CGWBrepresenting Aquifer-I and data of 6Bore wells in the taluk representing Aquifer-II were also collected and compiled.
- **iii.** Exploratory Drilling – six exploratory wells were drilled in the study area during by CGWB were compiled.
- **iv.** Geophysical Data – Data of4 no of Vertical Electric Sounding (VES) conducted in NR Pura 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 6numbers of exploratory wells and 2 observation wells were drilled by CGWB in the taluk and its depth varies from 91 to 203 m. all the wells are drilled during 2000-2001 and 2001-2002. Figure 9 represents the location of the exploratory wells.

2.2.2 Ground Water Monitoring Wells

Data gap analysis revealed the existence of 13 GWMWs (12DW+1PZ) in the NR Pura taluk. Additional 5 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

There existed 11 water quality data for Aquifer-1. Additionally, 22 samples were collected from KOWs for major element analysis of which 6 are from DW and balances 16 are from BW. The details of quality monitoring stations are shown in figure 11.

2.2.4 Geophysical data

Data gap analysis revealed the existence of 4 geophysical data in the taluk. Additional 12 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

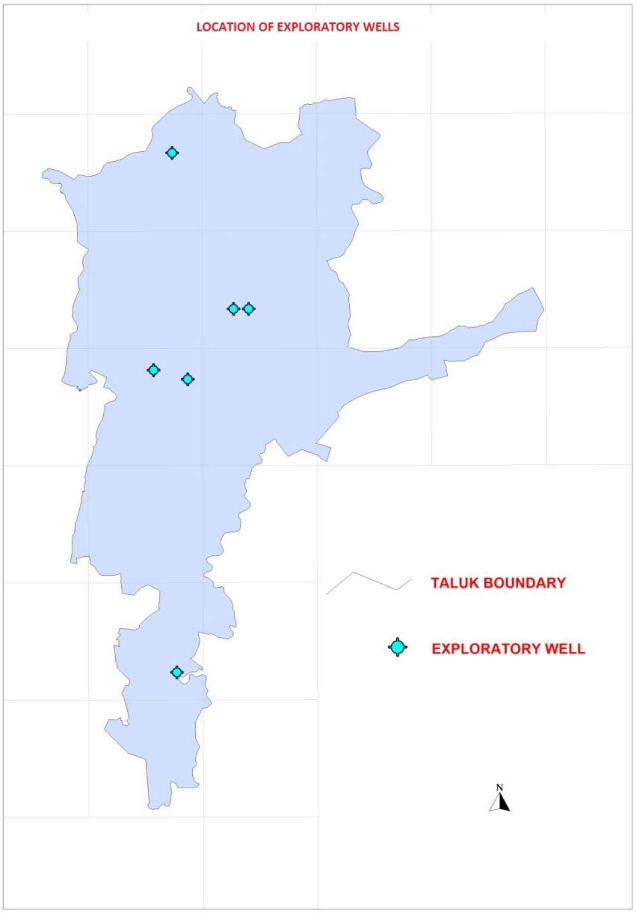

Figure 9. Location of EWs drilled in the study area

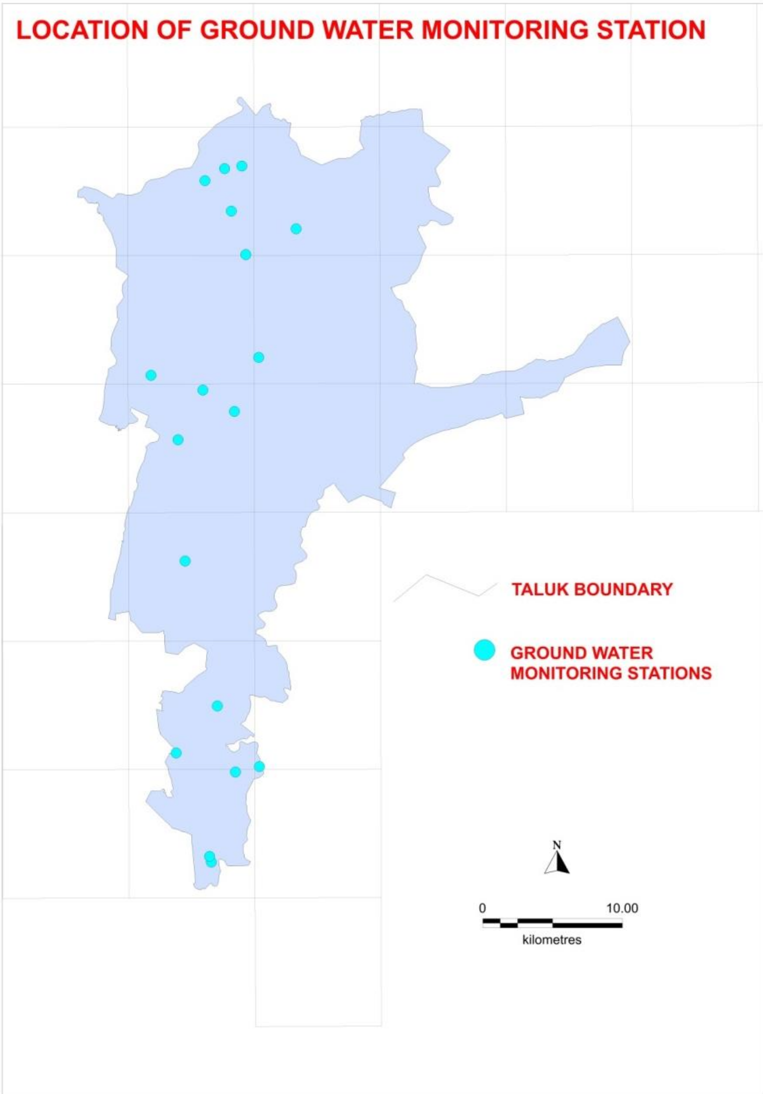

Figure 10. Location of water level monitoring stations (DWs) in the study area

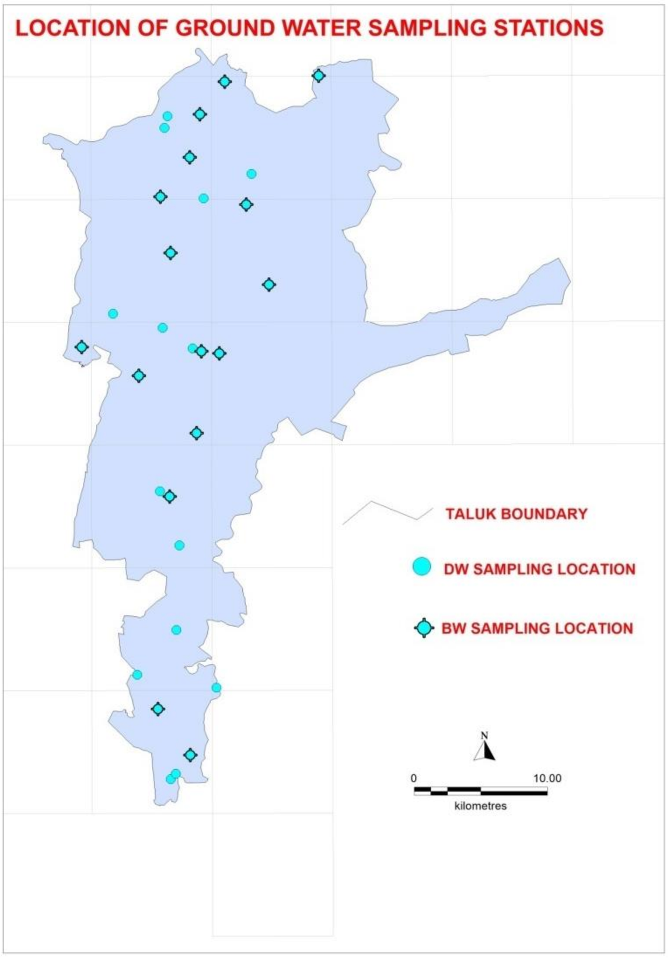

Figure 11. Location of water quality sampling stations

3 Data Interpretation, Integration and Aquifer Mapping

Various data pertaining to hydrogeology, geophysicsand exploratory drilling were collected and validated. Using these data maps ofground 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 Banded Gneissic complex, Schists and Laterite. Nearly 90% of the area in N.R.Pura taluk is covered by gneiss and rest of the area is occupied by schist formation. Laterite, weathered, fractured and jointed gneiss and schist serves as potential aquifers in the area

