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

## Sagara Taluk, Shimoga District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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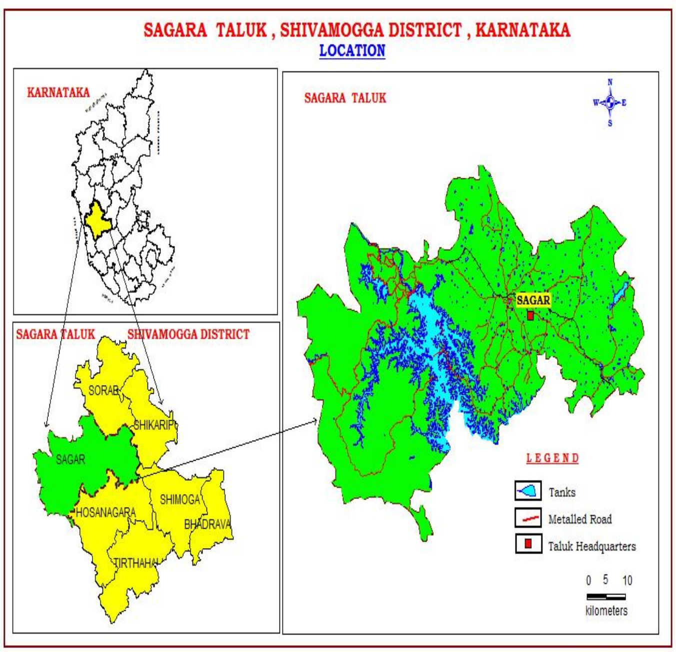
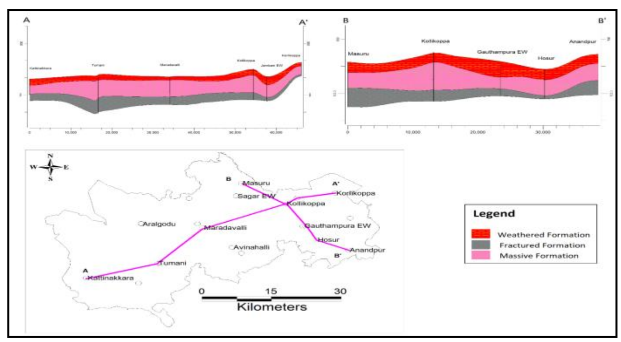
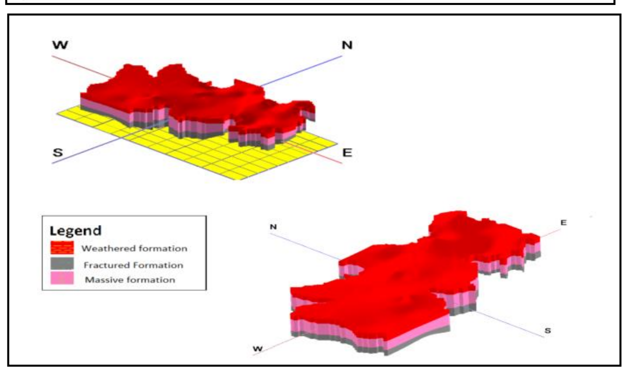
# Aquifer Maps and Management Plan, Sagara Taluk, Shimoga District, Karnataka State

**(AAP: – 2022-2023)**




*By*

***Aneesh Kumar, Sc-C, CGWB, KR, Trivendrum***

**APRIL 2023**

# Aquifer Maps and Management Plan, Sagara Taluk, Shimoga District, Karnataka State

**(AAP: – 2022-2023)**

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# Aquifer Maps and Management Plan, Sagara Taluk, Shimoga District, Karnataka State

**(AAP: – 2022-2023)**

## 1. Introduction

The vagaries of rainfall, inherent heterogenity, over exploitation of once copious aquifers, lack of regulation mechanism etc. has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from “Traditional Groundwater Development concept” to “Modern Groundwater Management concept”. Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Plan. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The proposed management plans will provide the “Road Map” for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation.

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present studies of Sagara taluk of Shimoga district, Karnataka have been taken up in AAP 2022-‘23 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Shimoga district and other user agencies for its effective implementation.

### 1.1 Objective and Scope of the Study

The major objectives of aquifer mapping are

- Delineation of lateral and vertical disposition of aquifers and their characterization
- Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at

appropriate scales through participatory management approach with active involvement of stakeholders.

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The main activities under NAQUIM are as follows:

a). Identifying the aquifer geometry

b). Aquifer characteristics and their yield potential

c). Quality of water occurring at various depths

d). Aquifer wise assessment of ground water resources

e). Preparation of aquifer maps and

f). Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a "Road Map" to systematically manage the ground water resources for equitable distribution across the spectrum.

With this background the following aspects are identified as most significant in the context of present study area:

- To understand the aquifer disposition of the area.
- The western part of the taluk, which is part of Malnad area, is having less groundwater potential. To increase the resource of the area, suitable artificial recharge measures to be recommended.
- The eastern part is of the taluk is comparatively potential sector with good rainfall. In this area, groundwater can be developed for agriculture as well as for water based eco-tourism activities.
- By considering groundwater quantity and quality aspects suitable groundwater management strategies to be adopted.

## 1.2 Approach and Methodology

In order to achieve above mentioned objectives, present study incorporated collection and compilation of available information on aquifer systems. The work has been approached through demarcation of aquifer extents, characterization and finally compilation of this information in form of aquifer maps at 1:50000 scale along with block-wise groundwater management plan. The approach and methodology followed for Aquifer mapping is as given below:

Compilation of existing data (Central & State Govt.)

↓

Generation of different thematic layers

↓

Identification of Primary Aquifer

↓

Identification of data gaps

↓

Data generation (water level, exploration, geophysical, hydro chemical, hydrogeological etc.

↓

Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

↓

Capacity building in all aspects of ground water through IEC Activities

Artificial recharge measures are proposed based on the feasibility in the area based upon earlier prepared Master Plan for Artificial Recharge of Groundwater. For the purpose, groundwater flow system has been conceptualized based on collected data, keeping in view of sustainable groundwater development. Groundwater quality data has been analysedand vulnerable areas were demarcated. Methodologies adopted include preparation of various thematic maps like land-use and land cover map, geomorphological map, geological & hydro geological map by using various GIS tools. Hydrogeological sections, panel diagrams, geophysical sections, hydro-chemical diagrams were prepared. Data from concerned agencies/departments were also collected for preparation of status of data gap. Groundwater resource data has been taken from 'Report on Dynamic Groundwater Resources of Karnataka State-2020' by CGWB. Groundwater level has been monitored from existing NHS wells as well as from newly established key wells. Groundwater quality data is based on water samples collected from existing NHS wells and from established key-wells during June-2022. Based on outcome of various analyses, block-wise groundwater management plan has been prepared. By considering groundwater quantity and quality aspects suitable groundwater management strategies to be adopted.

## 1.3 Area Details

Sagara taluk with geographical area coverage of 1942 sq.km (Fig. 1.1). The taluk extends between North latitude 13.8515° and 14.3401°and East longitudes 74.6260° and 75.3017°respectively. The taluk is bounded in north by Soraba taluk of Shimoga district and Siddapura taluk of U. Kannada district, in east by Shikaripur and Shimoga taluks, in west by Udupi district and south by Hosanagara taluk.

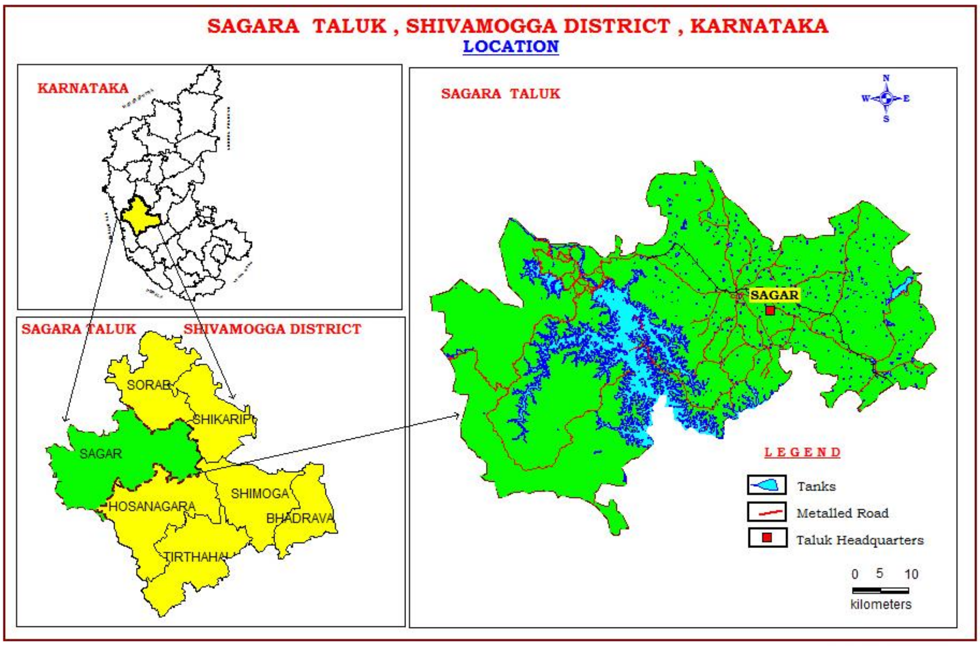


**Fig. 1.1 Index Map of Sagara taluk covered under NAQUIM**

As per Govt. of India Population Census (2011), total population of the taluk is 206319 with decadal growth rate of 2.65%. Projected population as on 2021 is 211786. During 2022-2023 AAP, under National Aquifer Mapping programme, the Sagara taluk been taken up for detailed hydrogeological survey and preparation of Aquifer maps and Management plan. Under this programme, hydrogeological study, groundwater quality studies have been undertaken and the data generated have been used in conjunction with the existing data available for the area in preparation of the aquifer maps and formulation of aquifer management plan.

