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

Bhatkal Taluk, Uttara Kannada District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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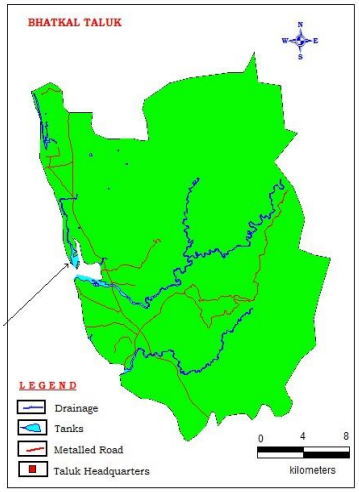
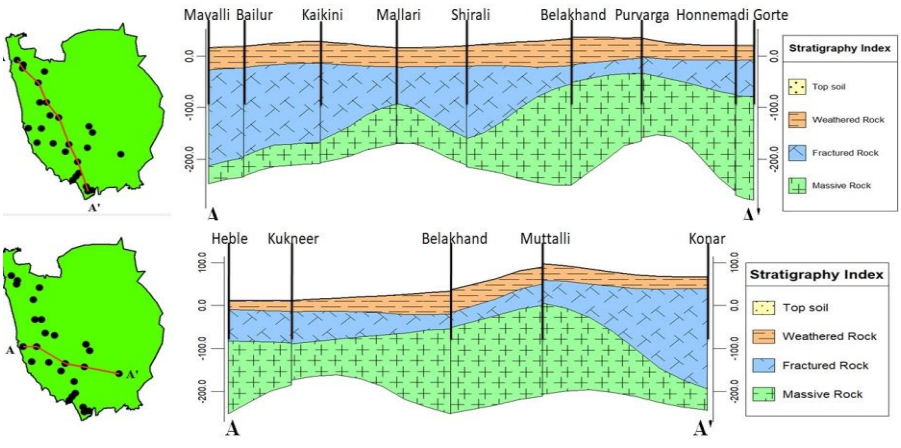
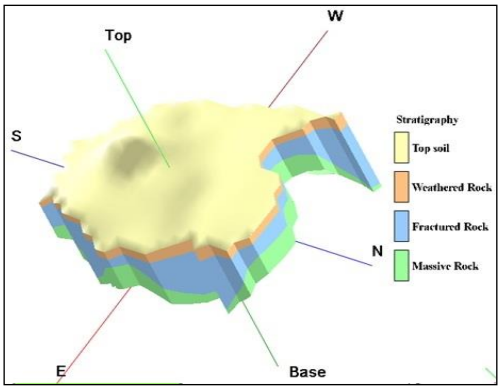
AQUIFER MAPPING AND MANAGEMENT PLAN OF BHATKAL TALUK, UTTARA KANNADA DISTRICT, KARNATAKA

(AAP- 2022-2023)







By

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MAY 2023

AQUIFER MAPPING AND MANAGEMENT PLAN OF BHATKAL TALUK, UTTARA KANNADA DISTRICT, KARNATAKA

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AQUIFER MAPPING AND MANAGEMENT PLAN OF BHATKAL TALUK, UTTARA KANNADA DISTRICT, KARNATAKA

1. INTRODUCTION

National Project on Aquifer Mapping (NAQUIM) initiated by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India with a vision to identify and map the aquifers at the micro level with their characteristics, to quantify the available groundwater resources, to propose plans appropriate to the scale of demand and institutional arrangements for participatory management in order to formulate a viable strategy for the sustainable development and management of the precious resource which is subjected to depletion and contamination due to indiscriminate development in the recent past.

Groundwater is being increasingly recognized as a dependable source of supply to meet the demands of domestic, irrigation and industrial sectors of the country. The developmentactivities over the years have adversely affected the groundwater regime in many parts of the country. Hence, there is a need for scientific planning in development of groundwater under different hydrogeological situations and to evolve effective management practices with the involvement of community for better groundwater governance.

Aquifer Mapping has been taken up in BHATKAL taluk, UTTAR KANNADA district with a view to formulate strategies for sustainable management plan for the aquifer system in accordance with the nature of the aquifer, the stress on the groundwater resource and prevailing groundwater quality which will help in drinking water security and improved irrigation facility. It will also result in better management of vulnerable areas.

1.1. Objectives

The objectives of the aquifer mapping can broadly be stated as:

- To define the aquifer geometry, type of aquifers and their lateral and vertical extent
- To determine the groundwater regime scenario
- To determine the hydrogeochemical characteristics of the aquifer units
- To define 2D and 3-D dispositions of the aquifer units
- To estimate the availability of groundwater resources in the aquifer system
- To develop a sustainable groundwater management plan for the aquifer system

1.2. Scope of the Study

The important aspect of the aquifer mapping programme is the synthesis of the large volume of data already generated during specific studies carried out by **Central Ground Water Board (CGWB)** and various Government organizations with a new data set generated that broadly describe the aquifer system. The available generated data are assembled, analyzed, examined, synthesized and interpreted from available sources. These sources are predominantly non-computerized data, which is to be converted into computer-based GIS data sets.

Data gaps have been identified after proper synthesis and analysis of the available data collected from different state organizations like GWD, Watershed department, etc. In order to bridge the data gap, data generation programme has been formulated in an organized way in the study area. Exploration work has been carried out in different segments of the regions and aquifer parameters have been estimated. Groundwater monitoring regime has been strengthened by establishing/adding State agencies additional monitoring wells. 2D and 3D sections have been prepared to bring out more realistic as the data points are more closure to the field.

1.3 Approach & Methodology

Integrated multi-disciplinary approach involving geological, geophysical, hydrological and hydrogeological and hydrogeochemical components were taken up in 1:50000 scale to meet the objectives of study. Geological map of the study area has been generated based on the GSI maps, geophysical data have been generated through vertical electrical soundings and geoelectrical layers with different resistivity have been interpreted in corroboration with the litho-stratigraphy of the observation wells and exploratory wells down to depths of 200mbgl. Hydrological and Hydrometeorological data have been collected from Statistical department, Govt of Karnataka. Drainage, Soil and Geomorphology of the taluk were prepared based on the satellite data interpreted by KSRSAC.

Based on the data gap analysis, data generation process has been scheduled through establishing key observation wells, integrating Ground Water Directorate (GWD) observation wells, pinpointing exploratory sites for drilling through in-house, collecting geochemical samples in order to study groundwater regime, geometry of the aquifer and aquifer parameters, and quality of the groundwater respectively. Groundwater recharge and draft have been computed based on approved guidelines and method to estimate the ground water resources of the aquifer system.

Based on the above studies Management strategies both on the supply side through augmentation of groundwater through artificial recharge and water conservation and on demand side through change in irrigation pattern have been formulated for sustainable management of the groundwater resource.

2. SALIENT FEATURES

Name of the Taluk: BHATKAL

District: Uttar Kannada

State: Karnataka

Area: 351 Sq kms

Population: 1,61,576

Annual Normal Rainfall: 4322 mm

2.1. Study area

Aquifer Mapping Studies have been carried out in Bhatkal taluk, Uttar Kannada district of Karnataka, covering an area of 351sq.kms under National Aquifer Mapping Project. The Bhatkal taluk is located between North Latitudes 74°37'35.07" and 14°08'28.14" and East Longitudes between 74° 29'17.54" to 14°09'24.96". The study area is bounded on the East by Sagara taluk of Shimoga District, on the North by Honnavar Taluk of Uttar Kannada District, on the South by Bynduru Taluk of Uttar Kannada District, on the West by Arabian sea. Location map of Bhatkal taluk of Uttar Kannada district is presented in Fig-1. Bhatkal is taluk headquarters. There are 59 villages and 16 Gram panchayats in this taluk.

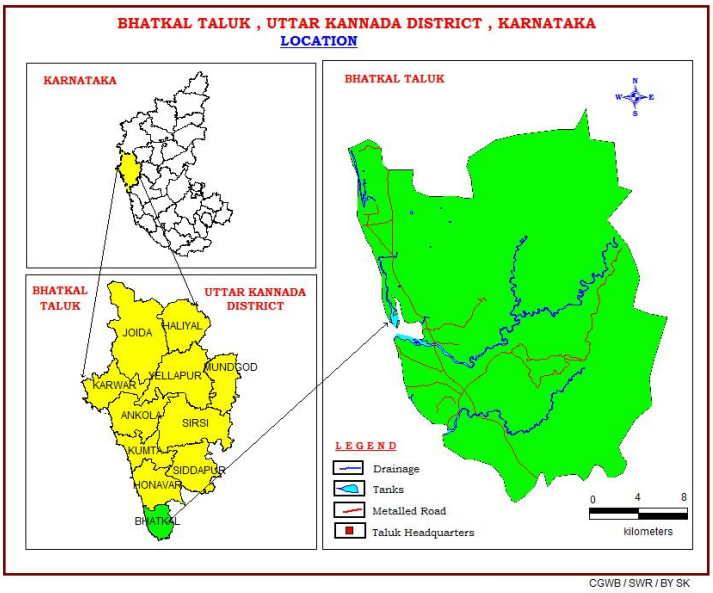


Fig. 1: Location Map

2.2. Population

According to 2011 census, the population in Bhatkal taluk is 161576, in which 80753 male population and 80823 is the female population. The decadal variation in population from 2001-2011 is 8.19% in Bhatkal taluk (Table.1).