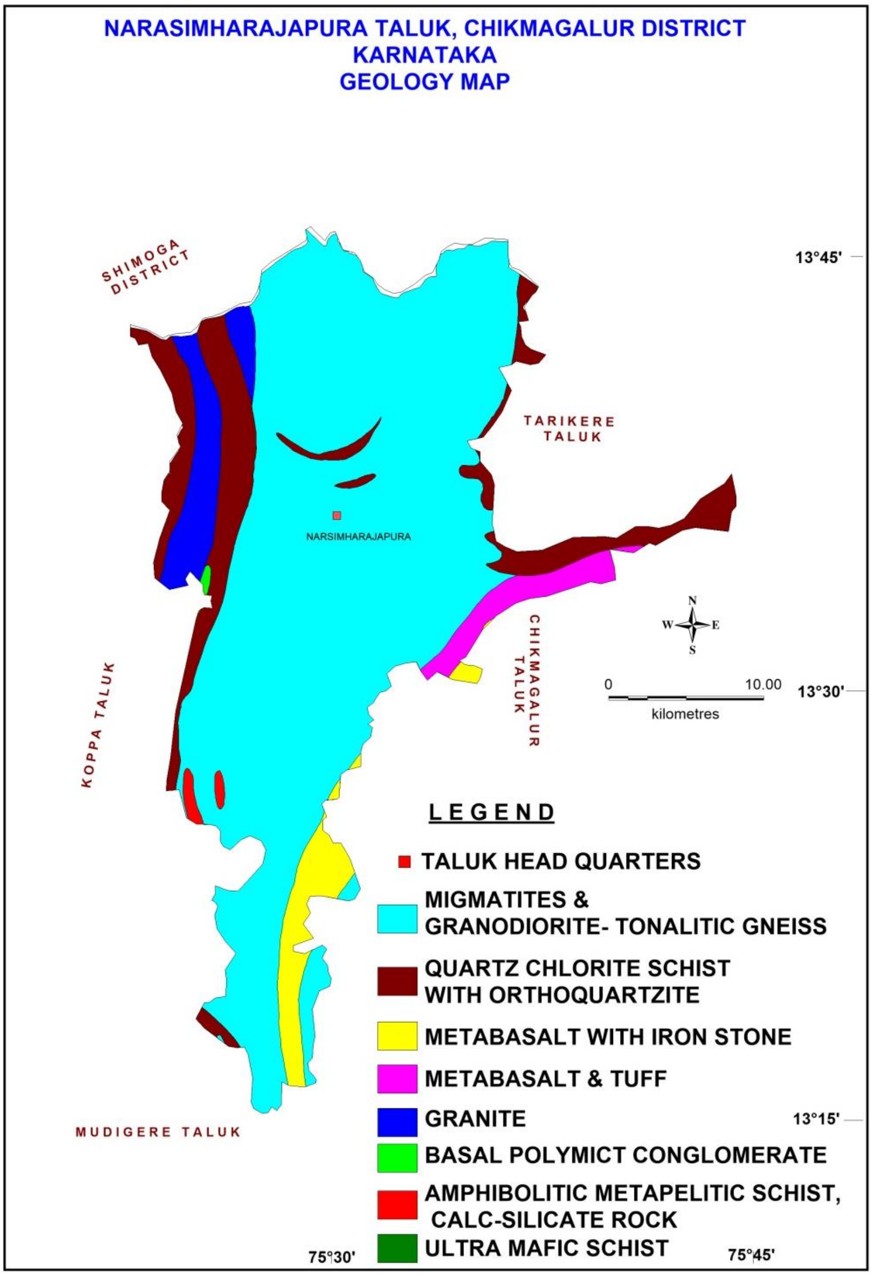

Figure 12. Geology-NR Pura taluk.

3.2 Hydrogeological data interpretation

The Aquifer Systems exists in the taluk is broadly categorized into shallow/phreatic aquifer and deeper crystalline (fractured) aquifers. Weathered rock, Laterite and associated shallow fractures forms the phreatic aquifer. 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 30 groundwaterand 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 eastern part of the taluk near the reservoir during pre-monsoon season and during post monsoon all the wells are showing rise in water level. Depth of Dug wells analysed generally ranges from 6.5 to 13 m bgl and depth to water level generally ranges from 1.74 to 11.05 m bgl during pre-monsoon and from 1.47 to 7.94 during post-monsoon. The depth to water level map of NR Pura taluk for pre- monsoon season (May 2022) is shown in figure 13 and for post monsoon season (Nov 2022) in figure 14.

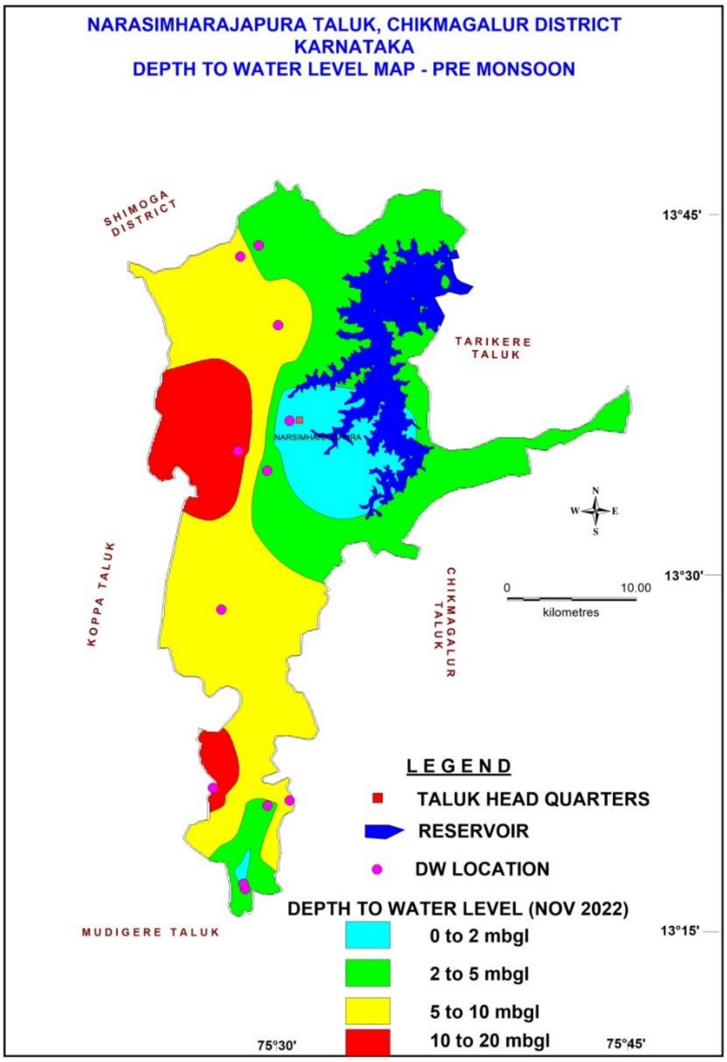

Figure 13.Depth to water level Map pre-monsoon (May 2022)

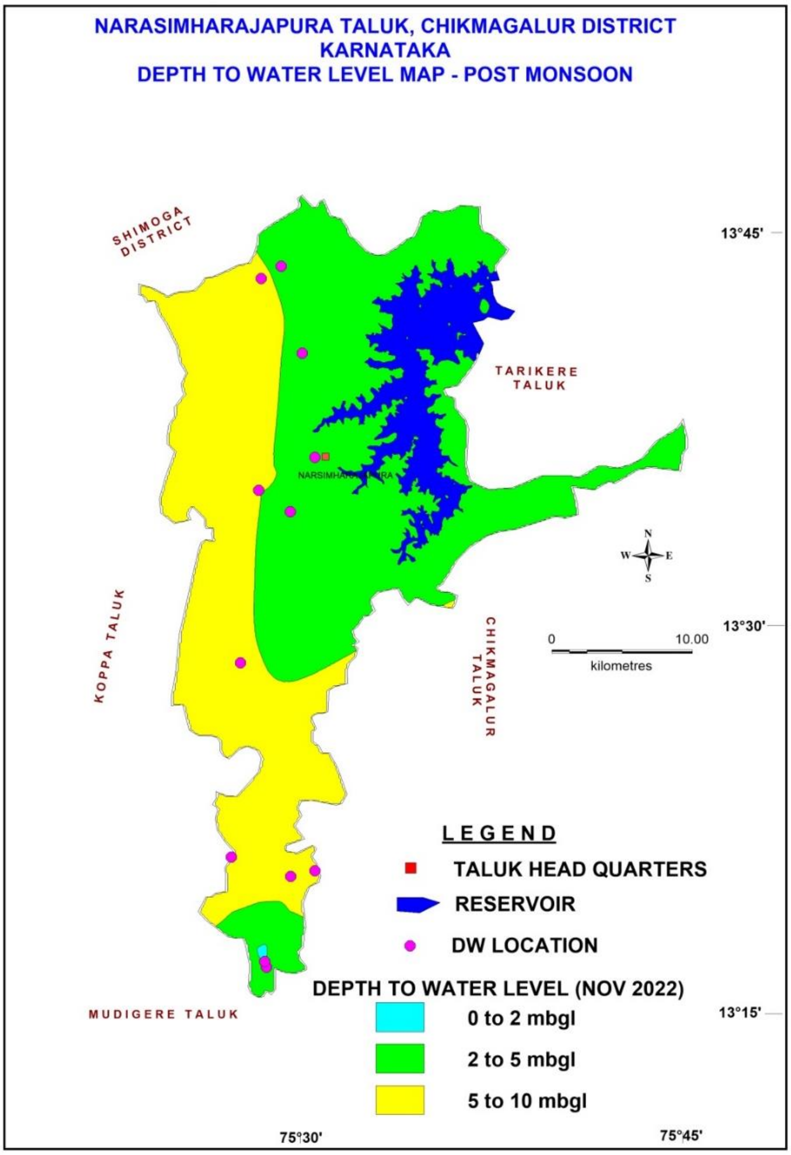

Figure 14: Depth to water level Map post monsoon (Nov 2022)

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 whole taluk is showing rise in water level during post monsoon season. Major part of the taluk is showing rise in the range of 0-2 m bgl. The western part of the taluk having water level more than 5 m bgl during both the season are ideal for artificial recharge. The fluctuation map as well as water table contour map with direction of flow of NR pura taluk is depicted in figure 15 and 16 respectively.

