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

Kundapura Taluk, Udupi District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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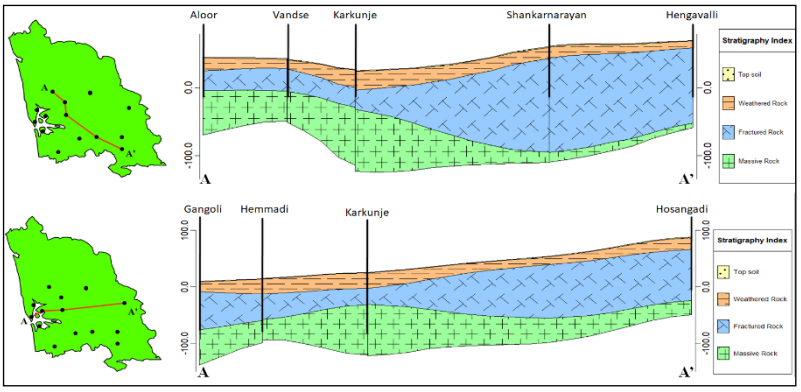
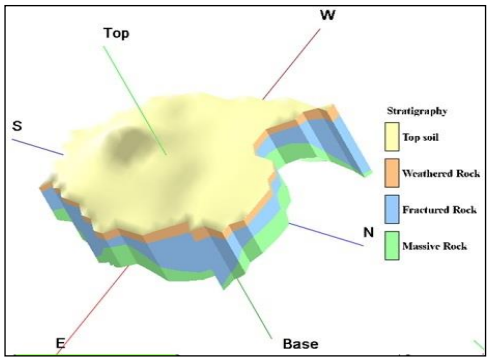
AQUIFER MAPPING AND MANAGEMENT PLAN OF KUNDAPURA TALUK, UDUPI DISTRICT, KARNATAKA

(AAP- 2022-2023)





By

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MAY 2023

AQUIFER MAPPING AND MANAGEMENT PLAN OF KUNDAPURA TALUK, UDUPI DISTRICT, KARNATAKA

Contents

AQUIFER MAPPING AND MANAGEMENT PLAN OF KUNDAPURA TALUK, UDUPI 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 todepletion 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 development activities 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 Kundapura taluk, Dharwad district with a view to formulate strategies for sustainable management plan for the aquifer system in accordance with thenature 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 programe 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: KUNDAPURA

District: Udupi

State: Karnataka Area: 1571 Sq.Kms.

Population: 3,98,471

Annual Normal Rainfall: 3925 mm

2.1. Study area

Aquifer Mapping Studies have been carried out in Kundapura taluk, Udupi district of Karnataka, covering an area of 1571sq.kms under National Aquifer Mapping Project. The Kundapura taluk is located between North Latitudes 74°46'37" and 13°32'25.92" and East Longitudes between 74° 39'55.86" to 13°58'20.58". The study area is bounded on the East by Hosanagara taluk of Shimoga District, on the North by Byndur Taluk of Udupi District, on the South by Bramhavara taluk of Udupi District, on the West by Bay of Bengal sea. Location map of Kundapura taluk of Udupi district is presented in **Fig-1**. Kundapura is taluk headquarters. There are 98 villages and 65 Gram panchayats in this taluk.

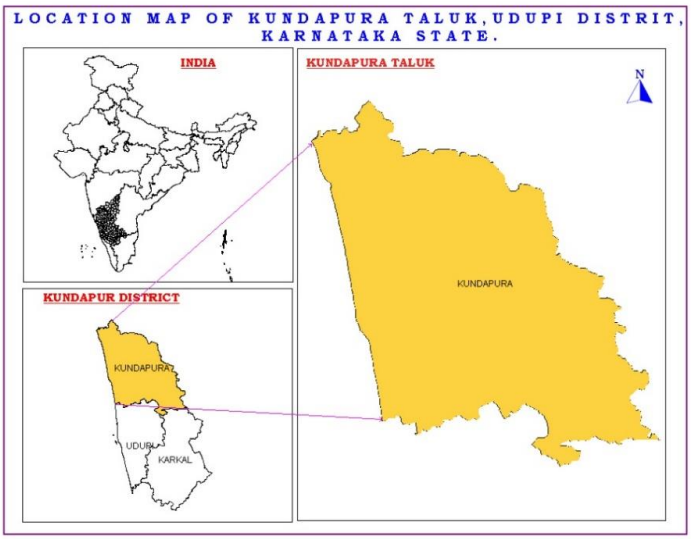

Fig. 1: Location Map

2.2. Population

According to 2011 census, the population in Kundapura taluk is 3,98,471, in which 1,87,586 male population and 2,10,885 is the female population. The taluk has an overall population density of 254 persons per Sq.Kms. The decadal variation in population from 2001-2011 is 5.58% in Kundapura taluk **(Table.1).**

Table-1: Population details of Kundapura Taluk, Udupi District

Total	Male	Female	Share of the district population	Rural population	Urban population	Decadal change in population	Decadal change in rural population	Decadal change in urban population
398471	187586	210885	-	357798	40673	5.58	2.57	42.26

Source: District at a Glance 2015-16, Govt. of Karnataka

2.3. Rainfall

Kundapura taluk experiences typical maritime climate. The normal annual rainfall in Kundapura taluk for the period 1951 to 1990 is 3925 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	4553	4756	5440	4013	5749	5176	5077	4283	4864	3909	3573

Source: District at a Glance 2015-16, Govt. of Karnataka

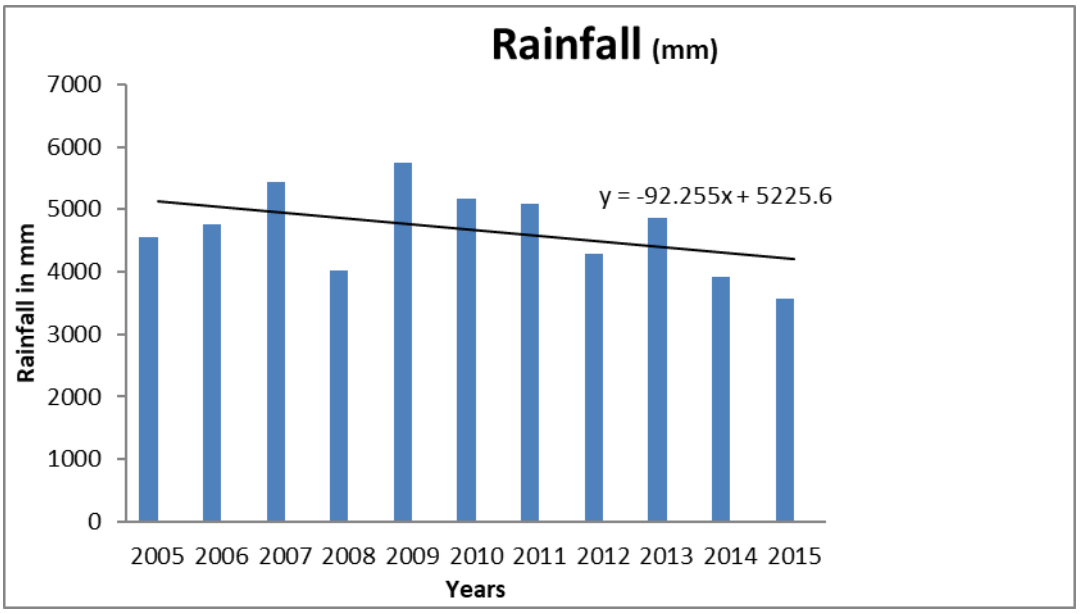

Fig. 2: Rainfall Trend Analysis

2.4. Agriculture & Irrigation

Agriculture is the main occupation in Kundapura taluk. More than 80% 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 over 75% 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 sugarcane, groundnut, paddy and cardamom is also grown in valley are grown in Kundapura Taluk **(Table 3).**

Table-3: Cropping pattern in Kundapura taluk

Principle crops grown in Kundapura Taluk

Crops	Cereals (Area in Ha)					Fruits (Area in Ha)	Veg (Area in Ha)	Oil seeds (Area in Ha)	Sugarcane
	Paddy	Maize	Green gram	Black gram	Cow pea			Groundnuts	
	20532	8	215	1489	22	10956	500	1374	16
Total	20540		1726			10956	500	1374	16
Sub Total	22266					10956	500	1374	16

Source: District at a glance 2015-2016

It is observed that net sown area accounts 41669 (Ha) and area sown more than once is 6163 (Ha) of total geographical area 156062 (Ha) in Kundapura taluk **(Table-4).** Area under Forest is 62605 (Ha) Area not available for cultivation and Fallow land cover 23469 (Ha) and 1370 (Ha) of total geographical area respectively. 371(Ha) of net area is irrigated from surface water and 12,563 (Ha) are irrigated from Groundwater **(Table-5).** Irrigation Vs Area analysis is shown **in Fig.3.**

Table-4: Details of land use in Kundapura Taluk

Landuse pattern of Kundapura 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
156062	62605	23469	26949	1370	41669	6163	47832

Source: District at a glance 2015-2016

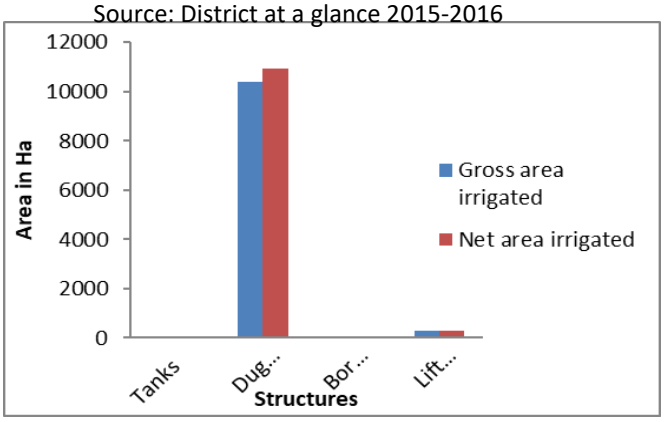

Fig-3: Irrigation Vs Area Analysis

Table-5: Irrigation details in Kundapura taluk

Details of irrigation in Kundapura Taluk

S.No	Source		No/Length	Net area irrigated	Gross area irrigated
1	Surface water	Tanks	30	86	86
		Lift irrigation	384	285	285
2	Ground water	Dug wells	10914	10374	10914
		Bore wells	25	25	25
3	Other sources	Other sources		1624	1864
		Total	-	12394	13174

Source: District at a glance 2015-2016

2.5. Geomorphology, Physiography & Drainage

The geomorphology of the Kundapura 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 river, it covers part of Mulki, Shirva, Swarna yennehole, Madisala, Sita, Haladi, Chakravani, Kollur, Baindur and 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 Kundapura taluk falls in varaha river basin. The Drainage pattern is dendritic to sub dendritic **(Fig.-5).**

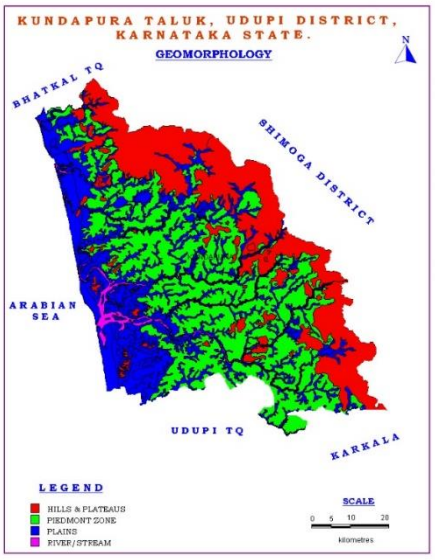

Fig-4: Geomorphology Map

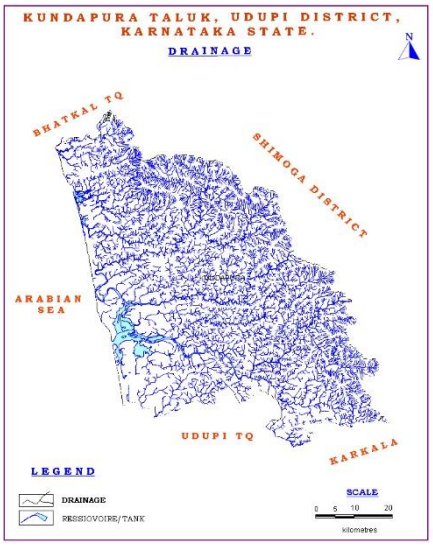

Fig-5: Drainage Map

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 6.00mbgl 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