Table-1: Population details of BHATKAL Taluk, UTTAR KANNADA District

Total	Male	Female	Share of the district population	Rural population	Urban population	Decadal change in population	Decadal change in rural population	Decadal changein urban population
161576	80753	80823	11.24	111846	49730	8.19	4.34	18.01

Source: District at a Glance 2019-20, Govt. of Karnataka

2.3. Rainfall

BHATKAL taluk experiences typical maritime climate. The normal annual rainfall in BHATKAL taluk for the period 1951 to 1990 is 4322 mm. The year is usually divided into four seasons: summer from March to May; rainy season or south-west monsoon season from June to September; post-monsoon season covering the months of October and November and dry or winter Season from December to February. Rainfall trend analysis is shown in **Fig.2.**

Table-2: Actual Annual rainfall (mm) in rain gauge station from 2005 to 2015

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
mm	4794	4175	3788	4668	3678	3243	3343	3773	3334	5307	5255

Source: District at a Glance 2019-20, Govt. of Karnataka

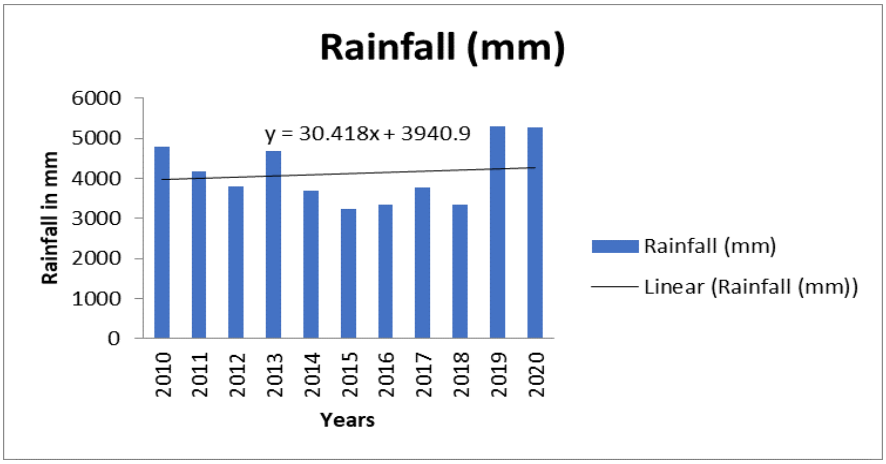


Fig. 2: Rainfall Trend Analysis

2.4. Agriculture & Irrigation

Agriculture is the main occupation in Bhatkal taluk. More than 85% of the households are engaged in agriculture. Agriculture activity in the area is confined to traditional Kharif cultivation depending upon the monsoon rainfall. During October-February (Rabi) and January-May (Summer) crops are raised whenever irrigation facilities are available. Paddy is the major crop raised more of the cultivated area in Kharif season, The other crops are Chillies, Sweet potato, Ginger and Vegetables. In rabi season paddy, chillies, blackgram and greengram are raised. Pulses are raised during the dry season. The crops raised during summer are limited with chief crop being Cocunuts, Arecanut, paddy and fruits is also grown in valley are grown in Bhatkal Taluk **(Table 3).**

Table-3: Cropping pattern in BHATKAL taluk

Principle crops grown in Bhatkal Taluk

Crops	Cereals (Area in Ha)					Fruits (Area in Ha)	Veg (Area in Ha)	Flowers	Oil seeds (Area in Ha)	Sugarcane	Arecanut	Cocunut
	Paddy	Maize	Green gram	Black gram	Cow pea				Groundnuts			
	2176	0	2	6	2	471.21	6.21	42	185	14	1286	1225
Total	2176		10			471.21	6.21	42	185	14	1286	1225
Sub Total	2186					471.21	6.21	42	185	14	1286	1225

Source: District at a glance 2019-2020

It is observed that net sown area accounts 5263 (Ha) and area sown more than once is 393 (Ha) of total geographical area 34892 (Ha) in Bhatkal taluk **(Table-4).** Area under Forest is 25433 (Ha) Area not

available for cultivation and Fallow land cover 1570 (Ha) and 1322 (Ha) of total geographical area respectively. 12(Ha) of net area is irrigated from surface water and 2587 (Ha) are irrigated from Groundwater **(Table-5).** Irrigation Vs Area analysis is shown **in Fig.3.**

Table-4: Details of land use in BHATKAL Taluk

Landuse pattern of BHATKAL Taluk (Ha)

Geographical area	Area under Forest	Area not available for cultivation	Uncultivable land	Fallow land	Area Sown		
					Net sown area	Area sown more than once	Total sown/ Cropped area
34892	25433	1570	1303	1322	5263	393	5656

Source: District at a glance 2019-2020

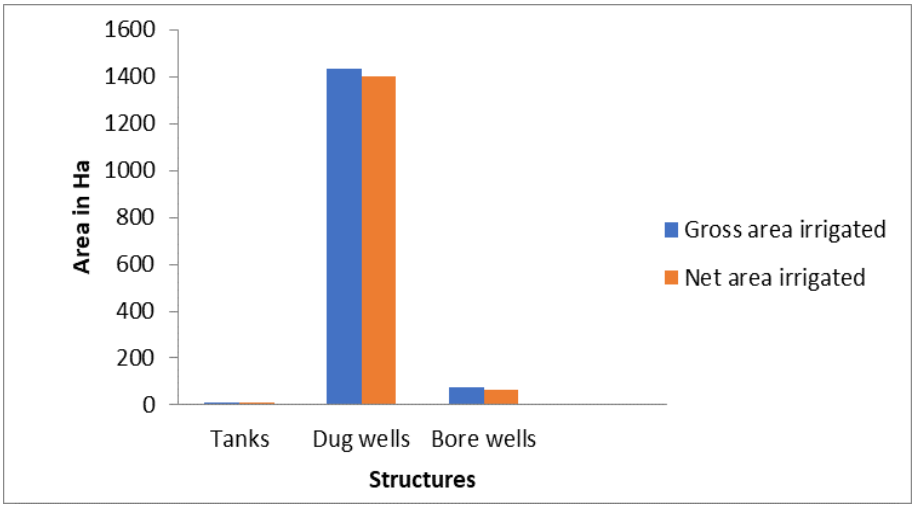


Fig-3: Irrigation Vs Area Analysis

Table-5: Irrigation details in BHATKAL taluk

Details of irrigation in BHATKAL Taluk

S.No	Source		No/Length	Net area irrigated (ha)	Gross area irrigated (ha)
1	Surface water	Canals	0	0	0
		Tanks	132	12	12
		Lift irrigation	0	0	0
		Total	132	12	12
2	Ground water	Dug wells	1253	1400	1436
		Bore wells	5	65	78
3	Other sources	Other sources	-	1122	1248
		SubTotal	-	2599	2774

Source: District at a glance 2019-2020

2.5. Geomorphology, Physiography & Drainage

The geomorphology of the Bhatkal is formed by various land forms like 1, Narrow stretch of coastal tracts, 2, Upland area, 3, Hilly terrain in covered all over the taluk. The elevation in the taluk varies from 4m to 211m in the taluk. The taluk is endowed with a west flowing rivers, It covers part of Mulki,Shirva, Swarna yennehole, Madisala, Sita, Haladi, Chakravani, Kollur, Baindur amnd sankadagudi hole basin. These are perennial during normal rainfall. whereas tributaries and smaller streams become dry during summer. The prevailing high gradient in the hilly terrain and heavy rainfall brings great volume of water in these rivers during monsoon. These rivers join Arabian Sea and are prone to tidal effects to considerable lengths in the inland area. The drainage system is well developed in the taluk. The differential altitude is significant because, it is likely to cause irregular ground water flow patterns on the micro scale **(Fig.-4).** Topography is dominantly controlled by geological structures. The entire Bhatkal taluk falls in varaha river basin. The Drainage pattern is dendritic to sub dendritic **(Fig.-5)**

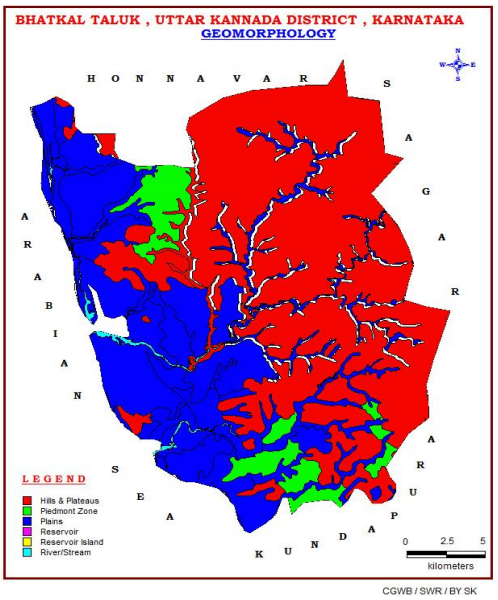


Fig-4: Geomorphology Map

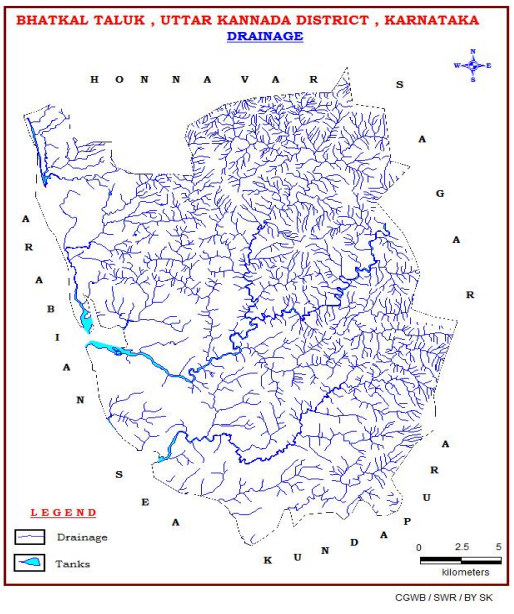


Fig-5: Drainage Map

2.6. Geology, Soil and Landuse

Geologically the rocks like Granitic gneisses with occasional laterite capping and unconsolidated river and marine sediments, occupy the area. The gneiss, which is wide spread in the distinct outcrops at varying magnitude especially along river courses. Basic intrusive like dolerites and gabbro's and acidic intrusive like pegmatite and quartz veins and pink porphyritic granites are found all over the district. The recent alluvium and colluvial deposits occur along the riverbanks and seacoast. The exposures of crystalline rocks found as isolated hills along the shore and off shore. The black clayey marine sediments with a thickness of 0.30m to >1.00m occur as lenses along the coast and in the deltaic islands. Its occurrence is marked at a depth range of 5.00 to 6.00 mbgl and it is shown in (**Fig. 6).**