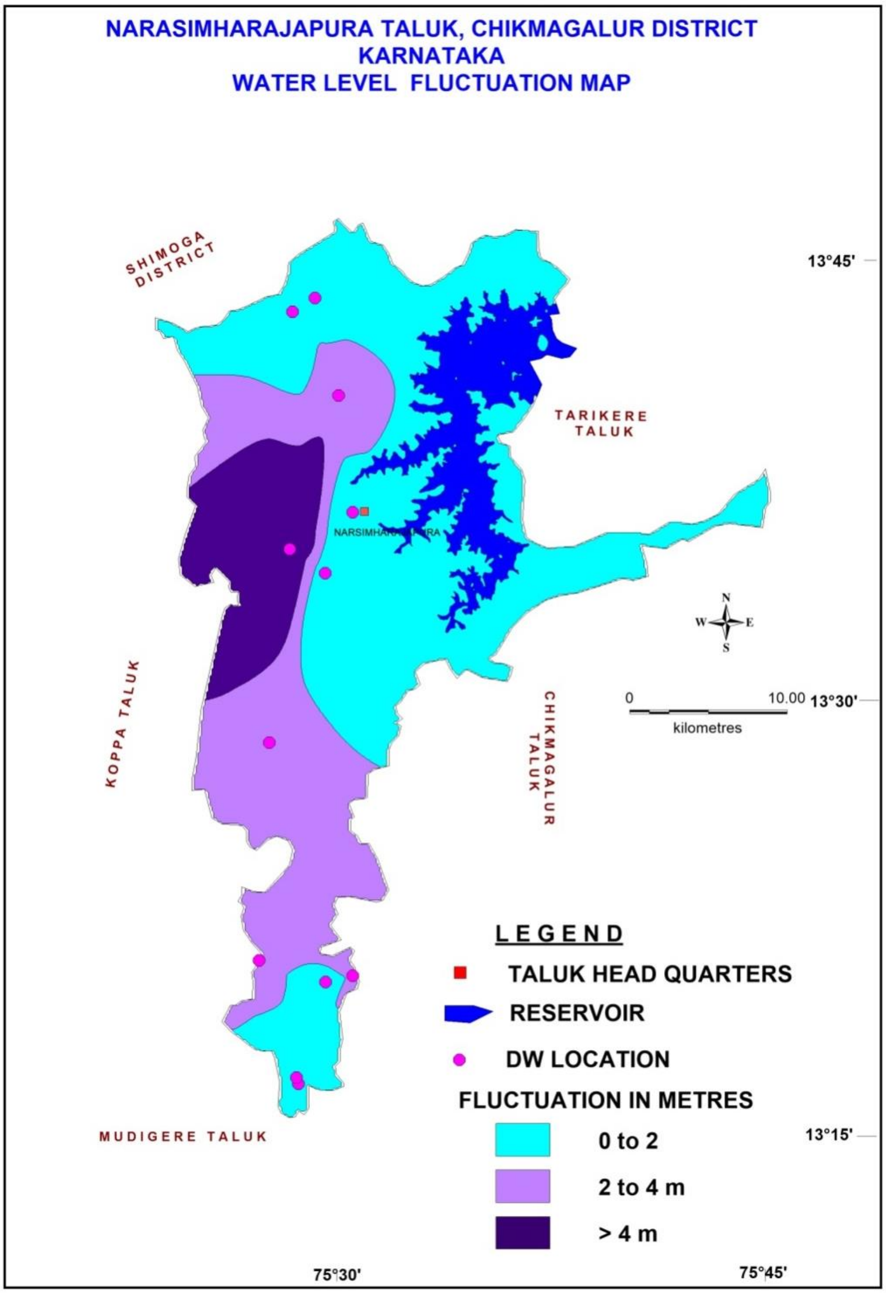

Figure 15: Water level Fluctuation Map

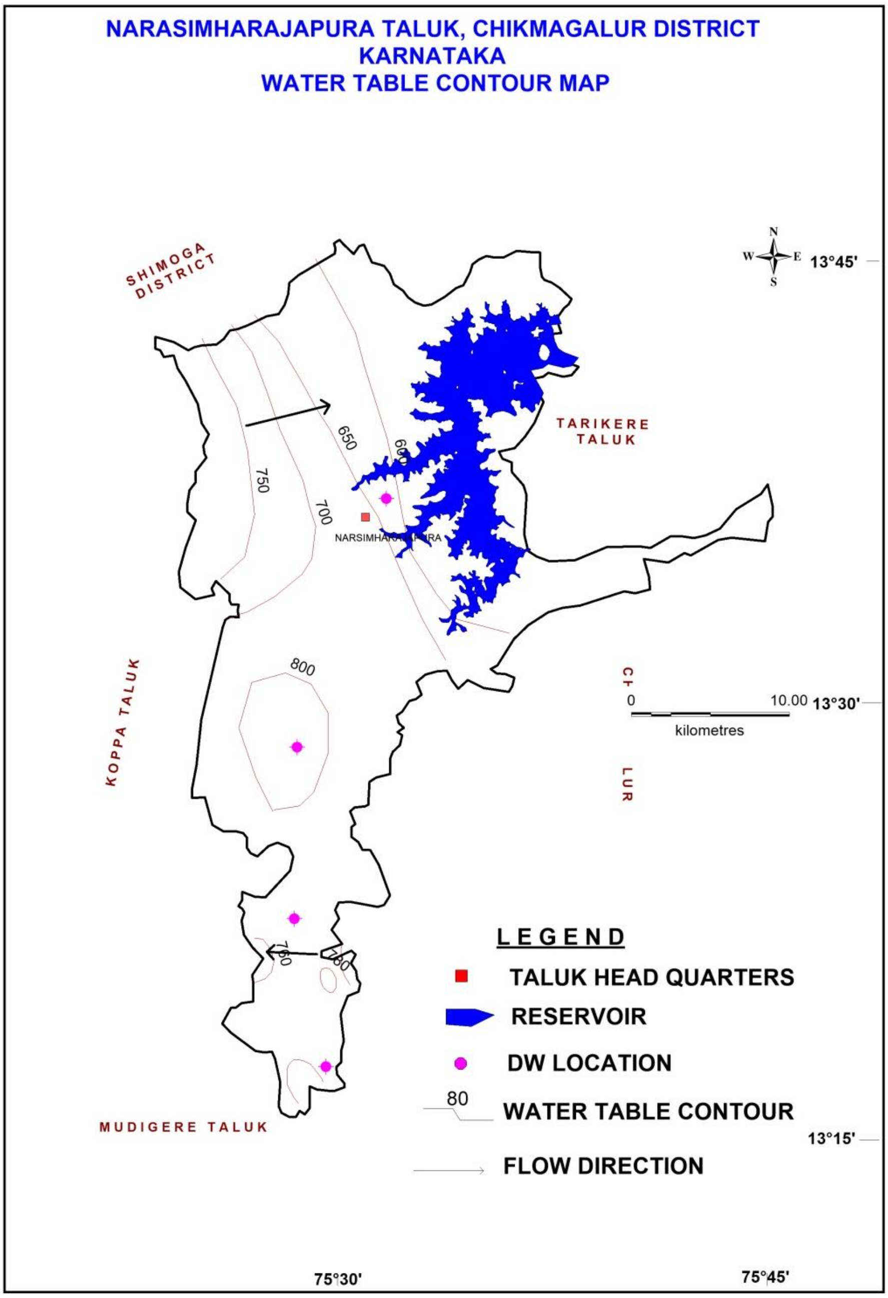

Figure 16: Water table contour map

3.2.2. Weathered thickness

From the exploratory drilling data and field studiestwo 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 to 37 m. The weathered thickness in the area vary highly 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 southern part and increases as moving towards the eastern part. The Spatial variations of weathered zone thickness in the area are given in Fig 17.

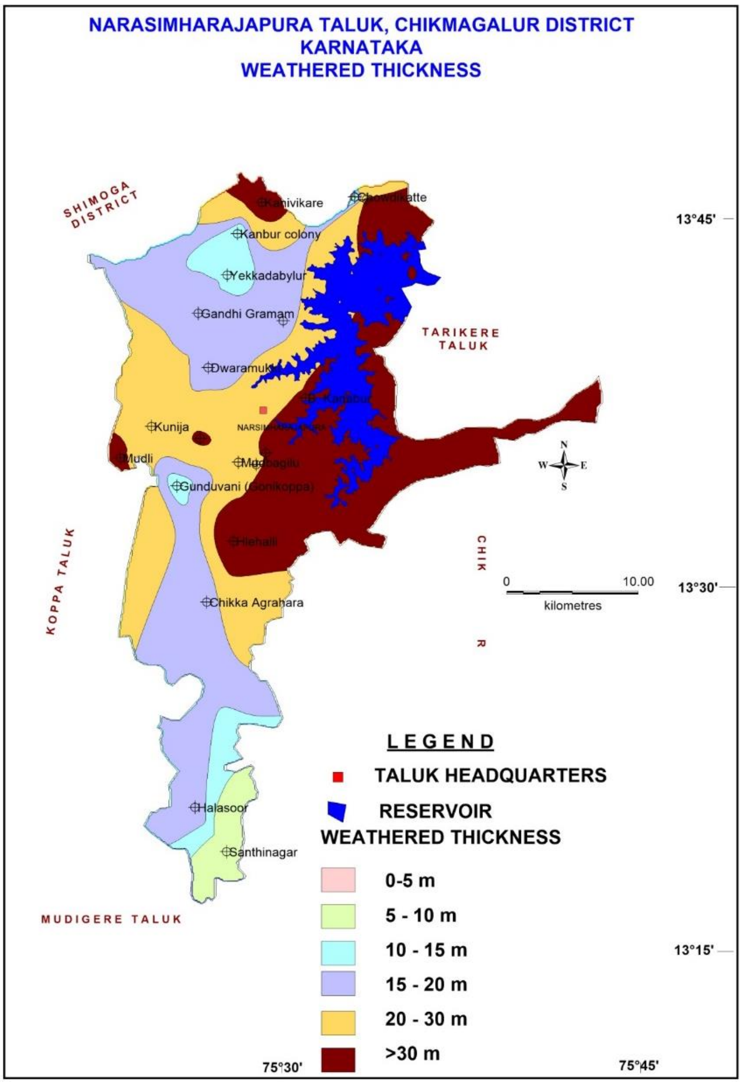

Figure 17. Map showing the spatial variation of weathered thickness.