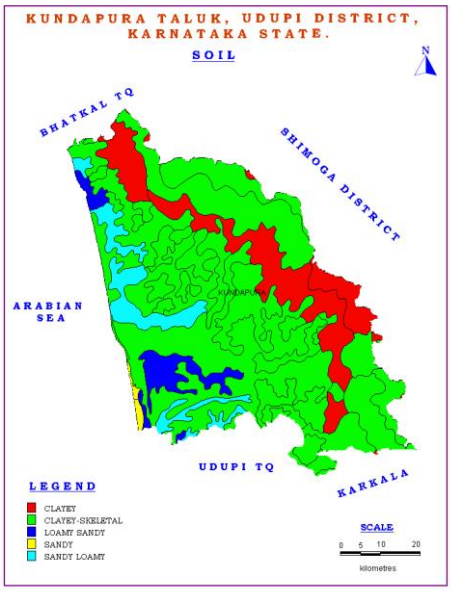

Fig-7: Soil Map

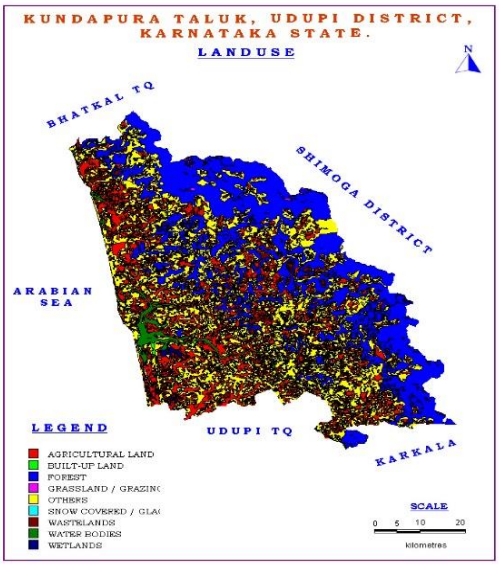

Fig-8: Land use Map

3. AQUIFER CHARACTERISATION

3.1 Ground Water level behavior

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

In (CGWB+SGWB) total 31+11=42 wells water level data have been taken as a representative monitoring stations 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 0.04 to 12.65mbgl in dug wells and 15.04 in bore well, In post monsoon season water level ranges from 0.4 to 12.8mbgl in dug wells and 12.12 in bore well. In SGWB during pre-monsoon season water level ranges from 2.62 to 10.35mbgl in dug wells and from 5.23 to 13.60 mbgl in bore wells, in post monsoon season water level ranges from 1.75 to 7.40mbgl in dug wells and from 5.16 to 13.12 mbgl in bore wells and the map shown in (**Fig's.10a, 10b Fig.11a, 11b)**

3.1.2 Seasonal Fluctuation (May 2022 to November 2022)

The seasonal Fluctuation of May 2022 to November 2022 is analysed, In Aquifer-I a comparison of water level shows that a rise in the water level is recorded in 69% of wells analysed, while 31% recorded fall and in Aquifer-II a comparison of water level shows that a rise in the water level is recorded in 100% of wells analysed, the maps shown in (**Fig.12a, b)**.

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, In Aquifer-I a comparison of water level shows that a rise in the water level is recorded in 77% of wells analysed, while 23% 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 10% of wells analysed, while 90% recorded fall, In Aquifer-II comparison of water level shows that a rise in the water level is recorded in 40% of wells analysed, while 60% recorded Fall. In post monsoon, November 2022 to November 2021 a comparison of water level shows that a fall in the water level is recorded 100%, the maps shown in (**Fig.13a, b & Fig.14a, b).**

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

The Decadal mean fluctuation 2012-2021 with respect to 2022 of Pre-monsoon is analysed, In Aquifer-I a comparison of water level shows that a rise in the water level is recorded in 87% of wells analysed, while 13% recorded Fall. In post monsoon, a comparison of water level shows that a rise in the water level is recorded in 13% of wells analysed, while 87% recorded fall and In Aquifer-II a comparison of water level shows that a rise in the water level is recorded in 80% of wells analysed, while 20% recorded Fall. In post monsoon, a comparison of water level shows that a fall in the water level is recorded in 100% recorded, the maps shown in (**Fig.15a, b & Fig.16a, b).**

Table-6: Depth to Water level in Kundapura 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	0.04-12.65	15.04	0.4-12.8	12.12	2.62-10.35	5.23-13.60	1.75-7.40	5.16-13.12
Average	6.62	15.04	5	12.12	5.81	8.88	4.69	9.08

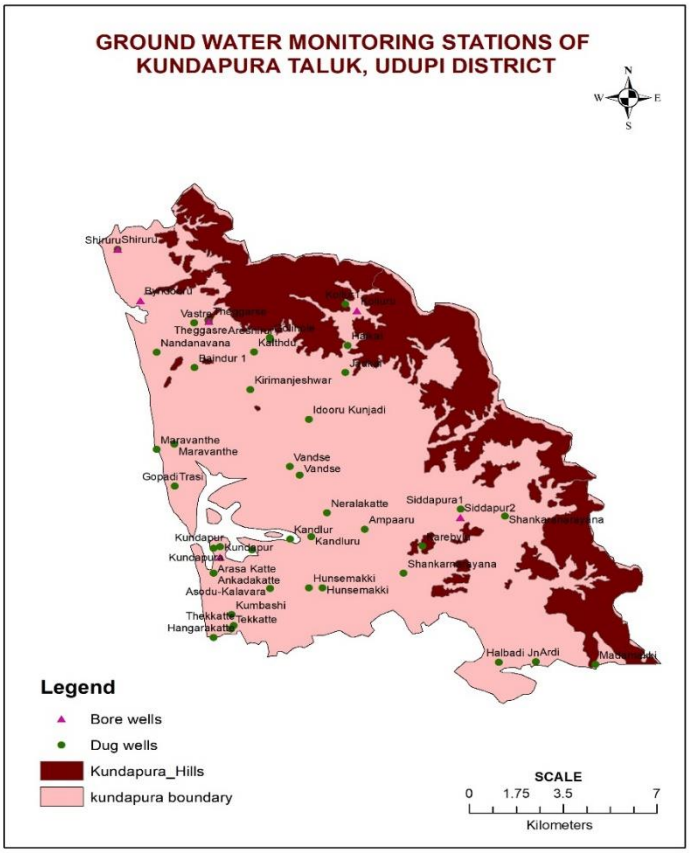

Fig-9: Groundwater monitoring stations of Kundapura Taluk

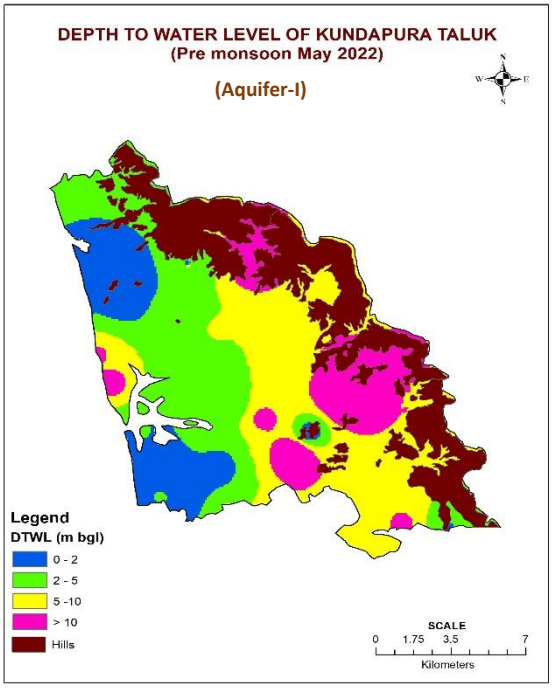

Fig-10a: Pre-monsoon Depth to Water Level (Aquifer-I)

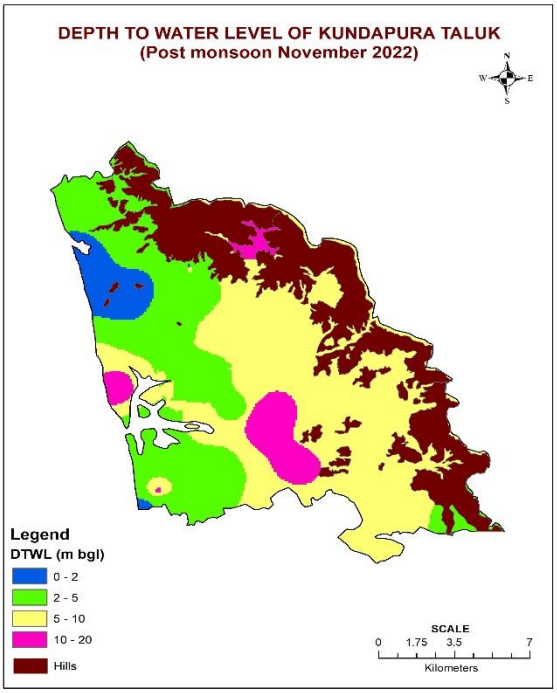

Fig-11a: Post-monsoon Depth to Water Level (Aquifer-I)

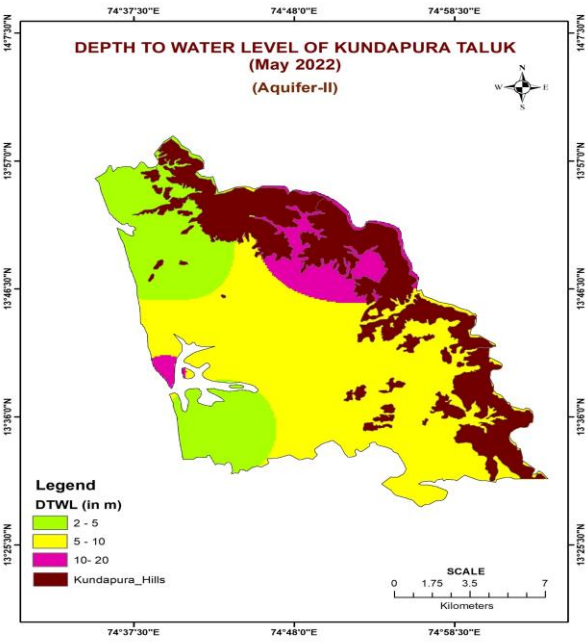

Fig-10b: Pre-monsoon Depth to Water Level (Aquifer-II)

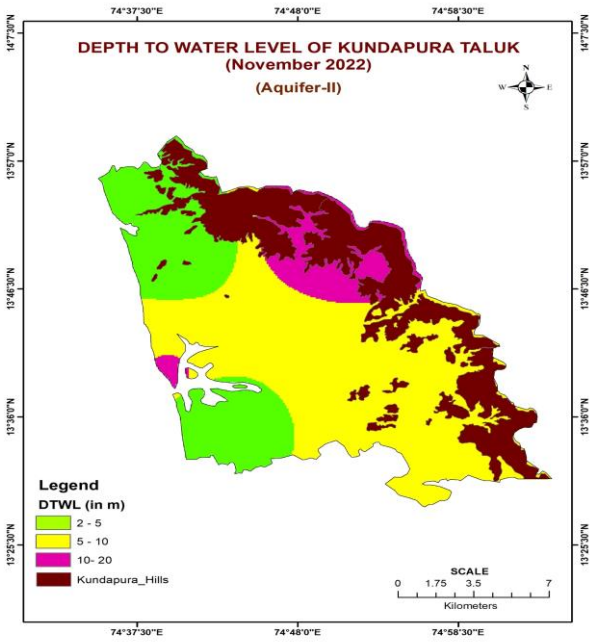

Fig-11b: Post-monsoon Depth to Water Level (Aquifer-II)