The district is covered with three types of soils i) sandy soil covering the beaches and the adjoining stretches ii) yellow loamy soil and iii) red lateritic soil. The sandy soils are confined to a narrow strip of the coast having width ranging from less than 100 m to as much as a kilometer. This fine to medium texture sands are characterized by their extremely high rate of infiltration and act as a good recharge media for ground water. Yellow loamy soils are transported from origin and are found mostly along riverbanks and lower reaches of valleys. They are mostly used for tile industries. This soil type is very well suited for irrigation and shows good response to irrigation practices. Red lateritic soil is the most dominant soil type in the area. The texture of these soils varies from fine to coarse. The soil in the valleys and immediate slopes are rich in loam where as in upper slopes and pediplain are much coarser in nature. The degree of leaching undergone by this soil type is also variable. **(Fig-7)** and mainly this taluk covered by agricultural land. Land Use and Land Cover map also included **(Fig.8)**

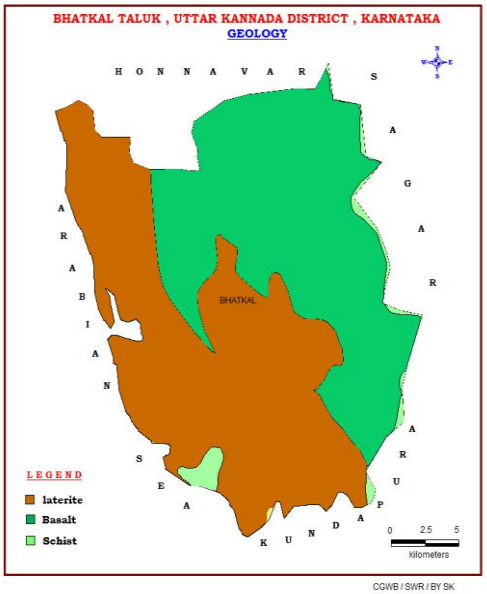


Fig-6: Geology Map

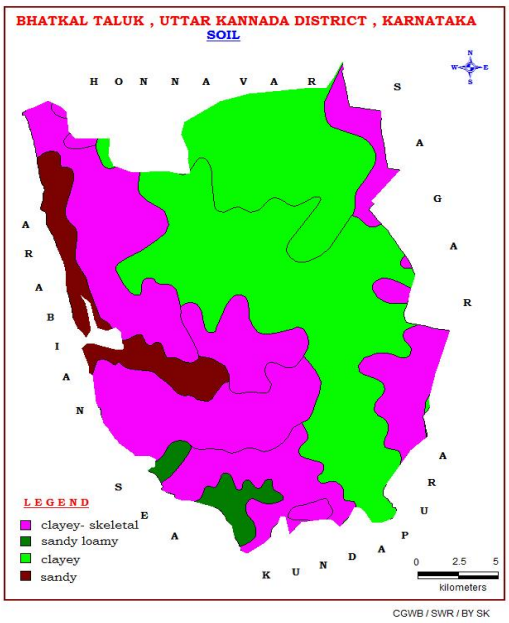


Fig-7: Soil Map

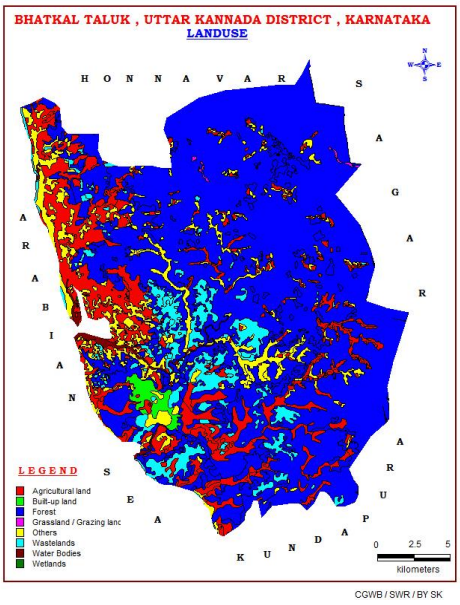


Fig-8: Land use Map

3. AQUIFER CHARACTERISATION

3.1 Ground Water level behavior

3.1.1 Depth to Water level (May 2022 & November 2022)

In (CGWB+SGWB) total 4+8=12 wells water level data have been taken as a representative monitoring station for both pre-monsoon and post monsoon of Aquifer-1 and Aquifer-II **(Table 6) in Fig.9**. In CGWB during pre-monsoon season water level ranges from 1.48 to 5.11mbgl in dug wells, in post monsoon season water level ranges from 3.3 to 5.56mbgl in dug wells. In SGWB during pre-monsoon season water level ranges from 0.55 to 3.60mbgl in dug wells and from 2.16-8.9mbgl in bore wells, in post monsoon season water level ranges from 1.35 to 6.60mbgl in dug wells and from 1.35 to 10mbgl in bore wells and the map shown in **Fig.10 & Fig.11.**

3.1.2 Seasonal Fluctuation (May 2022 to November 2022)

The seasonal Fluctuation of May 2022 to November 2022 is analysed, A comparison of water level shows that a rise in the water level is recorded in 0% of wells analysed, while 100% recorded fall and the maps shown in **Fig.12**.

3.1.3 Annual Fluctuation (May 2021 to May 2022 & November 2021 to November 2022)

The Annual Fluctuation of Pre-monsoon May 2022 to May 2021 (Average of May 2015 to May 2019) is analysed, A comparison of water level shows that a rise in the water level is recorded in 89% of wells analysed, while 11% recorded Fall. In post monsoon, November 2022 to November 2021 a comparison of water level shows that a rise in the water level is recorded in 0% of wells analysed, while 100% recorded fall and the maps shown in **Fig.13 & Fig.14.**

3.1.4 Decadal Mean Fluctuation (Pre and Post monsoon 2012-2021 to 2022)

The Decadal mean fluctuation 2012-2021 with respect to 2022 of Pre-monsoon is analysed, A comparison of water level shows that a rise in the water level is recorded in 11% of wells analysed, while 89% recorded Fall. In post monsoon, a comparison of water level shows that a rise in the water level is recorded in 0% of wells analysed, while 100% recorded fall and the maps shown in **Fig.15 & Fig.16.**

Table-6: Depth to Water level in BHATKAL Taluk.

	CGWB				SGWB			
	Pre-monsoon 2022		Post-monsoon 2022		Pre-monsoon 2022		Post-monsoon 2022	
	Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Range	1.48-5.11	-	3.3-5.56	-	0.55-3.60	2.16-8.9	1.35-6.60	1.35-10
Average	3.45	-	4.46	-	2.66	5.53	4.26	5.68

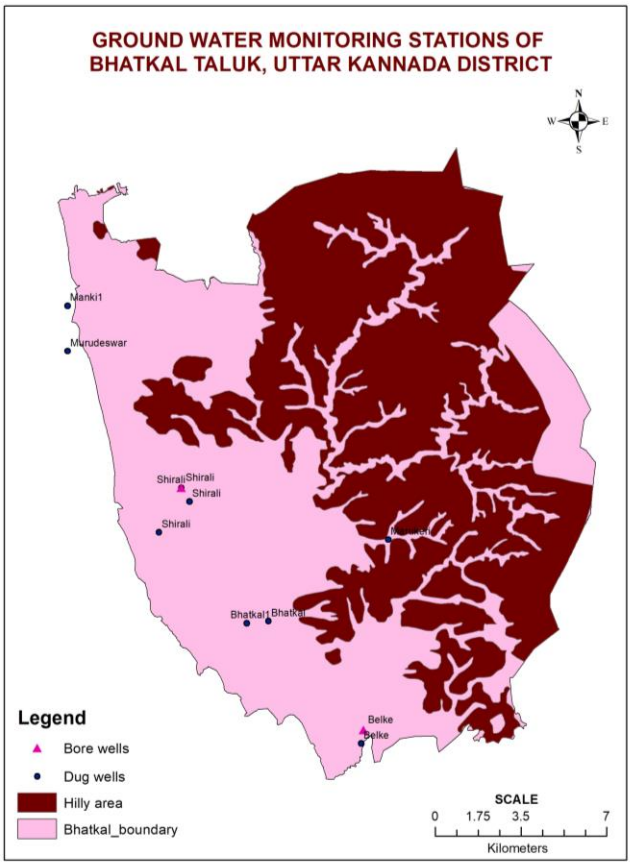
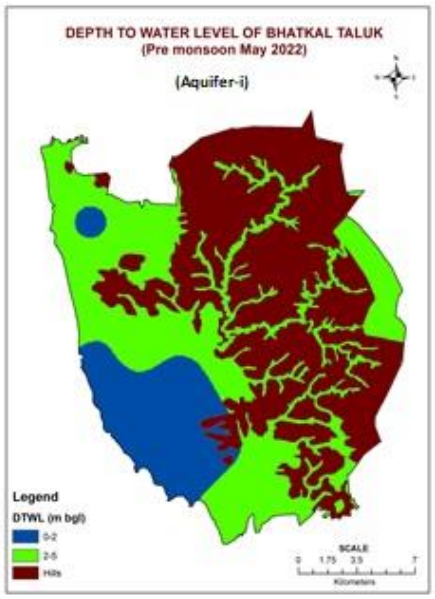


