# 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

## Mangalore Taluk, Dakshina Kannada District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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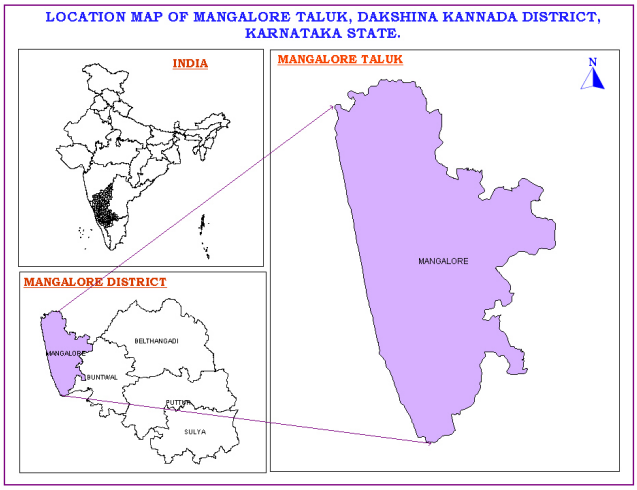
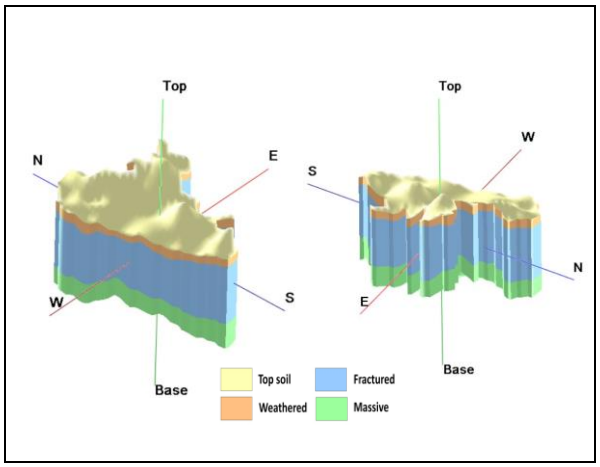
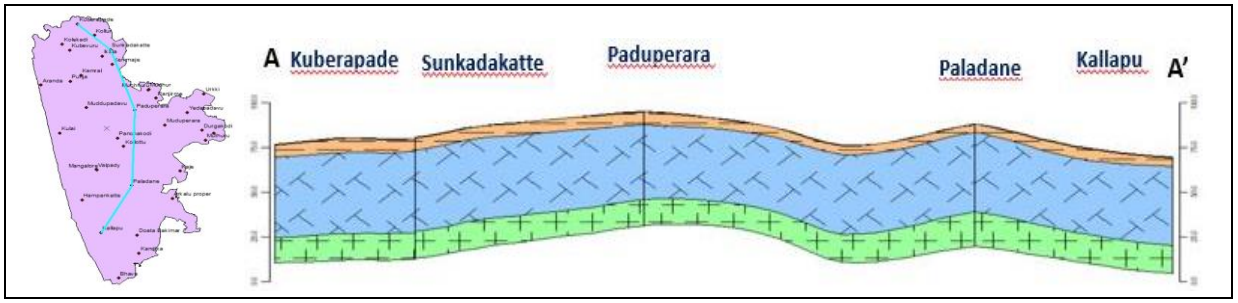
# AQUIFER MAPS AND MANAGEMENT PLAN, MANGALORE TALUK, DAKSHIN KANNADA DISTRICT, KARNATAKA STATE

***(AAP – 2022-2023)***




*By*

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MAY 2023

# AQUIFER MAPS AND MANAGEMENT PLAN, MANGALORE TALUK, DAKSHIN KANNADA DISTRICT, KARNATAKA STATE

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# AQUIFER MAPS AND MANAGEMENT PLAN, MANGALORE TALUK, DAKSHIN KANNADA DISTRICT, KARNATAKA STATE

## 1 SALIENT INFORMATION

Name of the taluk: **Mangalore**

District: **Dakshin Kannada**; State: Karnataka

Area: **580** sq.km.

Population: **8,89,226**

Annual Normal Rainfall: **3436** mm

### 1.1 Aquifer management study area

Aquifer mapping studies was carried out in Mangalore Taluk, Dakshin Kannada district of Karnataka, covering an area of 580 sq.kms under National Aquifer Mapping. Mangalore Taluk of Dakshin Kannada district is located between north latitude **12°45'57.72"** and **13°07'40.68"** & east longitude **74°50'16.66"** and **74°53'21.75"** and is covered in parts of Survey of India Toposheet Nos. 48K/16,48P/1 & 48L/13. It is bounded by Western Coast in West side, Bantwal Taluk, Dakshin Kannada District in East, Udupi district in north, Kerela State on the southern side. Location map of Mangalore Taluk of Dakshin Kannada district is presented in **Fig. 1.**

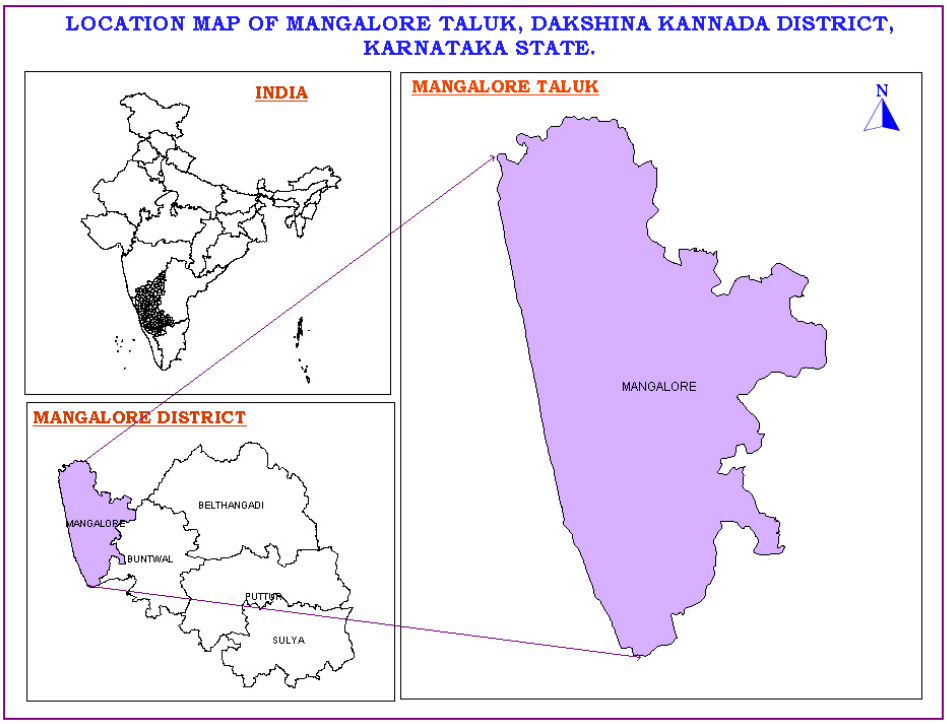



**Fig. 1: Location Map of Mangalore Taluk, Dakshin Kannada district**

Mangalore taluk is taluk of Dakshin Kannada District. Mangalore town is the Administrative Headquarter of Mangalore Taluk. There are **5** Hoblis, **43** Gram panchayat and **51** villages in Mangalore Taluk. It is made up of Mangalore city co-orporation, Ullal city Municipality that govern the Mangalore Urban Agglomeration. It is situated 415 km western side of Bangalore. The highway serves as the conduit for several arterial routes leading to Mangalore.Mangalore is connected with other cities in Karnataka such as Mysore and Bangalore, which is approx. 415km by National Highway 275 and Connected via National Highway 48 & NH 73 respectively.

## Population

According to 2011 census, the population of Mangalore Taluk is **8,89,226**. Out of the total population 4,39,075 constitute the male population and 4,50,151 is the female population. The urban population is 7,55,138 and rural one is 1,34,088. Decadal change in population from 2001-2011 is 12.66% in Mangalore Taluk. Decadal change in rural and urban population is 25.46% and 30.53 % respectively. The density of population is **1533** persons per square km.

## 1.2 Rainfall

Mangalore Taluk has typical **Maritime climate**. Hot and Humid weather prevails in major part of the year. The taluk is marked by heavy rainfall, high humidity and oppressive weather in hot season. The weather is hot and humid throughout of the year. The year is usually divided into four seasons namely 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. April and May are regarded as the summer months with maximum temperature around 44 degree Celsius and minimum temperature is around 18 degree Celsius. The average annual rainfall is **3436** mm and rainfall is received mainly during the south-western monsoon extending from June to September.

There is **48** rain gauge station in Mangalore Taluk, the rainfall data in respect of this station from the year 1981 to 2010 is analyzed. The data pertaining to these gauges is of long-term nature and are well maintained. It is presumed that they are representative of the Taluks and the same is used for analysis. Normal annual rainfall in the Taluk for the period 1981 to 2010 is **3436 mm**.

Computations were carried out for the **30** years blocks of **1981- 2010** on Mean, Standard deviation and coefficient of variation (CV) of each month pre -monsoon, monsoon, post monsoon and annual and are shown in **Table 1**.

The mean monthly rainfall at Mangalore Taluk is ranging between 0 mm during February to 1002 mm during June. The CV percent for pre-monsoon, monsoon and post monsoon season is 92, 19 & 50 percent respectively. Annual CV at this station works out to be 14 percent.

**Table-1: Statistical Analysis of Rainfall Data of Mangalore taluk, Dakshin Kannada district (1981 to 2010)**

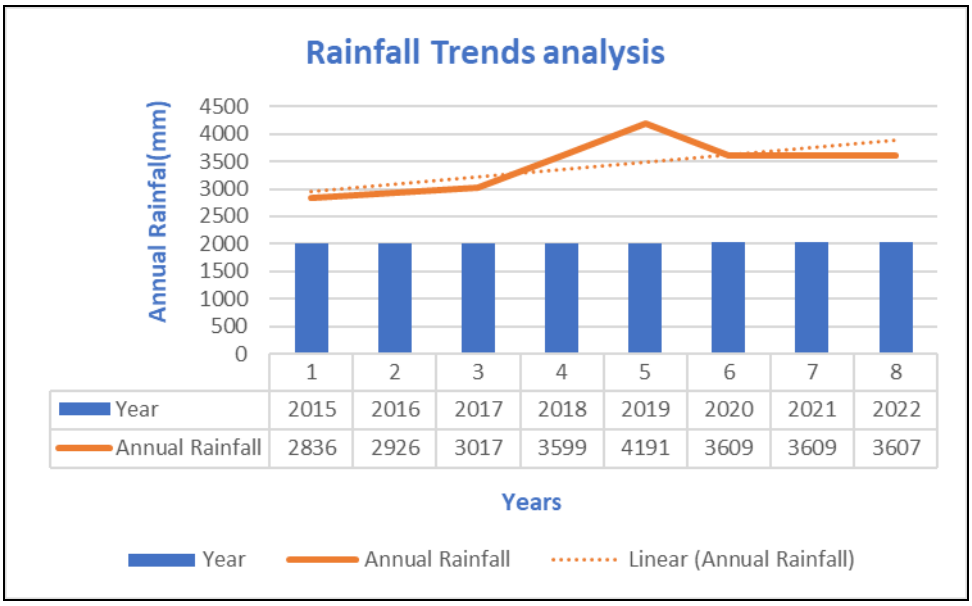
| STATION | | JAN | FEB | MAR | APR | MAY | PRE MONSOON | JUN | JUL | AUG | SEP | SOUTH WEST MONSOON | OCT | NOV | DEC | NORTH EAST MONSOON | ANNUAL RAINFALL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mangalore | Normal Rainfall (mm) | 2 | 0 | 12 | 24 | 195 | 232 | 1002 | 922 | 681 | 280 | 2884 | 222 | 90 | 8 | 319 | **3436** |
| | STDEV | 9 | 0 | 53 | 32 | 211 | 213 | 251 | 352 | 236 | 193 | 562 | 135 | 102 | 17 | 158 | **489** |
| | CV% | 548 | 393 | 433 | 136 | 108 | 92 | 25 | 38 | 35 | 69 | 19 | 61 | 113 | 218 | 50 | **14** |

## Annual Rainfall (2015-2022)

Computation were carried out for the annual rain fall for the year 2015-2022.The annual rainfall from **2015-2022** for month is below **(Table-2).**

**Table 2: Analysis of Annual Rainfall Data of Mangalore Taluk, Dakshin Kannada District, Karnataka for the Period 2015 to 2022**

| ANNUAL RAINFALL (2015-2022) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | JAN | FEB | MAR | APR | MAY | PRE MONSOON | JUN | JUL | AUG | SEP | SOUTH WEST MONSOON | OCT | NOV | DEC | POSTMONSOON MONSOON | ANNUAL RAINFALL |
| **2015** | 2 | 0 | 8 | 110 | 96 | 216 | 641 | 976 | 489 | 222 | 2328 | 215 | 60 | 17 | 292 | **2836** |
| **2016** | 0 | 0 | 0 | 3 | 125 | 128 | 1112 | 947 | 463 | 206 | 2728 | 50 | 14 | 6 | 70 | **2926** |
| **2017** | 0 | 0 | 0 | 16 | 150 | 166 | 863 | 689 | 728 | 330 | 2610 | 169 | 50 | 22 | 241 | **3017** |
| **2018** | 0 | 0 | 4 | 25 | 683 | 712 | 1059 | 833 | 553 | 102 | 2547 | 229 | 96 | 15 | 340 | **3599** |
| **2019** | 0 | 0 | 0 | 2 | 35 | 37 | 601 | 920 | 1403 | 648 | 3572 | 509 | 28 | 45 | 582 | **4191** |
| **2020** | 2 | 0 | 13 | 55 | 200 | 270 | 1030 | 1047 | 699 | 279 | 3055 | 194 | 78 | 12 | 284 | **3609** |
| **2021** | 2.4 | 0.3 | 13.2 | 54.7 | 200.1 | 271 | 1029 | 1047 | 699 | 279 | 3054 | 194 | 78 | 12 | 284 | **3609** |
| **2022** | 2.4 | 0.3 | 13.2 | 54.7 | 200 | 271 | 1029 | 1047 | 699 | 278 | 3053 | 193 | 78 | 12 | 283 | **3607** |




**Rainfall Trends analysis of Mangalore Taluk**

## 1.3 Agriculture & Irrigation

Agriculture is the main occupation in Mangalore Taluk, since 15% of the total population constitutes the rural population. The amount of rainfall and its distribution throughout the season contributes to the cropping pattern in the area. There are two agricultural seasons namely Kharif (June – October) and Rabi season (Mid October – Mid February). Most of the agriculture is through open well,bore-well and ground water is a major source of irrigation. Major Kharif crops are paddy and vegetables. Main crops of Rabi season is pulses. Among the commercial crops, Paddy is grown. Fruits and vegetables are also grown in the area (**Table 3**).

**Table 3: Area wise crops grown in Mangalore Taluk**

| Year | Paddy | Banana | Coconut | Arecanuts | Pulses | Sugarcane | Total plantation crop | Total fruits | Total vegetables | Total Food Grains |
|---|---|---|---|---|---|---|---|---|---|---|
| | Area under cultivation (in ha) | | | | | | | | | |
| **2018 - 19** | 1152 | 238 | 3795 | 3898 | 21 | 5 | 253 | 272 | 69 | 1173 |

During the year 2018-19, percentage of gross sown area of total geographical area is 18.66 % and net sown area was 17.87 % in Mangalore Taluk (**Table-4** and **Fig 2**). Irrigation practices by different sources in the Taluk are presented in **Table 5**.