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 is given in table 5.

Table 5: Water Quality of Dug wells

Sl no	Location	Latitude	Longitude	pH (6.5-8.5)	EC in mS/cm	TH (600)	Ca (200)	Mg (100)	Na	K	CO_3	HCO_3	Cl (1000)	SO_4 (400)	NO_3 (45)	SiO2	PO4	F (1.5)	U (30 ppb)	TDS (2000)	TA (600)
						-----mg/l-----															
1	Kanbur colony DW	13.72411	75.48917	8.71	350	170	28.05	24.3	4.6	0.782	9	61	60.265	20	23.7	45.87	0.02	0.04	NA	250	65
2	Yekkadabylur DW	13.69494	75.48207	7.7	350	120	30.06	10.935	23	1.564	0	146.4	21.27	15	0	45.19	0.28	0.04	NA	236	120
3	Kunija DW	13.58855	75.42873	6.43	160	35	10.02	2.43	18.4	1.173	0	30.5	14.18	15	24.2	29.14	0	0.06	NA	133	25
4	Kichebbe DW	13.43142	75.47447	6.52	220	80	26.05	3.645	13.8	1.173	0	48.8	31.905	15	20.8	39.34	0.03	0.05	NA	181	40
5	Seeke DW	13.37404	75.47227	9.65	250	70	10.02	10.935	23	2.737	9	18.3	17.725	15	65.2	27.06	0.02	0.02	NA	188	30

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

The ground water quality data of 5 dug wells were analysed and the results shows that quality of ground water in the phreatic aquifer in the region is generally good for all purposes. The electrical conductivity (in µS/cm at 25o C) of groundwater in phreatic zone is in the range of 160 to 350 and Chloride in the range of 14.18 to 60.26 mg/l. Fluoride content in the observation wells monitored is in the range of 0.02 to 0.06mg/l in the study area. Except for pH, which shows range above permissible limit in two locations, all the other parameters are with in permissible range. At a location by name Seeke, Nitrate above permissible limit is observed.

The percentage of the epm values of cations and anions in the samples from phreatic zone were plotted in Hill- Piper diagram (Fig. 18) for classifying the water types and the same is given in table 6below. Also the results of chemical analysisare plotted in Wilcox diagram to evaluate the suitability of water for irrigation purpose (Fig 19) and the samples are falling in low Sodium hazard zone and low to medium salinity zone indicating the suitability of water for irrigation use.

Table 6. Showing the type of water of dug well samples

#	location	Type of water
1	Kanbur colony	Calcium Bicarbonate type
2	Yekkadabylu	Calcium bicarbonate type
3	Kunija	Mixed type
4	Kichebbe	Mixed type
5	Seeke	Mixed type

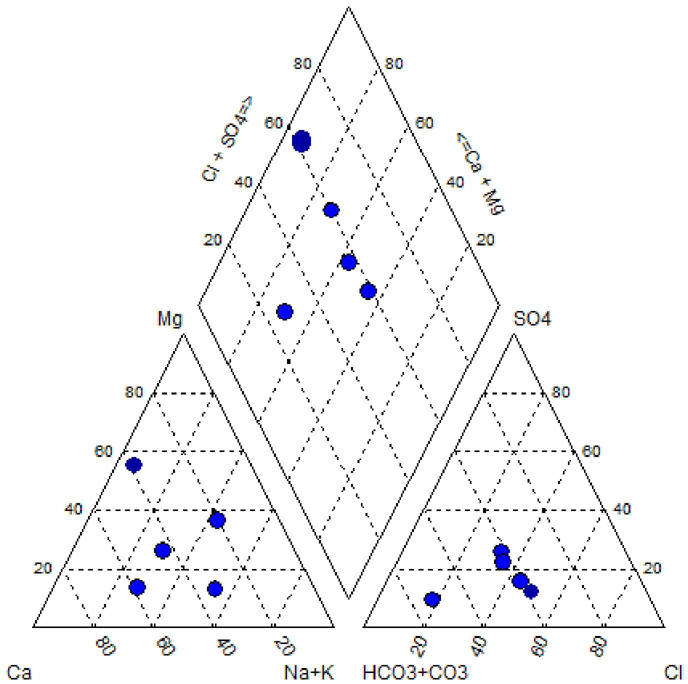

Figure 18. Hill –Piper diagram of phreatic aquifer

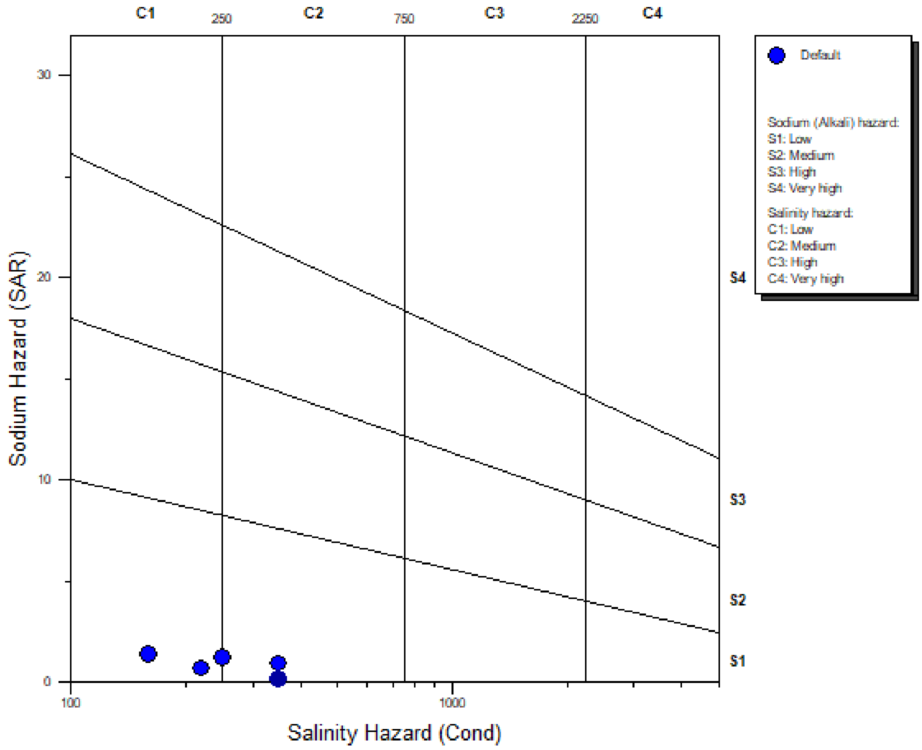

Figure 19. Showing Wilcox diagram of phreatic aquifer.

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 5 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 60.03 m to 203mbgl. Groundwater in the deeper fractured aquifer system exists under semiconfined state, in general. Weathered zone thickness varies in the range of 6 to 37 m and the thickness of the weathered zone generally decreases towards the southern part and increases as moving towards the eastern part. Moving from north towards south the Migmatites and Granodiorite – Tonalite Gneiss are overlain by Meta basalt. The static depth to water level ranges from 5.51 to 15.99 mbgl. Most of the bore wells in the area tap the fracture zones within the depth range of 40 to 85m bgl and rarely extend up to 120m bgl. In order to understand the aquifer disposition 2D (figure 20), fence diagram (Figure21) and 3D view models were created using RockWorks software (Figure22) of the area were prepared using details of bore well of depth greater than 100 m depth.