**Table 1.1 Demographic details of Sagara taluk, Shimoga district**

| District | Block | Total Area (Sq. km.) | Rural Population | Urban Population | Total Population |
|---|---|---|---|---|---|
| **Shimoga** | **Sagara** | 1942 | 140922 | 65397 | **206319** |

*(as per 2011 population census)*

## 1.4 Brief Description

Sagara taluk comes under Sagara sub-division of Shimoga district with taluk headquarter located at Sagara. The taluk is drained by Sharavathi River and its tributaries. The lower order rivers form number of cascades and waterfalls in the upper reaches such as Jog falls, which forms tourist attractions of the taluk. The majority area of the taluk comprises of forest land followed by agriculture land. The taluk can be broadly classified into two parts: the western Malnad area consisting of the Sahayadri hill ranges and the eastern Semi-Malnad area consisting of table-land topography.

## 1.5 Data Availability

Central Ground Water Board carried out hydrogeological surveys, reappraisal surveys and groundwater exploration in different parts of the taluk. Ground water regime monitoring is carried out on a regular frequency during January, May, August and November every year. The data available from the earlier surveys have been compiled and data gap analysis has been carried out for working out the need for additional data generation in the study area.

## 1.6 Rainfall and Climate

The taluk forms part of the Malnad area and therefore, experiences a tropical humid climate. Monsoon rainfall initiates in the district by early June and continues till September. South West monsoon contributes major part of monsoon rainfall. The area receives maximum rainfall during the months of July and August. Winter season starts from month of November and lasts till February. Summer season initiates from March to early June, while the monsoon starts from early June to September. Normal rainfall (from 1961 to 2010) of the area is 1465 mm. Month-wise rainfall pattern for previous ten years from 2012 to 2021 is given in table 1.2.

April is generally the hottest month with the mean daily maximum temperature at 35.8°C and minimum at 22°C. On individual days during the summer, the day temperature rises up to about 38°C.

**Table 1.2: Month-wise rainfall from 2012 to 2021 (Source: IMD Website)**

| Year | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Total | M | NM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2012** | 0 | 0 | 1 | 112.5 | 20.1 | 284.8 | 466.1 | 664.4 | 223.4 | 54.6 | 85.3 | 0.8 | 1913 | 1693.3 | 219.7 |
| **2013** | 3.6 | 18.8 | 6.4 | 33.8 | 77.7 | 527.4 | 1239.4 | 476.4 | 222.2 | 136 | 13.5 | 1.2 | 2756.4 | 2601.4 | 155 |
| **2014** | 0 | 8.3 | 9.9 | 71.8 | 141.9 | 303.3 | 1105.6 | 849.9 | 312.9 | 127.2 | 22.1 | 25 | 2977.9 | 2698.9 | 279 |
| **2015** | 0 | 0 | 25.6 | 47.4 | 129.7 | 568 | 294.1 | 241.6 | 129 | 89.7 | 64.9 | 0.4 | 1590.4 | 1322.4 | 268 |
| **2016** | 0.8 | 0 | 0 | 1.9 | 57.9 | 399.2 | 440.9 | 313.1 | 157.3 | 38.1 | 32.6 | 3.9 | 1445.7 | 1348.6 | 97.1 |
| **2017** | 0.3 | 0 | 5.3 | 10.6 | 107.7 | 355 | 418.4 | 303.5 | 176.7 | 80.5 | 14 | 0.7 | 1472.7 | 1334.1 | 138.6 |
| **2018** | 0 | 0 | 17.8 | 36.2 | 146 | 372.8 | 510.6 | 480.3 | 77.9 | 66.9 | 17.5 | 23.8 | 1749.8 | 1508.5 | 241.3 |
| **2019** | 0 | 0.4 | 4.2 | 20.7 | 5 | 185.6 | 580.1 | 1005.3 | 354.7 | 347.7 | 26.8 | 10.4 | 2540.9 | 2473.4 | 67.5 |
| **2020** | 0 | 0.1 | 1.5 | 38.3 | 97.9 | 281.1 | 362.3 | 703.6 | 309.9 | 178.7 | 4.9 | 11 | 1989.3 | 1835.6 | 153.7 |
| **2021** | 46.7 | 22.8 | 8.6 | 78.4 | 159.5 | 407.8 | 650.1 | 301.4 | 257.3 | 229.1 | 169.6 | 10.5 | 2341.8 | 1845.7 | 496.1 |

*(Note: M-Monsoon, NM-Non Monsoon)*

Trend and distribution of rainfall in the taluk (Figure 1.2, 1.3& 1.4) show that maximum rainfall occurs in the month of July and August. Monsoonal rainfall shows sort of cyclicity during the taken period. From the monthly distribution of rainfall of the year 2021, it can be observed that actual monthly rainfall is way more than normal rainfall especially during the non-monsoon season. The area has received highest rainfall during the year 2014 as compared to rest of the taken years. Non-monsoon rainfall in the area shows irregular trend.