**Table 4: Land use pattern of Mangalore Taluk**

| Year | Total Geographical Area (ha) | Area under Forest (ha) | Area not available for cultivation (ha) | Other uncultivated land (ha) | Total fallow land (ha) | Net sown area (ha) | Area sown more than once (ha) |
|---|---|---|---|---|---|---|---|
| **2018-19** | 55980 | 0 | 33432 | 9287 | 2213 | 10003 | 443 |

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

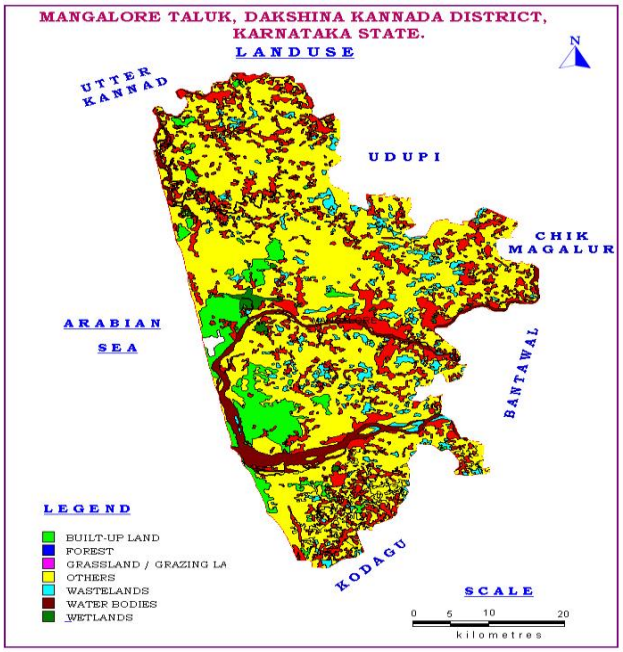
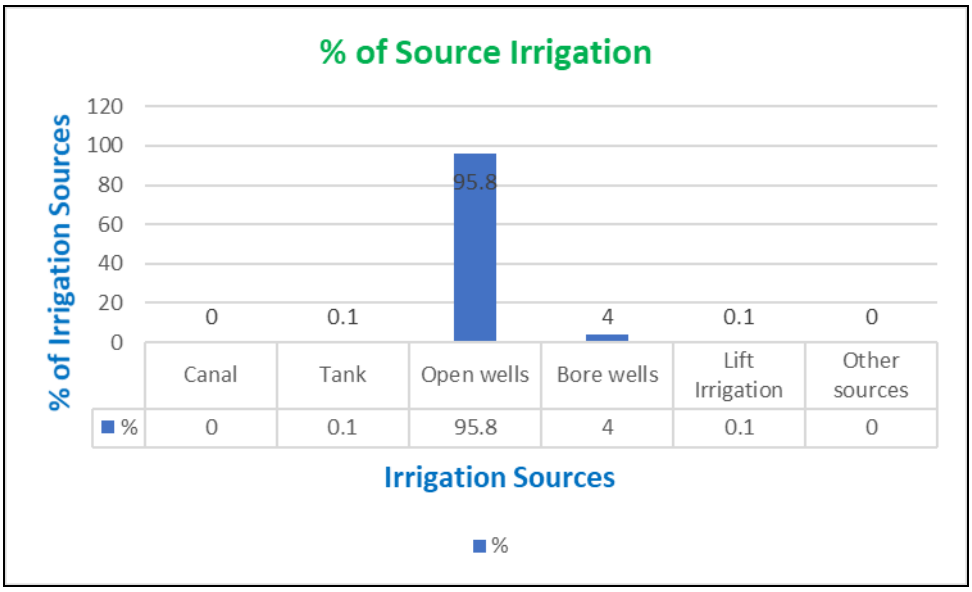



**Fig. 2: Land use map**

**Table 5: Irrigation practice in Mangalore Taluk**

| Source of irrigation | No. of irrigation source | Gross area irrigated (ha) | Net area irrigated (ha) |
|---|---|---|---|
| **Canals** | 0 | 0 | 0 |
| **Tanks** | 2 | 0 | 0 |
| **Open Wells** | 6315 | 3718 | 3614 |
| **Tube/ Bore wells** | 206 | 1326 | 964 |
| **Lift Irrigation** | 2 | 32 | 32 |
| **Other Sources** | - | 2668 | 2600 |
| **Total** | **6523** | **7744** | **7210** |

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




## Source of Irrigation in Mangalore Taluk

## 1.4 Geomorphology, Physiography & Drainage

Geomorphologically, Mangalore Taluk belongs to **West flowing region** which is characterized by Coastal plain in Western side and occur almost all over the taluk, Piedmont zone in spread in all taluk and settlement is found in western zone. (**Fig.3)**.Coastal plain is a narrow, thickly populated and intensely cultivated area adjoining the coast. There is considerable extent of barren land along the coast partly because it is sandy, rocky and marshy. The area near the sea is covered with coconut garden. The piedmont zone interspersed which is moderately cultivated with a considerable extent of fallow land, which can be put to agriculture use. The hill and plateau capped with laterite, which form plateau usually of oval or elongated configuration.

The Taluk lies in **Gurupura river and Netravathi river basin**. They exhibit **dendritic to sub-dendritic** drainage pattern.(**Fig.4**.) **Netravathi river** originated in Bangrabalige valley,Yelaneeru ghat in Kudremukh in Chikamagaluru District of Karnataka. The river merges with Kumaradhara river at Uppinangadi before flowing to Arabian sea, south of Mangalore city. The river is Main source of **Bantwal and Mangalore**. **Gurupura river** originated in Western ghat and tributary of Netravathi river, which empties into Arabian sea,south of Mangalore. It gets its name from the town Gurupura, situated near Mangalore. **Gurupura** is also called **Pachamagaru River** and it is Main river of Mangalore.

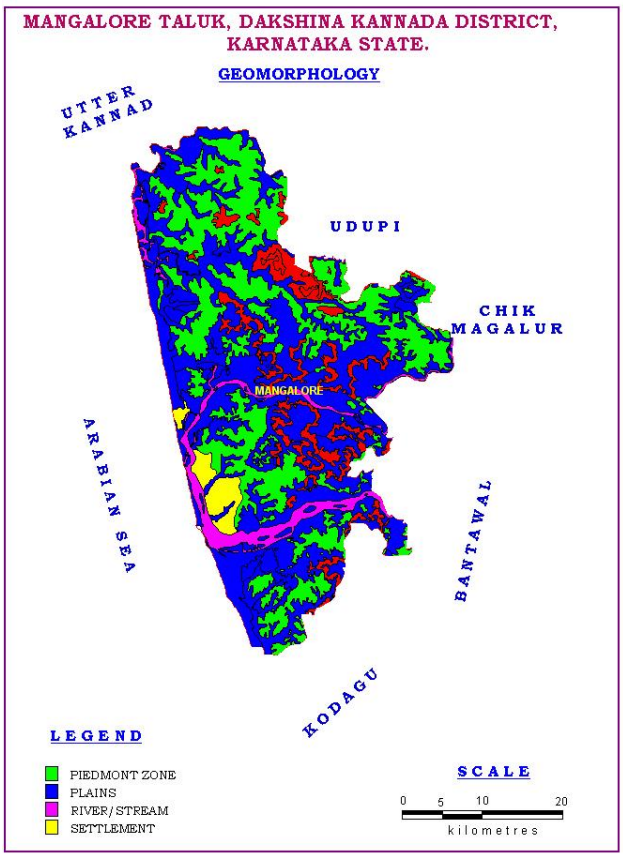



**Fig. 3: Geomorphology map**

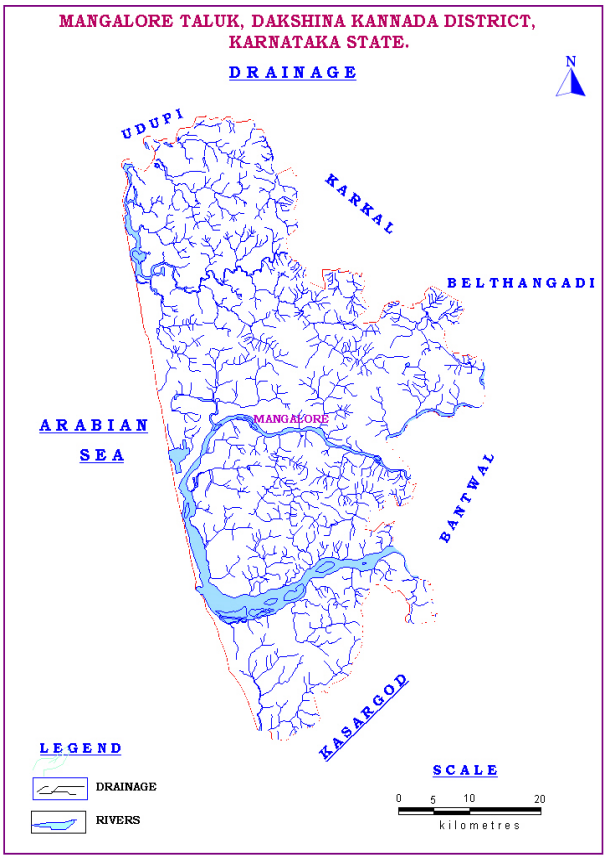



**Fig. 4: Drainage map**

## 1.5 Soil

The Taluk is mainly covered by clayey soil and varieties of **clayey soil like mixed and skeletal variety** found mostly all over the taluk.(**Fig. 5).** Soil derived from granite and gneiss with occasionally present of laterite type,characterised by High iron and aluminium content. Laterite type is suitable for Paddy, Sugarcane, Arecanut and Plantation crops. Sandy loamy are altered product of Granite gniesses, shallow to medium in depth intermixed with quartzite and gravelly material occur in central part of taluk. Loamy sand and sandy mostly occur near to Coastal area of Taluk.

Water holding capacity is Good. They have good Infiteration capacity and are well-suited for agriculture due to their fertility.

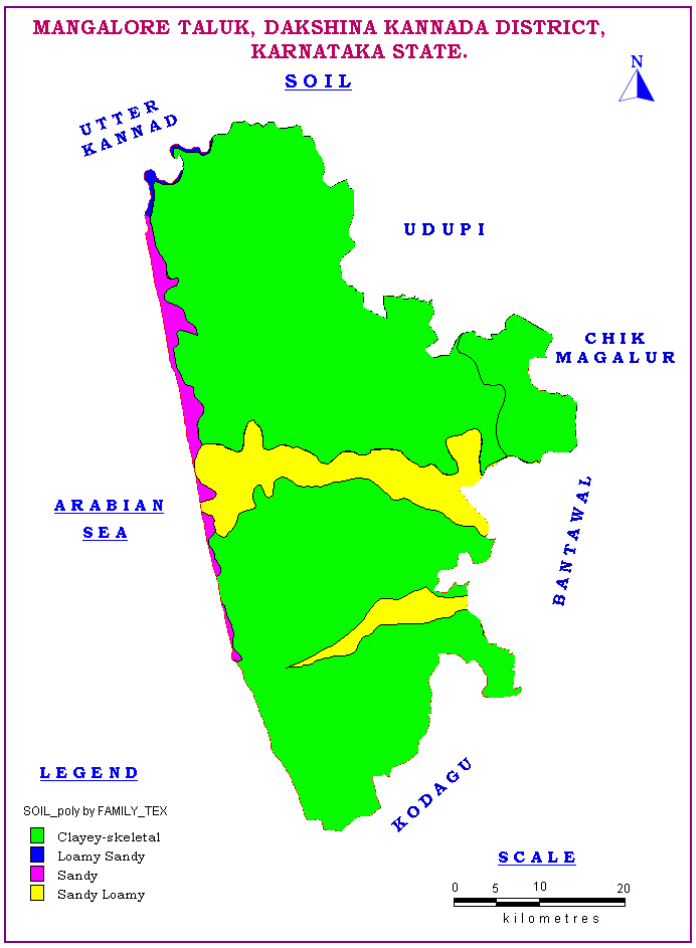


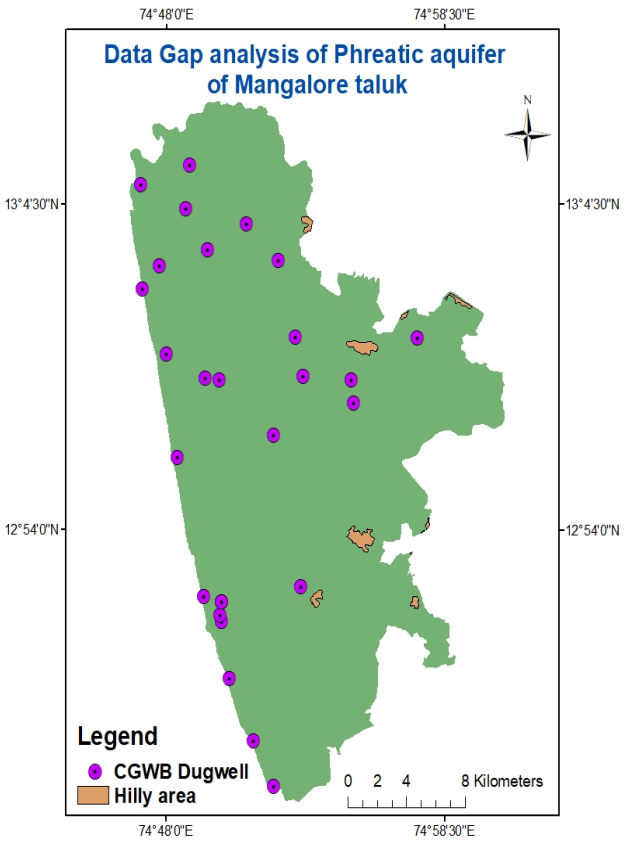

**Fig. 5: Soil map**

## 1.6 Existing and future water demands (as per GEC-2022) Table:6

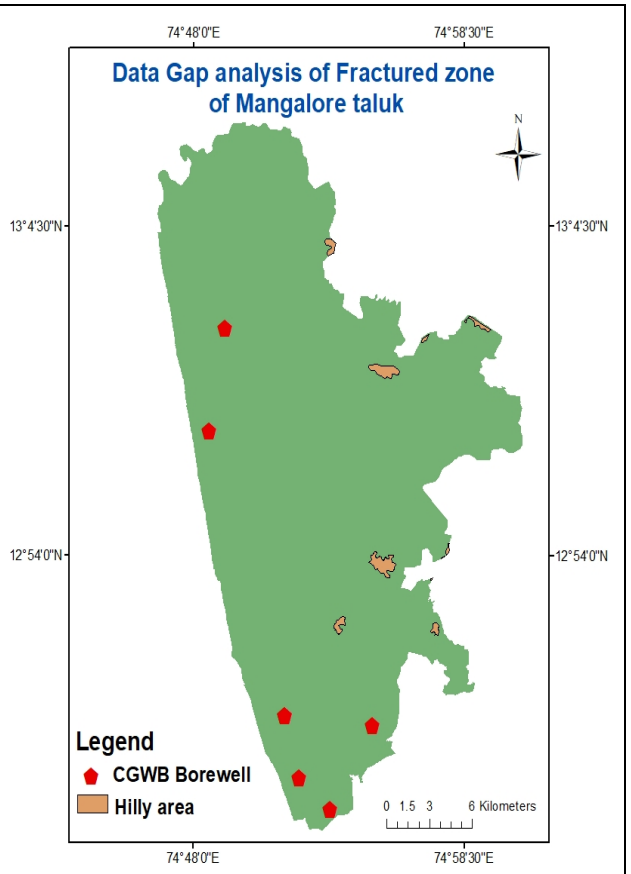
| Year | Existing Gross GW extraction for Irrigation (ham) | Existing Gross GW extraction for domestic and industrial water supply (ham) | Allocation for domestic and industrial use for the next 25 years (ham) | Net GW availability for future Irrigation development (ham) | Existing stage of Groundwater development (%) |
|---|---|---|---|---|---|
| **2017** | 1673 | 423 | 454 | 1502 | **58** |
| **2020** | 2545.49 | 687.45 | 728.68 | 6475.96 | **33.16** |
| **2022** | 2806.17 | 2265.609 | 2550.21 | 4877.18 | **49.51** |

## 1.7 Data Gap analysis and Well-Inventory with Pre-monsoon water-level Monitoring and Sample Collection

Pre-Monsoon water level monitoring generally analysed during May month. Based on the CGWB data Total **27** Dugwell and **1** Borewell present in the Mangalore taluk for Monitoring. Dugwell mostly covered in the taluk and pre-monsoon water level has been collected from the well ranges from **1.42 – 14.77 m** in dug well **(Aquifer-1)** and **11.48-49.73 m** in Borewell **(Aquifer-2)** included state groundwater department data. From most of the **27** dugwell, water sample collection of Pre-Monsoon has been collected for Chemical Quality analyses.




**Data Gap analysis of Phreatic Aquifer**

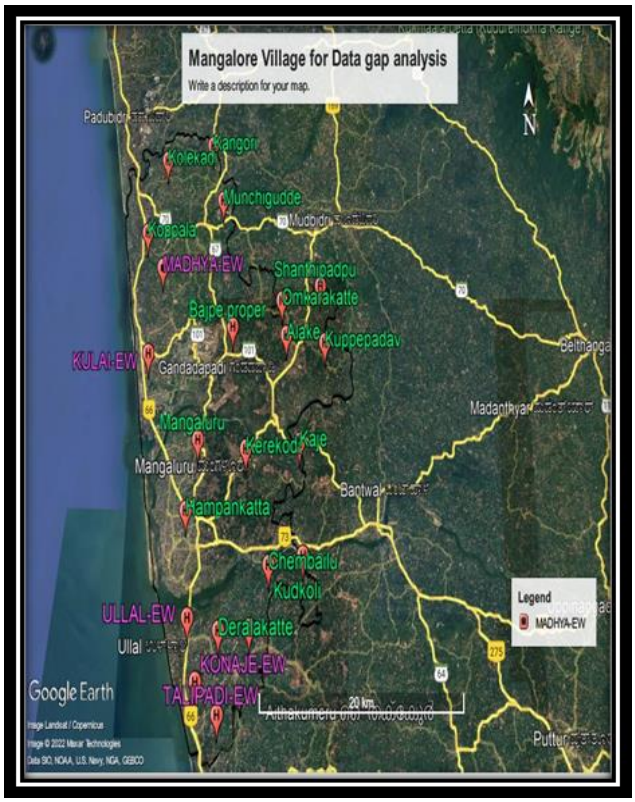



**Data Gap analysis of Fractured Aquifer**

**6 Borewell** drilled in Mangalore Taluk of shallow aquifer during Phase-1 of Drilling. Based on the available borewell data. It is showing that most of the taluk needs Data gap analysis and Well-Inventory for fractured aquifer.