Fig-9: Groundwater monitoring stations of BHATKAL Taluk



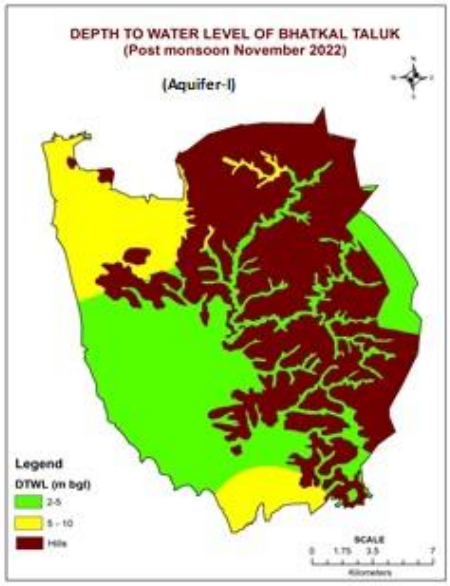


Fig-10: Pre-monsoon Depth to Water Level

Fig-11: Post-monsoon Depth to Water Level

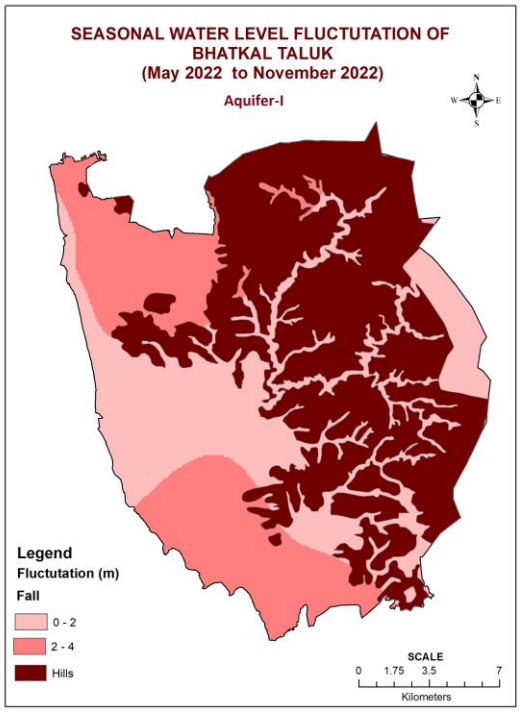


Fig-12: Seasonal Fluctuation of BHATKAL Taluk (May 2022 - November 2022)

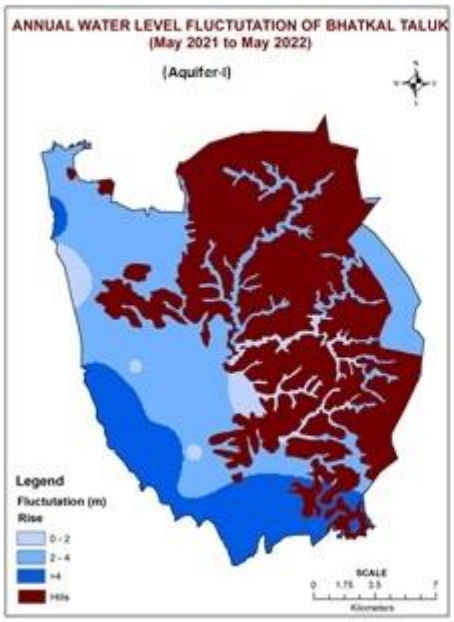


Fig-13: Annual Fluctuation of BHATKAL Taluk (May 2021 to May 2022)

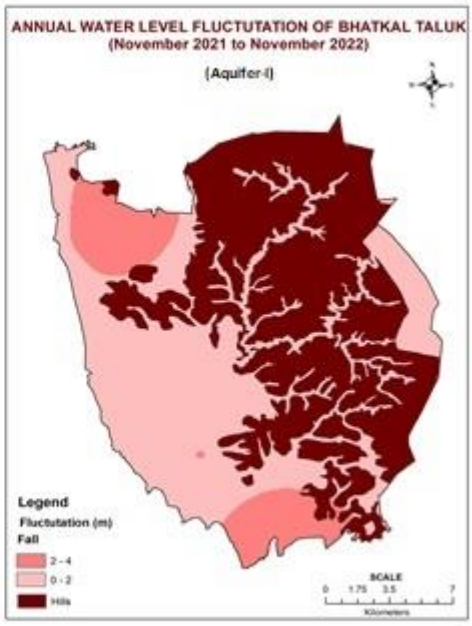


Fig-14: Annual Fluctuation of BHATKAL Taluk (Nov 2021 to Nov 2022)

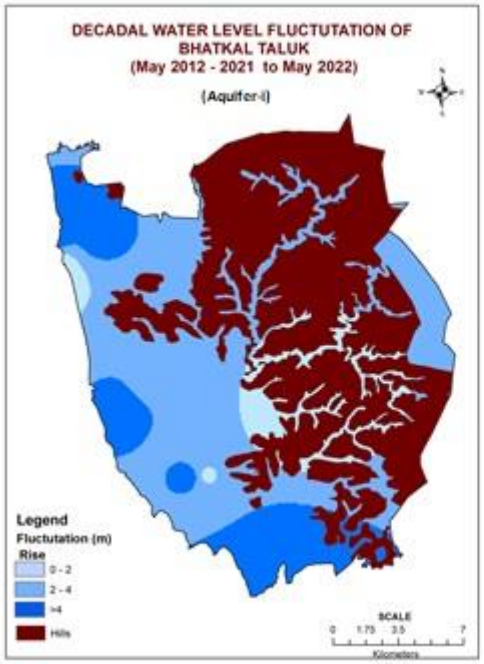


Fig-15: Decadal Mean Fluctuation of BHATKAL Taluk (May 2012–2021 to May 2022)

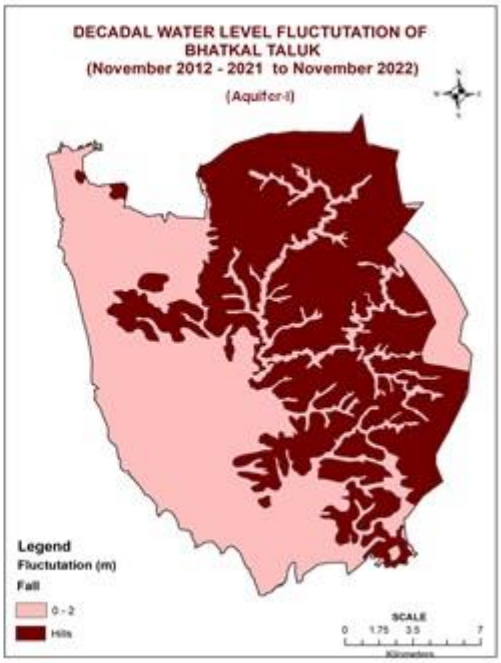


Fig-16: Decadal Mean Fluctuation of BHATKAL Taluk (Nov 2012 – 2021 to Nov 2022)

3.2. AQUIFER DISPOSITION & GEOMETRY

The occurrence and movement of water in the subsurface is broadly governed by geological frameworks i.e., nature of rock formations including their porosity (primary and secondary) and permeability. The principal aquifers in the area are Gneisses and Schist and the occurrence and movement of ground water in these rocks is controlled by various factors and it primarily depends on the degree of interconnection of secondary pores/voids developed by fracturing and weathering in the hard rock.

Aquifer Types

In BHATKAL taluk, there are mainly two types of aquifer systems

- Aquifer-I (Phreatic aquifer) comprising Granitic gneisses with occasional laterite capping and unconsolidated river and marine sediments.
- Aquifer-II (Fractured aquifer) comprising fracture Granitic gneisses with occasional laterite capping and unconsolidated river and marine sediments.

In Bhatkal taluk, the rock groups of metamorphic, residual capping and volcanics and metavolcanics are found with the yield range of <1, 1 to 3 and >3 lps and EC contour distribution of <750 is shown in **(Fig-17).** Ground water occurs within the weathered and fractured Schist, Granite and Granitic gneiss under water table condition and semi-confined condition. In Bhatkal taluk bore wells were drilled from a minimum depth of 70m to a maximum of 200m. Depth of weathered zone ranges from 10mbgl to 90mbgl. Ground water exploration reveals that aquifer-II fractured formation was encountered between the depths of 24 to 345mbgl. Yield ranges from 0.06 to 6.05lps. The Fracture analysis has done, 84% of fractures are falling in 0 to 50m depth and 32% of fractures falling in 50-100m depth and 11% of fractures falling in 100-150m depth it is shown in **Fig.18**. The basic characteristics of each aquifer are summarized **Table-7.** The 3D aquifer disposition models, 2D aquifer sections and 3D aquifer fence diagrams have been prepared and presented in **Fig. 19a, b and c.**

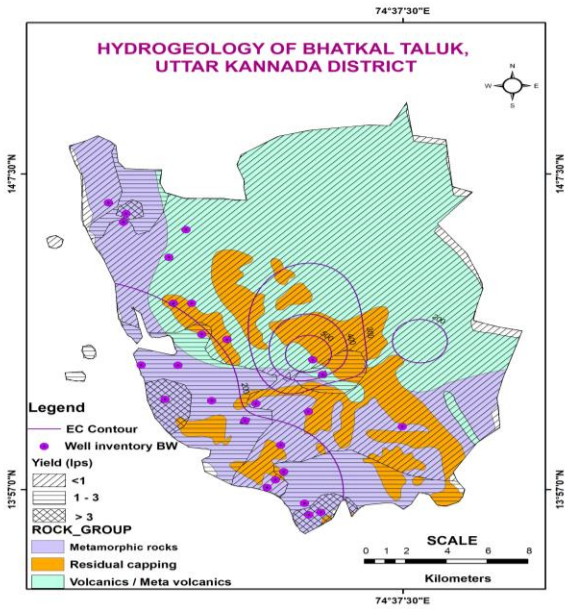


Fig.17: Hydrogeology of Bhatkal Taluk

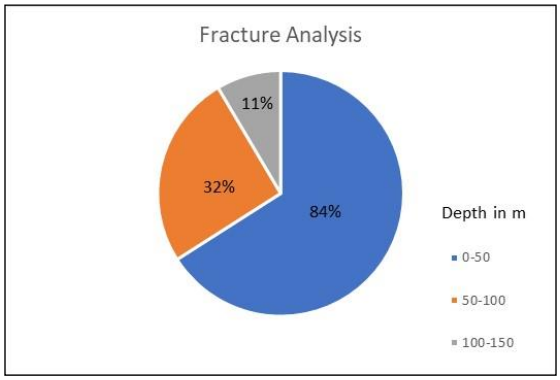


Fig.18: Fractures Analysis of BHATKAL taluk

Table-7: Basic characteristics of Aquifer

Aquifers	Fractured Zone (Aq.-II)
Prominent Lithology	Fractured gneiss
Depth range	70 to 500mbgl
Weathered Thickness range(mbgl)	10 to 90mbgl
Depth range of occurrence of fractures (mbgl)	24-345
Range of yield potential (lps)	0.06 – 6.05

3D Aquifer disposition, Aquifer Fence Diagram and 2D Cross-Sections

2D & 3D aquifer disposition models of the aquifer system have been deciphered by using ROCKWORKS software and 2D cross section have been generated along different directions of Bhatkal taluk. All such 2D cross sections were verified and the model was calibrated to bring out the 3D aquifer disposition of the aquifer system. The type cross sections generated in different direction of the aquifer system are presented in **Fig.19a** and 3D aquifer disposition in **Fig.19b** fence diagram **in Fig.19c.**

Hydrogeological cross section A-A' (Fig.-) represents North eastern – southern direction and data of 8 exploratory wells has been utilised. It can be clearly seen from the North eastern to south eastern part i.e., from Mavalli to Gorte, the thickness of Aquifer-II (deeper aquifer) is high in mavalli and it is gradually decreasing towards Gorte and in Shirali it shows more thickness. The maximum depth of Aquifer-II is attained at Mavalli Village. On the contrary, the thickness of Aquifer-I (shallow aquifer) is constant from North to South part. In the next cross section, it represents the West-East direction and data of 5 exploratory wells has been utilised. From Western part the thickness of Aquifer-II is gradually increasing towards east and it shows maximum depth at Konar and the thickness of Aquifer-I is same as it as from Hebli to Konar.