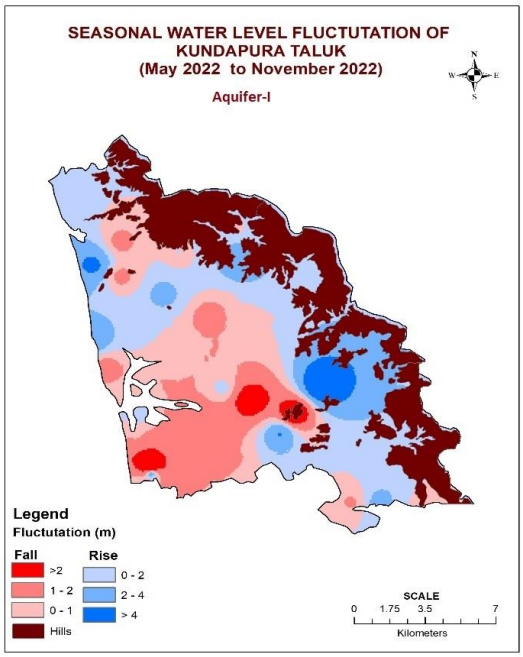

Fig-12a: Seasonal Fluctuation of Kundapura Taluk {Aquifer-I (May 2022 - November 2022)}

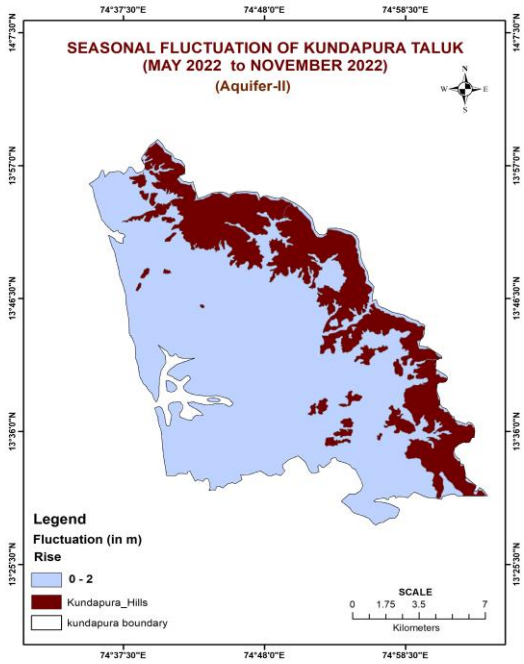

Fig-12b: Seasonal Fluctuation of Kundapura Taluk {Aquifer-II(May 2022 - November 2022)}

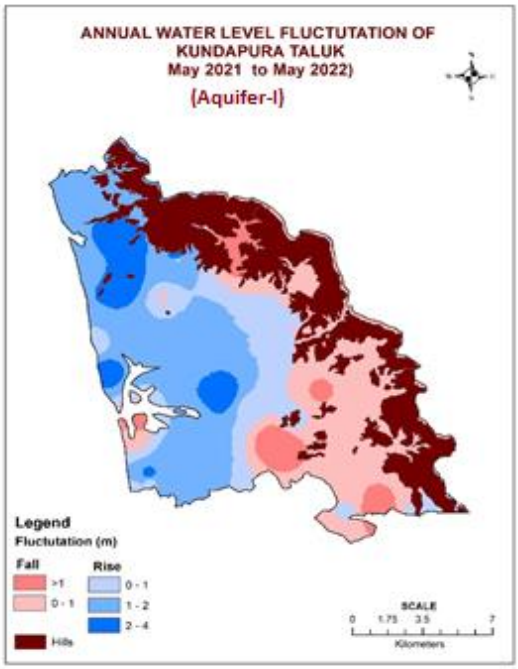

Fig-13a: Annual Fluctuation of Kundapura Taluk (Aquifer-I (May 2021 to May 2022)

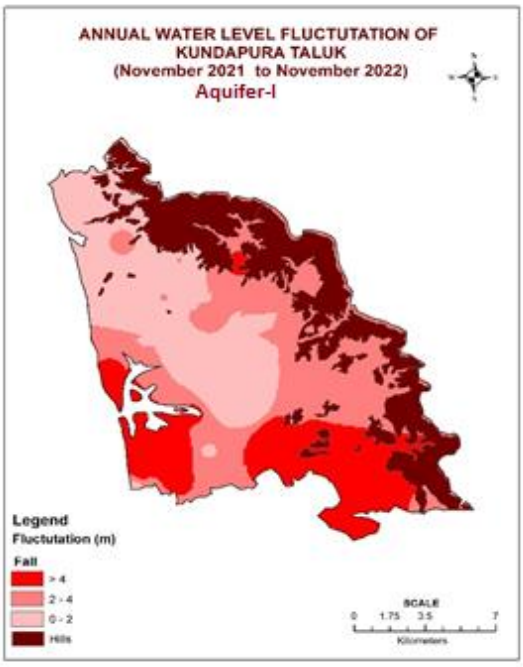

Fig-14a: Annual Fluctuation of Kundapura Taluk (Aquifer-I(Nov 2021 to Nov 2022)

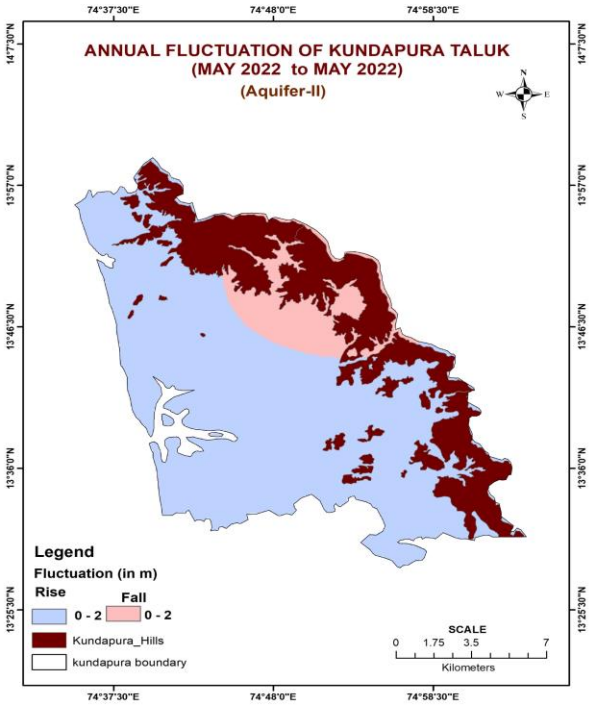

Fig-13b: Annual Fluctuation of Kundapura Taluk (Aquifer-II (May 2021 to May 2022)

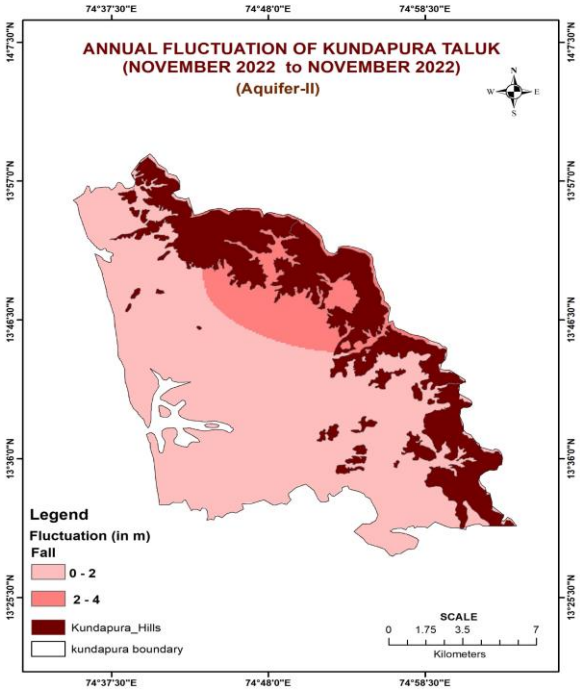

Fig-14b: Annual Fluctuation of Kundapura Taluk (Aquifer-II(Nov 2021 to Nov 2022)

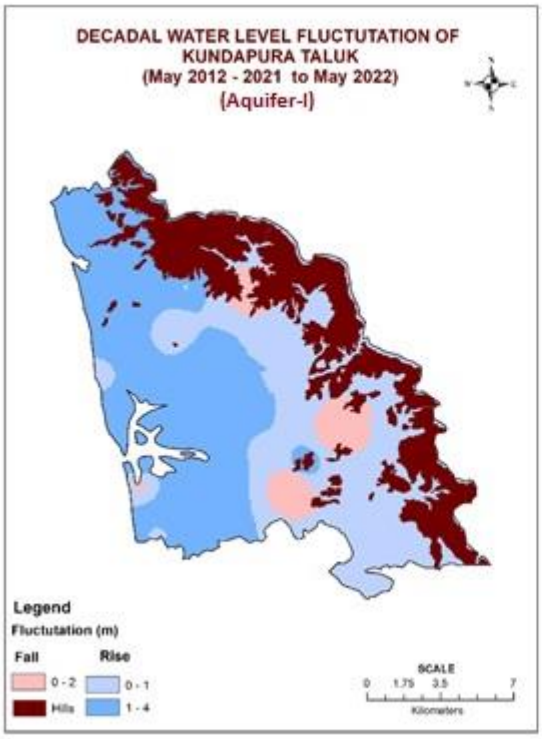

Fig-15a: Decadal Mean Fluctuation of Kundapura Taluk (Aquifer-I (May 2012–2021 to May 2022)

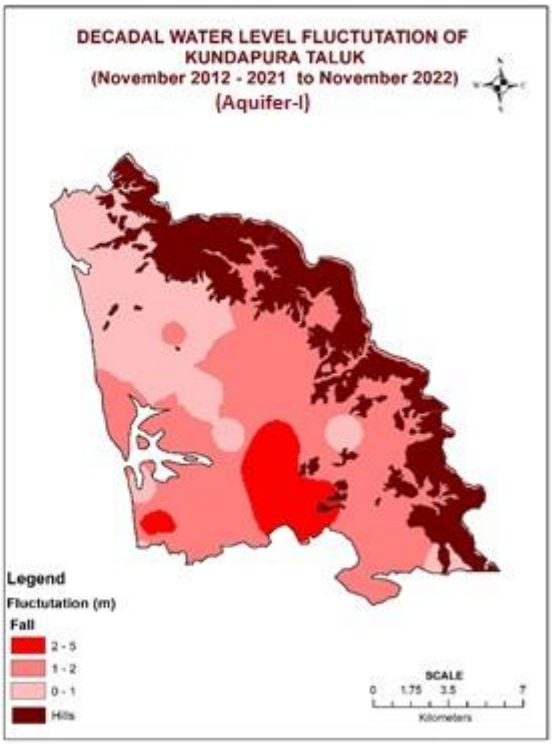

Fig-16a: Decadal Mean Fluctuation of Kundapura Taluk (Aquifer-I (Nov 2012 – 2021 to Nov 2022)