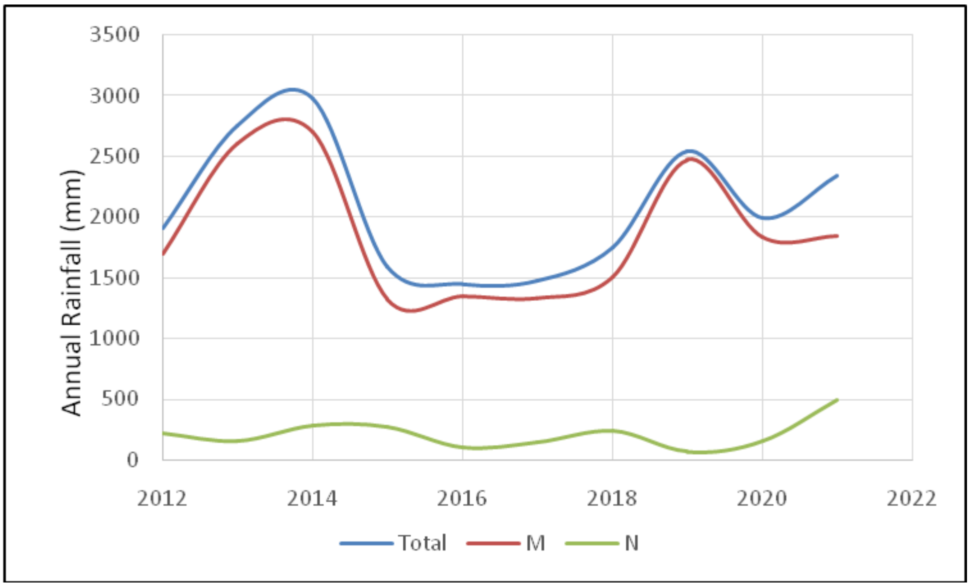


**Fig. 1.2: Rainfall trend in Sagara taluk during 2012 to 2021**

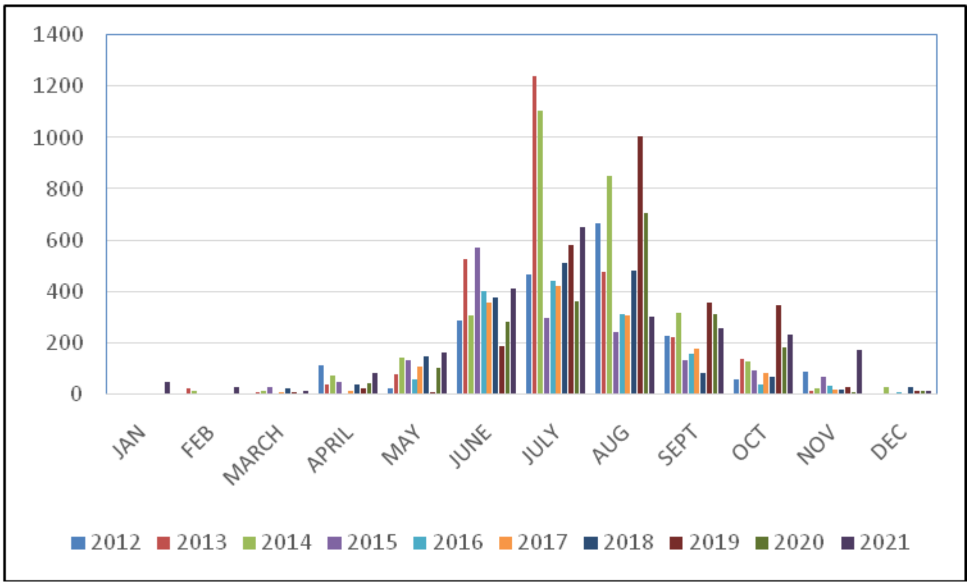


**Fig. 1.3 Monthly rainfall pattern of Sagara taluk during 2012 to 2021**

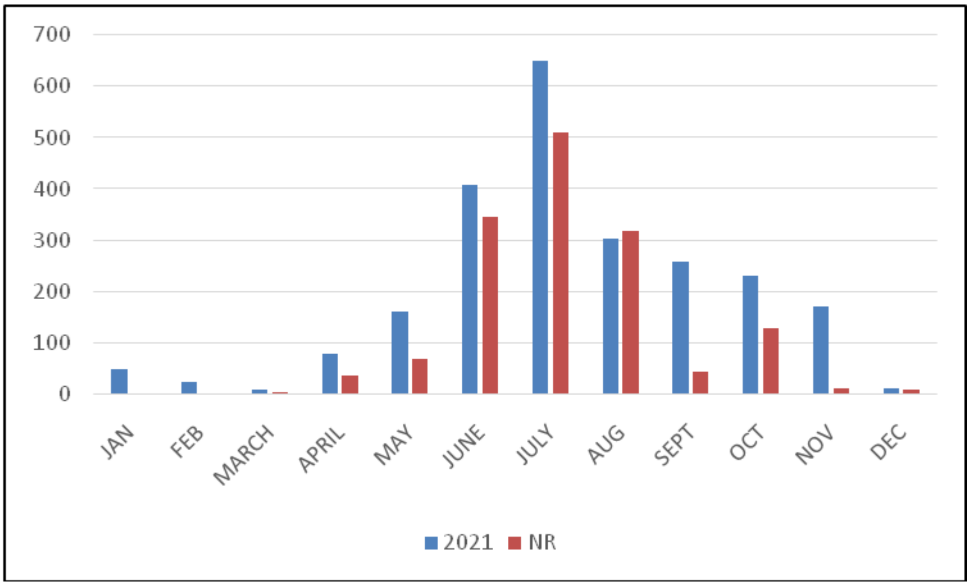


**Fig. 1.4:Figure showing Normal rainfall & monthly rainfall during 2021**

## 1.7 Physiographic Setup

The area can be broadly divided into two major physiographic units. The western hilly area made up of Sahayadri ranges and the plateaus and plains on the eastern side forming part of Semi-Malnad region. Elevation of the hilly terrain ranges from 640 m to 529 m above mean sea level. Eastern part of the taluk is under cultivation while the central part and western part comprises of dense tropical rain forest. A digital elevation model (DEM) generated from SRTM has been provided in figure 1.5. The undulating topography of the area is clear from the elevation variation (from 27 m to 1250 m amsl). However, in most part of the taluk, the elevation varies from 100 to 600 m amsl.

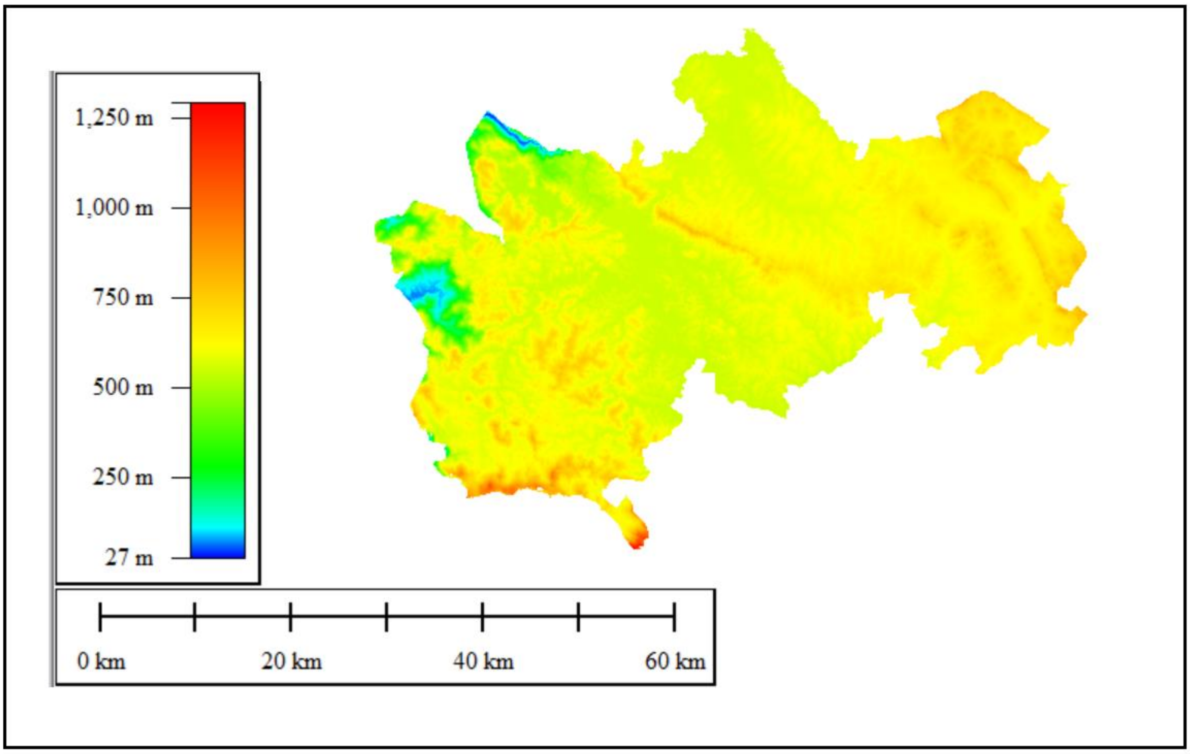


**Fig. 1.5:SRTM DEM of Sagara Taluk**

## 1.8 Geomorphology

Geomorphologically, the taluk can be broadly divided into the western hill ranges, and eastern plateau and table lands. The taluk is drained by river Sharavati and its tributaries. The western part of the taluk is covered by Pre-cambrian crystalline rocks. The eastern part of the taluk is covered by plateau hills, pediment-pediplain complexes and flat table lands. As per the geomorphology map (fig. 1.6), majority of the area is covered by plain table-land followed by the Sahayadri hill-valley system. In the south and south-western parts, number of meta-volcanic rock outcrops can be observed.

A number of waterfalls and river cascades can be observed in southern and central part of the study area, showing the high energy system and youthful stage associated with the rivers and abrupt change in morphology of the landforms. One such example is the world-famous Jog falls formed by a deep gorge. The waterfalls contribute to the Sharavati reservoir system in the south-central part of the study area.

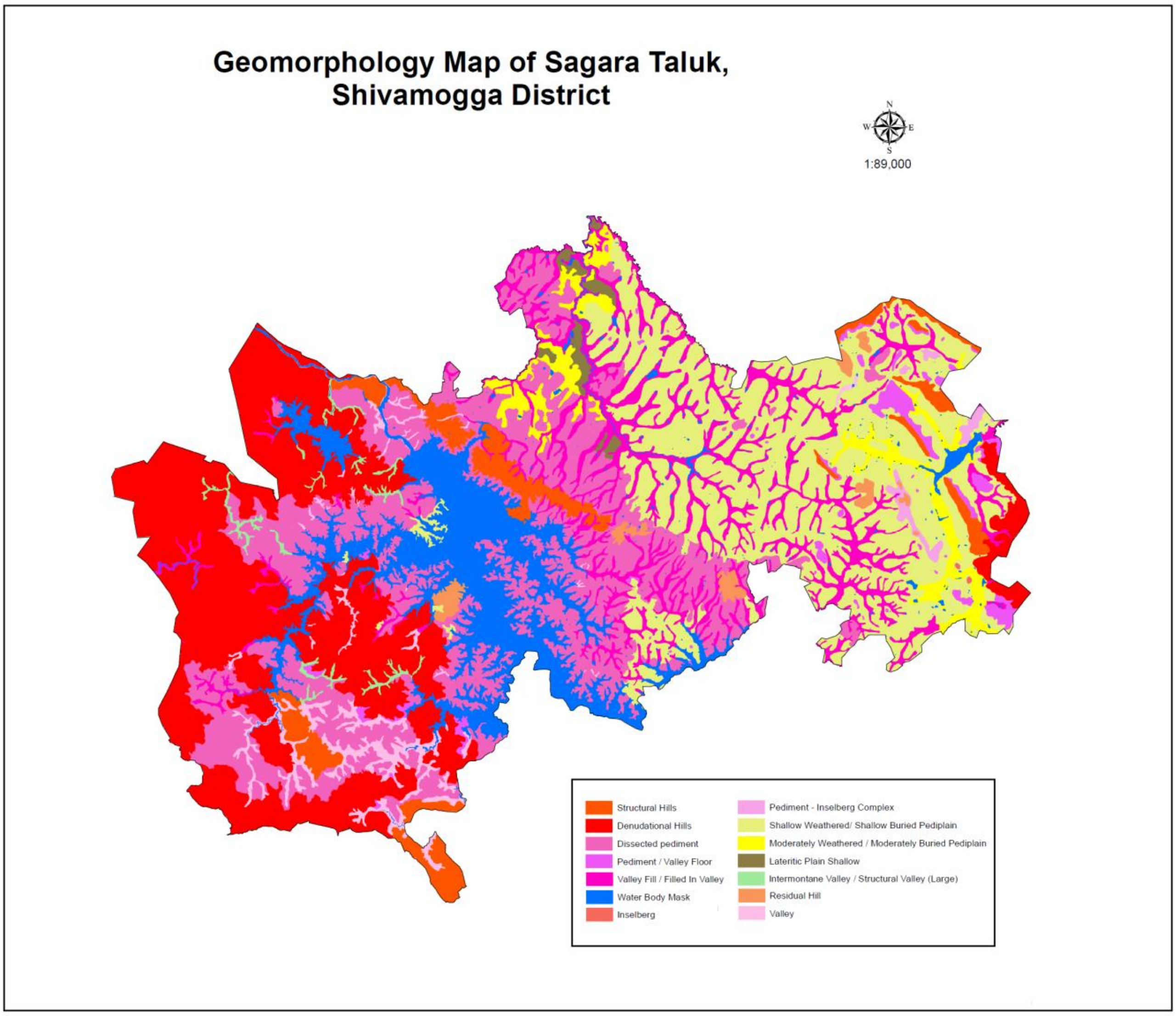


**Fig. 1.6: Simplified geomorphological map of Sagara taluk (Source: KSRSAC, Govt. of Karnataka)**

## 1.9 Land use-Landcover Pattern

Majority of the geographical area in Sagara taluk comprises of forest and grass land followed by barren/waste land. As per the record of Department of Agriculture, Government of Karnataka, the forest covers of the taluk is 66125 ha. Out of the total net sown area 57.59% is contributed by cereal cultivation. Land-use details of the taluk is given in table 1.3. A detailed land-use map of the taluk is given in fig. 1.7.