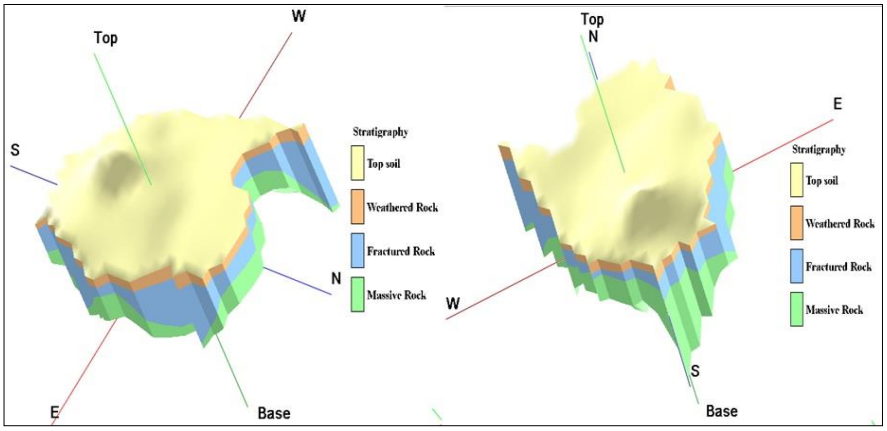


Fig-19a: 3D Aquifer Dispositions

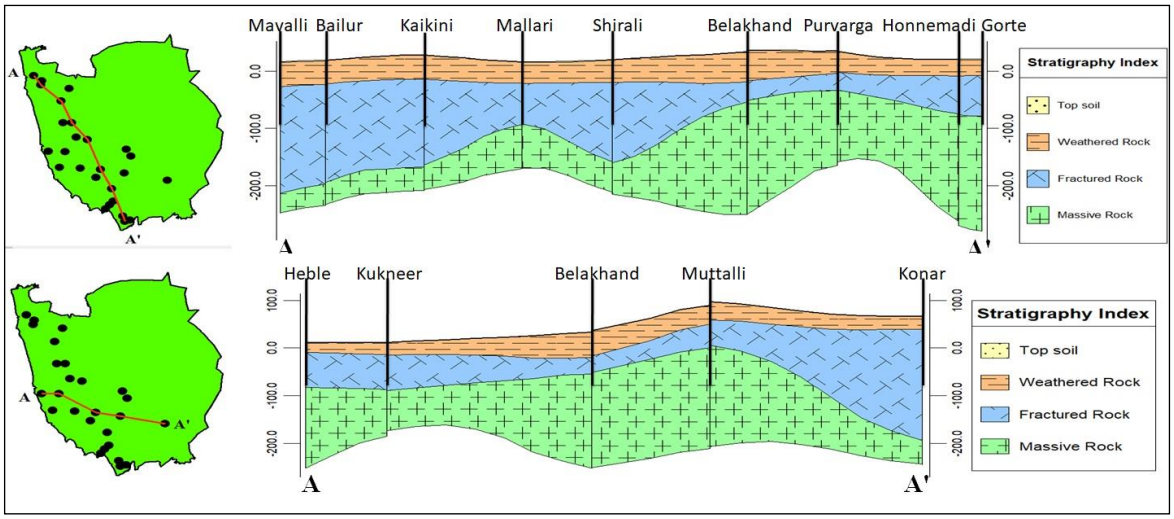


Fig-19b: 2D Cross sections in different direction

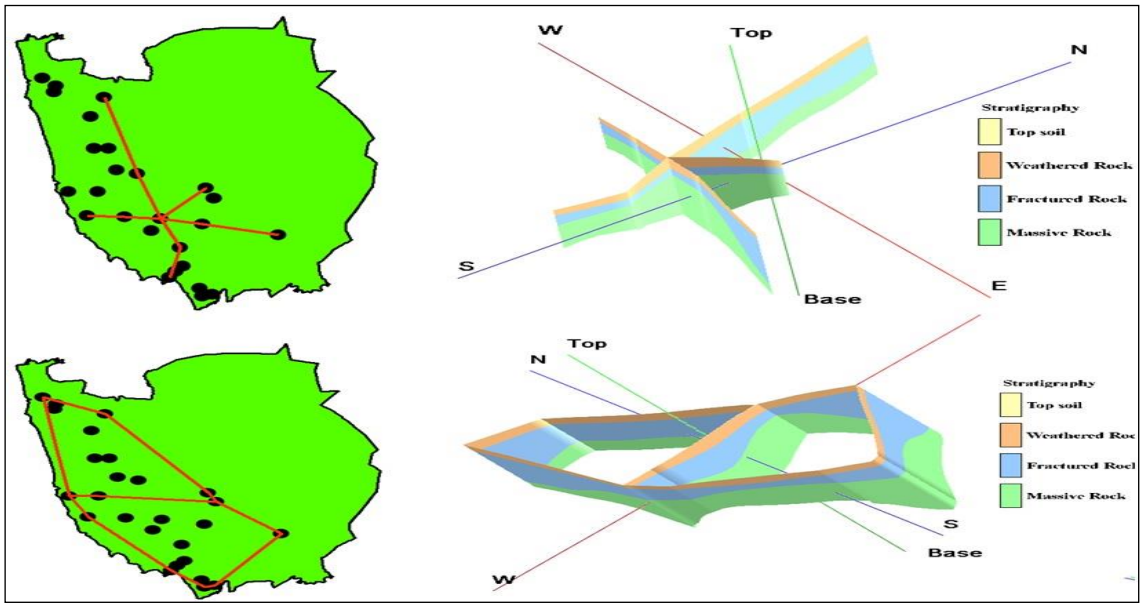


Fig-19c: 3D Aquifer Fence Diagram

3.2.1 Depth wise Aquifer System

The data generated from ground water monitoring wells, micro level hydrogeological inventories exploratory and observation wells, various thematic layers was utilized to decipher the aquifer disposition of the area. In the Taluk, if we consider the vertical distribution of aquifer, two types of aquifer system are observed i.e., Aquifer – I which is a shallow phreatic aquifer and Aquifer – II which constitutes the deeper fractured aquifer.

Aquifer-I (Shallow Phreatic aquifer)

Aquifer – I comprises of Laterite, schist and weathered Banded Gneissic Complex. The spatial distribution of depth of occurrence and aquifer thickness of Aquifer-I is depicted in **Fig. 19d**. It indicates that the depth of occurrence of aquifer – I ranges from 2 to 90 m bgl. However, it mainly occurs in the depth range of 20 to 50 m bgl covering 80% all over parts of the Taluk. The depth of occurrence of 2 to 25m bgl is observed in patches of about 12% of area in the western part of the taluk. 25 to 50 m bgl is observed in 70% of the area throughout the Taluk. The depth of occurrence of 50 to 75 m bgl is observed in about 10% of the area in central parts of taluk. The deeper depth of occurrence of 75 to 90 m bgl is observed in about 8% of the area in central parts of the taluk. The perusal of the map for aquifer thickness indicates that it ranges from 1 to 15 m, however aquifer thickness of 1 to 5 m is observed in 40% of the area covering all over the parts of the taluk. The aquifer thickness of 5 to 10m is observed in about 50% of the area all over the parts of the taluk. The aquifer thickness of 10 to 15m is observed in about 10% of the area as a patch of southern and northern parts of the taluk

Aquifer-II (Deeper Fractured aquifer)

It comprises of fractured Banded Gneissic Complex and Schistose rock. The spatial distribution of depth of occurrence and aquifer thickness of Aquifer-II is depicted in **Fig. 19d**. It indicates that the depth of occurrence of aquifer – II ranges from 27 to 332 m bgl. However, it mainly occurs in the depth range of 50 to 120 m bgl covering 60% of the area throughout all the parts of the taluk. The depth of occurrence of 27 to 100 m bgl is observed in about 30% of area in all parts of the taluk. The depth of occurrence of 100 to 175 m bgl is observed in 40% in all parts of the taluk. The deeper depth of occurrence of 175 to 250 & 250 to 332 m bgl is observed in about 20% & 10% of area respectively in all over the parts of the taluk. The perusal of the map for fractured aquifer thickness indicates that it ranges from 2 to 14 m, however aquifer thickness of 2 to 6 m is observed in 20% of the area covering western and northern parts of the taluk. The aquifer thickness of 6 to 10 m is observed in 70% of the area covering all parts of the taluk. 10 to 14 m thickness is observed in 10% of the area in southern parts of the taluk.