## Proposed Villages should be covered under NAQUIM Studies based on Data gap analysis

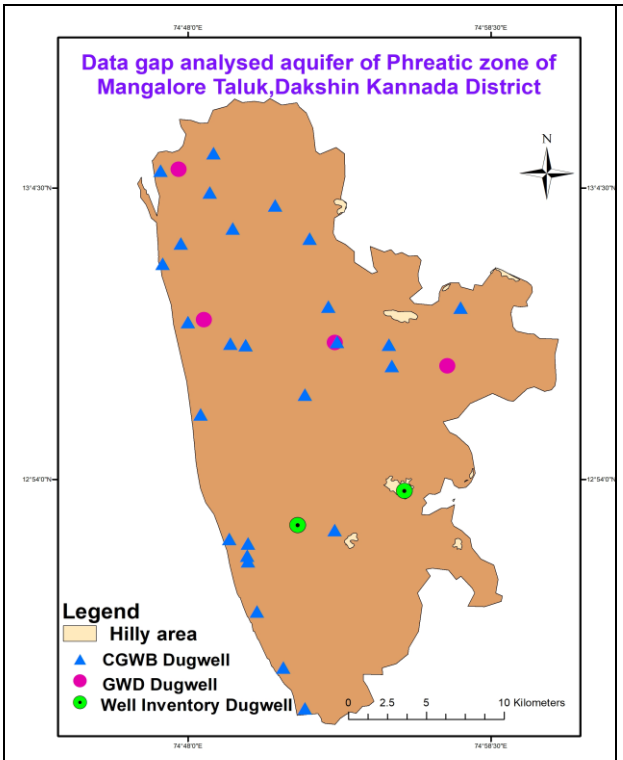
| S.N | VILLAGE NAME | LATITUDE | LONGITUDE | ELEVATION |
|---|---|---|---|---|
| 1 | **Deralakatte** | 12.8089 | 74.8960 | 56m |
| 2 | **Chembailu** | 12.8433 | 74.9249 | 86m |
| 3 | **Kaje** | 12.9123 | 74.9542 | 19m |
| 4 | **Mangaluru** | 12.9142 | 74.8431 | 20m |
| 5 | **Koppala** | 13.0431 | 74.7951 | 8m |
| 6 | **Kuppepadav** | 12.9727 | 74.9853 | 81m |
| 7 | **Bajpe proper** | 12.9820 | 74.8717 | 40m |
| 8 | **Kudkoli** | 12.8513 | 74.9663 | 7m |
| 9 | **Hampankatta** | 12.8759 | 74.8578 | 33m |
| 10 | **Kerekodi** | 12.9111 | 74.9121 | 7m |
| 11 | **Alake** | 12.9802 | 74.9492 | 121m |
| 12 | **Omkarakatte** | 13.0033 | 74.9465 | 106m |
| 13 | **Shantipadpu** | 13.0110 | 74.9772 | 79m |
| 14 | **Munchigudde** | 13.0709 | 74.8864 | 93m |



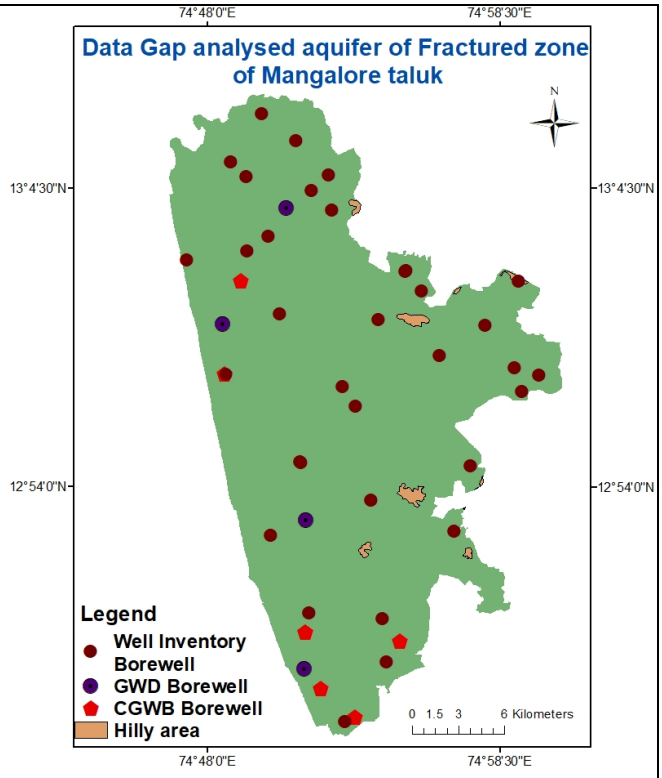
## 1.8 Data Gap analysed aquifer of Phreatic and Fractured aquifer

Based on the presence of Dugwell data, the Phreatic zone is covered mostly in all reliable zone except hilly areas and 2 Dugwell inventory has been done and 4 state government well utilized for data gap. Ground water exploration programme of CGWB was carried out in three phases in the district. There are few wells have been drilled in Mangalore Taluk during 1st phase, which reveals that the weathered, jointed and fractured granite is the potential aquifer system. 6 Borewell drilled in Mangalore Taluk during Phase-1 of Drilling. Based on the available borewell data, It is showing that most of the taluk needs Data gap analysis and Well-Inventory for fractured aquifer.

Data Gap analysis and Well-inventory conducted in total **36** villages in entire taluk and 4 state government well utilized. Based on the Well-Inventory, Total depth of well drilled, Discharge, Weathered zone, casing and Fractured zone data has been collected.




**Data Gap analysed aquifer of Phreatic aquifer**




**Data Gap analysed aquifer of Fractured aquifer**

## 1.9 Water level behavior

### A. DEPTH TO WATER LEVEL of Aquifer-I:

The distribution of depth to water level of Phreatic aquifer in different depth ranges is presented. Salient features of the depth to water level scenario during May 2022 and Nov 22 are given below. **(Fig-6)**

**Pre-Monsoon 2022 DTWL of Aq-I- (Fig-6A)**

A perusal of the water level data reveals that the depth to water level ranged from **1.42 m bgl to 14.77 m bgl**. Depth to water level of less than 2 m bgl has been recorded in 9 % of wells analysed, 2 to 5 m bgl water level has been recorded in 15 % of wells analysed, 5 to 10 m bgl water level has been recorded in 31 % of wells analysed and 10 to 15 m bgl water level has been recorded in 45 % of wells analysed.

**Post-Monsoon 2022 DTWL of Aq-I - (Fig-6B)**

A perusal of the water level data reveals that the depth to water level ranged from **1.25 m bgl to 13.80 m bgl** . Depth to water level of less than 2 m bgl has been recorded in 5 % of wells analysed, 2 to 5 m bgl water level has been recorded in 20 % of wells analysed, 5 to 10 m bgl water level has been recorded in 60 % of wells analysed and 10 to 15 m bgl has been recorded in 15 % of wells analysed.

**Table-7: Depth to water level of Pre-monsoon and post-Monsoon 2022**

| Sr. No | Village | Source | Pre-monsoon Depth to water May-2022 (mbgl) | Post-monsoon Depth to water Nov-2022 (mbgl) | Seasonal Fluctuation |
|---|---|---|---|---|---|
| 1 | Adyar | Dug Well | 1.95 | 2.10 | -0.15 |
| 2 | Bajpe | Dug Well | 5.95 | 1.25 | 4.7 |
| 3 | Bala | Dug Well | 10.55 | 7.70 | 2.85 |
| 4 | Elathur | Dug Well | 7.7 | 7.22 | 0.48 |
| 5 | Garadi | Dug Well | 10.44 | 9.71 | 0.73 |
| 6 | Haleangady | Dug Well | 6.42 | 5.28 | 1.14 |
| 7 | Kateel | Dug Well | 2.36 | 3.70 | -1.34 |
| 8 | Kenchanekere | Dug Well | 6.1 | 5.55 | 0.55 |
| 9 | Kenjaru | Dug Well | 6.08 | 6.65 | -0.57 |
| 10 | Kinni Kambala | Dug Well | 11.2 | 11.80 | -0.6 |
| 11 | Kinnigoli | Dug Well | 14.77 | 13.80 | 0.97 |
| 12 | Kotekar Dw | Dug Well | 13.4 | 9.97 | 3.43 |
| 13 | Mangalore Attawara | Dug Well | 7.26 | 7.25 | 0.01 |
| 14 | Mangalore Bandaru | Dug Well | 1.42 | 1.70 | -0.28 |
| 15 | Mangalore Jappu | Dug Well | 9.15 | 8.50 | 0.65 |
| 16 | Mangalore Kankanadi | Dug Well | 2.55 | 4.25 | -1.7 |

| | | | | | |
|---|---|---|---|---|---|
| 17 | Mangalore Lalbhag | Dug Well | 11.99 | 11.05 | 0.94 |
| 18 | Mukka | Dug Well | 7.3 | 4.58 | 2.72 |
| 19 | Mulki | Dug Well | 11.33 | 10.00 | 1.33 |
| 20 | Padil | Dug Well | 11.15 | 11.20 | -0.05 |
| 21 | Pakshikere | Dug Well | 7.89 | 6.78 | 1.11 |
| 22 | Panambur Beach | Dug Well | 2 | 4.50 | -2.5 |
| 23 | Mulki pz | Borewell | 13.33 | 12.73 | 0.6 |
| 24 | Kotekar BW | Borewell | 55.53 | 49.73 | 5.8 |
| 25 | Surathkal BW | Borewell | 11.88 | 11.48 | 0.4 |
| 26 | Kadri BW | Borewell | 43.15 | 37.8 | 5.35 |
| 27 | Kinnigoli BW | Borewell | 15.65 | 15 | 0.65 |

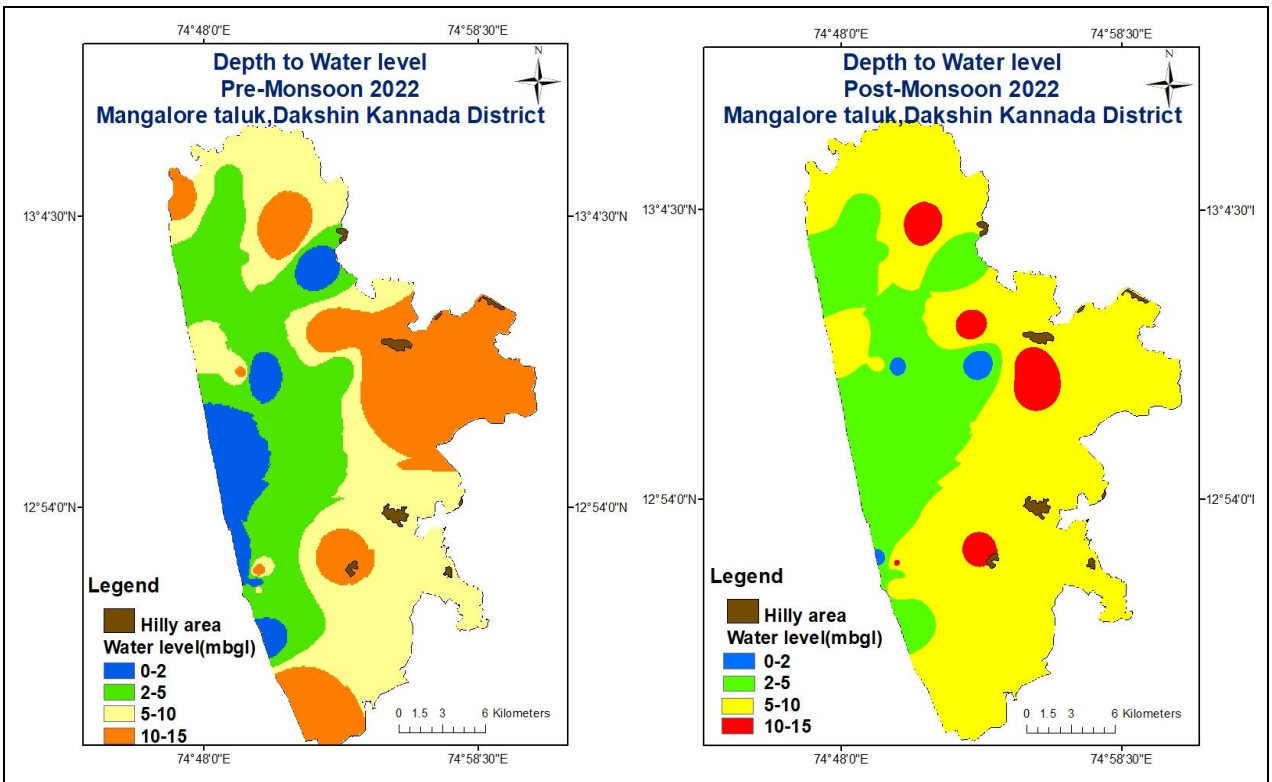



**Fig 6A&B: Pre monsoon and Post-Monsoon 2022 Phreatic water level map**

### B. DEPTH TO WATER LEVEL OF PIEZOMETRIC SURFACE:

The distribution of depth to water level of Piezometric surface in different depth ranges is presented. Salient features of the depth to water level scenario during May 2022 and Nov 22 are given below.

**Pre-Monsoon 2022 DTWL of Aq-II -(Fig-6C)**

A perusal of the water level data reveals that the depth to water level ranged from **11.88 m bgl to 55.53 m bgl** . Depth to water level in the range of 0 to 15 m bgl has been recorded in 40 % of wells analysed,15 to 45 m bgl water level has been recorded in 40 % of wells analysed and more than 45 m bgl water level has been recorded in 20% of wells analysed.

**Post-Monsoon 2022 DTWL of Aq-II -(Fig-6D)**

A perusal of the water level data reveals that the depth to water level ranged from **11.48 m bgl to 49.73 m bgl** . Depth to water level in the range of 0 to 15 m bgl has been recorded in 40 % of wells analysed, 15 to 45 m bgl water level has been recorded in 40 % of wells analysed and more than 45 m bgl water level has been recorded in 20 % of wells analysed.

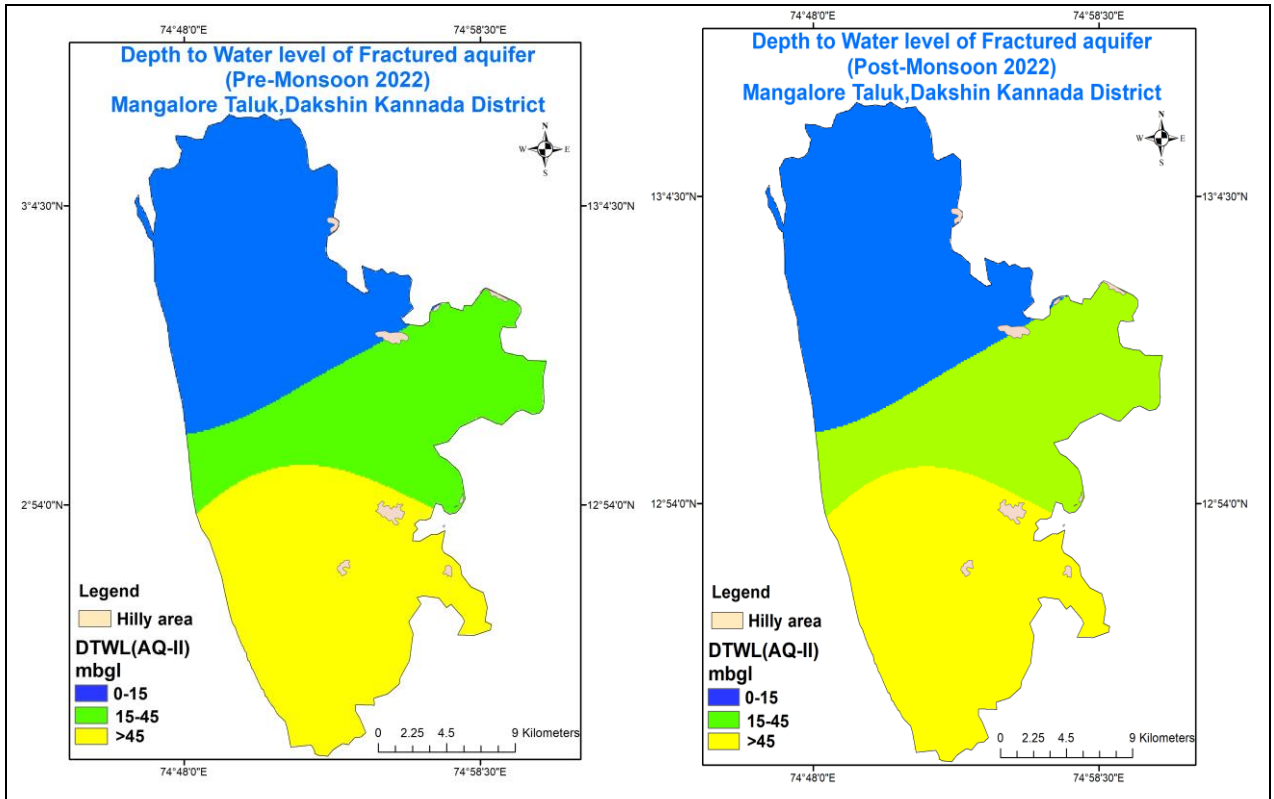



**Fig 6C &D: Pre monsoon and Post-Monsoon 2022 Fractured water level map**

### C. SEASONAL FLUCUATION of Aq-I (May 2022-Nov2022) –

The distribution of ground water monitoring wells of Aq-I showing rising and falling in different ranges of fluctuation is presented. **(Fig-6E)**

Rise in the water level in the range of 0-2 m has been observed in **25%** of wells analysed, 2-4 m rise has been observed in **5%** of wells and more than 4m rise has been observed in **2%** of wells analysed. The fall in water level in the range of 0-1 m has been observed in **60%** of wells analysed and 1-2 m fall has been observed in **8%** of wells analysed.