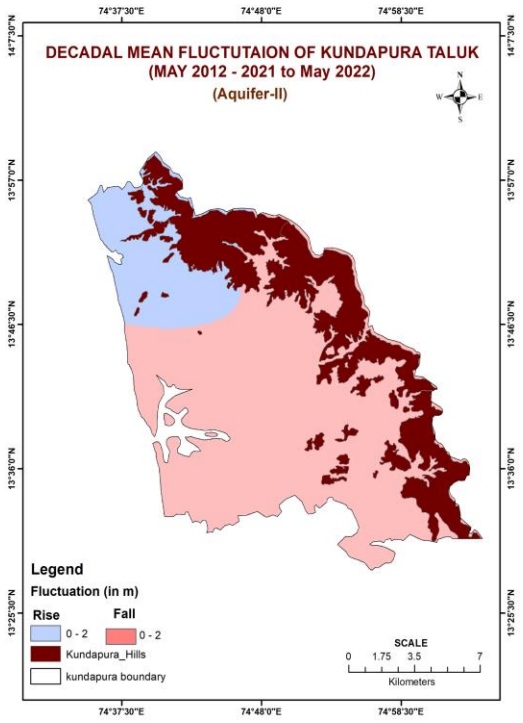

Fig-15b: Decadal Mean Fluctuation of Kundapura Taluk (Aquifer-II (May 2012–2021 to May 2022)

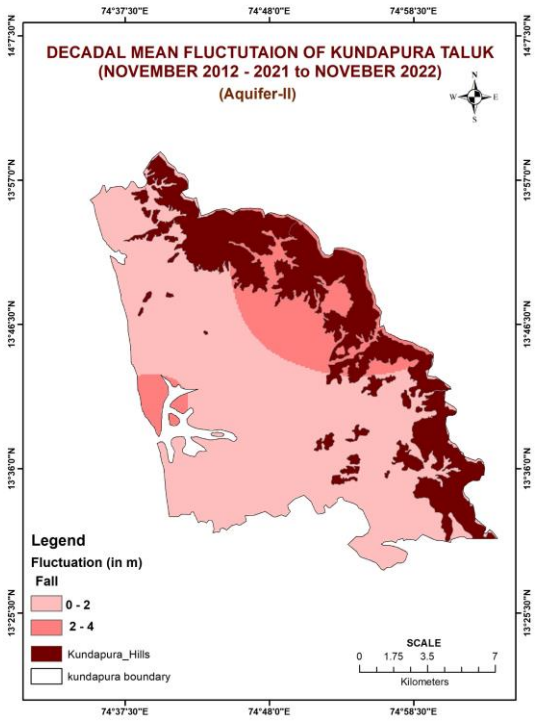

Fig-16b: Decadal Mean Fluctuation of Kundapura Taluk (Aquifer-II (Nov 2012 – 2021 to Nov 2022)

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 Kundapura 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 Kundapura taluk, the rock groups of metamorphic, plutonic, residual capping, unconsolidated sediments 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 gneiss under

water table condition and semi-confined condition. In Kundapura taluk bore wells were drilled from a minimum depth of 44mbgl to a maximum of 185mbgl. Depth of weathered zone ranges from 4mbgl to 37mbgl. Ground water exploration reveals that aquifer-II fractured formation was encountered between the depths of 18 to 177mbgl. Yield ranges from 1.2 to 67lps. The Fracture analysis has done, 46% of fractures are falling in 0 to 50m depth and 24% of fractures falling in 50-100m depth and 19% of fractures falling in 100-150m depth and 11% of fractures falling in 150 to 200m depth and it is shown in **Fig.18**. The basic characteristics of each aquifer are summarized **Table-7.**

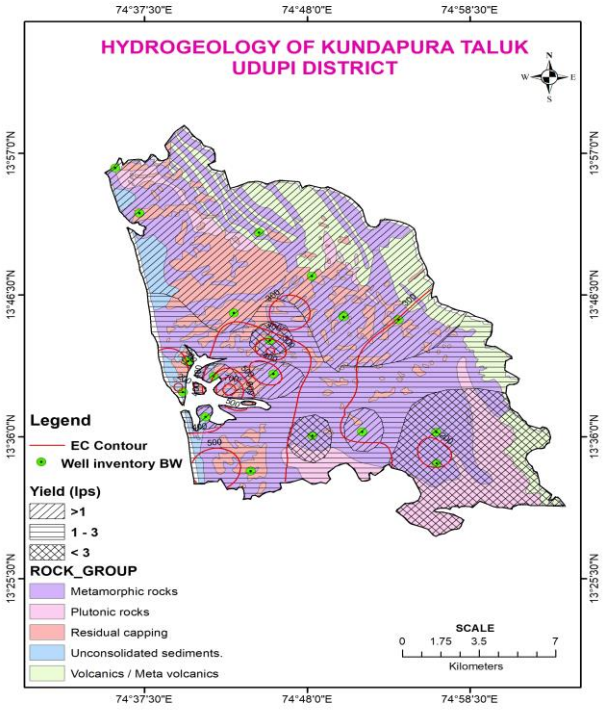

Fig.17: Hydrogeology of Kundapura Taluk.

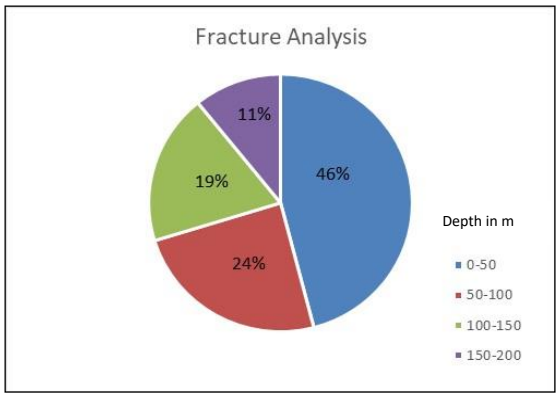

Fig.18: Fractures Analysis of Kundapura taluk

Table-7: Basic characteristics of Aquifer

Aquifers	Fractured Zone (Aq.-II)
Prominent Lithology	Fractured gneiss
Depth range	44 to 185 mbgl
Weathered Thickness range(mbgl)	4 to 37 mbgl
Depth range of occurrence of fractures (mbgl)	18-177
Range of yield potential (lps)	1.2 – 67

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 Kundapura 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 west – east direction and data of 5 exploratory wells has been utilised. It can be clearly seen from the North western to south eastern part i.e., from Alur to Hengavalli, the thickness of Aquifer-II (deeper aquifer) is increasing gradually. The maximum depth of Aquifer-II is attained at Shankarnarayan Village. On the contrary, the thickness of Aquifer-I (shallow aquifer) is constant from North western to south eastern part.

In the next cross section, it represents the West-East direction and data of 4 exploratory wells has been utilised. From Western part the thickness of Aquifer-II is gradually increasing towards east at Hosanagdi and the thickness of Aquifer-I is same as it as from Gangoli to Hosanagadi.