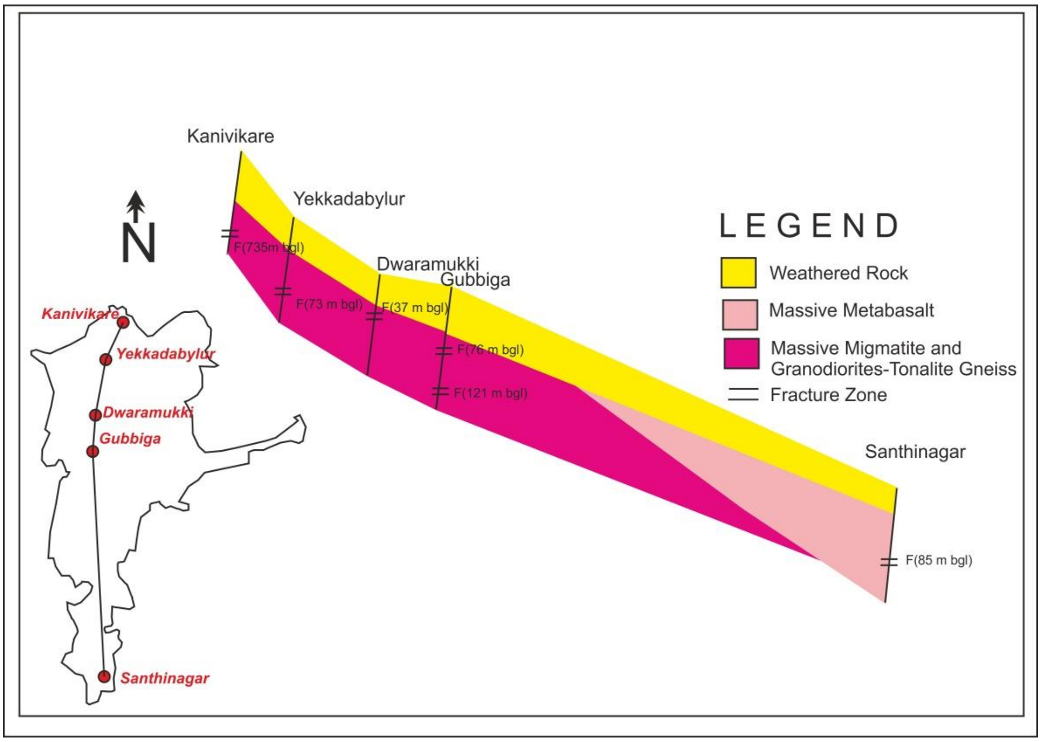

Figure 20: Cross section along Kanivikkare and Santhi Nagar

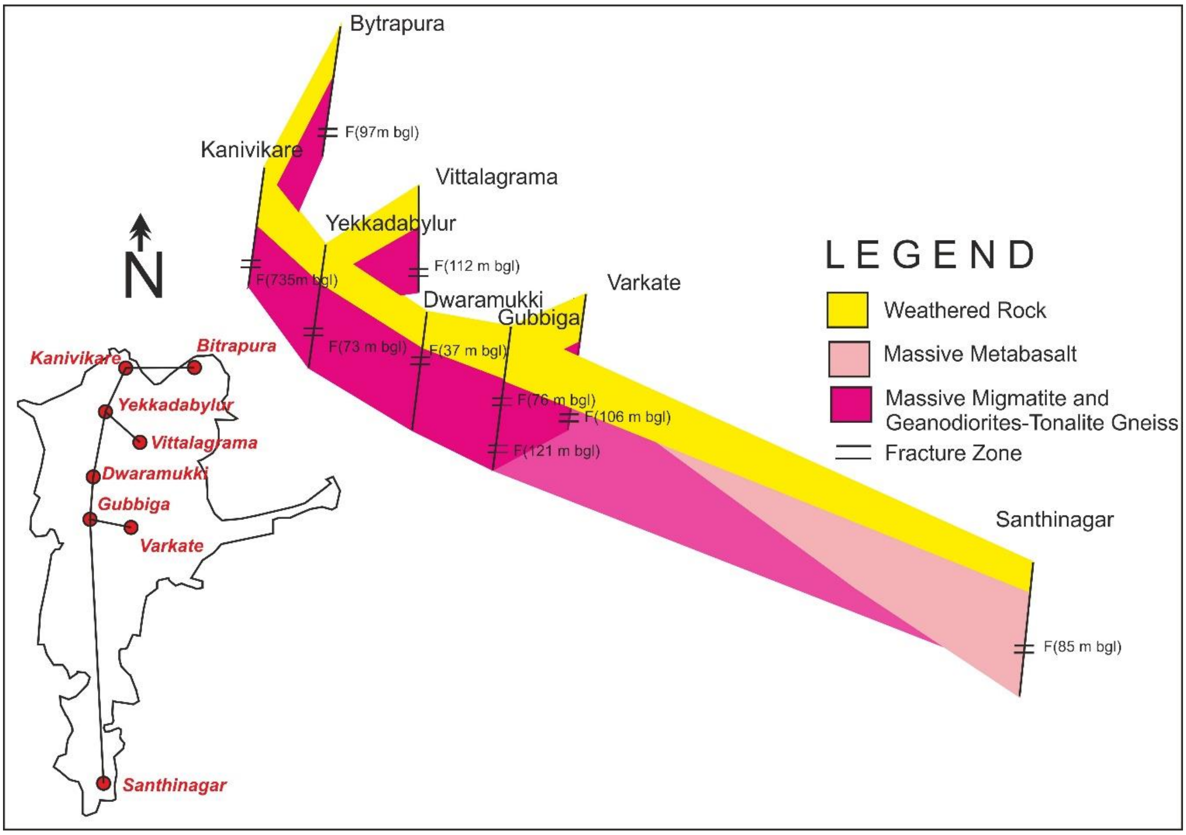

Fig. 21. Fence diagram showing aquifer disposition in NR pura taluk.

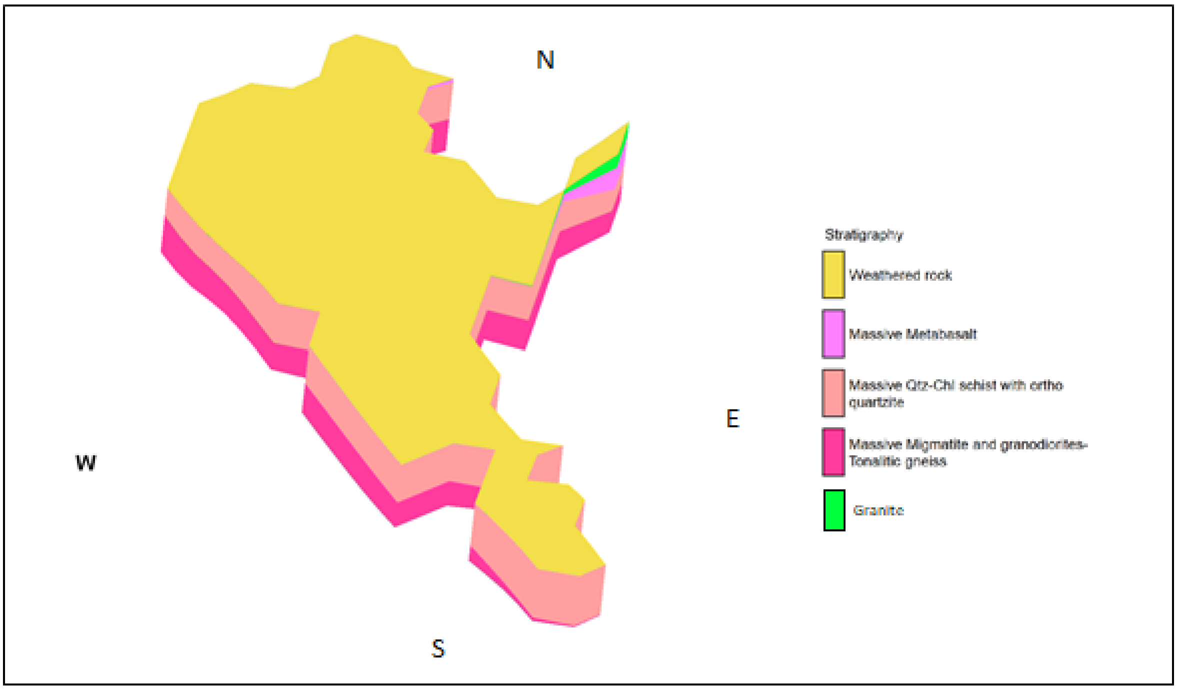

Fig. 22: 3D model showing aquifer disposition in NR pura taluk.

3.2.5 Aquifer characteristics

The hydraulic properties of fracture systems are evaluated from pumping tests. The Transmissivity value varies from 2.43 to 108 m^2 /day and the specific capacity of the wells ranges from 4.93 to 73.56 lpm/m dd.

3.2.6Waterlevel in fractured aquifer

The water level of four piezometers of depth ranging from 95 to 107 are analysed for both pre and post monsoon season. The waterlevel is found to be ranging between 7.6 to 16.9 mbgl during pre-monsoon and ranging in between 6.8 and 15.75 mbgl during post monsoon season. The wells show rise in water level ranging from 0.8 to 4.5 m.

3.2.7 Water Quality of fractured aquifer

The ground water quality data of 15 bore wells were analysed (Table 8) and the results shows that quality of ground water in the fractured zone in the region is generally good for all purpose. The electrical conductivity (in µS/cm at 25^o C) of groundwater is in the range of 120 to 810 and Chloride in the range of 10.64 to 49.63 mg/l. Fluoride content in the wells monitored is in well with in permissible range in the study area.

The percentage of the epm values of cations and anions in the samples from fractures were plotted in Hill- Piper diagram (Fig. 23) for classifying the water types and the water samples fall in Mixed Ca- Na-HCO_3 type, Ca-HCO_3 type and CaCl type. Also the quality is plotted in Wilcox diagram to evaluate the suitability of water for irrigation purpose (Fig 24) and the samples are falling in low Sodium hazard zone and low to medium salinity zone indicating the suitability of water for irrigation use.

The salient characteristics of the 2 aquifer systems mapped in the taluk is given in table 8.