### SEASONAL FLUCUATION of Aq-II (May 2022-Nov2022) –

The distribution of ground water monitoring wells of Aq-II showing rising and falling in different ranges of fluctuation is presented. **(Fig-6F)**

Rise in the water level in the range of 0-1 m has been observed in **60%** of wells analysed and more than 1m rise has been observed in **40%** of wells analysed.

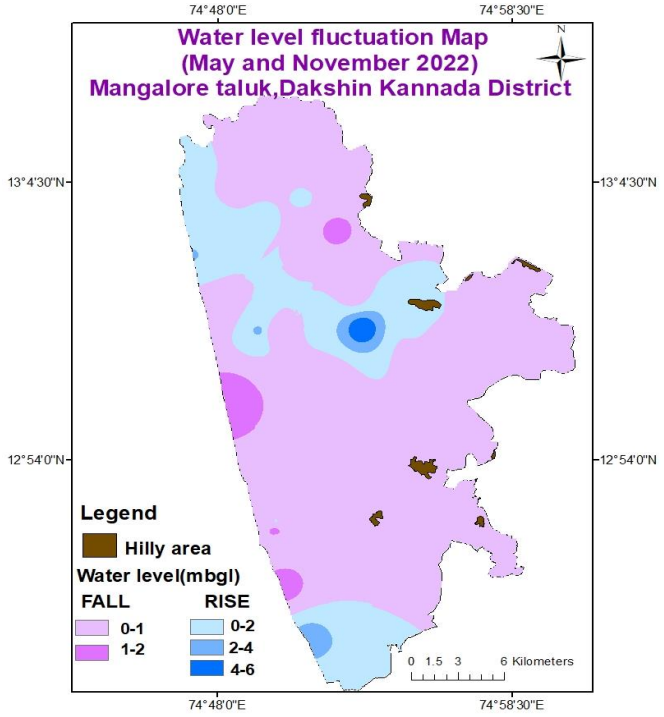



**Fig-6E Seasonal Fluctuation Map of Mangalore Taluk of Aquifer-I**

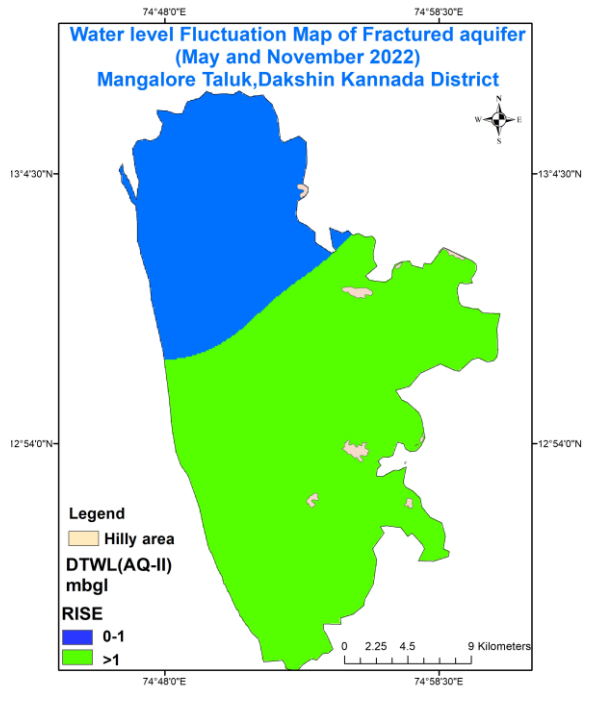



**Fig-6F Seasonal Fluctuation Map of Mangalore Taluk of Aquifer-II**

**D. ANNUAL FLUCTUATION OF PRE & POST MONSOON-**

**Annual Fluctuation of Pre-Monsoon (May 21 to May 22)-**

The distribution of ground water monitoring wells falling in different ranges of fluctuation is showing in **Fig-6B**. A comparison of water level shows that a fall in the water level is recorded in 65 % of wells analysed, while 35 % recorded rise. Salient features of the comparison of water levels are given below. **(Fig-6G)**

Rise in the water level in the range of 0-2 m has been observed in **35%** of wells analysed. The fall in water level in the range of 0-2 m has been observed in **49%** of wells analysed,2-4 m fall has been observed in **8%** of wells analysed and more than 4 m has been observed in **8 %** of wells analysed.

**Annual Fluctuation of Post-Monsoon (Nov 2021 to Nov 22)-**

The distribution of ground water monitoring wells falling in different ranges of fluctuation is showing in **Fig-6C**. A comparison of water level shows that a fall in the water level is recorded in 91 % of wells analysed, while 9 % recorded rise. Salient features of the comparison of water levels are given below. **(Fig-6H)**

Rise in the water level in the range of 0-2 m has been observed in **6 %** of wells analysed and more than 2 m rise has been observed in **3 %** of wells analysed. The fall in water level in the range of 0-2 m has been observed in **63%** of wells and more than 2 m fall has been observed in **28%** of wells.

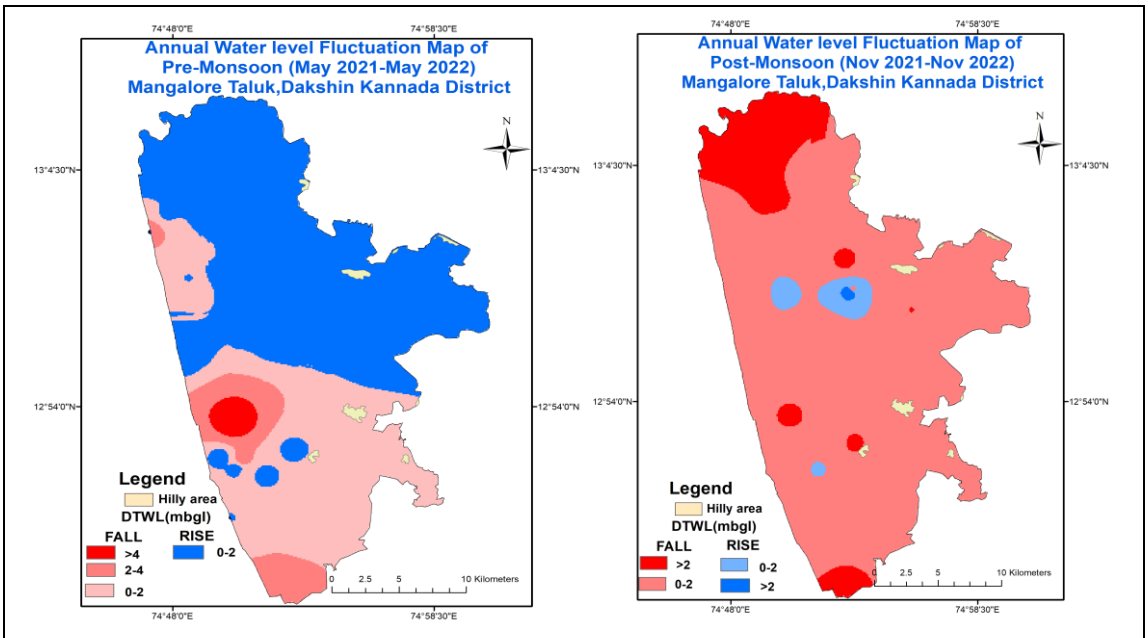



**Fig 6G & H: Annual water level fluctuation Map of Pre monsoon & Post-Monsoon**

## E. DECADAL AVERAGE PRE & POST MONSOON—

### Decadal average Pre-Monsoon (2013-2022) DTWL-

A perusal of the water level data reveals that the depth to water level ranged from **1.65 m bgl to 14.05 m bgl**. **(Fig-6I)** Depth to water level in the range of 0 to 2 m bgl has been recorded in **8 %** of wells analysed, 2 to 5 m bgl water level has been recorded in **17 %** of wells analysed, 5 to 10 m bgl water level has been recorded in **47 %** of wells analysed and 10 to 15 m bgl water level has been recorded in **28 %** of wells analysed.

### Decadal average Post-Monsoon (2013-2022) DTWL-

A perusal of the water level data reveals that the depth to water level ranged from **1.27 m bgl to 13.18 m bgl** . **(Fig-6J)** Depth to water level in the range of 0 to 2 m bgl has been recorded in **8 %** of wells analysed, 2 to 5 m bgl water level has been recorded in **32 %** of wells analysed, 5 to 10 m bgl water level has been recorded in **52 %** of wells analysed and 10 to 14 m bgl water level has been recorded in **8 %** of wells analysed.

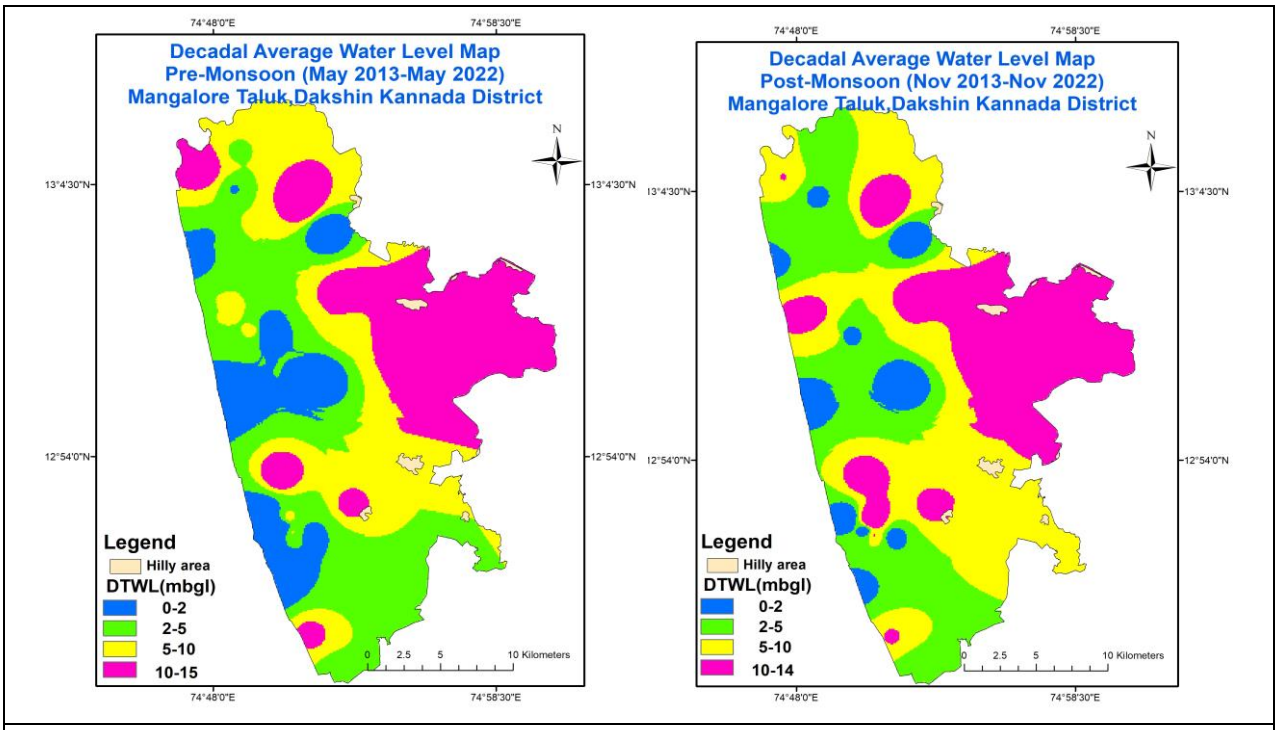



**Fig 6I &J: Decadal average Pre Monsoon and Post-Monsoon water level map**

## F. DECADAL FLUCTUATION OF PRE & POST MONSOON-

### Decadal Fluctuation of Pre-Monsoon (May 2012-21 to 22)-

The distribution of ground water monitoring wells falling in different ranges of fluctuation is showing in **Fig-7**. A comparison of water level shows that a fall in the water level is recorded in 31 % of wells analysed, while 69 % recorded rise. Salient features of the comparison of water levels are given below.

Rise in the water level in the range of 0-2 m has been observed in **18%** of wells analysed and more than 2-4 m rise has been observed in **6%** of wells analysed. The fall in water level in the range of 0-2 m has been observed in **20%** of wells, 2-4 m fall has been observed in **8%** of wells and more than 4 m fall has been observed in **3%** of wells.

### Decadal Fluctuation of Post-Monsoon (Nov 2012-21 to 22)-

The distribution of ground water monitoring wells falling in different ranges of fluctuation is showing in **Fig-8**. A comparison of water level shows that a fall in the water level is recorded in 89 % of wells analysed, while 11 % recorded rise. Salient features of the comparison of water levels are given below.

Rise in the water level in the range of 0-2 m has been observed in **8 %** of wells analysed and more than 2m rise has been observed in **3 %** of wells analysed. The fall in water level in the range of 0-2 m has been observed in **44%** of wells, 2-4 m fall has been observed in **37%** of wells and more than 4 m fall has been observed in **8%** of wells.