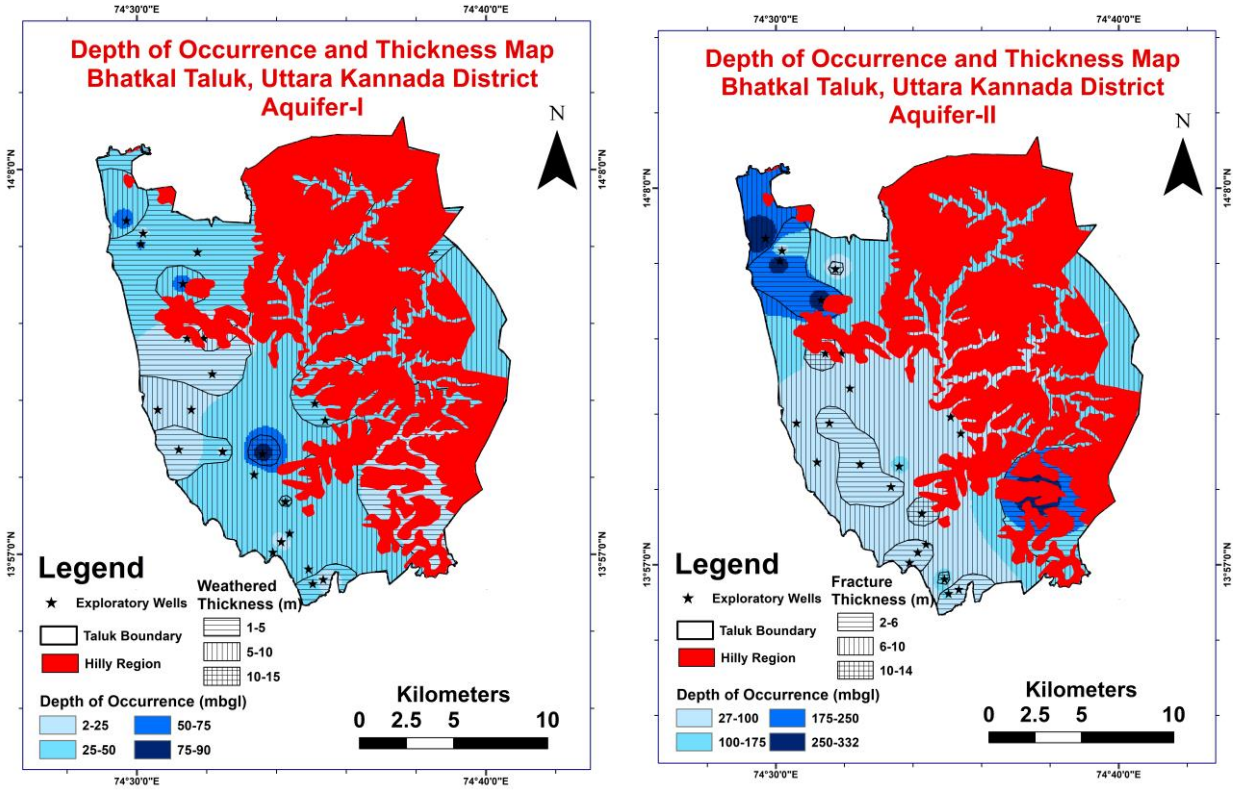


Fig.19d: Depth of occurrence and weathered thickness map of Aquifer-I and Aquifer-II.

3.3. GROUND WATER QUALITY

Interpretation from Chemical Analysis results in BHATKAL taluk (Aquifer.1) is mentioned below: In general, all the water quality parameters are within the permissible limit in the taluk.

- **ELECTRICAL CONDUCTIVITY:** In general, EC values range from 60 to 590 µ/mhos/cm in the aquifer-I at 25^{o}C **(Fig-20)**
- **NITRATE:** Nitrate concentration in ground water ranges from 3.45 to 29.71mg/l in the Aquifer –I (Fig-11) In Kollur village Nitrate value is slightly beyond the permissible limit. **(Fig-20)**
- **FLUORIDE:** Fluoride concentration in ground water ranges between 0.005 to 0.52 mg/l in the aquifer-I **(Fig-20)**
- **CHLORIDE:** Fluoride concentration in ground water ranges between 7 to 96 mg/l in the aquifer-I **(Fig-20)**

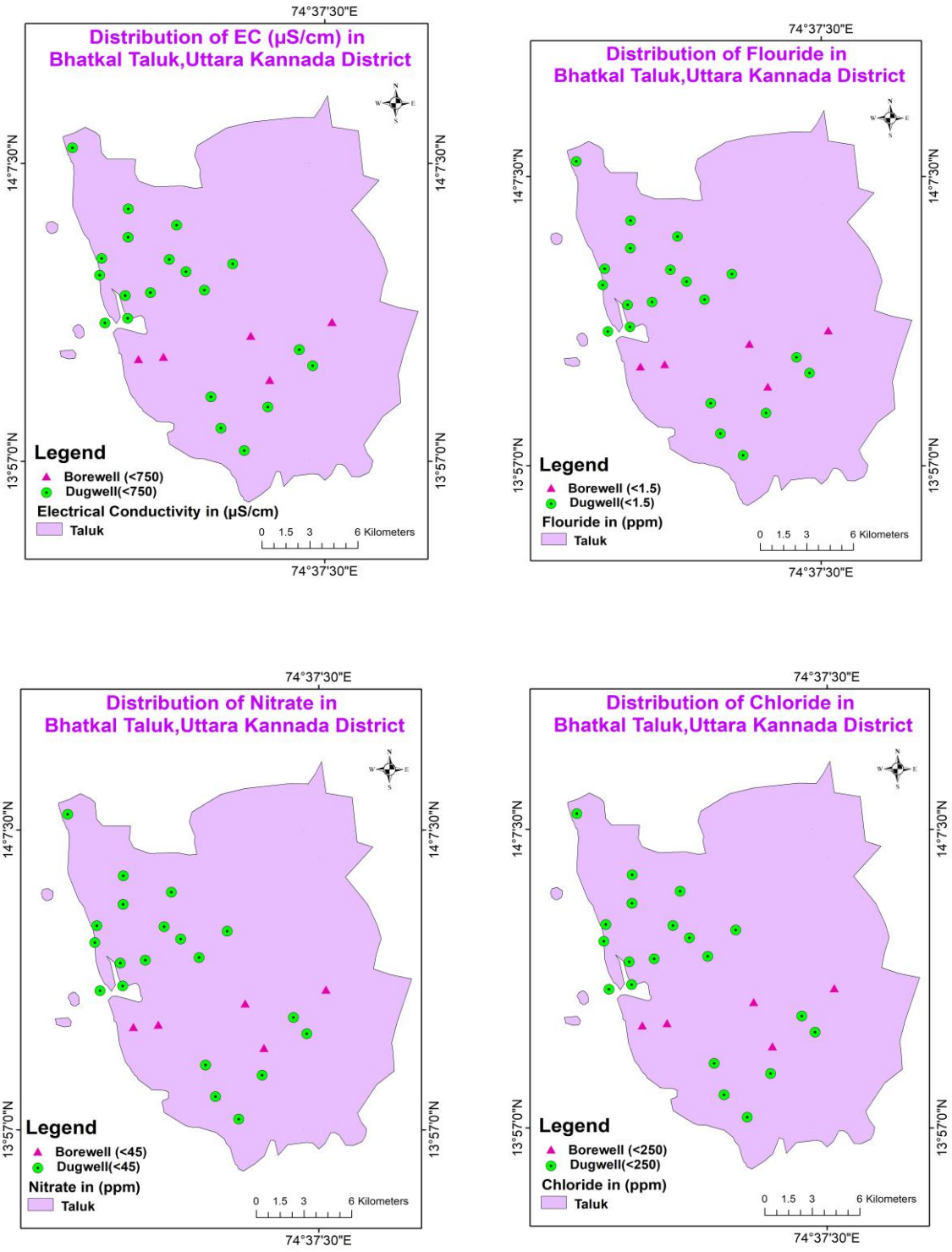


Figure-19. Groundwater Quality Maps

Interpretation from Chemical Analysis result in BHATKAL taluk (Aquifer-II) basic parameters is mentioned below in Table.8: In general, all the water quality parameters are within the permissible limit in the taluk.

- **ELECTRICAL CONDUCTIVITY:** EC values range from 130 to 590 µ/mhos/cm in the Aquifer-II. **(Fig-20)**
- **NITRATE:** Nitrate concentration in ground water ranges from 0.11 and 3.04mg/l in Aquifer-II. **(Fig-20)**
- **FLUORIDE:** Fluoride concentration in ground water ranges between 0.01 and 0.18 mg/l in the Aquifer-II. **(Fig-20)**
- **CHLORIDE:** Chloride concentration in ground water ranges between 7 and 96 mg/l in the Aquifer-II. **(Fig-20)**

Table.8. Water quality data of BHATKAL Taluk, UTTAR KANNADA District (Aquifer.II)

S.No	SITE_NAME	LAT	LONG	EC	Cl	NO3	F
1	Belke	13.95624	74.57986	80	11	2.37	0.033
2	Hadin	13.96932	74.56682	100	14	0.37	0.022
3	Bhatkal	13.98775	74.56123	210	11	1.28	0.046
4	Marukere	14.01542	74.61091	140	14	2.61	0.02
5	Bilurmane	14.00595	74.61844	120	14	3.69	0.014
6	Hargimakki	13.98175	74.59312	120	11	1.83	0.011
7	Bengre	14.04717	74.51294	90	7	1.73	0.009
8	Shiradi	14.0489	74.5271	100	11	1.63	0.007
9	Heggadde	14.06588	74.57344	60	7	0.62	0.009
10	Katugarkeppa	14.0504	74.55752	100	11	4.67	0.009
11	Byatugur	14.06129	74.54714	90	11	1.85	0.009
12	Abbere	14.06844	74.53775	110	11	1.31	0.005
13	Meedlu	14.08855	74.54193	60	7	0.4	0.52
14	Mavalli	14.09819	74.51471	80	11	1.12	0.013
15	Murudeshwar1	14.08153	74.51454	60	7	0.05	0.02
16	Sabbathe 2	14.06903	74.49968	140	21	1.26	0.017
17	Murudeshwar2	14.05925	74.49856	440	39	6.61	0.066
18	Gudumundarki	14.03106	74.5016	250	46	1.83	0.027
19	Alvekodi	14.03106	74.5016	460	28	11.24	0.038
20	Tattihakkal	14.03177	74.51841	310	35	14.13	0.022
21	Bhatkal Baindur	13.98775	74.56123	210	18	2.23	0.01
22	Murudeshwar3	14.08153	74.51454	230	32	18.97	0.011
23	Bailur	14.13399	74.4833	340	32	10	0.013
24	Hadin	13.96992	74.5671	130	14	0.48	0.063
25	Kitre	14.02365	74.58357	590	96	0.89	0.18
26	sabbatte1	13.99775	74.59418	200	11	0.36	0.034
27	Haduvalli	14.03182	74.62924	180	7	0.11	0.022
28	Bhatkal	14.01142	74.5344	130	18	3.04	0.01
29	T jali	14.01001	74.52041	130	14	0.2	0.014

4. GROUND WATER RESOURCES

The dynamic groundwater resources have been estimated as on 2022 based on the methodology suggested by Ground Water Estimation Committee (GEC) 2015. The groundwater recharge is calculated both by groundwater fluctuation-specific yield method and by rainfall infiltration method. The annual replenishable groundwater recharge is the summation of four components viz.,

i) Monsoon recharge due to rainfall

ii) Monsoon recharge from other sources

iii) Non-monsoon recharge due to rainfall

iv) Non-monsoon recharge due to other sources

Taluk wise dynamic groundwater resources have been taken from the approved resources estimation done as on March 2022, jointly by Ground Water Directorate of Karnataka and CGWB, to arrive at the total resources available in BHATKAL taluk.