**Table. 1.3: Land use land cover data of SagaraTaluk (source: Bhuvan)**

| Landuse type | Area (ha) | Percentage area (%) |
|---|---|---|
| Agriculture, Crop land | 28202 | 14.54 |
| Forest and grass land | 66125 | 34.87 |
| Agriculture, Fallow | 3713 | 1.91 |
| Wetlands/Water Bodies,River/Stream/canals | 30416 | 15.68 |
| Barren/Wastelands/Gullied/Ravinous Land | 67652 | 34.08 |

## 1.10 Soil

Major soil class in the taluk is clayey and clay-loamy soil (Fig. 1.8). Based on texture, the loam in the taluk can be categorised into different soil classes. They are coarse loamy-fine loamy, fine, fine to fine loamy, fine to very fine, fine loamy, fine loamy to coarse loamy, fine loamy to fine, and loamy to fine loamy types. Based on the mode of origin, they are categorised into Red Sandy, Mixed Red and Black Soils, Red loamy Soils and Lateritic gravelly soils. Red loamy Soils are medium, shallow to moderate, deep with reddish brown to Black in colour. They are Medium in water holding capacity, low in organic matter, deficient in Zinc and Boron in some patches. These soils are found in the eastern parts of Sagara, Soraba, Shikaripura and Hosanagara Taluks.Laterite soils are derived from acidic ignetious rocks, sand stones and sedimentary rocks, yellowish red to reddish brown in colour. They are dominated with kaolinite clay mineral. The soils are acidic with low cation exchange capacity and medium water holding capacity. Laterite soils are found in western parts of Shikaripura taluk, Thirthahalli and parts of Hosanagar, Sagara and SorabaTaluks.

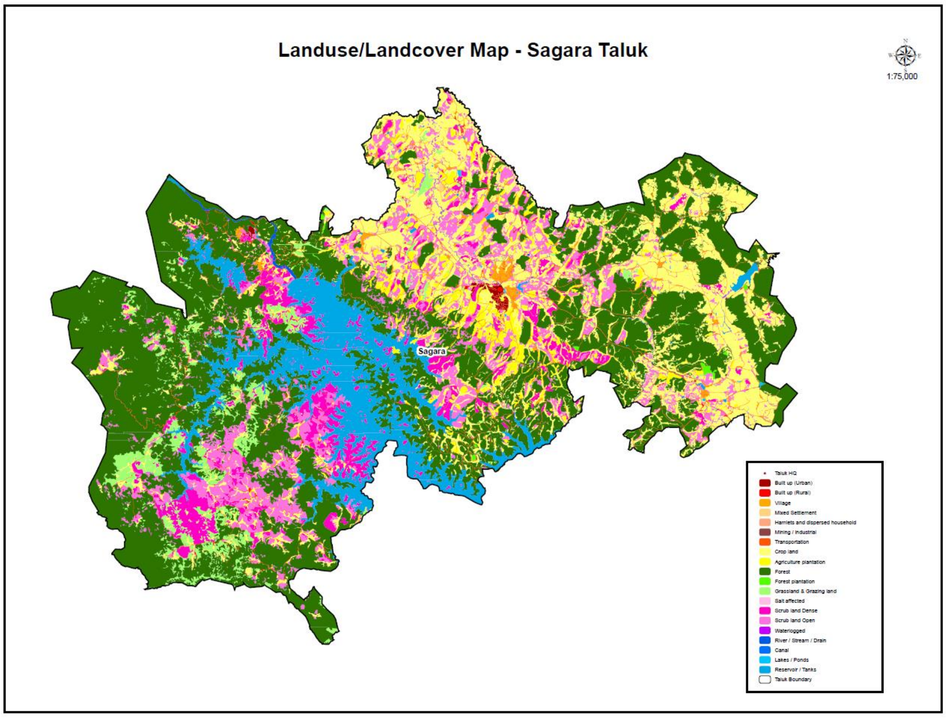


**Fig. 1.7:Landuse map of Sagara taluk (source: KSRSAC, Govt. of Karnataka)**

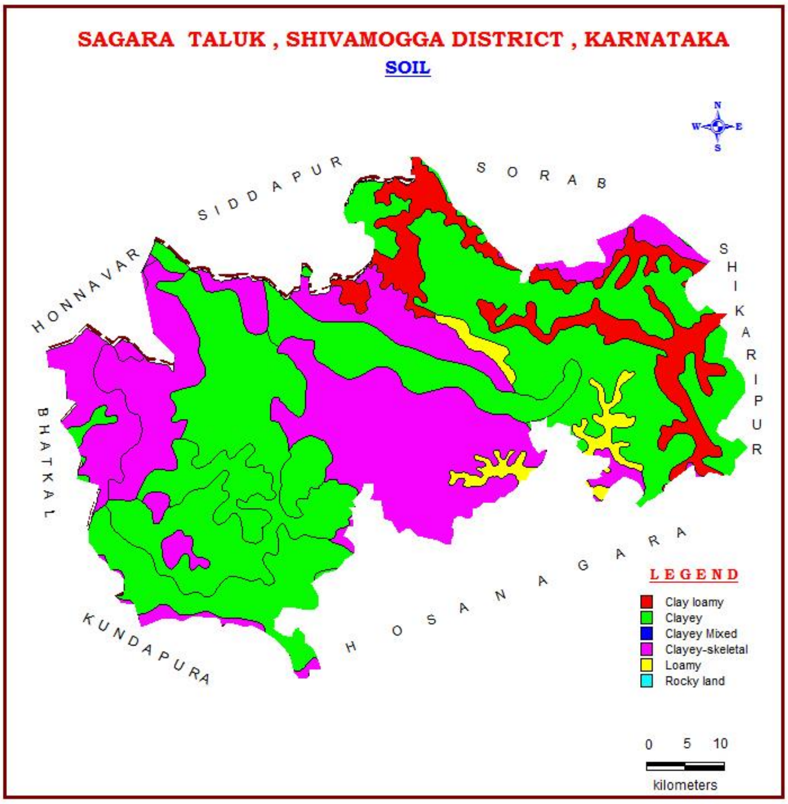


**Fig. 1.8: Soil map of Sagara taluk**

## 1.11 Slope

In most of the part of the taluk (55% of land area), slope varies from 1-5% and 25% of land area comes under less than 1%. A table showing details of different slope classes and corresponding area is given in table 1.4. Further a slope map has been prepared based on the tabled data and is provided in fig. 1.9. It is to be noted that the central and eastern part of the taluk is by and large is having gentle to moderate slope and can be considered as recharge worthy area. While the western part having moderate to steep slope and rainfall goes mainly as runoff.

**Table 1.4: Various slope classes in Sagara taluk**

| Nearly Level (0-1%) | Very Gentle Slope (1-3%) | Gentle Slope (3-5%) | Moderate Slope (5-10%) | Strong Slope (10-15%) | Moderately Steep Slope (15-35%) | Very steep slope (35-50%) | Total Area |
|---|---|---|---|---|---|---|---|
| 487 | 173 | 421 | 195 | 265 | 153 | 247 | 1942 |