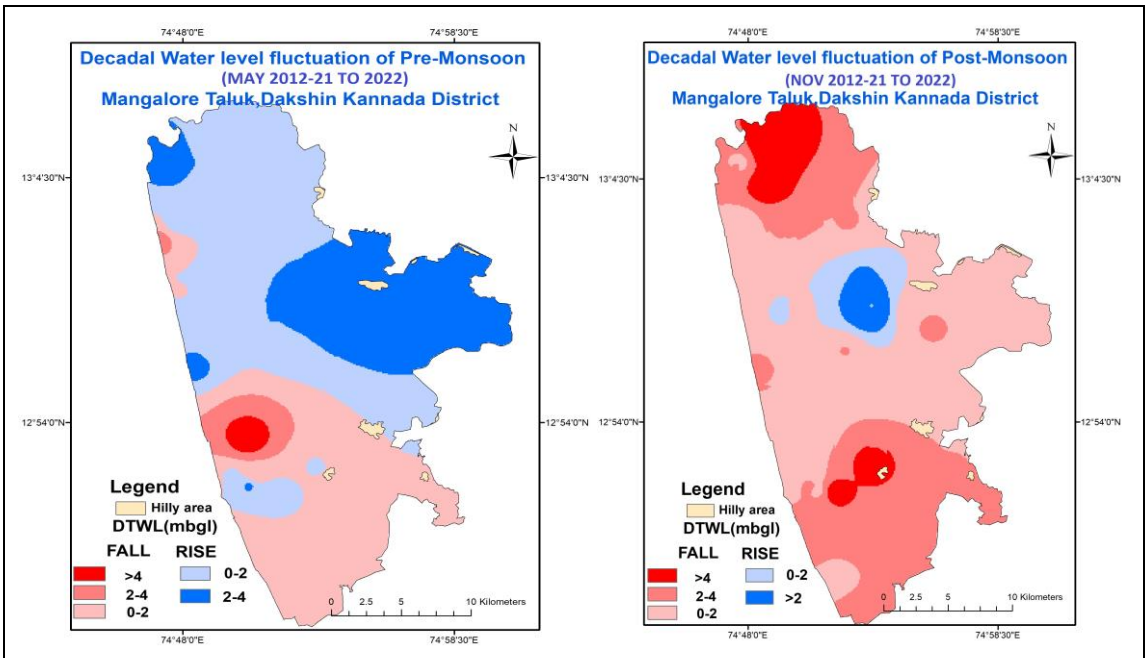
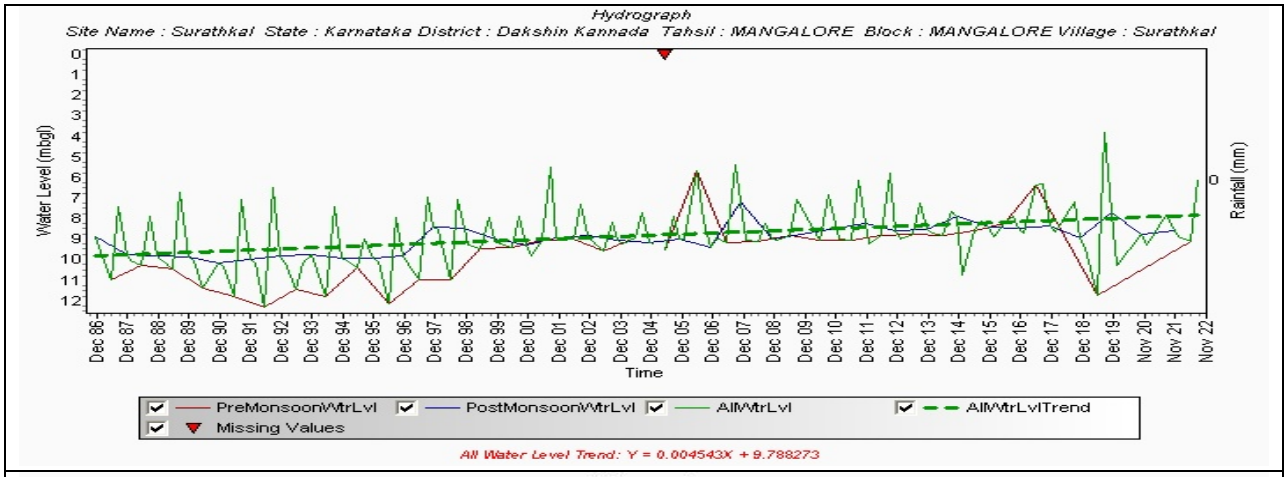
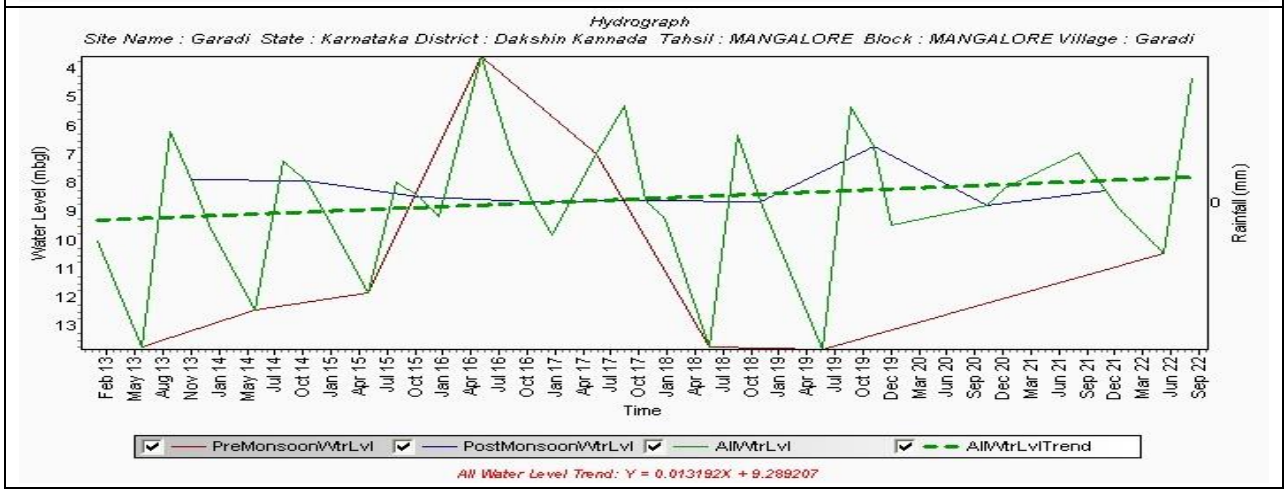
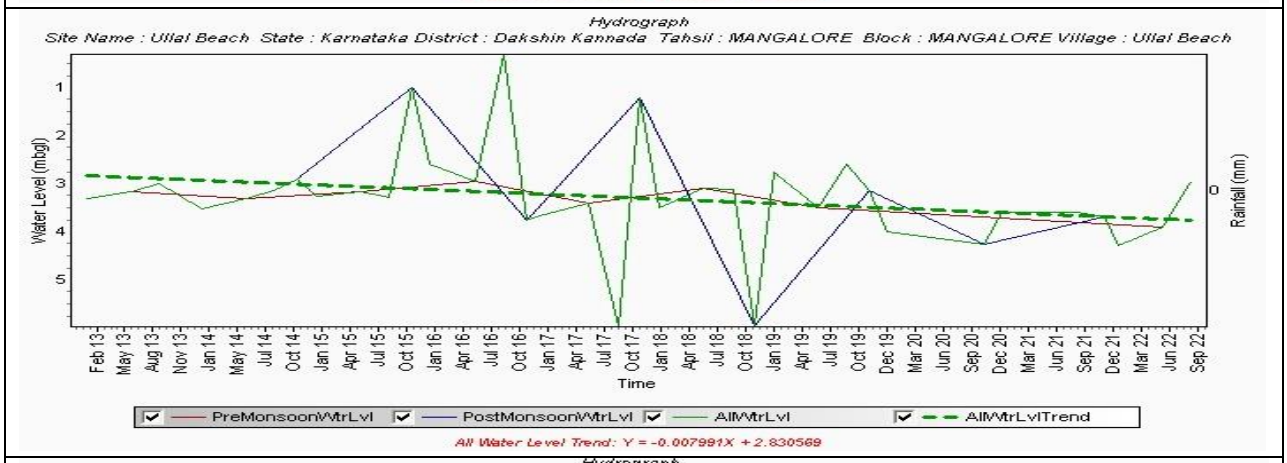


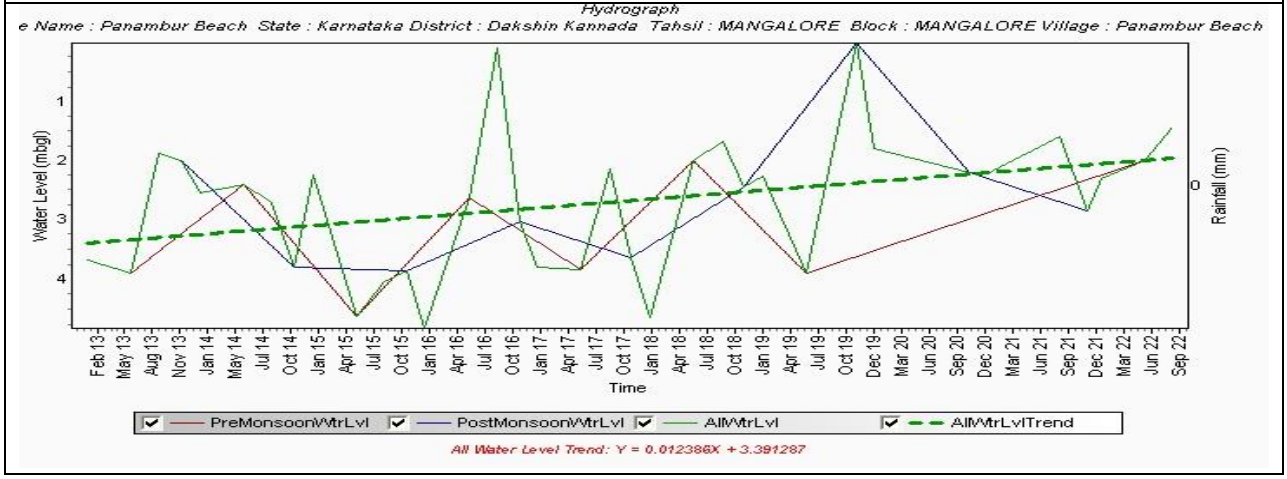

**Fig 7 & 8: Decadal water level fluctuation Map of Pre monsoon & Post-Monsoon**

## G. Long term water level trend & Hydrographs of Mangalore taluk-



# 2 AQUIFER DISPOSITION

Banded Gniessic Complex occupy nearly 80% of all over the taluk whereas alluvium occurs in the rest 10% in the western part of the Taluk **(Fig 8)** and laterite is mostly in all portion of taluk. The gneisses comprise of migmatites associated with biotites and hornblendes. The granites are grey in colour and are fine to coarse grain in nature. Ground water occurs under water table to semi confined condition depending upon disposition of aquifer which is mainly granite and schist. Ground water occur under water table to semi confined condition in granite whereas in schist groundwater occur in weathered, jointed and fractured zone under water table condition.

Ground water exploration programme of CGWB was carried out in three phases in the district. There are few wells have been drilled in Mangalore Taluk, which reveals that the weathered, jointed and fractured granite is the potential aquifer system.

Majority of the dug well in granitic gneiss ranges in depth from **12m to 39.6m** having a weathered zone from 9m to 30m. Water level lies in the range of **1.42 – 14.77 mbgl**.

Pumping test of 500 minutes conducted on open well in Mangalore have revealed that the discharge ranges between **0.2 to 8.72 lps** with a drawdown of 8.85 m and unit area specific capacity of **20.56 lpm/m/m.**

## 2.1 Number of aquifers:

In Mangalore Taluk, there are mainly two types of aquifer systems;

**i. Aquifer-I** (Phreatic aquifer, weathered zone) comprising of **Granitic Gneiss.**

**ii. Aquifer-II** (Fractured zone) comprising of **Fractured Granitic gneiss.**

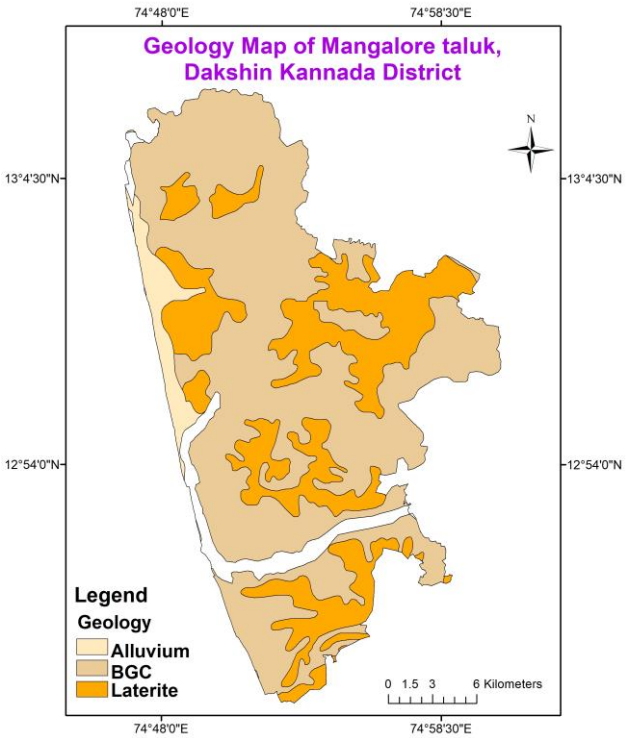



**Fig 9: Geology Map**

**Fig 9** showing the Geology of Mangalore taluk, Banded Gneissic Complex is found most of the part of taluk, alluvium in western part of taluk in Coastal area and Laterite is found in patches in almost all part of taluk.

**Table-8: Details of Ground Water Exploration**

| S. No | Location | Lat | Long | Depth m bgl | Casing (m) | Litholo gy | SWL (mbgl ) | Q (lps) | T ($m^2$/day) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Attepadavu SC Colony | 12.9655 | 74.9986 | 195 | 12 | ARCN, GRNT | - | - | - |
| 2 | Muthuru | 12.9557 | 74.9882 | 176.8 | 15.5 | ARCN, GRNT | - | - | - |
| 3 | Durgakodi | 12.9697 | 74.9838 | 192 | 15.2 | ARCN, GRNT | - | - | - |
| 4 | Muchhuru | 13.0261 | 74.9183 | 181 | 24 | ARCN, GRNT | - | - | - |
| 5 | Panjirme | 13.0146 | 74.9282 | 177.8 | 24 | ARCN, GRNT | - | - | - |
| 6 | Hampankatte | 12.8718 | 74.8380 | 149 | 26.5 | ARCN, GRNT | - | - | - |
| 7 | Valpady | 12.9146 | 74.8558 | 165 | 15.2 | ARCN, GRNT | - | - | - |
| 8 | Muddupadavu | 13.0012 | 74.8431 | 186 | 18.2 | ARCN, GRNT | - | - | - |
| 9 | Kolekadi | 13.0905 | 74.8138 | 182 | 18 | ARCN, GRNT | - | - | - |
| 10 | Sunkadakatte | 13.0826 | 74.8727 | 195 | 18 | ARCN, GRNT | - | - | - |
| 11 | Kallapu | 12.8260 | 74.8610 | 184 | 12 | ARCN, GRNT | - | - | - |
| 12 | Kollur | 13.1028 | 74.8531 | 198 | 27 | ARCN, GRNT | - | - | - |
| 13 | Kuberapade | 13.1187 | 74.8325 | 184 | 18 | ARCN, GRNT | - | - | - |
| 14 | Kubevuru | 13.0817 | 74.8231 | 198 | 24 | ARCN, GRNT | - | - | - |
| 15 | Punja | 13.0383 | 74.8239 | 181 | 12 | ARCN, GRNT | - | - | - |
| 16 | Kollottu | 12.9471 | 74.8886 | 198 | 12 | ARCN, GRNT | - | - | - |
| 17 | Konaje | 12.80980 | 74.91536 | 100 | 19.5 | ARCN, GRNT | 16.99 | 0.3 | 1 |
| 18 | Kulai | 12.96625 | 74.80997 | 29.85 |  | ARCN, | 0 | Negl | - |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | GRNT | | | |
| **19** | **Madhya** | 13.02065 | 74.82008 | 250 | 19 | ARCN, GRNT | 9.505 | 4.3 | 91 |
| **20** | **Talipadi** | 12.76549 | 74.88818 | 200 | 25 | ARCN, GRNT | 10.2 | 0.2 | 1 |
| **21** | **Uchila** | 12.78202 | 74.86791 | 7.7 | 2 | ARCN, GRNT | 0 | Negl | - |
| **22** | **Ullal- EW** | 12.81530 | 74.85861 | 29.7 | 5.5 | ARCN, GRNT | 3.75 | 8.72 | 43 |

**Table-9 Basic characteristics of each aquifer**

| Aquifers | Weathered Zone (Aq.-I) | Fractured Zone (Aq.-II) |
|---|---|---|
| **Prominent Lithology** | Weathered Gniess/Schist | Fractured Gniesses/Schist |
| **Thickness range (mbgl)** | 39.6 | Fractures upto 200 mbgl |
| **Depth range of occurrence of fractures (mbgl)** | 9-30 | 25-165 |
| **Range of yield potential (lps)** | Poor yield | 0.2-8.72 |
| **Specific Yield** | 2% | 0.2% |
| **T ($m^2$/day)** | - | 1-91 |
| **Quality Suitability for Domestic &Irrigation** | Suitable | Suitable |

## 2.2 Depth wise Aquifer System

The data generated from ground water monitoring wells, 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.

### 2.2.1 Aquifer-I (Shallow Phreatic aquifer)

Aquifer – I comprises of Alluvium,Laterite and weathered granitic gneiss. The spatial distribution of depth of occurrence and aquifer thickness of Aquifer-I is depicted in **Fig. 9A** and the hilly area, Drainage map and borewell location is also included in map. It indicates that the depth of occurrence of aquifer – I ranges from 9 to 40 m bgl. However, it mainly occurs in the depth range of 15 to 20 m bgl covering 65% of the area mostly in the all part of the taluk. The depth of occurrence of 9 to 15 m bgl is observed in about 20% of area mainly in Central, Western & eastern parts of the taluk.20-30 m depth occurred in patches in 10%. The deep depth of occurrence of 30 to 40 m bgl is observed in about 5% in the southern part of taluk.

The perusal of the map for aquifer thickness indicates that it ranges from 4 to 15 m, however aquifer thickness of 8 to 12 m is observed in about 75% of the area covering central part of the taluk. The aquifer thickness of 4 to 8 m is observed in 15% of the areas in patches covering all parts of taluk. The maximum thickness of 12 to 15 m observed in 10% mostly in patches in all over the taluk.

## 2.2.2 Aquifer-II (Deeper Fractured aquifer)

It comprises of Alluvium, laterite and fractured Granite Gneiss rock. The spatial distribution of depth of occurrence and aquifer thickness of Aquifer-II is depicted in **Fig. 9B** and the hilly area, Drainage map and borewell location is also included in map. It indicates that the depth of occurrence of aquifer – II ranges from 117 to 180 m bgl. However, it mainly occurs in the depth range of 145 to 160 m bgl covering 50% of the area in Central and southern part of the taluk. The depth of occurrence of 117 to 130 m bgl is observed in about 5% in patches in western part of taluk. The depth of Occurrence of 130-145 is observed in 15% in Western and Eastern part of taluk. The deeper depth of occurrence of 160 to 180 is observed in 30% in Northern and southern part of taluk. The perusal of the map for fractured aquifer thickness indicates that it ranges from 6 to 18 m, however aquifer thickness of 6 to 8 m is observed in about 60% of the area covering central and eastern parts of the taluk. The aquifer thickness of 8 to 12 m is observed in 30% of the areas covering western and northern parts. The higher fractured aquifer thickness of 12-18 m is observed in Northern part of taluk.