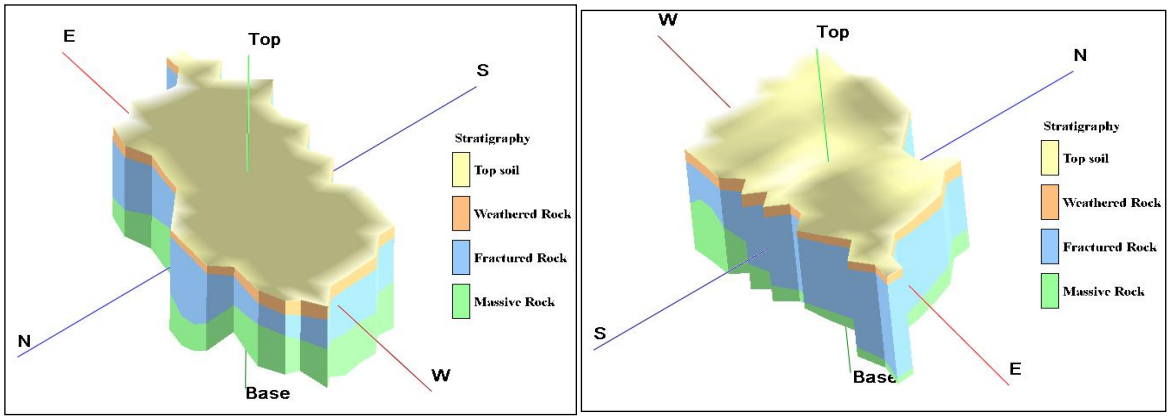

Fig-19a: 3D Aquifer Dispositions

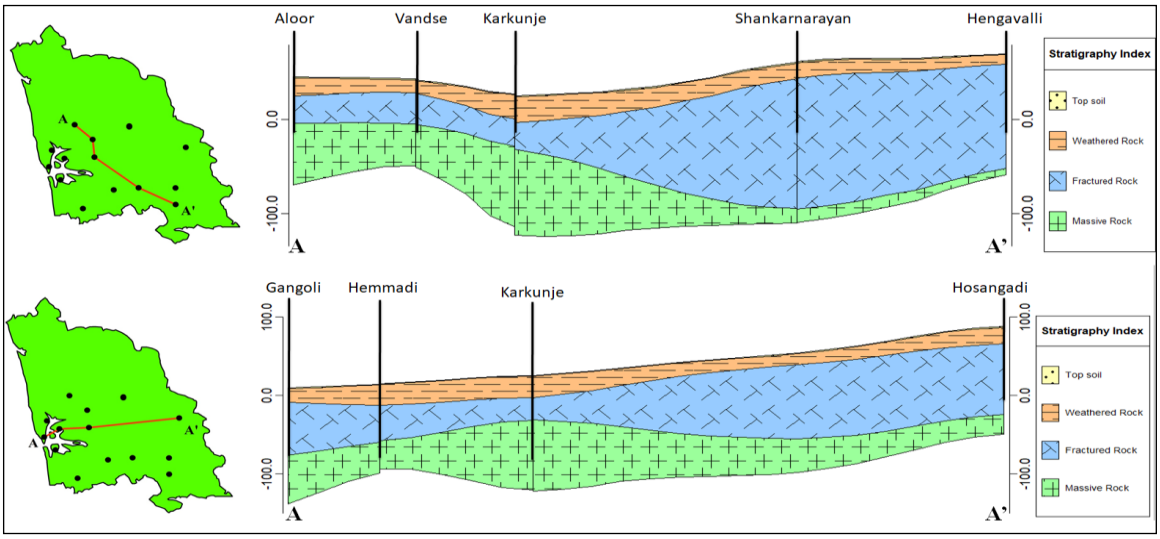

Fig-19b: 2D Cross sections in different direction

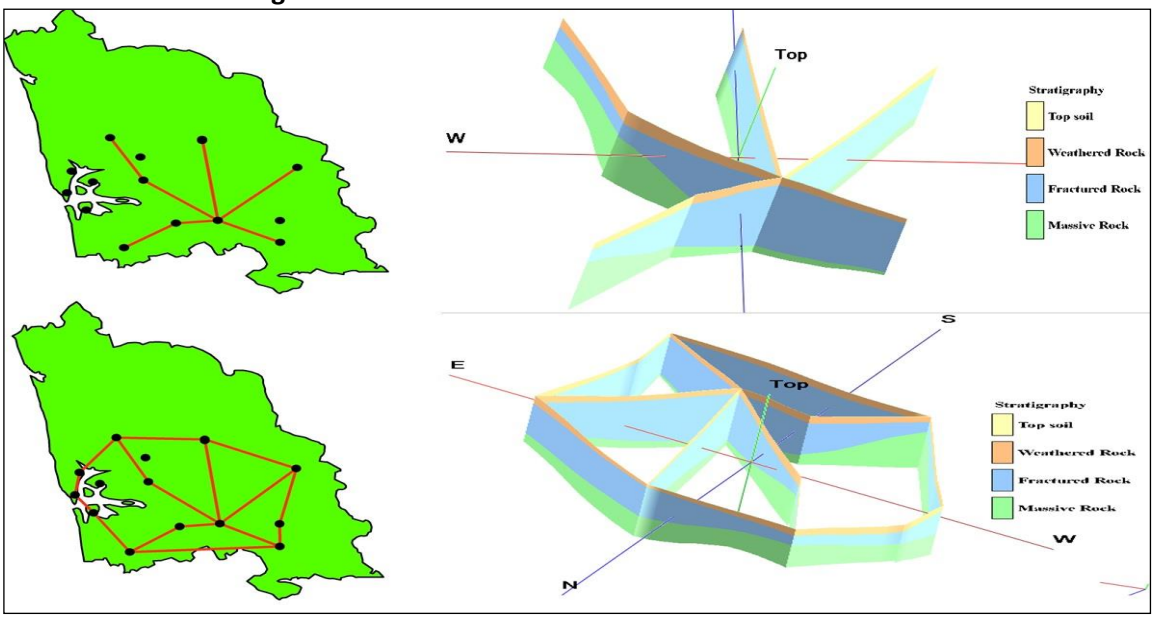

Fig-19c: 3D Aquifer Fence Diagram

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 5 to 46 m bgl. However, it mainly occurs in the depth range of 12 to 46 m bgl covering 75% all over parts of the Taluk. The depth of occurrence of 5 to 10 m bgl is observed in patches of about 10% of area throughout the taluk. 10 to 20 m bgl is observed in 70% of the area throughout the Taluk. The depth of occurrence of 20 to 30 m bgl is observed in about 20% of the area in eastern, western and southern parts of taluk. The deeper depth of occurrence of 30 to 46 m bgl is observed in about 10% of the area in western and southern parts of the taluk. The perusal of the map for aquifer thickness indicates that it ranges from 1 to 10.5 m, however aquifer thickness of 1 to 5 m is observed in 40% of the area covering northern and southern parts of the taluk. The aquifer thickness of 5 to 10.5m is observed in about 60% of the area covering eastern, western and central 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 30 to 178 m bgl. However, it mainly occurs in the depth range of 50 to 150 m bgl covering 60% of the area throughout all the parts of the taluk. The depth of occurrence of 30 to 70 m bgl is observed in about 20% of area in western parts of the taluk. The depth of occurrence of 70 to 100 m bgl is observed in 25% in northern, central and southern parts of the taluk. The deeper depth of occurrence of 100 to 140 & 140 to 178 m bgl is observed in about 40% & 15% 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 1.5 to 13 m, however aquifer thickness of 2 to 5 m is observed in 35% of the area covering western and northern parts of the taluk. The aquifer thickness of 5 to 9 m is observed in 35% of the area covering northern, central and southern parts of the taluk. 9 to 13 m thickness is observed in 30% of the area in eastern and southern parts of the taluk.

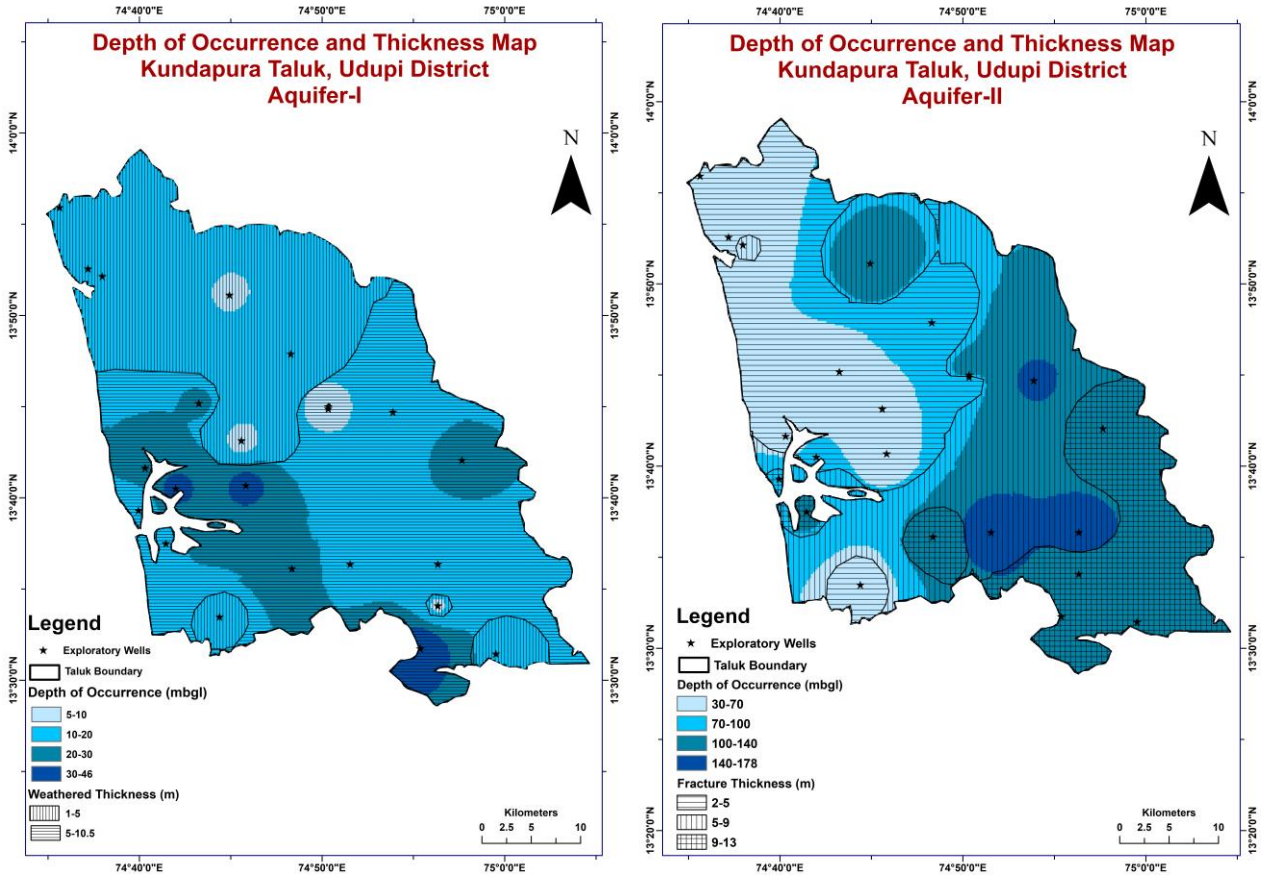

Fig.19d: Depth of occurrence and weathered thickness map of Aquifer-I and Aquifer-II.

3.3. GROUND WATER QUALITY

Interpretation from Chemical Analysis results in Kundapura 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 75 to 815 µ/mhos/cm in the aquifer-I at 25°C (**Fig-20**)
- **NITRATE:** Nitrate concentration in ground water ranges from 1 to 50mg/l in the Aquifer –I (**Fig-20**) In Kollur village Nitrate value is slightly beyond the permissible limit.
- **FLUORIDE:** Fluoride concentration in ground water ranges between 0.01 to 0.13 mg/l in the aquifer-I **(Fig-20)**
- **CHLORIDE:** Fluoride concentration in ground water ranges between 7 to 145 mg/l in the aquifer-I (**Fig-20**)

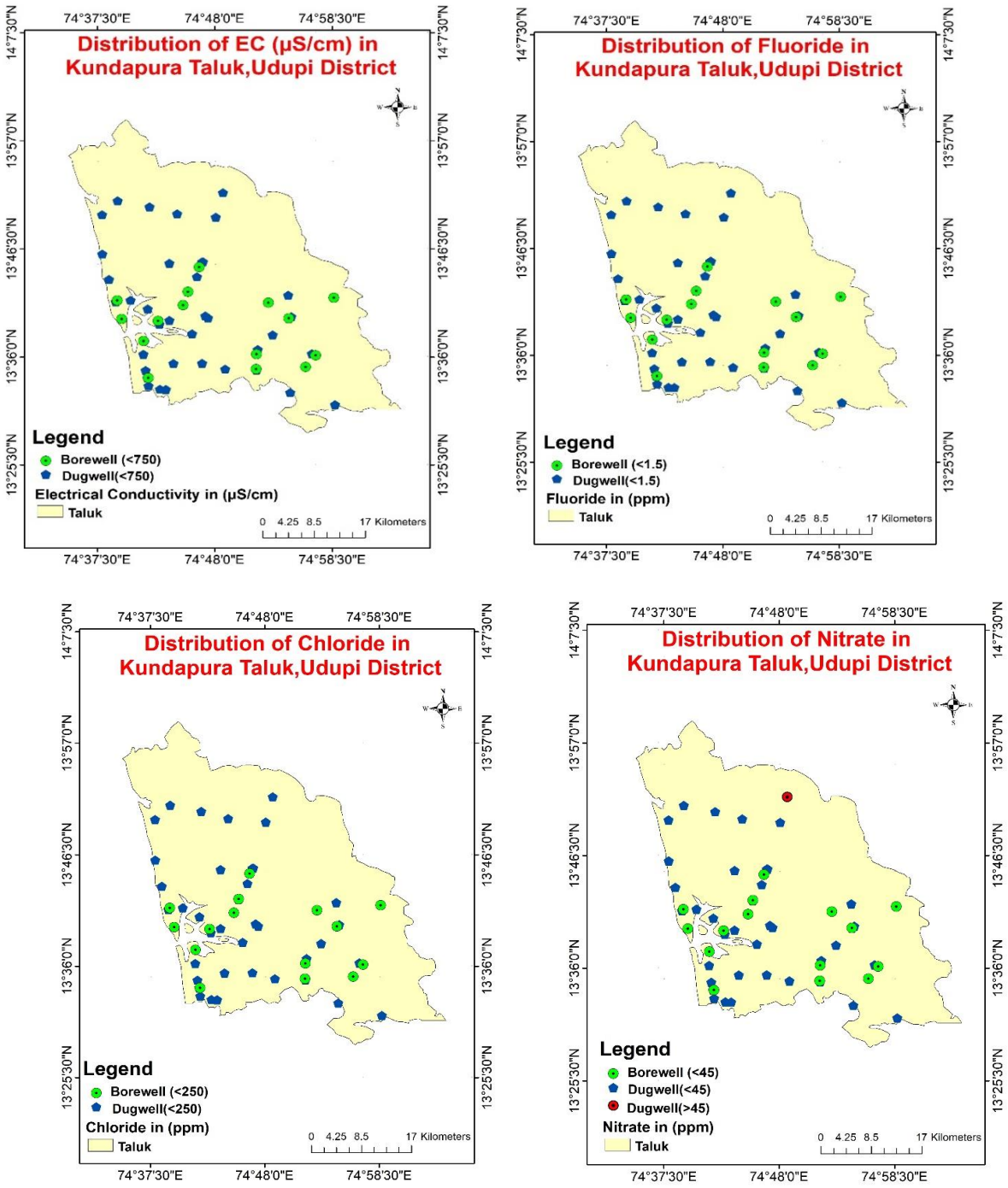

Figure-20. Groundwater Quality Maps

Interpretation from Chemical Analysis result in Kundapura taluk (Aquifer-II) basic parameters is mentioned below in Table.10: In general, all the water quality parameters are within the permissible limit in the taluk.