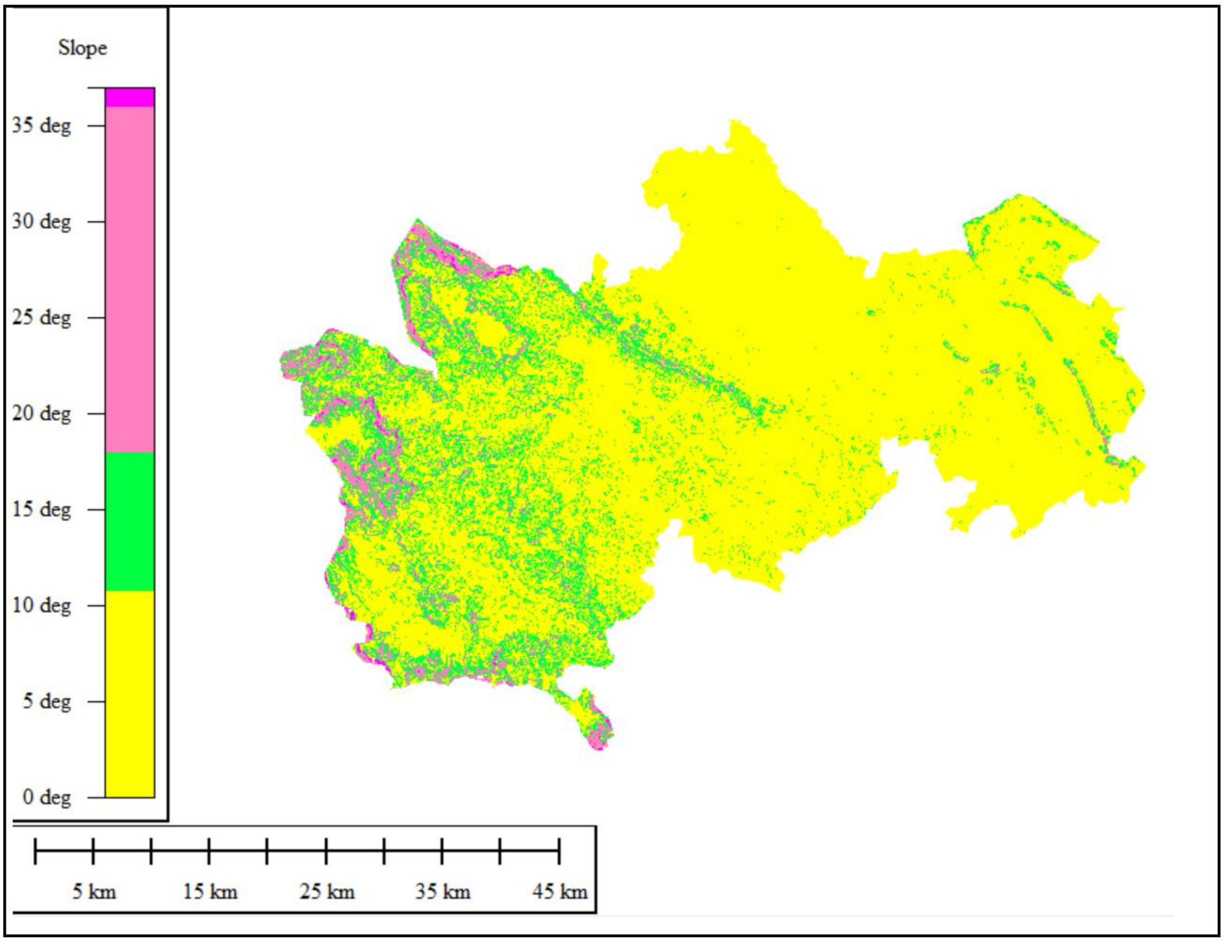


**Fig. 1.9: Slope map of Sagara taluk**

## 1.12 Hydrology and Drainage

Drainage in Sagara taluk is contributed by river Sharavati and its tributaries such as Nandihole, Haridravathi, Mavinahole, Hilkunji, Yennehole, Hurlihole, and Nagodihole. The river in the taluk forms major water falls (Jog falls). The river Sharavati originates at Ambutheertha in the Thirthahalli taluk and flows northwards and ultimately joins with Arabian Sea at Honnavar in Uttara Kannada district. The river is dammed at Linganamakki which is located at Kargal village of Sagara taluk. The dam has a length of 2.74 kilometres constructed across the river. The drainage system in the area is by and large structurally controlled and follows the lineaments. Fractures, joints, fault planes form these structurally controlled lineaments in the taluk. A drainage map is prepared and given in 1.10.

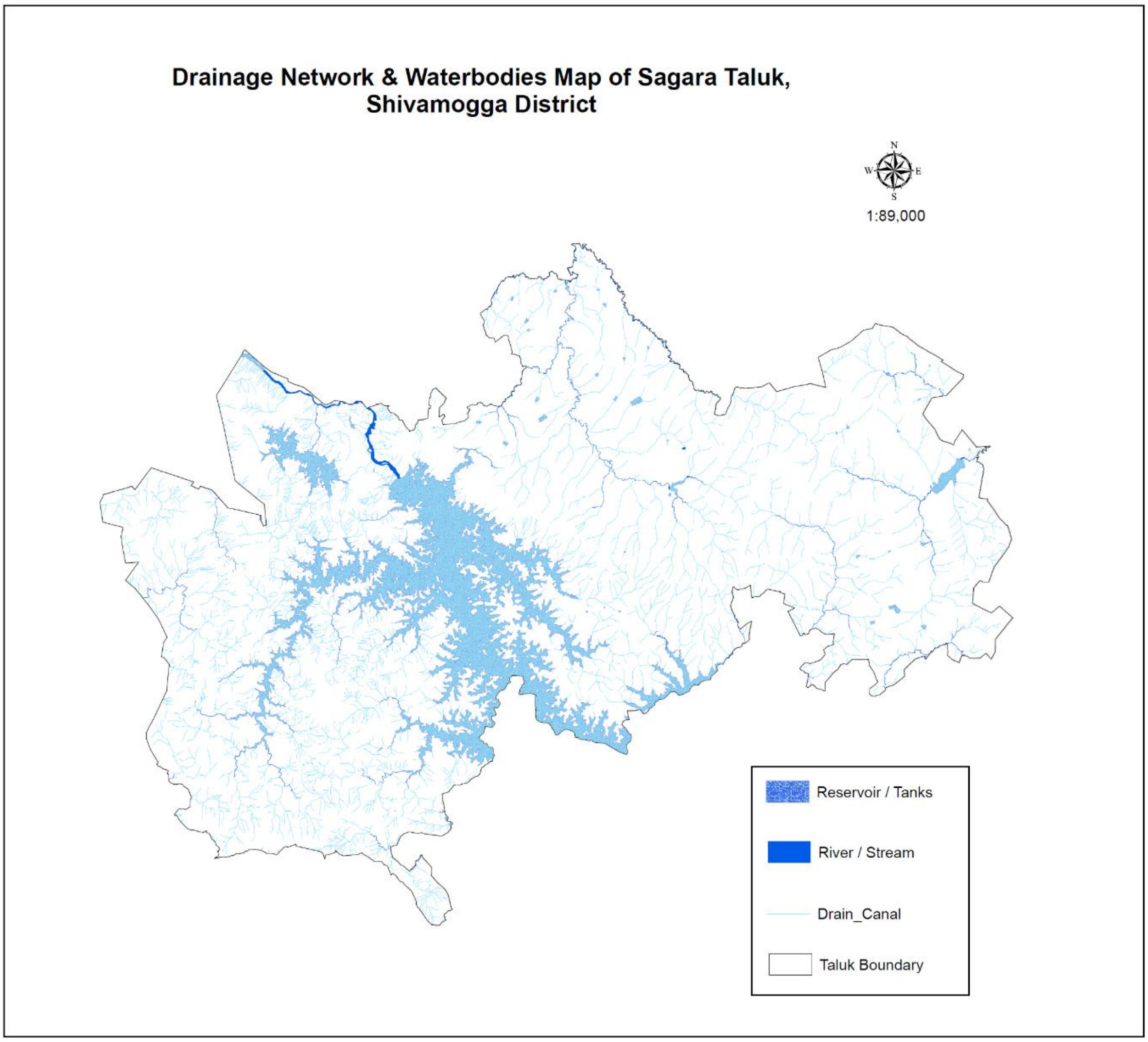


**Fig. 1.10: Drainage map of Sagara taluk (source: KSRSAC, Govt. of Karnataka)**

## 1.13 Agriculture

The taluk comes under hilly agro-climatic zones- southern transition zone. The net sown area of the taluk is 29733 ha and cropping intensity is 125%. (Source: District at a glance-Shimoga). The major crop cultivated in the taluk are cereals such as paddy (48.44%) followed by maize (20.05%).Rest of the area is mainly used for cultivation of commercial crops such as arecanut, coconut, spices and sugar cane. Apart from these, fruits, pulses and oil seeds are also cultivated in the taluk. Coming to land holding pattern, 64.12% of the total agriculture land is possessed by marginal farmers (<1 ha), while 32.73% is held by small to semi-medium farmers (1-4 ha).

## 1.14 Irrigation Practices

In Sagara taluk, out of the 29733 ham net sown area, 68.91% are being irrigated by different sources. 57% of the net area is irrigated by tanks and ponds. On the other hand, open wells and tube wells constitute 20.83% of the net irrigated area.The gross area irrigated through all sources in the taluk is 24943ha and net irrigated area is 20490 ha. A graph showing net area irrigated by various sources are given in fig. 1.11.

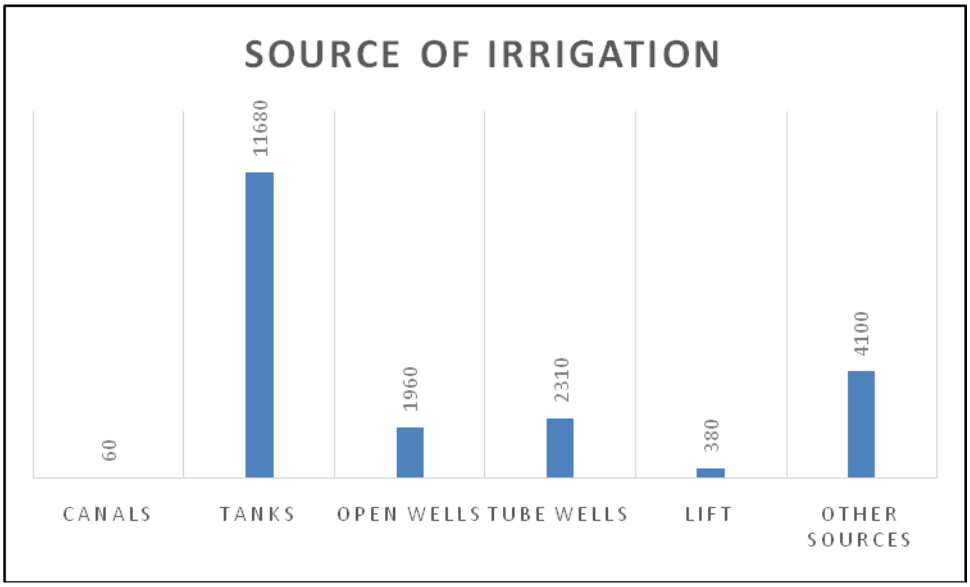


**Fig. 1.11: Graph showing area irrigated by various sources in Sagara taluk**

## 1.15 Cropping Pattern

The cropping calendar starts from the month of July and continue to the month of June of the succeeding year before the onset of monsoon. Thus a calendar year is divided into two crop season viz., Bhadai, Aghani, Rabi and Garma. During Kharif season, irrigation in the taluk is mainly dependent on monsoon rainfall. However, both rabi and garma crops are mainly depended groundwater. The season-wise major crops under irrigation in the taluk is given in table 1.5.