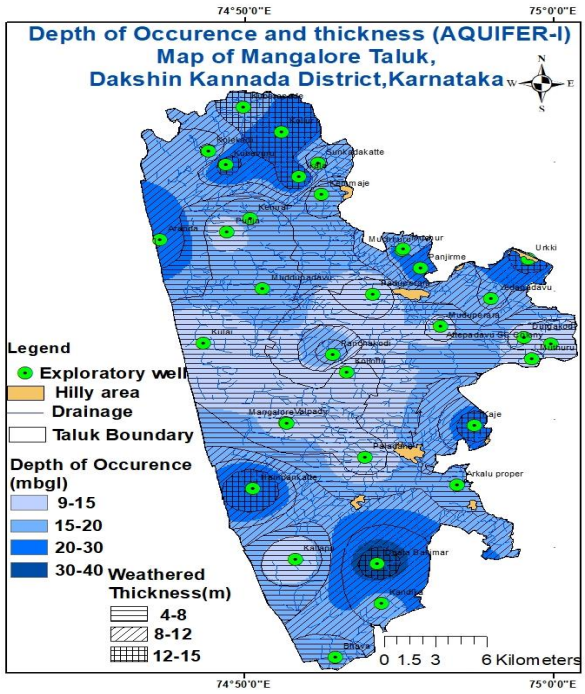



**Fig-9A Depth of Occurrence and thickness Map (Aq-I)**

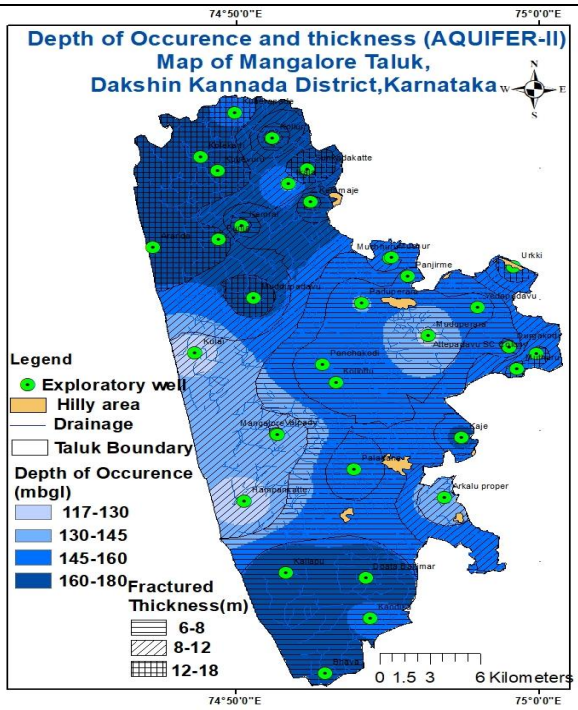



**Fig-9B Depth of Occurrence and thickness Map (Aq-II)**

## 2.3 3 D aquifer disposition and Cross-Sections

**Aquifer disposition –** The drilling data obtained from other departments is utilised for generating aquifer disposition maps through Rock works software. The **2D** and **3D** outputs thus obtained is presented in **Fig-10,Fig-11 & to Fig-12.**

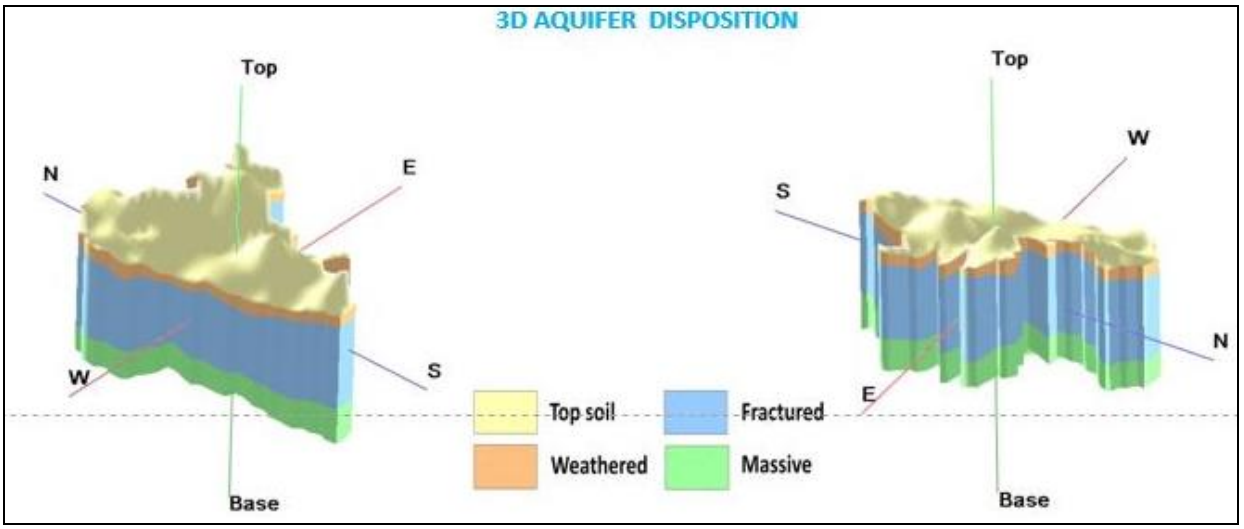



**Fig-10: 3D aquifer Disposition**

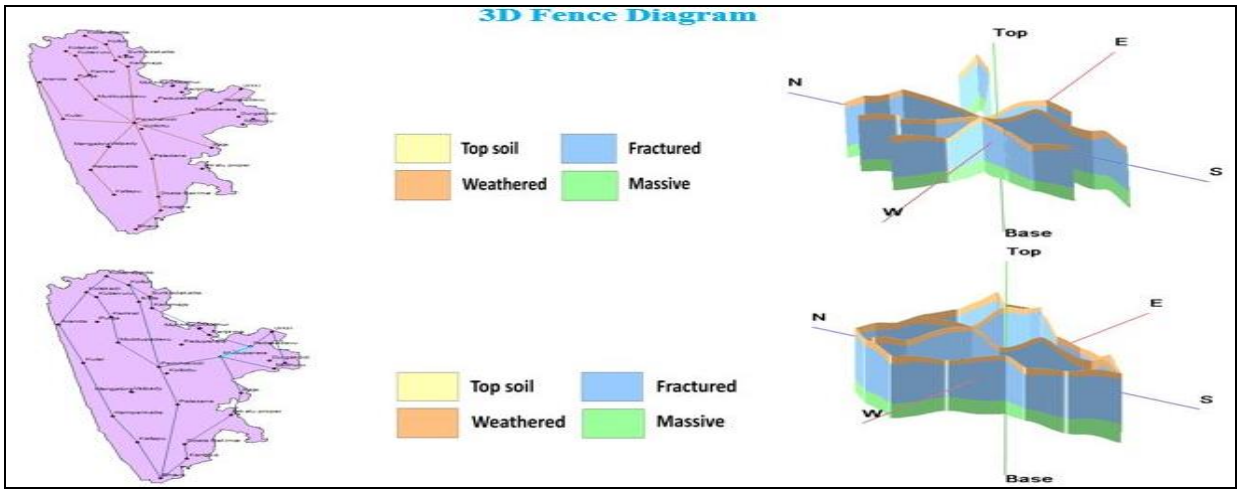



**Fig-11: 3D Aquifer Fence Diagram**

The fence diagram indicating the disposition of various aquifers is presented in **Fig.-11**. In all part of the taluk, the laterite present at top followed by Banded gneissic complex, whereas in Coastal part, alluvium is present.. The 3-D representation is presented in **Fig.-10**. The disposition of Aquifer-I and Aquifer-II followed by massive formation can be observed in the 3-D aquifer disposition. The depth of the top soil is in the range of 0 to 5 m bgl, followed by weathered aquifer observed upto 40 m, which is followed by fractured aquifer which is disposed upto 165 m bgl depth followed by massive formation devoid of any ground water.

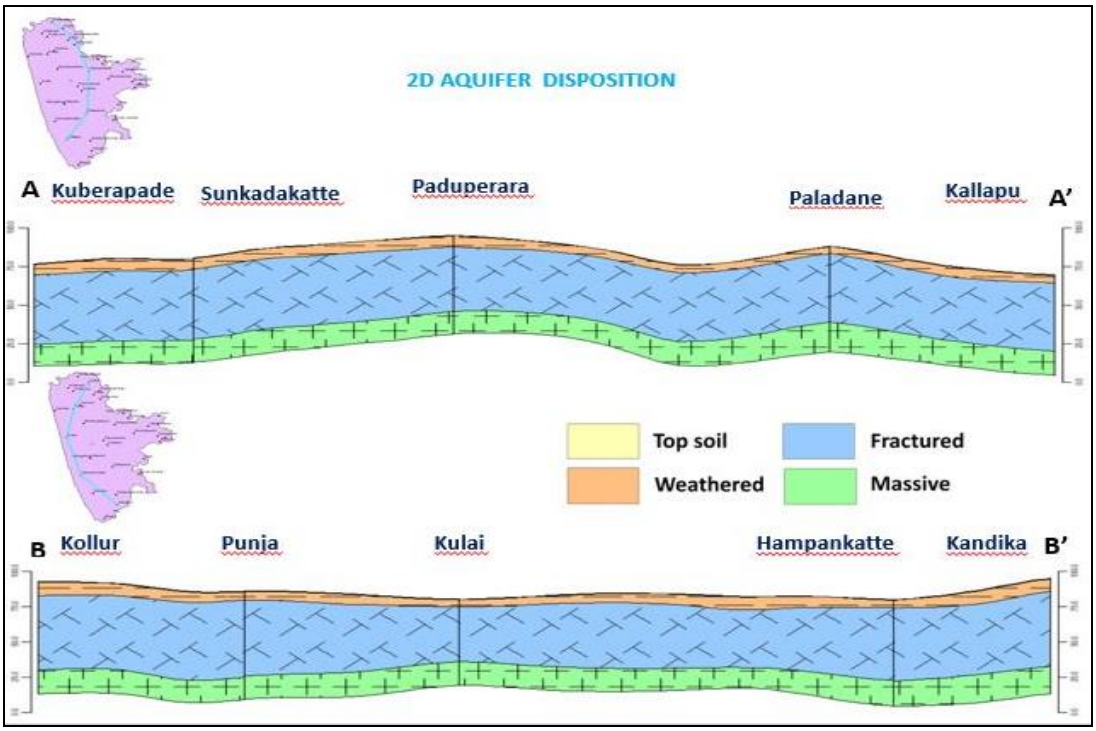



**Fig-12: Cross sections in different directions**

To study the aquifer disposition in detail, various hydrogeological cross section indicating aquifer geometry has been prepared viz. A-A' representing NE–SW direction, B-B' representing NW-SE direction respectively.**(Fig-12)**

Hydrogeological cross section A-A' (**Fig.-12**) represents NE–SW direction and data of 36 exploratory wells has been utilised. It can be clearly seen from the NE–SW direction i.e., from Kubarapade to Kallapu, the thickness of Aquifer-I (shallow aquifer) and Aquifer-II (deeper aquifer) is same and the thickness of Massive rock is also same from A to A'.

Hydrogeological cross section B-B' (**Fig.-12**) represents NW-SE direction and data of 36 exploratory wells has been utilised. It can be clearly seen from the section from NW-SE direction, from Kollur to Kandika, the thickness of Aquifer-I (shallow aquifer) and Aquifer-II (deeper aquifer) is same. On the contrary, the thickness of Massive rock is less in B and more in B'.

### 2.3 Hydrogeology of Phreatic and Fractured aquifer:-

Majority of the dug well in granitic gneiss ranges in depth from **12m to 39.6m** having a weathered zone from **9m to 30m**. Discharge of well is almost <1 lps. Transmissivity is very less and Water level lies in the range of **1.42 – 14.77 mbgl**.

0-10 m **weathered thickness** found in major southern part of taluk, 10-20m thickness found in central part of taluk, 20- 30m found in Northern & Southern part in taluk and more than 30m in patches in all taluk**.(Fig-13)**

Bore well in Fractured granitic gneiss ranges in depth upto **200 m** having a weathered zone from **9 m to 39 m** and Fractured zone from **25 to 165 mbgl**. Transmissivity of the Mangalore taluk is **1-91 m2/day**, Discharge ranges between **0.2 to 8.72 lps** with a drawdown of **8.85 m** and unit area specific capacity of **20.56 lpm/m/m.**

**Hydrogeology Map** of Mangalore taluk showing that Banded Gneissic Complex is found most of the part of taluk, alluvium in western part of taluk in Coastal area and Laterite is found in patches in almost all part of taluk. Yield of the taluk revealed that <1 lps found in almost all part of taluk in patches, 1-3 lps in central part of taluk and >3 lps found in some patches in southern part which show high yielding of the taluk. Lineament found in southern east part of taluk. **(Fig-14)**

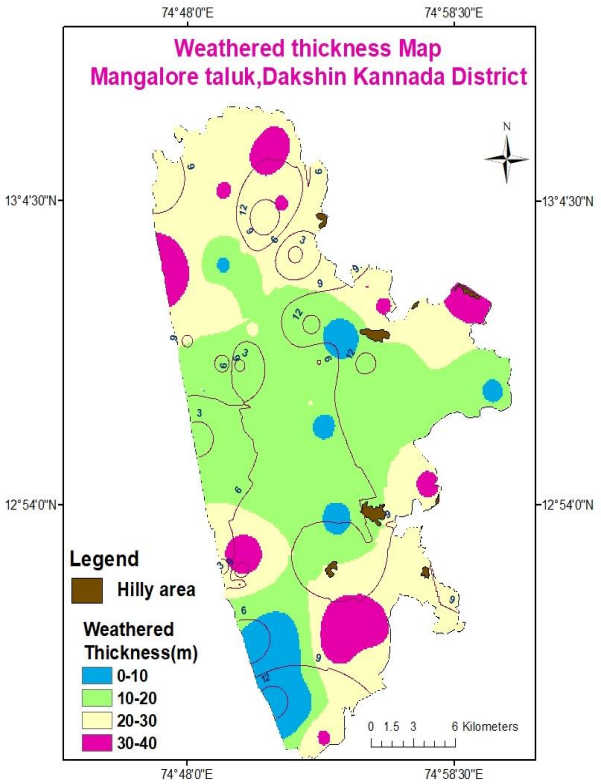



**Fig-13 Weathered Map of Mangalore Taluk**

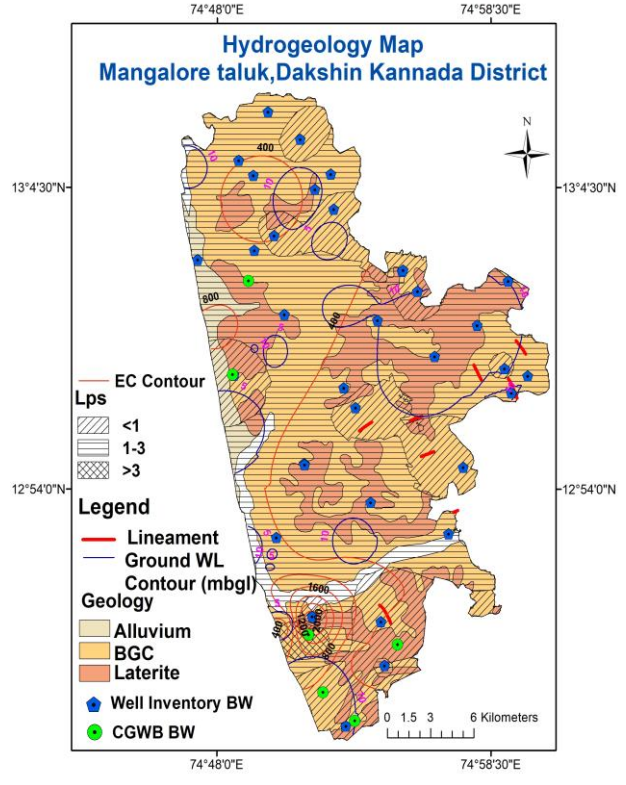



**Fig-14 Fractured Map of Mangalore Taluk**

# 3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

## 3.1 Aquifer wise resource availability and extraction (2022)

| Taluk | Annual Extract GW resource (ham) | Existing Gross GW extraction for Irrigation (ham) | Existing Gross GW extraction for domestic and industrial water supply (ham) | Existing Gross GW extraction for all uses (ham) | Allocation for domestic and industrial use for the next 25 years (ham) | Net GW availability for future Irrigation development (ham) | Stage of GW development (%) | Category |
|---|---|---|---|---|---|---|---|---|
| **Mangalore** | 10242.29 | 2806.17 | 2265.609 | 5071.78 | 2550.21 | 4877.18 | 49.51 | **Safe** |

**Table-10 Comparison of ground water availability and draft scenario in Mangalore taluk**

| Taluk | 2017 | | | 2020 | | | 2022 | | |
|---|---|---|---|---|---|---|---|---|---|
| | GW Availability | GW Draft | Stage of GW withdrawal | GW Availability | GW Draft | Stage of GW withdrawal | GW Availability | GW Draft | Stage of GW withdrawal |
| **Mangalore** | 3598 | 2096 | **58** | 9750.13 | 3232.94 | **33.16** | 10242.29 | 5071.78 | **49.51** |

From the above comparison**(Table-10),** it can be observed that the stage of ground water extraction is more during 2017 and less in 2020 and again the stage of ground water extraction increases in 2022.