- **ELECTRICAL CONDUCTIVITY:** EC values range from 160 to 740 µ/mhos/cm in the Aquifer-II.(**Fig-20**)
- **NITRATE:** Nitrate concentration in ground water ranges from 0.04 and 13.16mg/l in Aquifer-II.(**Fig-20**)
- **FLUORIDE:** Fluoride concentration in ground water ranges between 0.013 and 0.39 mg/l in the Aquifer-II. (**Fig-20**)
- **CHLORIDE:** Chloride concentration in ground water ranges between 7 and 170 mg/l in the Aquifer-II. (**Fig-20**)

Table.8. Water quality data of Kundapura Taluk, Udupi District (Aquifer.II)

S.No	SITE_NAME	Latitude	Longitude	EC	Cl	NO3	F
1	Ulthoor	13.54756	74.71871	240	28	2.27	0.065
2	Navagrama colony ulthoor	13.54724	74.72754	140	14	0.85	0.031
3	Kumbashi	13.56611	74.70034	140	18	3.58	0.031
4	Pinganigudde	13.6526	74.71777	270	43	16.48	0.03
5	Hattiyangadi	13.6592	74.7327	105	18	2.57	0.03
6	Hemadi	13.67769	74.70041	150	14	0.04	0.025
7	Neralakatte	13.66653	74.78625	220	14	0.43	0.06
8	Vandse	13.70523	74.76005	510	46	20.63	0.2
9	Chittor	13.7299	74.77371	320	28	5.59	0.1
10	Idur	13.75374	74.78129	140	11	1.41	0.035
11	Alur	13.75179	74.73278	200	14	1.94	0.036
12	Hosadu	13.69184	74.67483	150	18	0.44	0.025
13	Halady circle	13.57914	74.86244	150	21	0.44	0.022
14	Siddapura	13.66238	74.91047	170	21	12.14	0.024
15	Kamalashele	13.69998	74.90955	130	14	0	0.035
16	Amvashabailu	13.60529	74.94484	140	14	5.05	0.022
17	Molahalli	13.58037	74.81595	240	14	2.07	0.03
18	Kumbashi	13.56594	74.70136	560	82	1.66	0.15
19	Pinganigudde(Thallur)	13.65821	74.71602	740	170	0.6	0.1
20	Devalkunda	13.6839	74.75296	300	11	0	0.08
21	Vandse	13.70531	74.76032	620	35	0	0.39
22	Arman Idur	13.74538	74.77723	230	14	0	0.09
23	Gangoli	13.66139	74.66167	190	28	13.16	0.02
24	Trashi	13.9851	74.65319	280	14	0	0.046
25	Kundapura	13.62576	74.6944	350	21	0.49	0.1
26	Halady	13.58018	74.8619	390	21	0	0.013
27	Sankaranarayana	13.6042	74.8625	230	11	0	0.081
28	Siddapura	13.66243	74.91054	270	25	6.32	0.08
29	Bagmane	13.69573	74.97769	260	7	0.04	0.076
30	Ajire	13.68762	74.8801	280	14	0	0.1
31	Amvashabailu	13.60256	74.95041	220	14	0	0.027
32	Henagavalli	13.58363	74.93554	160	14	1	0.022

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 2020, jointly by Ground Water Directorate of Karnataka and CGWB, to arrive at the total resources available in Kundapura 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 not be 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 Kundapura taluk is **16688.06**Ham. The existing gross ground water draft for irrigation is **4322.25** Ham and the draft for domestic use is **643.33** Ham**.** The ground water draft for industrial is 16.823. Thus, the total ground water draft for all uses amounts to **4982.41** 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 **662.86** Ham. The net ground water availability for future irrigation development is **11686.13** 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 Kundapura Taluk (2022)

SNo.	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	UDUPI	KUNDAPURA	16688.06	4322.25	660.16	4982.41	662.86	11686.13	29.8	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
16688.06	4982.41	29.8	SAFE	17572.57	3781	21.51	SAFE

From the above comparison, it is observed that the stage of ground water extraction is more or less similar from 21.51% to 29.8% 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 Kundapura taluk is shown in **Fig.21b.**The tentative list of the proposed Percolation tanks and Check dams are listed in **Annexure 1.**

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

Details of Artificial Recharge structures in KundapuraTaluk		
S.No	Artificial recharge structures available/proposed	
1	Non committed monsoon runoff available in (MCM)	104.797
2	No of sub surface dykes	3
3	No of Check Dams	462
4	No of percolation tanks	94
5	Filter Beds	0
6	Tentative total cost of the project (Rs in lakhs)	6461.404
7	Expected Recharge in (MCM)	78.598
8	Likely additional irrigation potential to be created (Lakh.Ha)	0.095

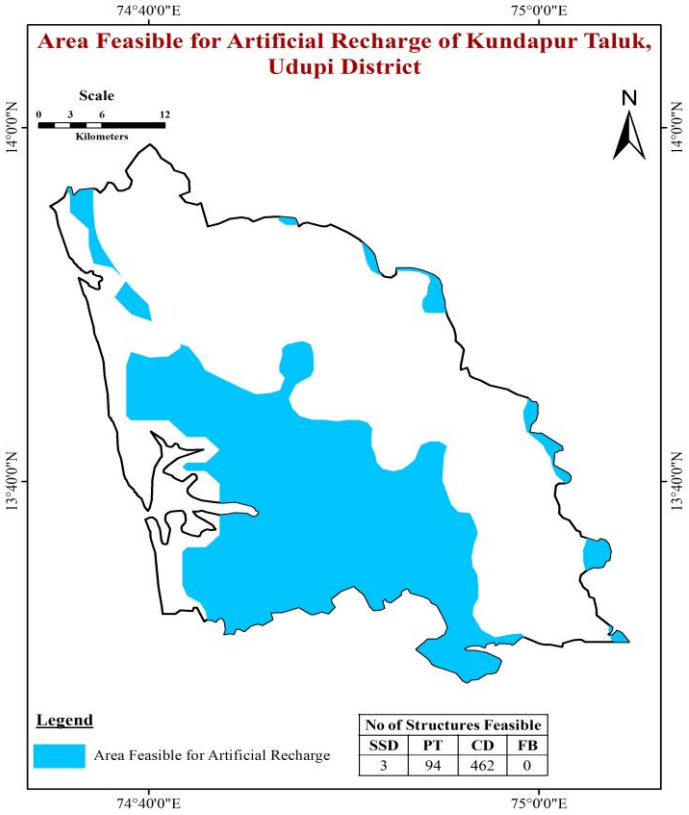

Fig-21a. Area feasible for Artificial Recharge structure

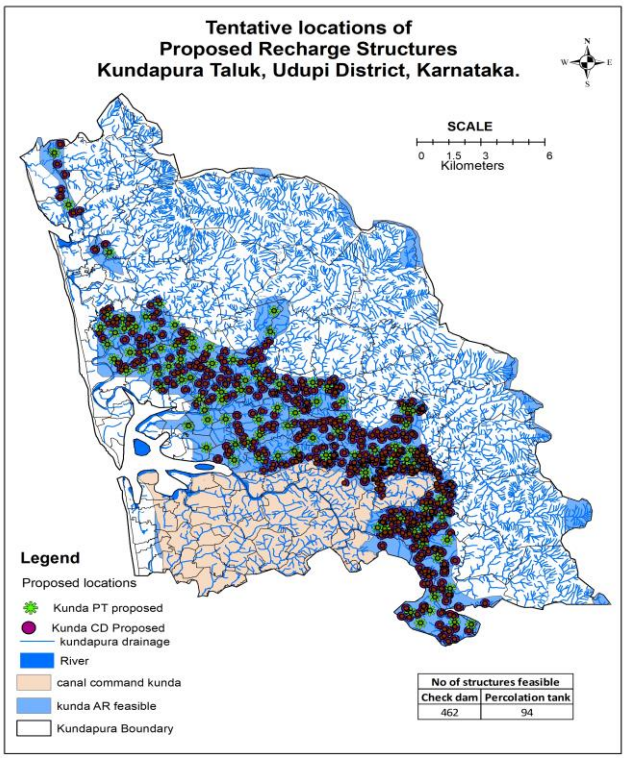

Fig-21b. Tentative locations for Artificial Recharge structure

5.2. Resource Savings by Demand Side Interventions

The important crops grown are Paddy, Jowar, Wheat, Bajra, Maize, Pulses, Vegetables and Sugarcane 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 has to be adopted by the farmers in the existing 12394 ha of net irrigated area and 10399 ha of net irrigated area by wells & bore wells It is proposed to adopt micro irrigation (drip) techniques in fruits and vegetables (11456 ha) and in Oilseeds (7623 ha). Implementation of efficient irrigation techniques will contribute in saving ground water by 1549 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 Kundapura Taluk		
S.No	**Resource Details**	**As per 2020 Estimation**
1	Net Groundwater Availability in Ham	16688.06
2	Existing stage of Ground water development in %	29.80%
3	Existing Gross Groundwater Draft for all use in Ham	4982.41
4	Expected recharge from Artificial recharge projects Ham	78598
5	Cumulative annual groundwater availability in Ham	24625.06
6	Saving due to adopting WUE measures	7623
7	Expected improvement in stage of ground water development after implementation of project in %	15%
8	Expected improvement in overall stage of ground water development in %	14%

Table.13 Savings in Ground Water Utilization due to proposed Modifications in Cropping Pattern and Irrigation Practices in Kundapura 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	20532	1.20	24638	24638	6160	7392	17247	14372
2	Jowar	0	0.00	0		0			
3	Bajra	0	0.00	0		797			
4	Maize	8	0.00	0		8			
5	Ragi	0	0.30	0	0	4791	1437	-1437	-4791
6	Wheat	0	0.00	0		63			-63
7	Other Cereals & Minor millets	0	0.00	0		34			-34
8	Pulses	1726	0.00	0		7648			-5922
9	Sugarcane	16	0.00	0		0			16
10	Oil seeds	1374	0.50	69	69	6165	308	-240	-4791
11	Total Fruits	10956	0.50	548	548	2023			8933

12	Total Vegetables	500	0.50	156	156	5291	1653	-1497	-4791
13	Groundnut	0	0.60	0		1269			-1269.00
		35112		25411	25411	34248	10790	14073	2930

Draft	Ham
Draft with existing Cropping Pattern:	25411
Saving due to Changed Cropping Pattern:	14073
Draft after Changed Cropping Pattern:	11338
Draft after adopting WUE measures:	7937
Saving due to adopting WUE measures:	3401
Total Saving:	17474
Savings in terms of %:	69

5.3 Ground Water Development Plan

In Kundapura taluk, the present stage of ground water extraction (2022) is 29.8 % with net ground water availability for future use is 11686.13 ham and total extraction is 4982.41 ham (2022). The ground water draft for irrigation purpose is 4322.25 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 5292 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 50 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 7739ha **(Table 14a, b).**

Table – 14 a: Feasibility of Additional GW abstraction structures based on GWRA 2020 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)
5030.43	**0.95**	**1**	**5242**	**50**	**15727**	**101**	**7662**	**77**	**7739**

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 – 5242**	**Bore well - 50**	**5292**
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 – 0.95 ham	Av. Annual Gross draft - 1 ham	
Additional irrigation potential created considering crop water requirement of 0.65 m (Ha)	**7662**	**77**	**7739**

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

5.4 Regulation and Control

Kundapura 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 measures to prevent the soil erosions.
- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- 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 Kundapura taluk is given below.