4.1. Aquifer wise resource availability and extraction-

The net groundwater availability refers to the available annual recharge after allowing for natural discharge in the monsoon season in terms of base flow and subsurface inflow/outflow. This annual groundwater potential includes the existing groundwater withdrawal, natural discharge due to base flow and subsurface inflow/ outflow in the monsoon season and availability for future development. As the groundwater development progresses the natural discharge gets suitably modified and comes down to negligible quantities due to interception by different groundwater structures. Hence, natural discharges in the monsoon season may notbe considered and the total annual groundwater recharge may be taken as net groundwater availability.

As per ground water estimation 2022, the annual ground water availability in BHATKAL taluk is **3871.49**Ham. The existing gross ground water draft for irrigation is **798.42** Ham and the draft for domestic use is **342.98**Ham**.** The ground water draft for industrial is **7.185**. Thus, the total ground water draft for all uses amounts to **1148.58** Ham **(Table.9).** The comparison of resource estimation from 2020 to 2022 is shown in **(Table.10).**

Allocation for domestic and industrial water supply for next 25 years is **352.74** Ham. The net ground water availability for future irrigation development is **1713.16** Ham. The existing stage of ground water development is **29.8 %** and the taluk is categorized as **'Safe'.**

Table-9: Dynamic Ground water Resources of BHATKAL Taluk (2022)

S No.	District	Taluk	ANNUAL EXTRACTABLE GROUND WATER RESOURCES	EXISTING GROSS GROUND WATER EXTRACTION FOR IRRIGATION	EXISTING GROSS GROUND WATER EXTRACTION FOR DOMESTIC AND INDUSTRIAL WATER SUPPLY	EXISTING GROSS GROUND WATER EXTRACTION FOR ALL USES	ALLOCATION FOR DOMESTIC AND INDUSTRIAL USE FOR NEXT 25 YEARS	NET GROUND WATER AVAILABILITY FOR FUTURE IRRIGATION DEVELOPMENT	STAGE OF GROUND WATER EXTRACTION %	CATEGORY
1	Karwar	Bhatkal	3871.49	798.42	350.173	1148.58	352.74	1713.16	39.9	SAFE

Table-10: Comparison of GEC 2020 with 2022

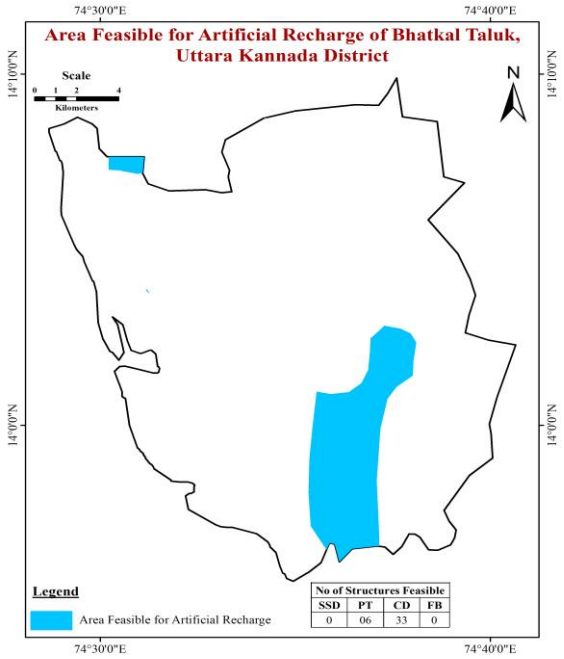
GWRA 2022				GWRA 2020			
Annual Extractable Ground Water Resource	Total Extraction	Stage of Ground Water Extraction (%)	Category	Annual Extractable Ground Water Resource	Total Extraction	Stage of Ground Water Extraction (%)	Category
3871.41	1148.58	39.9	SAFE	3699.59	799.75	21.62	SAFE

From the above comparison, it is observed that the stage of ground water extraction is changed from 21.62% to 39.9% during the period from 2020 to 2022. The category occupied is 'SAFE'.

5. GROUND WATER RESOURCE ENHANCEMENT

5.1 Resource Enhancement by Supply Side Interventions

The Master Plan for Artificial recharge to ground water prepared by CGWB (2020) recommended to replenish the desaturated aquifer system, both phreatic & deeper **(Aquifer I & II)** in the taluk through construction of artificial recharge structures, viz; check dams, percolation tanks & Sub surface dykes (**Table.11**). As of now, recharging dried-up phreatic aquifer in the taluk, through construction of artificial recharge and watershed treatment structures has already been taken up by state Government agencies and is being implemented under MGNREGA. The choice of recharge structures should be site specific and such structures need to be constructed in areas already identified as feasible for artificial recharge. **(Fig.21a).** The tentative location of the recharge structures in Bhatkal taluk is shown in **Fig.21b.**The tentative list of the proposed Percolation tanks and Check dams are listed in **Annexure 1.**



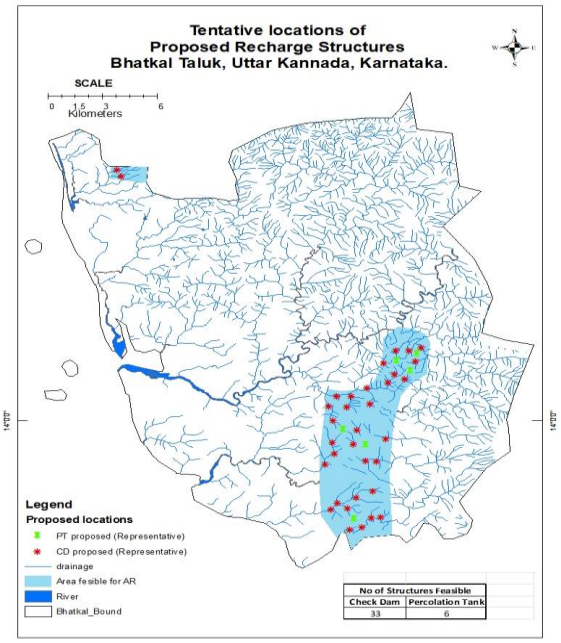


Fig-21a. Area feasible for Artificial Recharge structure **Fig-21b. Tentative locations for Artificial Recharge structure**

Table-11: Quantity of non-committed surface runoff & expected recharge through AR structures (CGWB Master plan 2020)

Details of Artificial Recharge structures in BHATKALTaluk		
S. No	**Artificial recharge structures available/proposed**	
1	Non committed monsoon runoff available in (MCM)	6.437
2	No of sub surface dykes	0
3	No of Check Dams	33
4	No of percolation tanks	6
5	Filter Beds	0
6	Tentative total cost of the project (Rs in lakhs)	452.635
7	Expected Recharge in (MCM)	4.828
8	Likely additional irrigation potential to be created (Lakh.Ha)	0.006

5.2. Resource Savings by Demand Side Interventions

The important crops grown are Paddy, Pulses, Vegetables, Arecanut, Coconut, Sugarcane and oil seeds etc. Ground water is the major source for irrigation. In view of this, Water Use Efficiency (**WUE**) practices like Drip needs to be strengthened to save irrigation water by way of precision farming mechanism. This ultimately enhances the area under irrigation potential.

Efficient irrigation practices like Drip irrigation and sprinkler have to be adopted by the farmers in the

existing 2599 ha of net irrigated area and 1465 ha of net irrigated area by wells & bore wells It is proposed to adopt micro irrigation (drip) techniques in fruits and vegetables (477.42 ha) and in oil seeds (185 ha). Implementation of efficient irrigation techniques will contribute in saving ground water by 346 ham. The details of the resource enhancement through artificial recharge in the taluk and also through Water Efficiency practices in Irrigation are shown in **Table.12 and Table.13.**

Table-12: Details of Resource enhancement after proposed artificial recharge structures.

Details of Resource enhancement after proposed artificial recharge structures of BHATKAL Taluk		
S. No	**Resource Details**	**As per 2020 Estimation**
1	Net Groundwater Availability in Ham	3871.41
2	Existing stage of Ground water development in %	39.9%
3	Existing Gross Groundwater Draft for all use in Ham	1148.58
4	Expected recharge from Artificial recharge projects Ham	482.8
5	Cumulative annual groundwater availability in Ham	4700.29
6	Saving due to adopting WUE measures	346
7	Expected improvement in stage of ground water development after implementation of project in %	24%
8	Expected improvement in overall stage of ground water development in %	15%

Table.13: Savings in Ground Water Utilization due to proposed Modifications in Cropping Pattern and Irrigation Practices in BHATKAL Taluk.