## 3.2 Chemical quality of ground water and contamination

The interpretation from Chemical Analysis results (Phreatic and fractured aquifer) of ground water samples in Mangalore taluk is summarized below. The results are presented in **Figure wise.**

**(a) Aquifer – I:** 27 samples were collected from NHS dug wells representing **Aquifer – I** in Mangalore Taluk and chemical analysis result indicate that the

**EC value** is in the ranges of 73 to 1731 m/mhos/cm at 25ºC. All the sample shows under desirable limit**. (Fig-15)** The value of **pH ranges** from 6.23 to 7.73. **Cl ranges** from 6 mg/l to 355 mg/l. Highest range in **Mukka Village** which is 355 mg/l. **(Fig-16)** The value of $NO_3$ ranges from 1.8 to 39 mg/l. All the sample shows under desirable limit as per BIS, 2012 drinking water standards. **(Fig-17)** All the samples show **fluoride** within desirable limit as per BIS, 2012. **(Fig-18)**

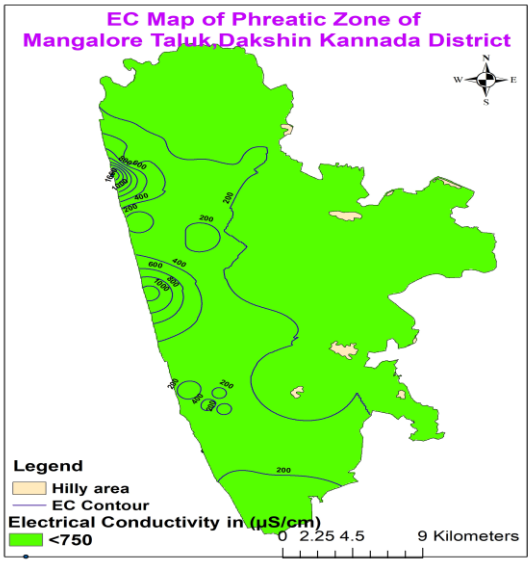



Fig-15 EC Map of Phreatic Zone

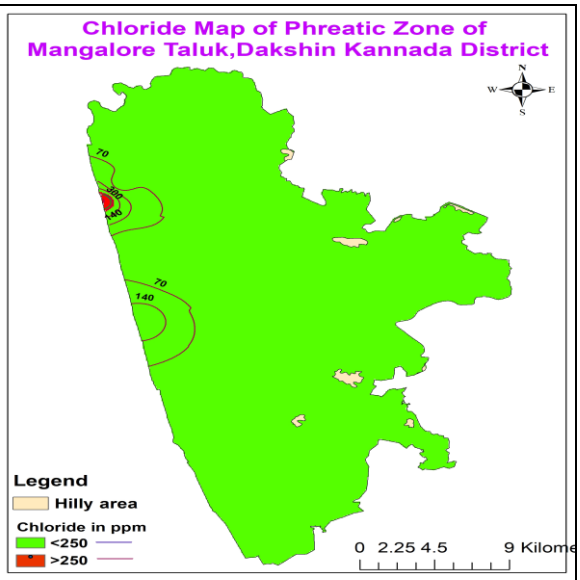



Fig-16 Chloride Map of Phreatic Zone

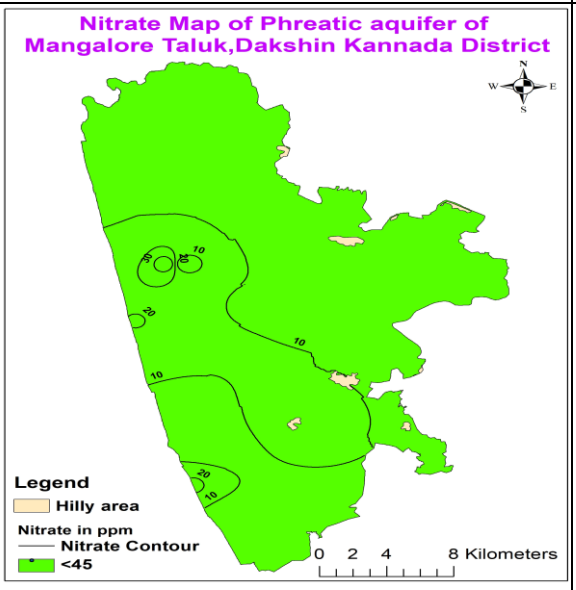



Fig-17 Nitrate Map of Phreatic Zone

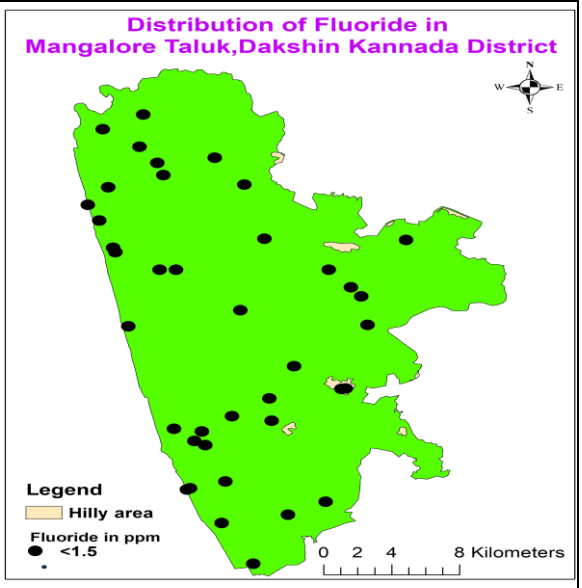



Fig-18 Distribution of Fluoride

**(b) Aquifer -II:** 14 samples were collected from borewells and Hand pump which represented the **aquifer II** in Mangalore Taluk.

**EC value** in groundwater is in the ranges of 80 to 2650 m/mhos/cm at 25ºC. Highest value is 2650 m/mhos/cm in **Kallapu Village. (Fig-19)** The value of **pH** ranges from 6.13 to 7.9.

**Cl ranges** from 7 mg/l to 539 mg/l. Highest range in **Kallapu Village** which is 539 mg/l.**(Fig-21)** The value of **$NO_3$** ranges from 5 to 39 mg/l. All the sample shows under desirable limit as per BIS, 2012 drinking water standards**. (Fig-20)** All the samples show **fluoride** value within desirable limit as per BIS.**(Fig-18)**

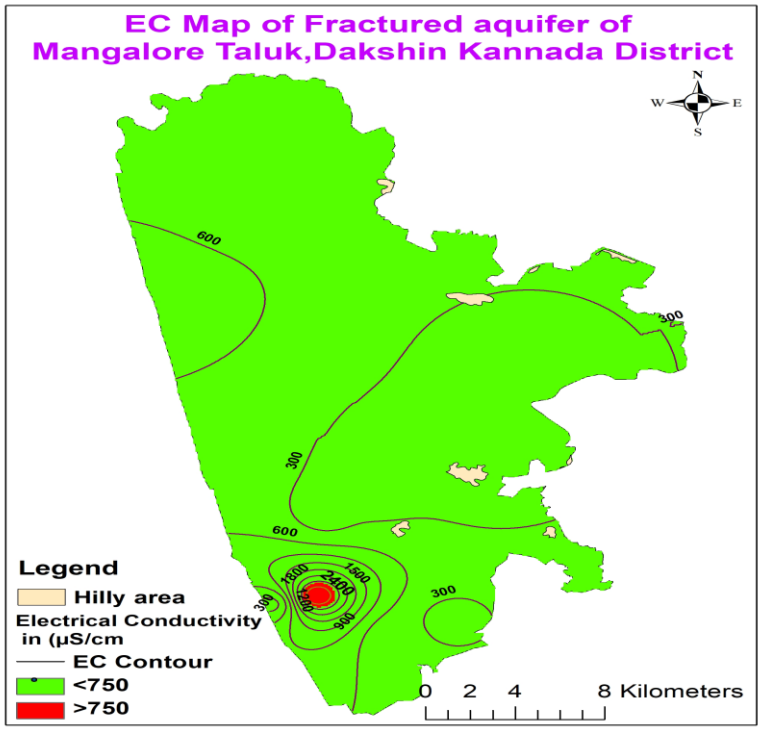



**Fig-19 EC Map of Fractured Zone**

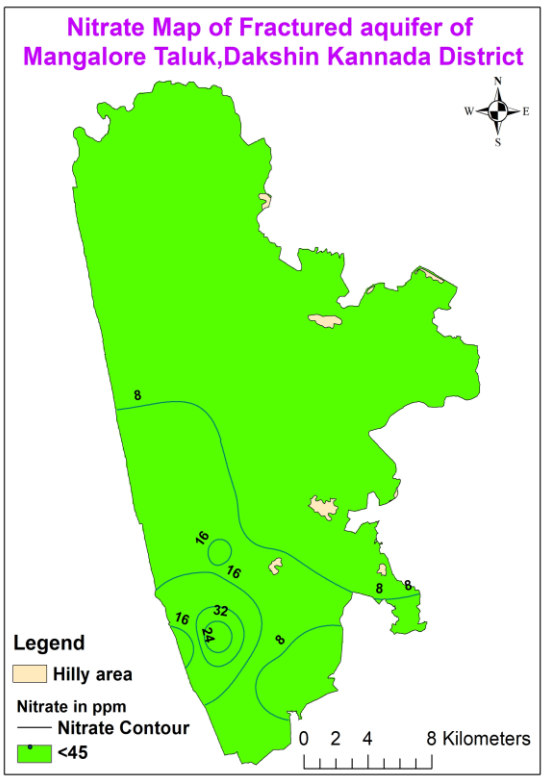



**Fig-20 Nitrate Map of Fractured Zone**

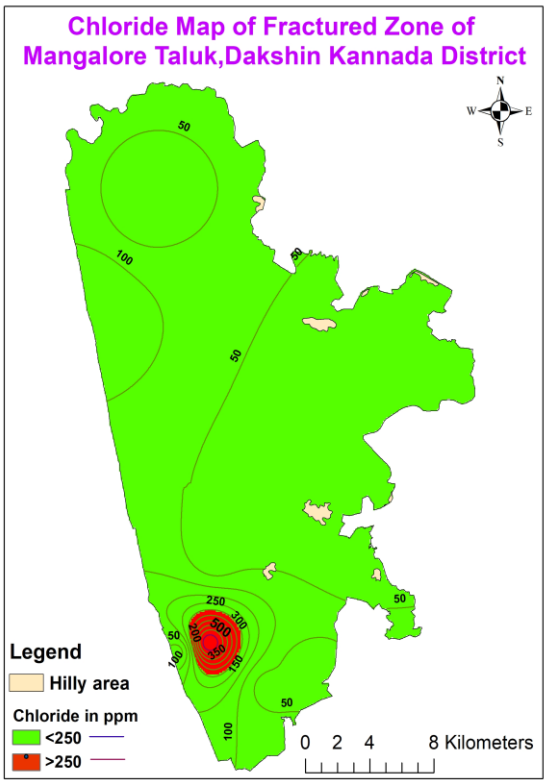



**Fig-21 Chloride Map of Fractured Zone**

In general, ground water quality in Mangalore Taluk is good and potable and EC is more in one village and all samples are found under permissible limit. Ground water samples have been found suitable for agriculture & irrigation purposes.

# 4 GROUND WATER RESOURCE ENHANCEMENT

## 4.1 Artificial recharge and proposed interventions

Increase in agricultural activity and excessive ground water withdrawal has resulted in depletion of ground water table, reduction in yield of bore wells and deterioration of ground water quality. Mangalore Taluk can be drought prone. Thus, there is need for ground water management, enhancement of storage capacity of aquifers, protection of ground water quality and proper utilization of ground water.

**Aquifer wise space available for recharge and proposed interventions**

**Table 11A: Quantity of water proposed to be made available through non-committed surface runoff**

| | |
|---|---|
| Non committed monsoon runoff available **(MCM)** | 40.182 |
| **Artificial Recharge Structures Proposed** | |
| Area feasible for artificial recharge structures (sq. km) | 490 |
| Number of Check Dams feasible | 57 |
| Number of Percolation Tanks feasible | 36 |
| Number of Point Recharge structures feasible | 50 |
| Tentative total cost of the project (Rs. in lakhs) | 1317.758 |
| Recharge capacity of sub surface dyke (MCM) | 6.027 |
| Recharge capacity of percolation tank (MCM) | 20.091 |
| Recharge capacity of Check dam (MCM) | 10.046 |
| Recharge capacity of filter bed (MCM) | 4.018 |
| Excepted recharge (MCM) | **30.137** |

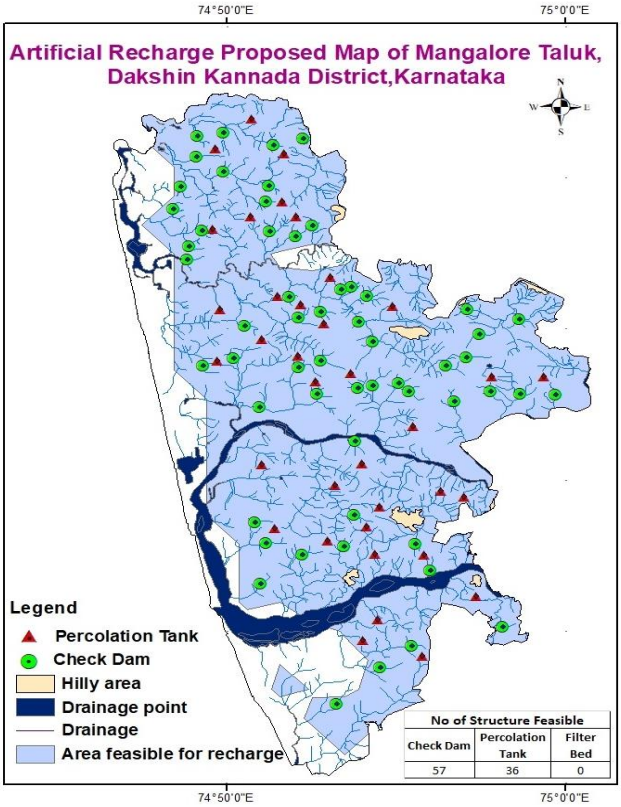



**Fig-22 Artificial Recharge structure Proposed Map**

**Table:11B Tentative location of Villages for Proposal of Artificial Recharge structure**

| Sr. No | Village | AR Structure Proposed | Longitude | Latitude |
|---|---|---|---|---|
| 1 | Konaje | Percolation tank | 74.92959 | 12.81997 |
| 2 | Belma | Percolation tank | 74.90021 | 12.82828 |
| 3 | Harekala | Percolation tank | 74.90749 | 12.83972 |
| 4 | Boliyuru | Percolation tank | 74.95601 | 12.85280 |
| 5 | Adyaru | Percolation tank | 74.93055 | 12.87569 |
| 6 | Kannuru | Percolation tank | 74.90627 | 12.87593 |
| 7 | Padavu | Percolation tank | 74.88296 | 12.88324 |
| 8 | Kadri | Percolation tank | 74.85678 | 12.89014 |
| 9 | Neerumarga | Percolation tank | 74.90223 | 12.89085 |
| 10 | Bodanthila | Percolation tank | 74.90869 | 12.90188 |
| 11 | Ullayibettu | Percolation tank | 74.95006 | 12.90727 |
| 12 | Bodanthila | Percolation tank | 74.93864 | 12.91060 |
| 13 | Pachhanadi | Percolation tank | 74.88676 | 12.91405 |
| 14 | Kunjatthabylu | Percolation tank | 74.85060 | 12.92535 |
| 15 | Moodushedde | Percolation tank | 74.89961 | 12.92583 |
| 16 | Mulluru | Percolation tank | 74.92507 | 12.94639 |
| 17 | Bajpe | Percolation tank | 74.87677 | 12.97113 |
| 18 | Thenka Edapadhavu | Percolation tank | 74.96362 | 12.97351 |
| 19 | Kelanjaru | Percolation tank | 74.98956 | 12.97365 |
| 20 | Kolambe | Percolation tank | 74.89438 | 12.97559 |
| 21 | Bala | Percolation tank | 74.82870 | 12.98232 |
| 22 | Bajpe | Percolation tank | 74.86820 | 12.98515 |
| 23 | Bala | Percolation tank | 74.85060 | 12.99407 |
| 24 | Permudhe | Percolation tank | 74.88105 | 13.00287 |
| 25 | Kutthetthuru | Percolation tank | 74.82991 | 13.01052 |
| 26 | Kompadavu | Percolation tank | 74.91501 | 13.01240 |
| 27 | Permudhe | Percolation tank | 74.86963 | 13.01358 |