**Table 1.5: Season-wise crops cultivated in Sagara Taluk (in ha)**

| | Kharif | Rabi | Summer |
|---|---|---|---|
| **Paddy** | 14150 | 0 | 350 |
| **Maize** | 5020 | 0 | 40 |
| **Pulses** | 60 | 0 | 60 |
| **Oil Seeds** | 95 | 0 | 95 |
| **Sugar Cane** | 250 | 0 | 250 |
| **Arecanut** | 4889 | | |
| **Banana** | 1258 | | |
| **Pineapple** | 443 | | |
| **Ginger** | 940 | | |
| **Other Crops** | 1788 | | |

## 1.16 Prevailing Water Conservation/Recharge Practices

In Sagara taluk, the existing village ponds and tanks associated with agriculture field acts as water conservation structures. Apart from these, check dams, point recharge structures can be effectively utilised in the western sector while roof top rain water harvesting structures can be recommended in the eastern sector which is comparatively urbanised than the western sector.

## 1.17 Geology

Geologically, Sagara taluk is characterised by various litho-units spanning from Archaean to Present day deposits. Geologically, the area forms part of Shimoga Schist belt of Western Dharwar Craton, comprises of gneisses of various grade, manganiferous phyllites, schists of various grades, greywacke and basic intrusives and its metamorphosed varieties. These litho-units are covered by on the top by ferruginous duricrusts/laterite (Radhakrishnaand Vaidyanathan, 1994). Gneisses are tonalitic-trondhjemite-granodioritic in composition and form a basement for the wide spread schist, phyllites and greywackes of Archean age. Laterites of Tertiary period formsone of the major lithounits of the study area, is of in-situ in nature. It is porous/concretionary in nature and composed of higher concentration of FeO, $Al_2O_3$, MgO etc.A simplified geological map of Sagara taluk is prepared from the existing published map of GSI and given under Fig. 1.12. General stratigraphy of the taluk is given below.

| Age | Supergroup | Lithology |
|---|---|---|
| Cenozoic | | Laterite |
| Palaeoproterozoic | | Dolerite, Ultramafite, Quartz veins |
| Archaean | Dharwar | Hornblende-Actinolite-Chlorite-Sericite-Schist, BIF, BMQ, Amphibolite, Metabasalt, Meta Gabbro, Meta Rhyolite, Quartzite |
| Archaean | Peninsular Gneissic Complex (PGC) | Granite Gneiss |

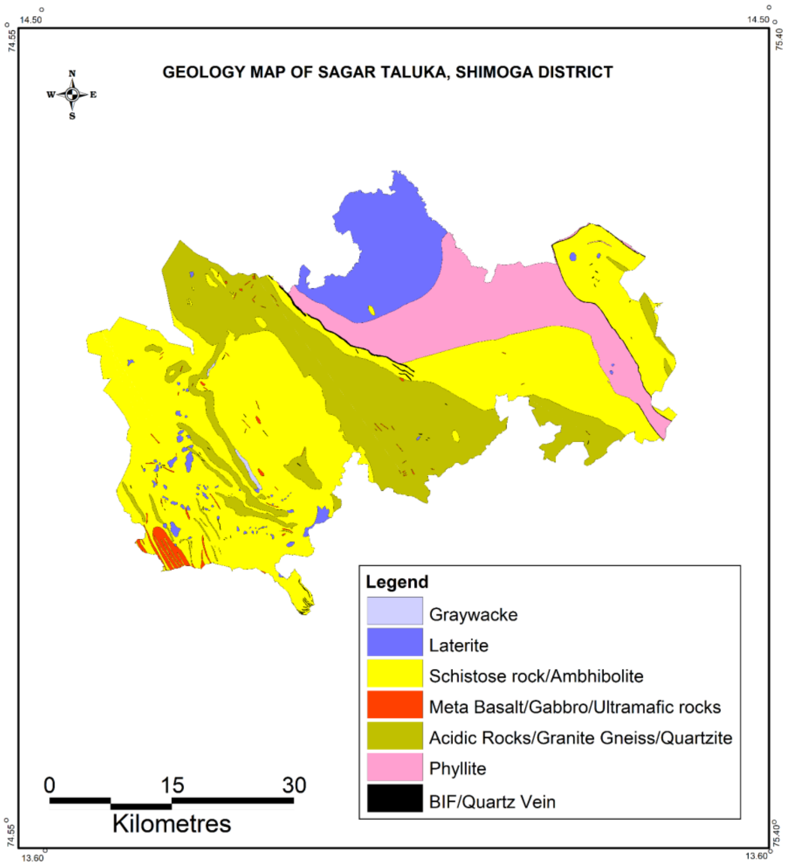


**Fig. 1.12: Simplified Geological Map of Sagara taluk**

# 2. Data Collection and Generation

The primary data such as water level, quality, and exploration details available with CGWB has been collected and utilised as baseline data. The Central Ground Water Board has established a network of observation wells under National Hydrograph Network programme to study the behaviour of ground water level and quality of ground water in the taluk. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc. were collected from concerned State and Central Government departments and compiled.

## 2.1 Hydrogeology

Geologically, Sagara taluk is characterised by the presence of Precambrian crystalline and high grade metamorphic rocks in eastern and western parts and low grade metapelites and insitu laterites in the northern part. Acidic igneous rocks are confined in the central part of the taluk. While recent alluvium of Quaternary age is confined to river channels and its old terraces. The alluvium sedimentation is considered to be the result of transport and deposition of riverine sediments by river Sharavathi and its tributeries. However, this sedimentation does not form potential aquifer system in the taluk. In rocky uplands of Sahayadri ranges, highly weathered, fractured and jointed gneisses, schists and meta-basalts form the groundwater reservoirs. While in the other parts, fractured gneiss and acid intrusives form groundwater reservoir.

## 2.2 Data-gap Analysis

Scientific data on groundwater regime available with State and central agencies were utilised for optimizing additional data requirements. Additional data were generated on ground water monitoring wells, litholog, water quality were incorporated and interpreted with the objectives of generating a visualization of the aquifer systems in the area. Identification of gaps in the existing data on various aspects of the aquifer being mapped. A table pertaining to datagap analysis is given in Table 2.1

**Table 2.1: Data gap analysis of Sagara taluk**

| # | Data Requirement | Data available with CGWB/State Govt. Agencies | Additional Data generated |
|---|---|---|---|
| 1 | Ground water level data | DW: 10 | DW:22<br>BW: 14 |
| 2 | Groundwater quality Data | DW: 10 | DW:22<br>BW: 14 |
| 3 | Borehole Lithology Data | 7 | -- |
| 4 | Geophysical Data (VES/TEM) | -- | -- |
| 5 | Pumping Test (EW/DW) | 7 | -- |

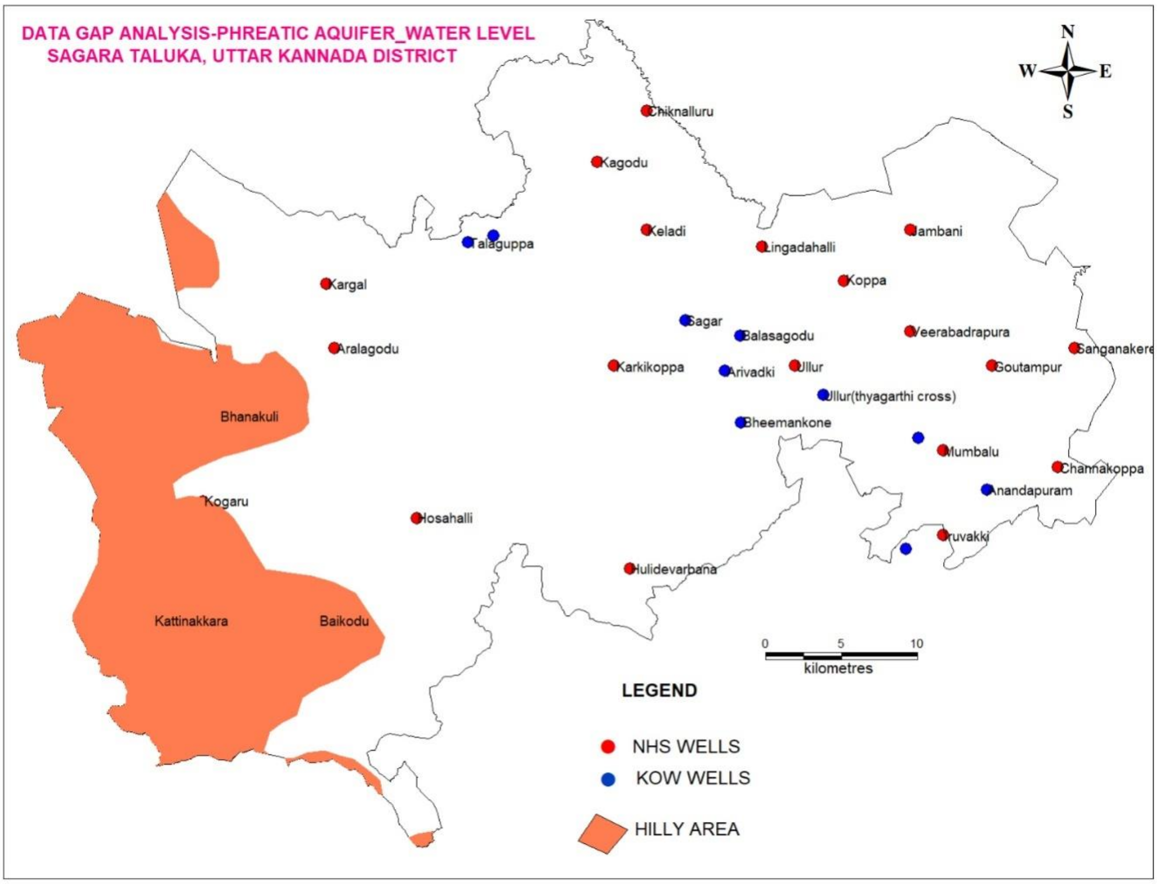


**Fig.2.1: Location of monitoring Wells in Sagara Taluk**

## 2.3 Depth to Water Level

Ground water monitoring had been carried out at 36 locations in the taluk during the course of study (2022-23). A map showing location of the established NHS monitoring stations and key wells in Sagara taluk is prepared and given in Fig. 2.1. The depth to water level map representing the shallow/phreatic aquifer has been prepared for pre-monsoon season and post-monsoon (Fig. 2.2 & 2.3). Depth to water level map of phreatic aquifer shows that majority of the area has water level between 5 to 10 m bgl in phreatic aquifer system and 5 to 15 m bgl in deep aquifer systemduring both pre monsoon and post monsoonseasons. In the central part of the taluk, deep water levels are observed for both seasons. This may be due to the presence of comparatively poor yielding Banded Gneissic Complex lithounits constituting the aquifer present in this part, as well as clay-rich top soil which hinders the rate of recharge into the phreatic aquifers as well.