Sl. No.	Name of Crop	Existing Crop Area (ha)	Unit Crop Water Requirement (m)	Draft (ham)	Existing GW Draft (ha)	Proposed / Changed Crop Area (ha)	Changed Draft due to Modified Cropping Pattern (ha m)	Reduction in Draft due to Modified Cropping Pattern (ha m)	Area available for Alternate Crop (ha)
1	Paddy	2176	1.20	2611	2611	653	783	1828	1523
2	Jowar	0	0.00	0		0			
3	Bajra	0	0.00	0		797			
4	Maize	0	0.00	0		0			
5	Ragi	0	0.30	0	0	508	152	**-152**	-508
6	Wheat	0	0.00	0		63			-63

7	Other Cereals & Minor millets	0	0.00	0		34			-34
8	Pulses	10	0.00	0		7648			-7638
9	Sugarcane	14	0.00	0		0			14
10	Oil seeds	185	0.50	9	9	693	35	-25	-508
11	Total Fruits	471.21	0.50	24	24	2023			-1552
12	Total Vegetables	6.21	0.50	2	2	514	161	-159	-508
13	Arecanut	1286	0.60	0		1269			17.00
		4148.42		**2646**	**2646**	**14201.2**	**1131**	**1491**	**-9273**

Draft	**Ham**
Draft with existing Cropping Pattern:	**2646**
Saving due to Changed Cropping Pattern:	**1491**
Draft after Changed Cropping Pattern:	**1154**
Draft after adopting WUE measures:	**808**
Saving due to adopting WUE measures:	**346**
Total Saving:	**1838**
Savings in terms of %:	**69**

5.3 Ground Water Development Plan

In BHATKAL taluk, the present stage of ground water extraction (2022) is 39.9% with net ground water availability for future use is 1713.16 ham and total extraction is 1148.58 ham (2022). The ground water draft for irrigation purpose is 798.42 ham, thus indicating that ground water irrigation needs to be encouraged in the area after considering the “Safe” level of extraction, which can be implemented in scientific manner. The implementation of the plan needs to be based on site specific detailed hydrogeological, geophysical and scientific surveys for pinpointing the sites for construction of dug wells and bore wells.

As per the conservative estimate and after considering the average unit draft figure for the taluk, about 1057 dug wells (15-30 m depth; 3 to 5 m diameter) are recommended to be constructed in feasible areas. Further as per the estimate about 1 bore wells (40 to 100 m depth; 150 mm dia) are also recommended to be drilled in feasible areas so as to maintain the safe category of the taluk. The likely additional irrigation potential which can be created considering prevailing crop water requirement for the area is will be 1807ha**. (Table.14a, 14b)**

Table – 14 a: Feasibility of Additional GW abstraction structures based on GWRA 2022 availability

Balance GWR available to make SOE 60%	DW unit draft	BW unit draft	No. of DW feasible @ 99% with unit draft of 0.95 ham	No. of BWs feasible @ 1% with unit draft of 1 ham	Cost of Proposed DW's/year @ unit cost of Rs. 3 lakhs	Cost of Proposed BW's @ unit cost of Rs. 2 lakhs	Additional irrigation potential created considering crop water requirement of 0.65 m (Ha)	Additional irrigation potential created considering crop water requirement of 0.65 m (Ha)	Total irrigation potential created by DW's and BW's (ha)
1174.31	**1.1**	**13**	**1057**	**1**	**3171**	**2**	**1789**	**18**	**1807**

Table – 14 b: Ground Water Resource Development Plan as per GWRA 2020 availability

Items	Proposed Structures		Total
Present GW Availability is 50.30 MCM	**Dug wells – 1057**	**Bore well - 1**	**1058**
Present Gross Annual Extraction is 49.82 MCM	Depth: 15 to 30 m	Depth: 40 to 100 m	
Present Stage of GW Development is 29.8%	Dia: 3 to 5 m	Dia – 150 mm	
	Av. Annual Gross draft – 1.1ham	Av. Annual Gross draft - 1 3ham	
Additional irrigation potential created considering crop water requirement of 0.65 m (Ha)	**1789**	**18**	**1807**

Note- Hydrogeological and scientific intervention is needed for pinpointing the sites for construction of dugwells and Borewells

5.4 Regulation and Control

BHATKAL taluk has been categorized as **Safe**. However mandatory guideline issued by Government of Karnataka like rain water harvesting and Artificial recharge structures should be constructed. Ground water recharge component needs to be made mandatory in the non-command area of the taluk for further development of ground water.

5.5 Other interventions proposed

The ground water worthy areas such as topographic lows, valley portions low fluctuations zones should be developed with an adequate soil conservation measure to prevent the soil erosions.

1.Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.

2.Excess nitrate concentration is found in ground water samples require remedial measures viz.

- Dilution of nitrate rich ground water through artificial recharge & water conservation.
- Roof top rain water harvesting, Insitu Rainwater harvesting and dilution of contaminated water.

6. SUMARY OF MANAGEMENT PLANS

The summary of Management plan of BHATKAL taluk is given below.

- **Ground Water resource**: As per the resource estimation – 2022, BHATKAL taluk falls under Safe category with the stage of ground water extraction of 39.9%. However, there is need to formulate management strategy to tackle the water scarcity related issues in the taluk during the summer and scarcity of water during the future days.
- **Ground water resource enhancement**: Increase in agricultural activity, excessive ground water withdrawal, depletion of ground water levels, reduction in yield and ground water quality related issues etc., suggests the need for scientific ground water management, enhancement of storage capacity of the aquifers and protection of ground water quality.
    - **Quantity of water available through non-committed surface run-off:** The surplus non-committed monsoon run off is estimated to be approximately **6.437** MCM. This can be used to recharge the aquifer mainly through percolation tanks (about 6), check dams (about 33) per CGWB, 2020 figures.
- **Advanced irrigation practices:** In 477.72 Ha area micro irrigation practices are being adopted. The important crops grown are Paddy, Pulses, Fruits, Vegetables, Oil seeds, Arecanut, Coconut. In view of this, Water Use Efficiency (WUE) practices like Drip needs to be strengthened to save irrigation water by way of precision farming mechanism. This ultimately enhances the area under irrigation potential.
- **De centralized Grey water treatments for upcycling of waste water**:

De- Centralized grey water ponds using NEERI technology / 5 pond technologies can be adopted for treatment of gray water from each village of or municipal waste water treatment for peri-urban agriculture. This treated water can be put in to use through micro irrigation techniques.

- **Ground Water Development Plan**: The stage of extraction is 39.9%, thus indicating that further scope of development exists in the area. The implementation of the plan needs to be based on site specific detailed hydrogeological, geophysical and scientific surveys for pinpointing the sites for construction of dug wells and bore wells. As per the conservative estimate and after considering the average unit draft figure for the taluk, about 1057 dug wells (15-30 m depth; 3 to 5 m diameter) are recommended to be constructed in feasible areas. Further as per the estimate about 1 bore well (40 to 100 m depth; 150 mm dia) are also recommended to be drilled in feasible areas so as to maintain the safe category of the taluk. The likely additional irrigation potential which can be created considering prevailing crop water requirement for the area is will be 1807 ha.
- **Drinking water Supply**: In view of ground water contamination with mainly higher concentration Nitrate and fluoride, drinking water supply from surface water needs to be explored/ ensured.

- **Regulation and Control**: Taluk is categorized as "Safe". However, the mandatory guidelines like rainwater harvesting and artificial recharge issued by Karnataka Ground Water Authority needs to be strictly implemented in the taluk, so that sustainable development of ground water is achieved.
- **Participatory management**: Awareness programmes and practice of participatory approach needs to be strengthened with the involvement of all the stake holders for sustainable management.
- **Water Linkages with other Activities:** Water sector has strong linkages with other developmental activities. Hence, the proposed management plans cannot be considered as static and needs to be reviewed and improved from time to time.
- **Other Management Options proposed:**
  - Scientific disposal of sewage water by the concerned agency
  - Periodical maintenance of artificial recharge structures is recommended for better recharge and long life of the structure.
  - Rooftop Rain Water Harvesting (RTRWH) from each building and in-situ storage and use /mixing with surface water supply or groundwater in urban areas.
  - Priority to promote recycle and reuse of grey water effectively in urban pockets.

Annexure 1:

A) Tentative Locations of Proposed Check dams, Bhatkal taluk

S.No	Longitude	Latitude	Villages
1	74.606999	13.946409	Belake
2	74.610864	13.951282	Belake
3	74.614690	13.951644	Belake
4	74.594215	13.955352	Belake
5	74.601039	13.956066	Belake
6	74.596842	13.958636	Belake
7	74.604580	13.961405	Belake
8	74.611379	13.964643	Belake
9	74.591715	13.978121	Hadila
10	74.612777	13.979628	Hadhalura
11	74.608436	13.979902	Hadhalura
12	74.595690	13.983329	Hadila
13	74.603228	13.988171	Konara
14	74.594822	13.988994	Hadila
15	74.616614	13.990684	Konara
16	74.604919	13.995344	Konara
17	74.595142	14.000141	Kotakanda
18	74.600807	14.006857	Kotakanda
19	74.593132	14.007222	Kotakanda
20	74.610309	14.008319	Marukeri
21	74.596649	14.012248	Kotakanda
22	74.602406	14.012339	Kotakanda
23	74.609076	14.016359	Marukeri
24	74.617482	14.019146	Marukeri
25	74.624609	14.020837	Marukeri
26	74.620223	14.023167	Marukeri
27	74.615789	14.028850	Marukeri
28	74.628931	14.029745	Hadavalli
29	74.626391	14.035091	Marthodi
30	74.620863	14.035228	Marthodi
31	74.631215	14.036598	Hadavalli
32	74.507975	14.122555	Byluru
33	74.506052	14.125682	Sulebeelu

(Source: Master Plan, CGWB, 2020. It is likely that the number of structures proposed may vary depending upon the ground truth verification and feasibility criteria)

B) Tentative Locations of Proposed Percolation Tanks, Bhatkal taluk

S.NO	Latitude	Longitude	Villages
1	13.950277	74.603690	Belake
2	13.987478	74.608412	Konara
3	13.995354	74.599274	Konara
4	14.024821	74.626914	Marukeri
5	14.029811	74.621222	Marukeri
6	14.033349	74.629426	Hadavalli

(Source: Master Plan, CGWB, 2020. It is likely that the number of structures proposed may vary depending upon the ground truth verification and feasibility criteria)