| | | | | |
|---|---|---|---|---|
| **28** | Thenka Ekyaru | **Percolation tank** | 74.85808 | 13.01786 |
| **29** | Badaga Ekyaru | **Percolation tank** | 74.88438 | 13.02857 |
| **30** | Kemral | **Percolation tank** | 74.82632 | 13.05503 |
| **31** | Mannabettu | **Percolation tank** | 74.84512 | 13.06169 |
| **32** | Mannabettu | **Percolation tank** | 74.86749 | 13.06208 |
| **33** | Thalipadi | **Percolation tank** | 74.86035 | 13.07026 |
| **34** | Elinje | **Percolation tank** | 74.86130 | 13.09667 |
| **35** | Kavatthuru | **Percolation tank** | 74.82751 | 13.09953 |
| **36** | Balkunje | **Percolation tank** | 74.84536 | 13.11595 |
| **37** | Kotekaru | **Check Dam** | 74.88768 | 12.79347 |
| **38** | Konaje | **Check Dam** | 74.90915 | 12.81350 |
| **39** | Konaje | **Check Dam** | 74.92458 | 12.82507 |
| **40** | Boliyuru | **Check Dam** | 74.96933 | 12.83563 |
| **41** | Mangalore | **Check Dam** | 74.84993 | 12.85948 |
| **42** | Adyaru | **Check Dam** | 74.93353 | 12.86699 |
| **43** | Maroli | **Check Dam** | 74.87079 | 12.87548 |
| **44** | Alape | **Check Dam** | 74.89133 | 12.87985 |
| **45** | Neerumarga | **Check Dam** | 74.92645 | 12.88139 |
| **46** | Kadri | **Check Dam** | 74.85293 | 12.88204 |
| **47** | Kadri | **Check Dam** | 74.84743 | 12.89320 |
| **48** | Kudupu | **Check Dam** | 74.89610 | 12.89755 |
| **49** | Moodushedde | **Check Dam** | 74.89682 | 12.93788 |
| **50** | Kenjaru | **Check Dam** | 74.84960 | 12.95673 |
| **51** | Badaga Vulipadi | **Check Dam** | 74.94546 | 12.95984 |
| **52** | Kolavuru | **Check Dam** | 74.99543 | 12.96371 |
| **53** | Mutthuru | **Check Dam** | 74.97812 | 12.96398 |
| **54** | Malavuru | **Check Dam** | 74.87811 | 12.96434 |
| **55** | Kolambe | **Check Dam** | 74.92323 | 12.96535 |
| **56** | Mogaru | **Check Dam** | 74.96349 | 12.96559 |

| | | | | |
|---|---|---|---|---|
| **57** | Kolambe | **Check Dam** | 74.89776 | 12.96740 |
| **58** | Kolambe | **Check Dam** | 74.90535 | 12.96870 |
| **59** | Kolambe | **Check Dam** | 74.91805 | 12.96987 |
| **60** | Bajpe | **Check Dam** | 74.86886 | 12.97873 |
| **61** | Bala | **Check Dam** | 74.82157 | 12.97947 |
| **62** | Mooduperaku | **Check Dam** | 74.94123 | 12.97977 |
| **63** | Bajpe | **Check Dam** | 74.87986 | 12.98221 |
| **64** | Bala | **Check Dam** | 74.83664 | 12.98354 |
| **65** | Badaga Vulipadi | **Check Dam** | 74.95152 | 12.98435 |
| **66** | Paduperaku | **Check Dam** | 74.90548 | 12.99278 |
| **67** | Thenka Edapadhavu | **Check Dam** | 74.95805 | 12.99702 |
| **68** | Kutthetthuru | **Check Dam** | 74.84229 | 13.00142 |
| **69** | Paduperaku | **Check Dam** | 74.89864 | 13.00378 |
| **70** | Badaga Edapadhavu | **Check Dam** | 74.97730 | 13.00525 |
| **71** | Permudhe | **Check Dam** | 74.86857 | 13.00634 |
| **72** | Thenka Ekyaru | **Check Dam** | 74.87992 | 13.00927 |
| **73** | Badaga Edapadhavu | **Check Dam** | 74.95169 | 13.01067 |
| **74** | Thenka Ekyaru | **Check Dam** | 74.86401 | 13.01759 |
| **75** | Kompadavu | **Check Dam** | 74.90254 | 13.01782 |
| **76** | Badaga Ekyaru | **Check Dam** | 74.88976 | 13.02182 |
| **77** | Badaga Ekyaru | **Check Dam** | 74.89463 | 13.02321 |
| **78** | Koikude | **Check Dam** | 74.81409 | 13.03802 |
| **79** | Thokuru | **Check Dam** | 74.81472 | 13.04567 |
| **80** | Kondemoole | **Check Dam** | 74.86716 | 13.05071 |
| **81** | Mannabettu | **Check Dam** | 74.85475 | 13.05353 |
| **82** | Thokuru | **Check Dam** | 74.82138 | 13.05400 |
| **83** | Mannabettu | **Check Dam** | 74.87562 | 13.05698 |
| **84** | Biliyuru | **Check Dam** | 74.80718 | 13.06612 |
| **85** | Thalipadi | **Check Dam** | 74.85274 | 13.07011 |

| | | | | |
|---|---|---|---|---|
| **86** | Kilippadi | **Check Dam** | 74.81057 | 13.07812 |
| **87** | Thalipadi | **Check Dam** | 74.85395 | 13.07901 |
| **88** | Elatthuru | **Check Dam** | 74.83163 | 13.08678 |
| **89** | Shimanthuru | **Check Dam** | 74.81851 | 13.09462 |
| **90** | Kolluru | **Check Dam** | 74.85631 | 13.10097 |
| **91** | Ulipadi | **Check Dam** | 74.87096 | 13.10478 |
| **92** | Adhikaribettu | **Check Dam** | 74.81897 | 13.10618 |
| **93** | Kavatthuru | **Check Dam** | 74.83163 | 13.10824 |

**Fig-22 Area suitable for AR Structures**

**Table 12: Present ground water availability and draft scenario (2022) in Mangalore Taluk and expected improvement in Stage of Ground Water Development in future, on implementation of artificial recharge schemes-**

| Taluk | Cumulative Annual Ground Water Availability | Existing Gross Ground Water Draft for All Uses | Existing Stage of Ground Water Development | Expected Recharge from Proposed Artificial Recharge Structures | Cumulative Ground Water Availability after Artificial Recharge Structure Implementation | Stage of Ground Water Development after Artificial Recharge Structure Implementation | Expected Improvement in Overall Stage of Ground Water Development |
|---|---|---|---|---|---|---|---|
| | **HAM** | **HAM** | **%** | **HAM** | **HAM** | **HAM** | **%** |
| **Mangalore** | 10242.29 | 5071.78 | **49.51** | **3013.7** | 13255.99 | **38.26** | **11.25** |

## 4.2 Water Use Efficiency by Micro Irrigation Practices

It is observed that wells and bore wells are the source for **4578 ha** of net irrigation in the taluk constituting about 63% of the irrigated area. Adoption of water use efficiency (WUE) techniques will contribute in ground water resource enhancement in the long run by way of saving of water. Efficient irrigation practices like Drip irrigation & sprinkler needs to be adopted by the farmers in the existing 4578 ha of net irrigated area by wells & bore wells. At present (2022), the irrigation draft is **2806.17** ham.

The water efficient methodology may be applied for growing arecanut which is grown in 3898 ha and is largely ground water dependent as compared to the other crops which are mainly grown during kharif. Efficient irrigation techniques will contribute in saving ground water by 1949 ham considering 50% of the arecanut area is dependent on ground water irrigation and thus will improve stage of development marginally by **2.96%.** However, in long run the practice of Efficient irrigation techniques will add to the ground water resource in large extent. **(Table-13).**

**Table 13: Improvement in GW availability (2022) due to saving by adopting water use efficiency**

| Net annual ground water availability after implementation of AR Structure | Existing gross ground water draft for all uses | Existing stage of ground water development after implementation of AR Structure | Arecanut grown area | Arecanut area considered for WUE (50%) | Saving due to adopting WUE measures @ 0.57 m in arecanut grown area | Cumulative annual ground water availability | Expected improvement in stage of ground water development after the implementation of the WUE project | Expected improvement in overall stage of ground water development |
|---|---|---|---|---|---|---|---|---|
| HAM | HAM | % | HA | HA | HAM | HAM | % | % |
| 13255.99 | 5071.78 | 38.26 | 3898 | 1949 | 1110.93 | 14366.92 | 35.30 | 14.21 |

## 4.3 Ground Water Development Plan

In Mangalore taluk, the present stage of ground water extraction (2022) is merely **49.51 %** with net ground water availability of **10242.29** ham and total extraction of **5071.78** ham. The ground water draft for irrigation purpose is @ **2806.17** ham, thus indicating that ground water irrigation needs to be encouraged in the area. Also the less ground water development is most probably linked to the low ground water potential areas and limited aquifer thickness in Aquifer-II. To overcome these, it is imperative to have a robust ground water resource development plan for the area, which can be implemented in scientific manner. The implementation of the plan needs to based on site specific detailed hydrogeological, geophysical and scientific surveys for pinpointing the sites for construction of dugwells and Borewells.

In view of above, the focus of proposed ground water development plan is to up the ante of ground water development from the present 49% to 60% in a systematic way by adopting scientific approach. About **1695** dugwells (15-30 m depth; 3 to 5 m diameter @ Rs. 3.00 lakh/dugwell) are recommended to be constructed in feasible areas. Further **23** borewells (40-100 m depth; 150 mm dia @ Rs. 2.00 lakh/borewell) are also recommended to be drilled in feasible areas. Additional irrigation potential which can be created considering crop water requirement of 0.65 m (Ha) will be **1652 ha**. The

detailed ground water development strategy to uplift the ground water use in the feasible areas is presented in **Table–14.**

**Table–14: 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 @ 96% with unit draft of 0.5 ham | No. of BWs feasible @ 4% with unit draft of 4.6 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 by DW's considering crop water requirement of 0.65 m (Ha) | Additional irrigation potential created by BW's considering crop water requirement of 0.65 m (Ha) | Total irrigation potential created by DW's and BW's |
|---|---|---|---|---|---|---|---|---|---|
| 1073.59 | 0.57 | 4.6 | 1695 | 23 | 5085 | 47 | 1487 | 165 | 1652 |

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

## 4.4 Change in cropping pattern

Change in cropping pattern is necessary since cultivation of water intensive crops like arecanut is prevalent in the Taluk. Though only 3898 hectares is covered under arecanut and paddy is also prevalent in taluk, which covered 1152 hectare in Mangalore taluk which can effect groundwater availability. At present (2022), the stage of ground water extraction is @ 49.51% and taluk has been categorised as Safe, thus change in cropping pattern has not been suggested.

## 4.5 Other interventions proposed

- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- If excess nitrate & fluoride concentration is found in ground water samples, its require remedial measures viz.
    - Dilution of nitrate rich ground water through artificial recharge & water conservation.
    - Roof top rain water harvesting.

# 5 SUMMARY AND RECOMMENDATIONS

The main ground water issues are Low Ground Water Development, Limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, Deeper Water Levels particularly in Aquifer-II in some parts of areas which are all inter-related or inter dependent and Inferior Ground Water Quality due to nitrate contamination major part of the area. The summary of ground water management plan of Mangalore taluk is given in **Table-15.**

**Table 15: Summary of Management plan of Mangalore taluk**

| | |
|---|---|
| Stage of GW Extraction and Category (2022) | 49.51 %, Safe |
| Annual Extractable GW Resource (Ham) | 10242.29 |
| Total Extraction (Ham) | 5071.78 |
| Total GW Resources (Dynamic & Static up to the depth of 200 mbgl) (Ham) | 10242.3 |
| Ground Water Draft for Irrigation (Ham) | 2806.17 |
| **Ground Water Resource Enhancement by Supply side Interventions** | |
| No of Proposed AR structures<br>SSD<br>PT<br>CD | <br>1<br>36<br>57 |
| Expected Additional Recharge to GW due to AR (Ham) | 3013.7 |
| Additional Irrigation Potential that can be created (Ha) | 3600 |
| Total Estimated Expenditure (Rs. in Cr.) | 13.177 |
| Change in Stage of GW Extraction (%) | 49.51 to 38.26 |
| **Ground Water Resource Savings by Demand side Interventions** | |
| Expected Saving due to adopting WUE measures in arecanut area (Ham) | 1949 |
| Change in Stage of GW development (%) | 49.51 to 35.30 |
| **Ground Water Resource Development Plan** | |
| Balance GWR available to enhance SOE 60% (Ham) | 1073.59 |
| No. of wells proposed<br>**DW** – Depth: 15 to 30 m, Dia: 3 to 5 m, Unit Cost –Rs. 3.00 lakh, Av. Annual Gross draft – 0.57 ham<br>**BW** – Depth: 40 to 100 m, Dia: 150 mm, Unit Cost – Rs. 2.00 lakh, Av. Annual Gross draft – 4.6 ham | <br>1695<br><br>23 |
| Additional irrigation potential created considering crop water requirement of 0.65 m (Ha) | 1652 |
| Increase in Stage of GW Extraction (%) | 49 to 60 |

As per the resource estimation – 2022 ,Mangalore taluk falls under Safe category with the stage of ground water extraction is 49.51 %. However, there is need to formulate management strategy to tackle the water scarcity related issues in the taluk in the coming days to avoid water crisis in the future. It is suggested to adopt a scientific and multi-pronged ground water management strategy covering supply side interventions, demand side interventions, ground water development interventions and ground water quality protection aspects as mentioned in the management plan suggested above

- **Ground water resource enhancement by supply side interventions**: Quantity of surface water available through non-committed surface run-off is estimated to be 40.182 MCM. This can be used to recharge the aquifer mainly through percolation tanks (36), check dams (57) and sub surface dyke structures (1). The volume of water expected to be conserved/recharged @75% efficiency is

3013.7 ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 13.17 Cr. The additional area which can be brought under assured ground water irrigation will be about 0.036 Lakh hectares.

- **Ground water resource enhancement by demand side interventions**: At present about 63 % of irrigation is by wells and bore wells (ground water). The micro irrigation practices like drip and sprinkler irrigation are comparatively less practiced in comparison with traditional surface flooding mode of irrigation. The micro irrigation water efficient methodology needs to be adopted for growing water intensive arecanut crop which is grown in 3898 ha and considering 50% area is dependent on ground water irrigation, efficient irrigation techniques will contribute in saving ground water by 1949 ham @ 0.57 m and thus will improve stage of development by 11.25% from **49.51 to 38.26%.** However, in long run the practice of efficient irrigation techniques will add to the ground water resource in large extent..
- **Change in cropping pattern**: Farmers are facing inadequacy of groundwater for agriculture during summer. Change in cropping pattern is necessary since cultivation of water intensive crops like arecanut is prevalent in the Taluk. Though generally 3898 hectares is covered under arecanut and paddy is also prevalent in taluk, which covered 1152 hectare in Mangalore taluk which can effect groundwater availability. At present (2022), the stage of ground water extraction is @ 49.51% and taluk has been categorised as Safe, thus change in cropping pattern has not been suggested.
- **Ground Water Resource Development Plan:** The present stage of ground water extraction (2022) is merely 49.51 % with net ground water availability of 10242.29 ham and total extraction of 5071.78 ham. The ground water draft for irrigation purpose is @ 2806.17 ham, thus indicating that ground water irrigation needs to be encouraged in the area. To overcome the low ground water development, it is imperative to have a robust ground water resource development plan for the area, which can be implemented in scientific manner. The implementation of the plan needs to based on site specific detailed hydrogeological, geophysical and scientific surveys for pinpointing the sites for construction of dugwells and Borewells.
- In view of above, the focus of proposed ground water development plan is to up the ante of ground water development from the present 49% to 60% in a systematic way by adopting scientific approach. About 1695 dugwells (15-30 m depth; 3 to 5 m diameter @ Rs. 3.00 lakh/dugwell) are recommended to be constructed in feasible areas. Further 23 borewells (40-100 m depth; 150 mm dia @ Rs. 2.00 lakh/borewell) are also recommended to be drilled in feasible areas. Additional irrigation potential which can be created considering crop water requirement of 0.65 m (Ha) will be 1652 ha.
- **Drinking water Supply:** In view of ground water contamination may be with higher concentration EC,Fluoride and Nitrate, 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 quality of ground water will improve in due course of time.
- **Participatory management:** Awareness programmes and practice of participatory approach needs to be strengthened with the involvement of all the stake holders for sustainable management.

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