- **Ground Water resource**: As per the resource estimation – 2022, Kundapura taluk falls under Safe category with the stage of ground water extraction of 29.8%. 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 **104.79** MCM. This can be used to recharge the aquifer mainly through percolation tanks (about 94), check dams (about 462) and sub surface dykes (about 3) per CGWB, 2020 figures.
- **Advanced irrigation practices:** In 12394 Ha area micro irrigation practices are being adopted. The important crops grown are Paddy, Pulses, Fruits, Vegetables, Oil seeds. 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 29.8%, 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 5242 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 50 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 7739 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, Kundapura taluk

S.No	Villages	Latitude	Longitude
1	Chara	13.48157	74.94068
2	Belva	13.48371	74.94615
3	Belva	13.48530	74.93566
4	Belva	13.48663	74.93740
5	Belva	13.49098	74.94169
6	Belva	13.49146	74.95801
7	Belva	13.49276	74.93766
8	Belva	13.49359	74.94615
9	Belva	13.49498	74.94638
10	Belva	13.49673	74.93379
11	Belva	13.50359	74.90815
12	Belva	13.50479	74.90203
13	Belva	13.50483	74.94543
14	Belva	13.50615	74.94243
15	Belva	13.50656	74.91488
16	Belva	13.50783	74.93512
17	Belva	13.51001	74.91955
18	Belva	13.51085	74.90661
19	Belva	13.51210	74.90567
20	Belva	13.51233	74.92142
21	Alpadi	13.51314	74.94960
22	Belva	13.51379	74.92031
23	Alpadi	13.51663	74.97168
24	Alpadi	13.51857	74.93938
25	Alpadi	13.52367	74.94040
26	Alpadi	13.52430	74.94137
27	Hengavalli	13.52895	74.92842
28	Hengavalli	13.52941	74.93657
29	Hengavalli	13.52997	74.93512
30	Belva	13.53440	74.92086
31	Belva	13.53503	74.92377
32	Hengavalli	13.53518	74.93564
33	Belva	13.54106	74.92450
34	Hengavalli	13.54356	74.92796
35	Belva	13.54359	74.92109
36	Hengavalli	13.54470	74.93763
37	Belva	13.54503	74.91920
38	Hengavalli	13.54585	74.92418
39	Hengavalli	13.54595	74.92119
40	Hengavalli	13.54653	74.93786
41	Hengavalli	13.54915	74.91710
42	Hengavalli	13.55105	74.93772

43	Hengavalli	13.55252	74.93758
44	Hengavalli	13.55591	74.94674
45	Hengavalli	13.55718	74.91535
46	Hengavalli	13.55910	74.91740
47	Hengavalli	13.56134	74.91857
48	Hengavalli	13.56337	74.93524
49	Hengavalli	13.56399	74.92426
50	Hengavalli	13.56432	74.93407
51	Hengavalli	13.56557	74.93050
52	Hengavalli	13.56584	74.92965
53	Hengavalli	13.56678	74.92134
54	Hengavalli	13.56701	74.91166
55	Hengavalli	13.56943	74.91424
56	Haladi (76)	13.56943	74.88561
57	Hengavalli	13.57422	74.91995
58	Hengavalli	13.57511	74.92140
59	Hengavalli	13.57535	74.91930
60	Hengavalli	13.57602	74.91380
61	Hengavalli	13.57611	74.91434
62	Hengavalli	13.57770	74.91436
63	Hengavalli	13.57804	74.91494
64	Kulanje	13.57925	74.88486
65	Hengavalli	13.57935	74.90531
66	Ratwadi	13.57988	74.92247
67	Kulanje	13.58025	74.89237
68	Hengavalli	13.58026	74.90828
69	Haladi (76)	13.58031	74.88749
70	Ratwadi	13.58079	74.92298
71	Hengavalli	13.58096	74.94233
72	Kulanje	13.58118	74.90261
73	Kulanje	13.58171	74.88792
74	Kulanje	13.58196	74.89240
75	Kulanje	13.58296	74.89680
76	Hengavalli	13.58328	74.92807
77	Ratwadi	13.58333	74.92069
78	Ratwadi	13.58355	74.92111
79	Kulanje	13.58393	74.89914
80	Hengavalli	13.58688	74.93148
81	Ratwadi	13.58720	74.90925
82	Ratwadi	13.58798	74.91032
83	Hengavalli	13.58833	74.93650
84	Ratwadi	13.58856	74.91168
85	Kulanje	13.58908	74.89349
86	Ratwadi	13.58922	74.91448
87	Ratwadi	13.58938	74.91518
88	Kulanje	13.59014	74.88704

89	Ratwadi	13.59048	74.91237
90	Kulanje	13.59064	74.89720
91	Kulanje	13.59066	74.88600
92	Kulanje	13.59092	74.89936
93	Ratwadi	13.59094	74.91171
94	Kulanje	13.59128	74.90640
95	Ratwadi	13.59302	74.91982
96	Kulanje	13.59331	74.88901
97	Ratwadi	13.59344	74.92097
98	Kulanje	13.59386	74.89312
99	Ratwadi	13.59420	74.92344
100	Kulanje	13.59421	74.89554
101	Ratwadi	13.59424	74.92452
102	Kulanje	13.59433	74.88744
103	Ratwadi	13.59503	74.90706
104	Ratwadi	13.59655	74.91649
105	Ratwadi	13.59831	74.90458
106	Ratwadi	13.59859	74.91006
107	Ratwadi	13.59878	74.92103
108	Ratwadi	13.59943	74.92741
109	Amasebylu	13.59998	74.94232
110	Kulanje	13.59997	74.89350
111	Ratwadi	13.60036	74.92982
112	Ratwadi	13.60055	74.90370
113	Amasebylu	13.60094	74.94005
114	Ratwadi	13.60100	74.92755
115	Ratwadi	13.60102	74.92687
116	Kulanje	13.60119	74.89270
117	Kulanje	13.60165	74.89755
118	Amasebylu	13.60390	74.93807
119	Machattu	13.60750	74.94139
120	Machattu	13.60762	74.93000
121	Machattu	13.60806	74.93190
122	Machattu	13.60855	74.92427
123	Machattu	13.60881	74.92214
124	Machattu	13.60950	74.91931
125	Machattu	13.60958	74.92601
126	Machattu	13.61474	74.94307
127	Ulluru	13.61552	74.88630
128	Machattu	13.61606	74.94361
129	Machattu	13.61657	74.92449
130	Machattu	13.61719	74.93753
131	Machattu	13.61972	74.93674
132	Ulluru	13.62127	74.88170
133	Ulluru	13.62155	74.88432
134	Machattu	13.62183	74.93221

135	Machattu	13.62287	74.93578
136	Machattu	13.62356	74.94464
137	Machattu	13.62417	74.93074
138	Machattu	13.62490	74.94052
139	Ulluru	13.62530	74.88526
140	Machattu	13.62539	74.94162
141	Machattu	13.62593	74.94258
142	Machattu	13.62639	74.93097
143	Ulluru	13.62700	74.88154
144	Shankaranarayana	13.62709	74.85395
145	Siddapura	13.62837	74.87102
146	Siddapura	13.62967	74.87108
147	Ulluru	13.62974	74.88128
148	Ulluru	13.63077	74.88050
149	Ulluru	13.63141	74.93258
150	Ulluru	13.63441	74.93095
151	Ulluru	13.63462	74.88758
152	Ulluru	13.63503	74.91085
153	Shankaranarayana	13.63549	74.85856
154	Ulluru	13.63574	74.90974
155	Siddapura	13.63575	74.88900
156	Ulluru	13.63630	74.93158
157	Siddapura	13.63666	74.88507
158	Ulluru	13.63690	74.89289
159	Ulluru	13.63733	74.91359
160	Siddapura	13.63772	74.88392
161	Amparu	13.63782	74.86455
162	Ulluru	13.63788	74.91263
163	Ulluru	13.63794	74.90234
164	Ulluru	13.63799	74.91048
165	Ulluru	13.63799	74.89303
166	Ulluru	13.63817	74.89472
167	Ulluru	13.63853	74.90323
168	Kavaradi	13.63867	74.78671
169	Ulluru	13.63881	74.91466
170	Ulluru	13.63899	74.92744
171	Ulluru	13.63966	74.92642
172	Amparu	13.63999	74.86245
173	Ulluru	13.64004	74.92269
174	Ulluru	13.64060	74.92066
175	Ulluru	13.64061	74.89666
176	Ulluru	13.64063	74.91021
177	Ulluru	13.64087	74.91948
178	Kavaradi	13.64082	74.79365
179	Ulluru	13.64093	74.91000
180	Amparu	13.64093	74.85926

181	Ulluru	13.64153	74.90248
182	Ulluru	13.64249	74.90382
183	Siddapura	13.64256	74.87035
184	Hosangadi	13.64338	74.92613
185	Amparu	13.64344	74.80577
186	Amparu	13.64351	74.83835
187	Kavaradi	13.64390	74.79456
188	Siddapura	13.64415	74.87062
189	Amparu	13.64433	74.80126
190	Amparu	13.64466	74.83749
191	Siddapura	13.64472	74.87987
192	Amparu	13.64479	74.86192
193	Amparu	13.64514	74.84230
194	Amparu	13.64518	74.83019
195	Amparu	13.64548	74.86199
196	Amparu	13.64580	74.85186
197	Ulluru	13.64598	74.89800
198	Hosangadi	13.64612	74.92316
199	Siddapura	13.64626	74.88561
200	Siddapura	13.64642	74.88657
201	Kavaradi	13.64656	74.78830
202	Ulluru	13.64664	74.91638
203	Siddapura	13.64663	74.86998
204	Amparu	13.64670	74.81102
205	Amparu	13.64674	74.81391
206	Amparu	13.64682	74.84174
207	Siddapura	13.64747	74.87860
208	Siddapura	13.64747	74.88596
209	Siddapura	13.64789	74.87741
210	Ulluru	13.64794	74.91711
211	Amparu	13.64801	74.83166
212	Siddapura	13.64808	74.86960
213	Siddapura	13.64835	74.88092
214	Hosangadi	13.64874	74.92304
215	Gulwadi	13.64907	74.74805
216	Amparu	13.64923	74.83088
217	Ulluru	13.64933	74.91943
218	Amparu	13.64936	74.81622
219	Siddapura	13.64958	74.87735
220	Siddapura	13.64976	74.88604
221	Amparu	13.65015	74.84511
222	Amparu	13.65061	74.82536
223	Amparu	13.65128	74.84527
224	Amparu	13.65142	74.81700
225	Siddapura	13.65190	74.91331
226	Siddapura	13.65193	74.89634

227	Siddapura	13.65217	74.91500
228	Siddapura	13.65216	74.86696
229	Amparu	13.65227	74.84519
230	Siddapura	13.65246	74.91898
231	Siddapura	13.65248	74.88534
232	Amparu	13.65248	74.81610
233	Siddapura	13.65267	74.89872
234	Siddapura	13.65280	74.87187
235	Gulwadi	13.65298	74.75668
236	Siddapura	13.65310	74.89482
237	Siddapura	13.65357	74.89918
238	Kavaradi	13.65358	74.78790
239	Kavaradi	13.65374	74.78205
240	Siddapura	13.65426	74.88550
241	Siddapura	13.65445	74.91585
242	Amparu	13.65455	74.85403
243	Siddapura	13.65529	74.88794
244	Siddapura	13.65535	74.90094
245	Siddapura	13.65541	74.91501
246	Siddapura	13.65651	74.90169
247	Kavaradi	13.65645	74.78667
248	Gulwadi	13.65666	74.75782
249	Siddapura	13.65683	74.90073
250	Siddapura	13.65693	74.92009
251	Amparu	13.65698	74.83053
252	Siddapura	13.65780	74.89139
253	Siddapura	13.65841	74.91976
254	Siddapura	13.65880	74.89127
255	Amparu	13.65949	74.83656
256	Gulwadi	13.65948	74.77675
257	Siddapura	13.65983	74.87777
258	Amparu	13.66060	74.84565
259	Gulwadi	13.66060	74.75552
260	Ajri	13.66095	74.86816
261	Karkunje	13.66354	74.77037
262	Karkunje	13.66460	74.77810
263	Ajri	13.66605	74.86784
264	Siddapura	13.66611	74.90573
265	Ajri	13.66692	74.86081
266	Siddapura	13.66716	74.88545
267	Kodladi	13.66804	74.81505
268	Siddapura	13.66901	74.90557
269	Karkunje	13.66899	74.76969
270	Kodladi	13.66924	74.84227
271	Ajri	13.66961	74.85097
272	Siddapura	13.66985	74.89356

273	Ajri	13.66984	74.86085
274	Kodladi	13.67042	74.81714
275	Siddapura	13.67065	74.91174
276	Ajri	13.67067	74.89667
277	Ajri	13.67085	74.87750
278	Ajri	13.67086	74.88506
279	Kodladi	13.67154	74.81998
280	Ajri	13.67179	74.86675
281	Siddapura	13.67197	74.91046
282	Ajri	13.67240	74.90320
283	Ajri	13.67243	74.86168
284	Ajri	13.67300	74.86913
285	Ajri	13.67313	74.88962
286	Ajri	13.67395	74.88162
287	Kodladi	13.67409	74.82190
288	Karkunje	13.67490	74.76616
289	Ajri	13.67547	74.89601
290	Kodladi	13.67562	74.82285
291	Karkunje	13.67611	74.78527
292	Kodladi	13.67666	74.83640
293	Gulwadi	13.67692	74.79436
294	Ajri	13.67702	74.86359
295	Ajri	13.67845	74.85364
296	Kodladi	13.67874	74.82120
297	Karkunje	13.67941	74.79058
298	Kodladi	13.67956	74.84739
299	Karkunje	13.67982	74.76438
300	Karkunje	13.68022	74.79500
301	Kodladi	13.68138	74.82880
302	Ajri	13.68142	74.86164
303	Kodladi	13.68153	74.81220
304	Kodladi	13.68171	74.82588
305	Kodladi	13.68189	74.83311
306	Kodladi	13.68194	74.81842
307	Kodladi	13.68218	74.84571
308	Kodladi	13.68318	74.83669
309	Ajri	13.68413	74.84952
310	Kodladi	13.68428	74.84219
311	Ajri	13.68491	74.90150
312	Ajri	13.68547	74.90778
313	Ajri	13.68553	74.89874
314	Ajri	13.68560	74.89652
315	Karkunje	13.68881	74.76410
316	Karkunje	13.68925	74.79559
317	Karkunje	13.69068	74.77731
318	Ajri	13.69117	74.90678