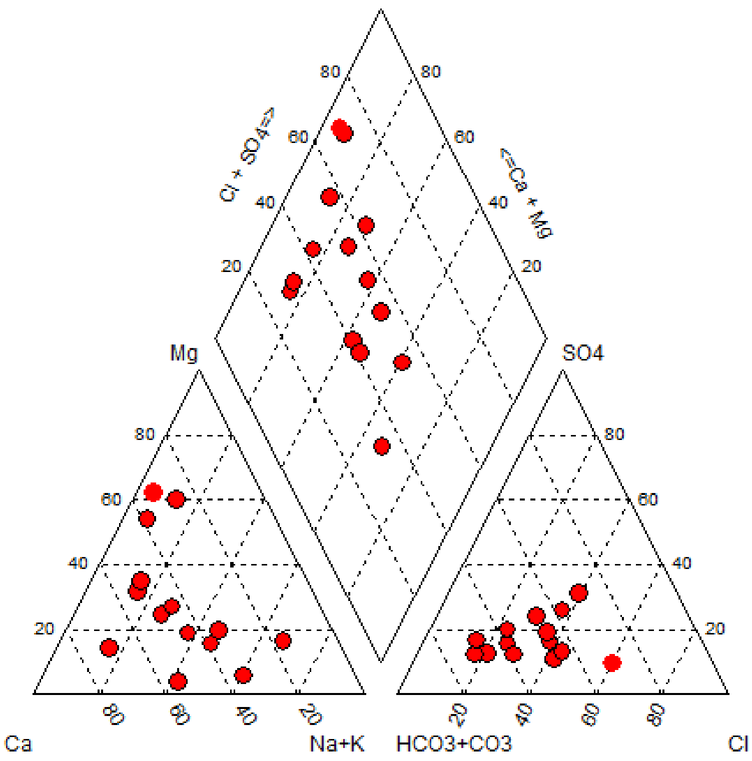

Figure 23: Piper Diagram of samples from fractured aquifer

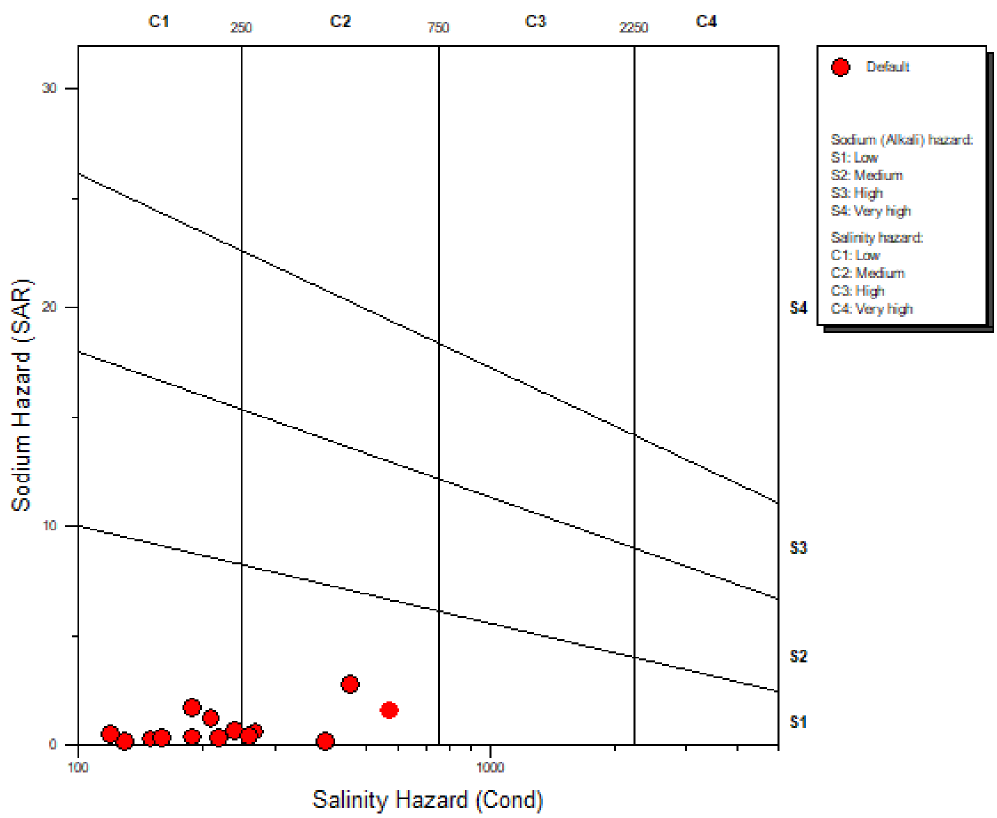

Figure 24: Wilcox diagram of fractured aquifer

Table 7. Salient aquifer characteristics of aquifer systems in the study area

Type of aquifer	Phreatic aquifer (Aq. I)	Fractured Zone (Aq.-II)
Formation	Weathered Crystallines	FracturedCrystallines.
SWL	Range between 1.74 to 11.05 mbgl	Range between 7.6 to 16.9 mbgl.
Weathered/Fractured zones encountered	Mostly weathered formations up to 37mbgl	Down to 121mbgl
Yield	Negligible to 20m^3/day	Negligible to 6.01lps
Aquifer Parameter (Transmissivity-m^2/day)	-	2.43 to 108 m ^{2} /day
Specific Capacity	-	4.93 to 73.56 lpm/m dd
Suitability for drinking & irrigation	Yes	Yes

Table 8. 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	Chowdikatte	7.84	810	380	66.132	52.245	11.5	0	0	378.2	46.085	15	8.95	43.09	0.05	0.22	NA	474	310
2	Kanivikare	8.56	280	115	24.048	13.365	2.5	0.296	3	42.7	21.27	20	50.15	10.58	0.04	0.072	NA	170	40
3	Kanbur colony	7.31	570	165	62.124	2.43	46	15.64	0	195.2	49.63	40	11.25	41.46	0.01	0.095	NA	388	160
4	Yekkadabylur	7.76	220	90	30.06	3.645	6.9	1.955	0	73.2	17.725	20	0	18.46	0.01	0.044	NA	143	60
5	Gandhi Gramam	6.73	270	70	20.04	4.86	11.27	27.756	0	61	17.725	10	64.5	49.7	0.18	0.015	NA	243	50
6	Dwaramukki	7.1	190	35	12.024	1.215	23	3.128	0	54.9	28.36	10	0	14.65	0	0.036	NA	126	45
7	Mudli	6.65	150	65	8.016	10.935	4.6	0	0	42.7	24.815	10	1.8	28.03	0	0.021	NA	114	35
8	B. Kanabur	6.62	400	190	26.052	30.375	4.6	0.782	0	61	70.9	15	22.35	39.27	0.02	0.021	NA	247	50
9	Vittalagrama	6.62	460	70	14.02	8.505	52.9	23.46	0	134.2	24.815	20	76.55	43.38	0.03	0.14	NA	346	110
10	Mudbagilu	7.23	210	55	14.028	4.86	20.7	1.955	0	36.6	17.725	10	50.85	33.75	0.01	0.072	NA	176	30
11	Balecolony	7.4	160	50	14.028	3.645	4.6	15.64	0	30.5	14.18	10	23.8	54.2	0.49	0.078	NA	159	25
12	Hlehalli	6.9	130	60	10.02	8.505	2.3	0	0	18.3	14.18	15	20.35	32.73	0.44	0.07	NA	114	15
13	ChikkaAgrahara	6.8	120	40	10.02	3.645	6.9	0.782	0	18.3	10.635	10	25.15	33.75	0	0.058	NA	112	15
14	Halasoor	6.67	190	80	20.04	7.29	6.9	0	0	73.2	10.635	10	8.65	38.3	0	0.041	NA	146	60
15	Santhinagar	7.8	260	110	26.05	10.94	9.2	0	0	103.7	14.18	20	4.4	41.01	0.04	0.12	NA	189	85

3.2.8 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 25 and fractured aquifer is shown in figure26.