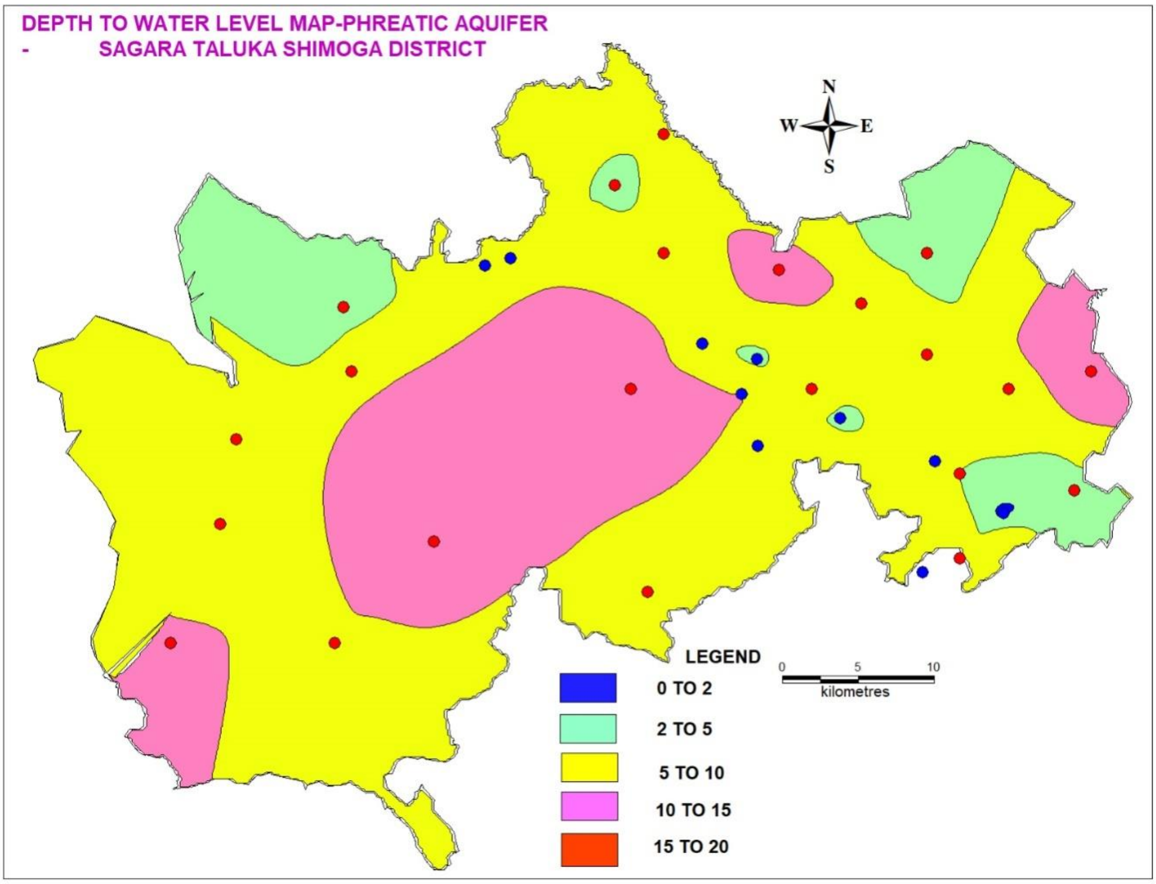


**Fig.2.2: Pre-Monsoon (May 2022)depth to water level map of phreatic aquifer of Sagara Taluk**

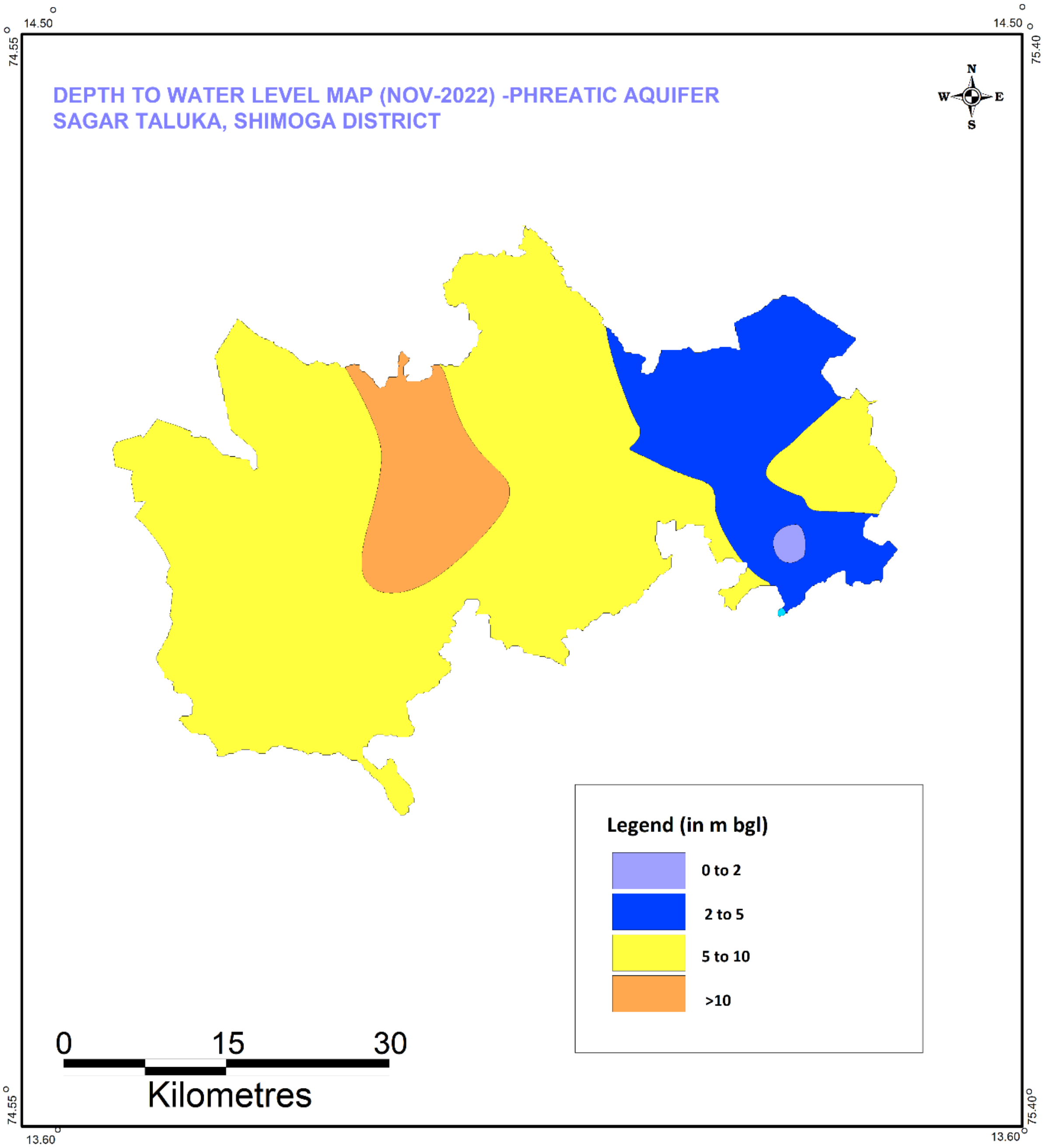


**Fig 2.3:Post-monsoon (November 2022) Depth to water level Map of Phreatic aquifer of Sagara Taluk**

## 2.4 Long Term Groundwater Level Trend

Long term groundwater level trend over ten years (from 2010 to 2019) has been analysed by using data from established network monitoring stations in Sagara Taluk. Depth to water level during January, May, August and November months has been enumerated over this period and hydrographs were prepared (Fig.2.4 to 2.6). From the hydrographs, it can be seen that, most of the stations record slightly falling trend of groundwater level over long term. The long term groundwater level trend is given in table 2.2.