319	Siddapura	13.69279	74.91633
320	Karkunje	13.69304	74.78550
321	Kodladi	13.69383	74.82174
322	Kodladi	13.69396	74.82010
323	Siddapura	13.69443	74.91741
324	Siddapura	13.69449	74.91861
325	Siddapura	13.69549	74.91956
326	Bellala	13.69763	74.84701
327	Ajri	13.69864	74.90819
328	Noojadi	13.69861	74.72981
329	Bellala	13.69926	74.81533
330	Ajri	13.69934	74.90925
331	Bellala	13.69979	74.82340
332	Ajri	13.70017	74.90183
333	Bellala	13.70091	74.82247
334	Ajri	13.70167	74.91031
335	Bellala	13.70172	74.81299
336	Vandse	13.70279	74.74028
337	Bellala	13.70469	74.81572
338	Bellala	13.70491	74.80597
339	Vandse	13.70546	74.75516
340	Vandse	13.70549	74.74337
341	Chitthuru	13.70667	74.78107
342	Vandse	13.70809	74.76104
343	Bellala	13.70842	74.84535
344	Bellala	13.70941	74.79592
345	Bellala	13.70955	74.79430
346	Bellala	13.71018	74.84612
347	Bellala	13.71029	74.82228
348	Noojadi	13.71026	74.73552
349	Bellala	13.71111	74.84170
350	Bellala	13.71184	74.82807
351	Bellala	13.71186	74.80270
352	Chitthuru	13.71225	74.77402
353	Kundha Barandhadi	13.71249	74.72110
354	Hakladi	13.71253	74.70200
355	Bellala	13.71265	74.81129
356	Bellala	13.71279	74.82165
357	Bellala	13.71303	74.81369
358	Chitthuru	13.71334	74.78568
359	Bellala	13.71380	74.80359
360	Bellala	13.71421	74.84821
361	Vandse	13.71486	74.74638
362	Bellala	13.71500	74.85049
363	Bellala	13.71518	74.84731
364	Bellala	13.71732	74.81931

365	Harkuru	13.71757	74.71121
366	Vandse	13.71762	74.75427
367	Vandse	13.71774	74.76387
368	Noojadi	13.71782	74.73735
369	Chitthuru	13.71840	74.78321
370	Harkuru	13.71845	74.69802
371	Noojadi	13.71852	74.73240
372	Bellala	13.71863	74.83379
373	Keradi	13.71953	74.84133
374	Bellala	13.71953	74.80818
375	Bellala	13.72037	74.81861
376	Harkuru	13.72098	74.70581
377	Chitthuru	13.72203	74.79069
378	Vandse	13.72207	74.75680
379	Keradi	13.72230	74.84530
380	Vandse	13.72248	74.75061
381	Bellala	13.72296	74.80542
382	Chitthuru	13.72369	74.76515
383	Noojadi	13.72380	74.73813
384	Chitthuru	13.72416	74.79460
385	Chitthuru	13.72596	74.78752
386	Noojadi	13.72701	74.74237
387	Harkuru	13.72707	74.71126
388	Vandse	13.72830	74.75722
389	Harkuru	13.72840	74.71481
390	Chitthuru	13.72848	74.77954
391	Harkuru	13.72963	74.71887
392	Chitthuru	13.72988	74.79000
393	Noojadi	13.73064	74.73944
394	Nada	13.73077	74.66754
395	Aluru	13.73199	74.75348
396	Harkuru	13.73247	74.69736
397	Aluru	13.73280	74.73375
398	Nada	13.73351	74.67115
399	Harkuru	13.73386	74.72941
400	Harkuru	13.73429	74.72415
401	Harkuru	13.73454	74.71530
402	Nada	13.73575	74.67863
403	Badakere	13.73713	74.66461
404	Aluru	13.73753	74.73070
405	Chitthuru	13.73772	74.76727
406	Nada	13.73782	74.68078
407	Chitthuru	13.73825	74.77404
408	Aluru	13.73832	74.75371
409	Nada	13.73888	74.68549
410	Chitthuru	13.73975	74.77908

411	Aluru	13.74106	74.73635
412	Chitthuru	13.74159	74.78483
413	Harkuru	13.74171	74.70787
414	Aluru	13.74202	74.75111
415	Nada	13.74381	74.69436
416	Aluru	13.74529	74.73781
417	Nada	13.74682	74.68234
418	Harkuru	13.74703	74.71735
419	Iduru Kunadi	13.74746	74.77603
420	Aluru	13.74775	74.75425
421	Chitthuru	13.74868	74.78179
422	Chitthuru	13.75341	74.78776
423	Aluru	13.75334	74.68420
424	Aluru	13.75356	74.68671
425	Aluru	13.75614	74.71471
426	Iduru Kunadi	13.75721	74.79069
427	Aluru	13.75752	74.71936
428	Herura	13.75839	74.67011
429	Aluru	13.75919	74.69215
430	Herura	13.75931	74.68236
431	Navundha	13.75963	74.65194
432	Herura	13.76159	74.69019
433	Herura	13.76332	74.70166
434	Aluru	13.76348	74.72184
435	Ulluru	13.76428	74.64867
436	Herura	13.76507	74.67678
437	Aluru	13.76595	74.71830
438	Ulluru	13.77301	74.66169
439	Ulluru	13.77336	74.67268
440	Ulluru	13.77371	74.65645
441	Ulluru	13.77410	74.66372
442	Herura	13.77435	74.70058
443	Ulluru	13.77464	74.66064
444	Herura	13.77718	74.67506
445	Ulluru	13.77752	74.67340
446	Ulluru	13.77764	74.66365
447	Ulluru	13.77926	74.65308
448	Herura	13.77937	74.69439
449	Kalthodu	13.78368	74.69715
450	Ulluru	13.78393	74.65310
451	Ulluru	13.78667	74.65707
452	Kalthodu	13.79074	74.69222
453	Kalthodu	13.79442	74.69795
454	Bijuru	13.84128	74.64531
455	Theggarne	13.84585	74.65411
456	Yadthare	13.87485	74.62715

457	Yadthare	13.87652	74.63239
458	Shiruru	13.89009	74.61622
459	Shiruru	13.89629	74.61648
460	Paduvari	13.91023	74.62012
461	Yadthare	13.91975	74.61391
462	Yadthare	13.93788	74.61607

(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, Kundapura taluk

S.No	Villages	Latitude	Longitude
1	Belva	13.4984186	74.9176807
2	Belva	13.4993663	74.9461862
3	Belva	13.5082183	74.9094519
4	Belva	13.5100704	74.9252302
5	Hengavalli	13.5222132	74.9297267
6	Alpadi	13.5302726	74.9424171
7	Hengavalli	13.5581637	74.9318637
8	Hengavalli	13.5712370	74.9195530
9	Hengavalli	13.5747046	74.9400567
10	Hengavalli	13.5819971	74.9126243
11	Kulanje	13.5851224	74.8877137
12	Kulanje	13.5859505	74.8818793
13	Ratwadi	13.5868086	74.9207073
14	Kulanje	13.5943428	74.9008008
15	Ratwadi	13.5956587	74.9357503
16	Ratwadi	13.6038018	74.9222667
17	Machattu	13.6119860	74.9347282
18	Siddapura	13.6365854	74.8716000
19	Ulluru	13.6451107	74.9121656
20	Siddapura	13.6462091	74.8932685
21	Gulwadi	13.6479752	74.7618552
22	Siddapura	13.6487682	74.9062450
23	Kavaradi	13.6493751	74.7824579
24	Amparu	13.6520043	74.7983126
25	Amparu	13.6521912	74.8625069
26	Amparu	13.6525411	74.8385416
27	Amparu	13.6564495	74.8121588
28	Siddapura	13.6572109	74.9096215
29	Siddapura	13.6572148	74.8792476
30	Kanyana	13.6594461	74.7385822
31	Siddapura	13.6606681	74.8970091

32	Gulwadi	13.6621900	74.7627080
33	Karkunje	13.6644445	74.7729452
34	Kodladi	13.6682205	74.8275360
35	Karkunje	13.6708828	74.7829043
36	Kodladi	13.6745334	74.8485169
37	Gulwadi	13.6794827	74.8066384
38	Kanyana	13.6795916	74.7236557
39	Ajri	13.6801521	74.9057084
40	Devalkundha	13.6851264	74.7396827
41	Karkunje	13.6851934	74.7822727
42	Kenchanuru	13.6854074	74.7547176
43	Ajri	13.6870228	74.8538204
44	Kodladi	13.6914082	74.8129701
45	Siddapura	13.6933548	74.9112610
46	Noojadi	13.6939578	74.7369794
47	Ajri	13.6956593	74.9041234
48	Karkunje	13.6961671	74.7979319
49	Bellala	13.7017544	74.8525144
50	Bellala	13.7017544	74.8308137
51	Vandse	13.7034559	74.7516034
52	Noojadi	13.7039082	74.7326073
53	Vandse	13.7104677	74.7509590
54	Vandse	13.7120575	74.7676093
55	Bellala	13.7155835	74.8396201
56	Hakladi	13.7155169	74.6998918
57	Bellala	13.7175600	74.7995833
58	Bellala	13.7191745	74.8275503
59	Chitthuru	13.7209805	74.7711785
60	Kundha Barandhadi	13.7218489	74.7176818
61	Chitthuru	13.7229930	74.7830471
62	Harkuru	13.7238061	74.7252251
63	Harkuru	13.7272764	74.6988364
64	Nada	13.7301409	74.6715484
65	Senapura	13.7311962	74.6851170
66	Harkuru	13.7339649	74.7069390
67	Chitthuru	13.7348427	74.7776695
68	Aluru	13.7365957	74.7433685
69	Chitthuru	13.7400161	74.7607683
70	Harkuru	13.7404623	74.7168970
71	Badakere	13.7406777	74.6611597
72	Nada	13.7469186	74.6746626
73	Nada	13.7476007	74.6890871
74	Harkuru	13.7508724	74.7003895
75	Aluru	13.7511399	74.7277311
76	Aluru	13.7516999	74.7413515
77	Aluru	13.7532412	74.7127464

78	Navundha	13.7541930	74.6555442
79	Aluru	13.7598270	74.7262731
80	Ulluru	13.7650101	74.6621493
81	Iduru Kunadi	13.7658928	74.7919988
82	Herura	13.7688671	74.6950357
83	Ulluru	13.7688671	74.6697540
84	Ulluru	13.7699422	74.6499893
85	Herura	13.7704063	74.6795299
86	Herura	13.7719914	74.7121753
87	Ulluru	13.7777973	74.6682029
88	Herura	13.7796057	74.6877145
89	Ulluru	13.7817017	74.6557183
90	Iduru Kunadi	13.7849285	74.7952705
91	Kalthodu	13.7916520	74.6994395
92	Theggarne	13.8386195	74.6574128
93	Paduvari	13.8824016	74.6231486
94	Yadthare	13.9299908	74.6112513

(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)