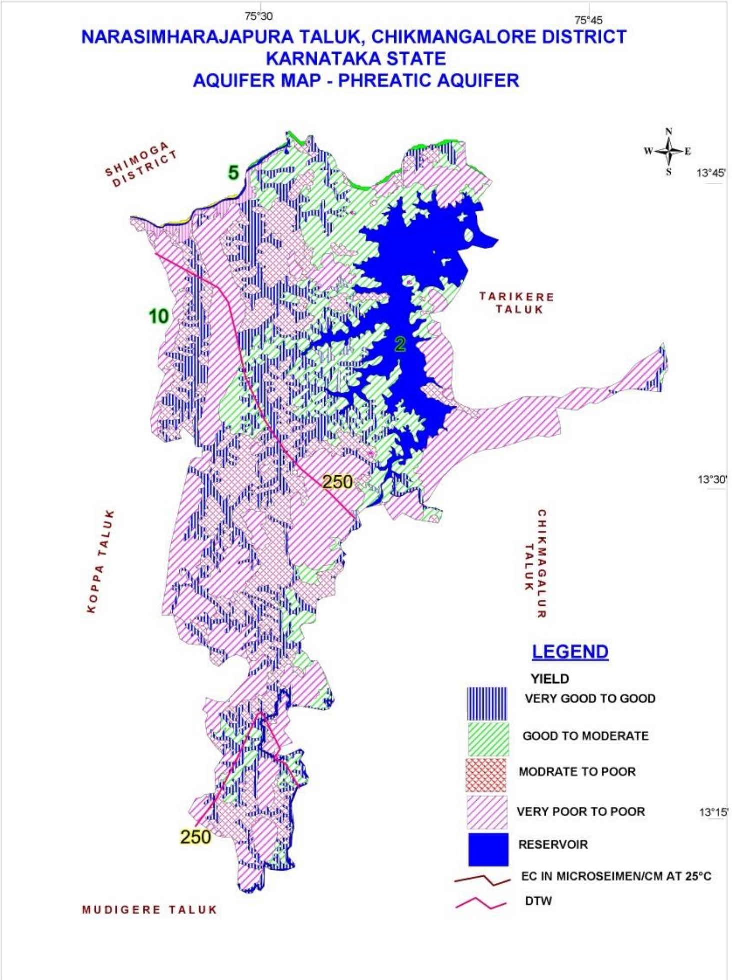

Figure 25 : Aquifer Map of Phreatic Aquifer

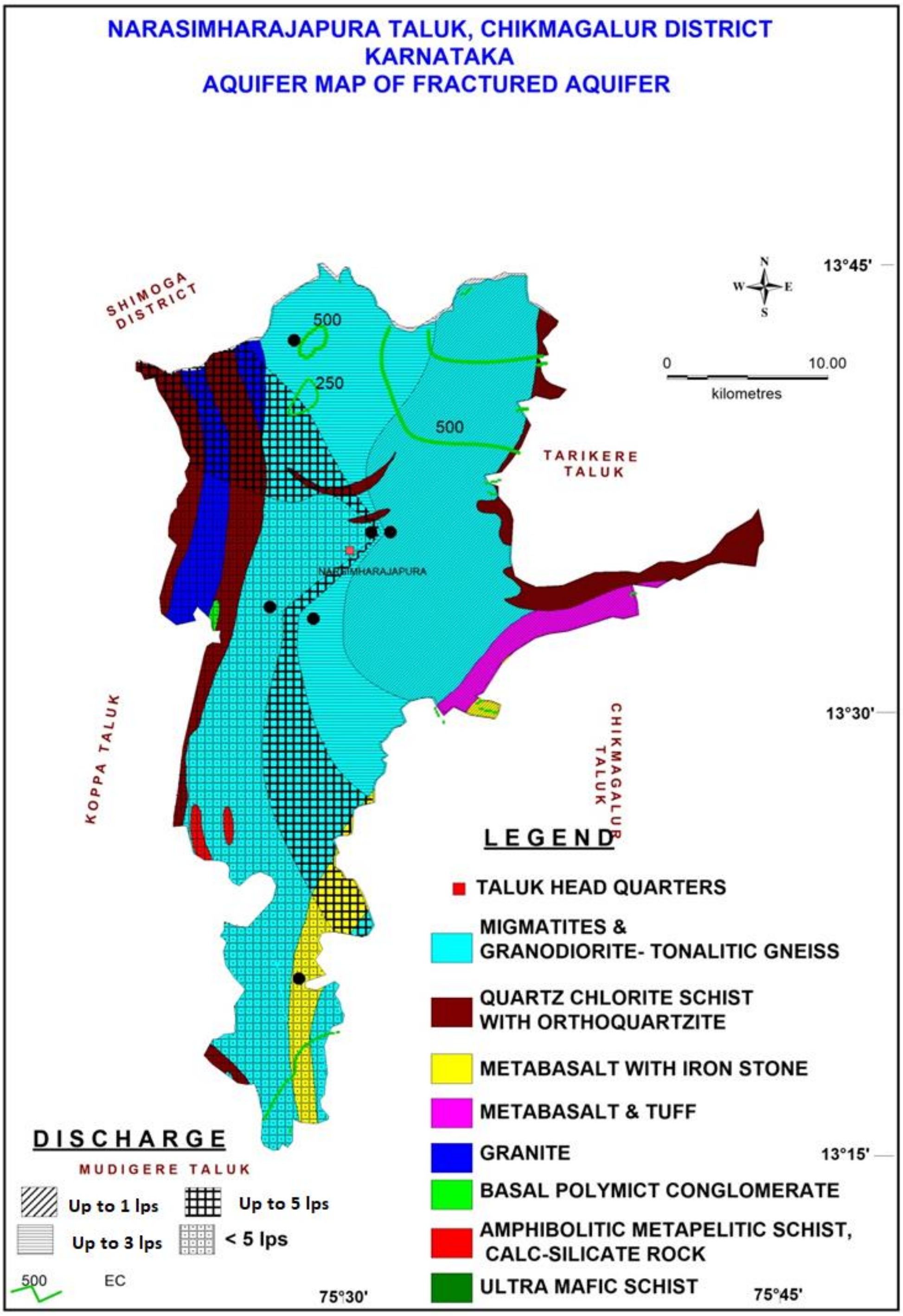

Figure 26: Aquifer Map of fractured aquifer

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 management 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 of 2022 Groundwater Resource assessment is detailed below.

The annual extractable groundwater recharge to unconfined aquifer is 53.42 MCM and the stage of groundwater extraction is 25.05 %. The net groundwater availability for future use is 35.99 MCM. Groundwater extraction for irrigation is on higher side (10.72 MCM) compared to the extraction for domestic as well as for industry. The total Ground water extraction of the area accounts to 12.04 MCM and 1.35 MCM of water is allocated for domestic utilisation for projected year 2025.The NR pura taluk falls under "Safe" category as per GWRA, 2022.

4. GROUND WATER RELATED ISSUES

NR pura receives high rainfall but the undulating topography and permeable aquifer in the subsurface facilitates base flow hence the area experiences scarcity of water during summer season.

The main ground water issues identified are

- Limited Ground Water Potential and low Sustainability of wells.
- Gradual increase in stage of ground water extraction and total extraction and decrease in net ground water availability.
- Drying up of dug wells during summer season and poor maintenance of dug wells.
- Lack of awareness among people programmes to maintain hygienic conditions around drinking water sources.
- Low stage of groundwater extraction.

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 current estimation, NR pura taluk falls under safe category. So, there is further scope for groundwater extraction for irrigation, being stage of extraction low. The groundwater development should be coupled with management of water resources through rainwater harvesting and artificial recharge schemes. Farmers may be encouraged to 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, seasonal 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 9):

Table 9 details of recharge structures proposed in the taluk as well as expected benefits.

Total Geographic area	805
Area Feasible for AR	427
Number of proposed recharge structures	
Subsurface dyke	1
Percolation pond	22
Checkdam	123
Filter Bed	5
Availability of surface non committed monsoon runoff (MCM)	24.192
Total Recharge capacity	24.192
Expected benefit of artificial recharge & RWH	
Volume of water likely to be recharged	18.144 MCM
Additional irrigation potential	0.022Lakh 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.

1. Inaddition to the construction of new recharge structures regular desilting (once in three years) and maintenance of these available ponds, tanks and recharge structures in the taluk is also recommended.
2. 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 27 and 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 storageand 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. ***Additional Ground Water irrigation potential:*** The taluk falls under safe category with stage of Ground Water extraction at 25.05% hence there is further scope for ground water development. An additional ground water irrigation potential through ground water via dug well and bore wells can be created in the NR pura taluk of the district without augmenting the stage of ground water extraction above 70%. About 3894 Ha of culturable wasteland in the taluk can be brought under cultivation by constructing 1038 dug wells and 2725 bore wells (Tentative).
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 1500 Ha of land.

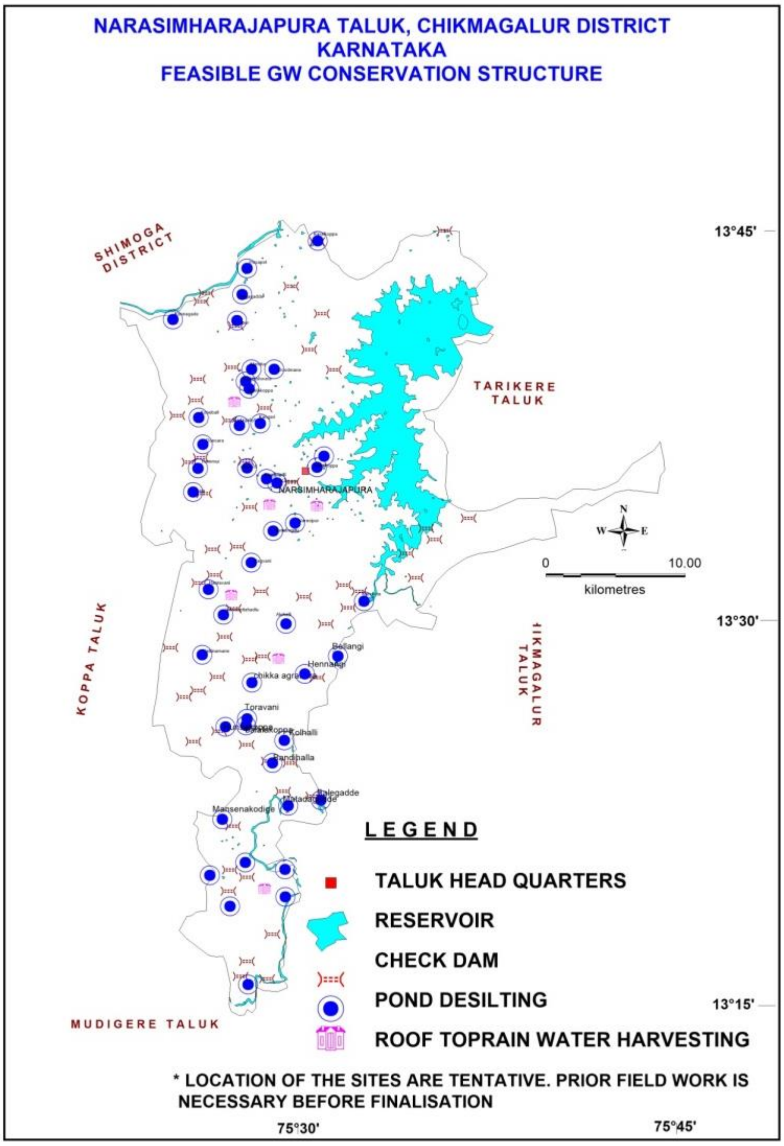

Figure 27: Map showing tentative location of feasible water conservation structures

6. SUMMARY

The annual extractable groundwater recharge to unconfined aquifer is 53.42 MCM and the stage of groundwater extraction is 25.05 %. The net groundwater availability for future use is 35.99 MCM. Groundwater extraction for irrigation is on higher side (10.72 MCM) compared to the extraction for domestic as well as for industry. The total Ground water extraction of the area accounts to 12.04 MCM and 1.35 MCM of water is allocated for domestic utilisation for projected year 2025.The NR pura taluk falls under "Safe" category as per GWRA, 2022.

NR pura receives high rainfall but the undulating topography and permeable aquifer in the subsurface facilitates base flow hence the area experiences scarcity of water during summer season.

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. Considering the long-term water level trend and seasonal water level, seasonal 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. Inaddition to the construction of new recharge structures regular desilting (once in three years) and maintenance of these available ponds, tanks and recharge structures in the taluk is also recommended. The ground water worthy areas like topographic lows, valley portions should be developed through adequate soil conservation measures.

Demand side management plan:

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.

Additional Ground Water irrigation potential: The taluk falls under safe category with stage of Ground Water extraction at 25.05% hence there is further scope for ground water development. An additional ground water irrigation potential through ground water via dug well and bore wells can be created in the NR pura taluk of the district without augmenting the stage of ground water extraction above 70%. About 3894 Ha of culturable wasteland in the taluk can be brought under cultivation by constructing 1038 dug wells and 2725 bore wells (Tentative).

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 1500 Ha of land.

Annexure 1:

Details of tentative location of ground water conservation structure.

Sl No	Latitude	Longitude	Structure
1	13.43204	75.44966	Check Dam
2	13.50129	75.52074	Check Dam
3	13.49286	75.45328	Check Dam
4	13.48028	75.47858	Check Dam
5	13.47836	75.47009	Check Dam
6	13.46715	75.44846	Check Dam
7	13.45833	75.4358	Check Dam
8	13.45391	75.42622	Check Dam
9	13.42329	75.46802	Check Dam
10	13.41259	75.48282	Check Dam
11	13.41127	75.49702	Check Dam
12	13.46662	75.51499	Check Dam
13	13.48588	75.41715	Check Dam
14	13.42511	75.43252	Check Dam
15	13.63287	75.45667	Check Dam
16	13.66728	75.45825	Check Dam
17	13.65974	75.43556	Check Dam
18	13.64598	75.43415	Check Dam
19	13.6361	75.42195	Check Dam
20	13.66586	75.52601	Check Dam
21	13.64089	75.47999	Check Dam
22	13.67882	75.50951	Check Dam
23	13.60681	75.4676	Check Dam
24	13.60596	75.42994	Check Dam
25	13.60893	75.43735	Check Dam
26	13.59314	75.49799	Check Dam
27	13.70988	75.43777	Check Dam
28	13.74862	75.51499	Check Dam
29	13.7198	75.49751	Check Dam
30	13.69401	75.46075	Check Dam
31	13.71521	75.44117	Check Dam
32	13.70201	75.51802	Check Dam
33	13.30046	75.48517	Check Dam
34	13.39296	75.49222	Check Dam
35	13.33746	75.46823	Check Dam
36	13.34208	75.45682	Check Dam
37	13.3705	75.45901	Check Dam
38	13.3898	75.51228	Check Dam
39	13.28306	75.46817	Check Dam
40	13.27339	75.46399	Check Dam
41	13.27186	75.48159	Check Dam
42	13.3285	75.45588	Check Dam
43	13.52248	75.47754	Check Dam

44	13.57698	75.47004	Check Dam
45	13.58573	75.4398	Check Dam
46	13.52657	75.53249	Check Dam
47	13.52238	75.54283	Check Dam
48	13.51186	75.53556	Check Dam
49	13.51893	75.50625	Check Dam
50	13.51121	75.45947	Check Dam
51	13.53305	75.44668	Check Dam
52	13.54966	75.44516	Check Dam
53	13.55134	75.46183	Check Dam
54	13.52785	75.43649	Check Dam
55	13.75582	75.59958	Check Dam
56	13.56978	75.61558	Check Dam
57	13.55592	75.59287	Check Dam
58	13.56317	75.58733	Check Dam
59	13.54695	75.57419	Check Dam
60	13.53124	75.58035	Check Dam

Sl No	Longitude	Latitude	Structure
1	75.51529	13.74896	Desilting of ponds
2	75.46843	13.73119	Desilting of ponds
3	75.46511	13.71426	Desilting of ponds
4	75.46166	13.69747	Desilting of ponds
5	75.41909	13.69826	Desilting of ponds
6	75.48575	13.56129	Desilting of ponds
7	75.48837	13.59238	Desilting of ponds
8	75.46832	13.60199	Desilting of ponds
9	75.51946	13.60969	Desilting of ponds
10	75.51504	13.60253	Desilting of ponds
11	75.48132	13.595	Desilting of ponds
12	75.43584	13.60191	Desilting of ponds
13	75.43253	13.58661	Desilting of ponds
14	75.5004	13.56662	Desilting of ponds
15	75.4711	13.5409	Desilting of ponds
16	75.45194	13.37473	Desilting of ponds
17	75.48537	13.41134	Desilting of ponds
18	75.49575	13.3837	Desilting of ponds
19	75.46728	13.34698	Desilting of ponds
20	75.44354	13.33857	Desilting of ponds
21	75.45706	13.31857	Desilting of ponds
22	75.49397	13.3246	Desilting of ponds
23	75.49355	13.34249	Desilting of ponds
24	75.51745	13.38709	Desilting of ponds
25	75.4691	13.26794	Desilting of ponds
26	75.48655	13.66601	Desilting of ponds
27	75.47149	13.66596	Desilting of ponds

28	75.46969	13.65337	Desilting of ponds
29	75.46748	13.65812	Desilting of ponds
30	75.4632	13.62954	Desilting of ponds
31	75.47716	13.63082	Desilting of ponds
32	75.43625	13.63472	Desilting of ponds
33	75.43902	13.61735	Desilting of ponds
34	75.52876	13.48037	Desilting of ponds
35	75.44264	13.52358	Desilting of ponds
36	75.45259	13.50711	Desilting of ponds
37	75.54616	13.51592	Desilting of ponds
38	75.49433	13.50118	Desilting of ponds
39	75.4385	13.4813	Desilting of ponds
40	75.47168	13.46321	Desilting of ponds
41	75.50692	13.46884	Desilting of ponds
42	75.45413	13.43457	Desilting of ponds
43	75.46768	13.43558	Desilting of ponds
44	75.46837	13.43978	Desilting of ponds
45	75.49311	13.42581	Desilting of ponds
46	75.47305	13.3817	Desilting of ponds
47	75.50403	13.41492	Desilting of ponds
48	75.5335	13.3922	Desilting of ponds
49	75.5163	13.38813	Desilting of ponds
50	75.50905	13.43118	Desilting of ponds
51	75.4818	13.44762	Desilting of ponds
52	75.48836	13.43297	Desilting of ponds
53	75.47465	13.43472	Desilting of ponds
54	75.50095	13.46797	Desilting of ponds
55	75.52547	13.47534	Desilting of ponds
56	75.53884	13.48696	Desilting of ponds
57	75.55432	13.52084	Desilting of ponds
58	75.45243	13.48376	Desilting of ponds
59	75.47096	13.51052	Desilting of ponds
60	75.45365	13.52795	Desilting of ponds
61	75.48171	13.5421	Desilting of ponds
62	75.49441	13.50766	Desilting of ponds
63	75.49765	13.56209	Desilting of ponds
64	75.51162	13.56854	Desilting of ponds
65	75.43728	13.58769	Desilting of ponds
66	75.44615	13.60658	Desilting of ponds
67	75.44913	13.62009	Desilting of ponds
68	75.44559	13.63838	Desilting of ponds
69	75.47143	13.60328	Desilting of ponds
70	75.4981	13.5941	Desilting of ponds
71	75.48978	13.59821	Desilting of ponds
72	75.52394	13.60387	Desilting of ponds
73	75.4837	13.63545	Desilting of ponds

74	75.47046	13.6335	Desilting of ponds
75	75.49951	13.6658	Desilting of ponds
76	75.47725	13.66976	Desilting of ponds
77	75.47845	13.66028	Desilting of ponds
78	75.48025	13.65261	Desilting of ponds
79	75.52344	13.75382	Desilting of ponds
80	75.4777	13.7356	Desilting of ponds
81	75.47407	13.7133	Desilting of ponds
82	75.46626	13.69643	Desilting of ponds
83	75.43095	13.70205	Desilting of ponds