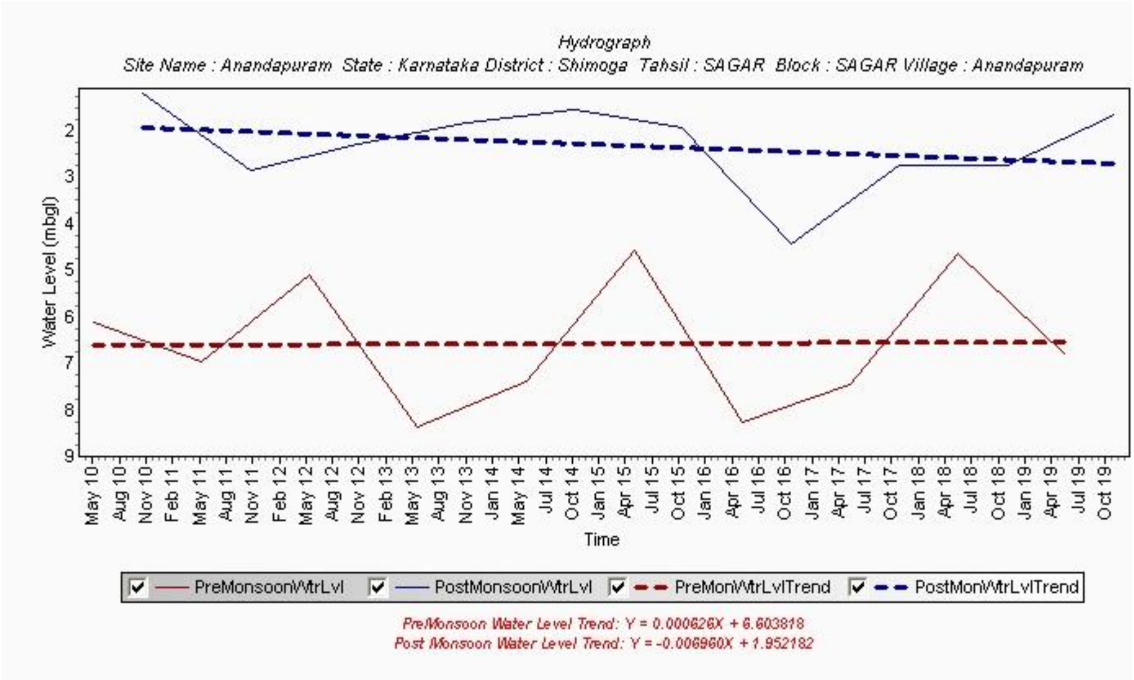


**Fig. 2.4: Hydrograph of NHS monitoring Well at Anandapura**

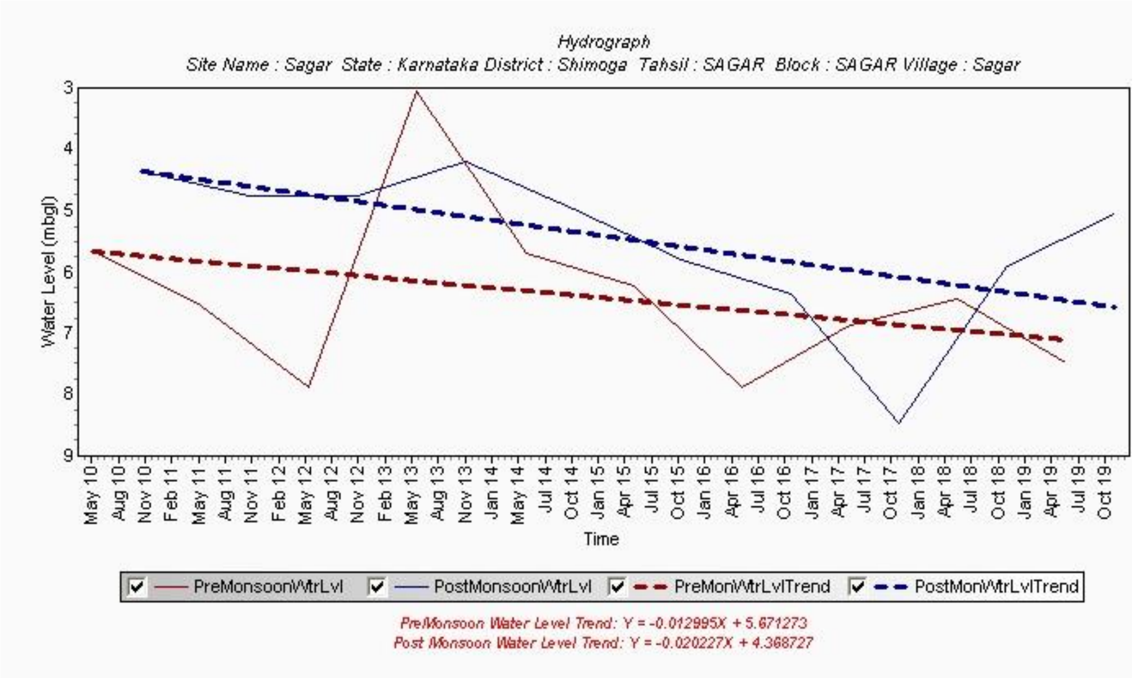


**Fig. 2.5: Hydrograph of NHS monitoring Well at Sagara**

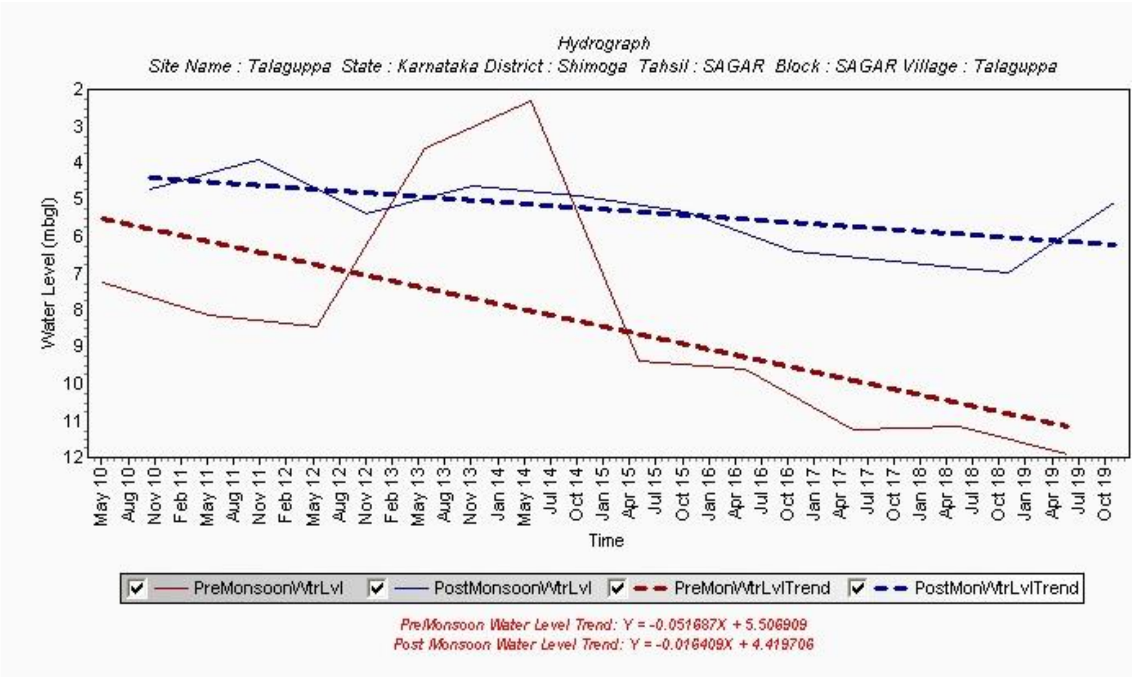


**Fig. 2.6: Hydrograph of NHS monitoring Well at Talaguppa**

**Table 2.2: Showing long term groundwater level trend of some NHS wells in Sagara Taluk**

| Sl. No. | NHS Well | Pre-monsoon Trend (cm/year) | Post Monsoon Trend (cm/year) | Pre/Post Trend |
|---|---|---|---|---|
| 1 | Anandapura | 0.06 | -0.69 | Flat/Flat |
| 2 | Sagara | -1.3 | -2.02 | Slightly Falling/ Slightly Falling |
| 3 | Talaguppa | -5.16 | -1.64 | Falling/ Slightly Falling |

## 2.5 Exploratory Drilling

Sub-surface lithological information (down to 190 mbgl) from the available drilling records of exploratory well of CGWB and sub-surface information obtained during field study have been tabulated in Table 2.3. CGWB has constructed 06 EW and 03 OW in the taluk in order to decipher aquifer parameters and sub-surface information.

**Table 2.3: CGWB exploratory wells drilled in Sagara Taluk**

| Sl.No. | Location | Block | Longitude | Latitude | Depth Drilled(m bgl) | Casing Depth (m) |
|---|---|---|---|---|---|---|
| 1 | Avinahalli | Sagara | 75.0111 | 14.0777 | 184.85 | 37 |
| 2 | Tumri | Sagara | 74.8528 | 14.0336 | 200.10 | 20.12 |
| 3 | Aralgodu | Sagara | 14.1444 | 74.8194 | 159.4 | 23.75 |
| 4 | Jambani EW | Sagara | 14.2166 | 75.1305 | 131.95 | 48.50 |
| 5 | Jambani OW | Sagara | 14.2166 | 75.1305 | 140.10 | 48.50 |
| 6 | Gauthampura EW | Sagara | 14.1375 | 75.1416 | 191 | 50.50 |
| 7 | Gauthampura OW | Sagara | 14.1375 | 75.1472 | 172.5 | 52.90 |
| 8 | Sagara EW | Sagara | 14.2228 | 75.0084 | 70.95 | 26.70 |
| 9 | Sagara OW | Sagara | 14.2228 | 75.0084 | 157.45 | 22.60 |

The exploratory bore wells drilled in Sagara taluk are having depths ranging from 70.95 to 200.10 m bgl. The discharge ranges between negligible to 18 lps. The yield cum recuperation tests conducted on the wells show that the general specific capacity ranges from 1.29 to 46.01 lpm/m/d.d. The transmissivity of aquifer material in general range from 0.56 to 34.18 m2/day.

## 2.6 Pumping Test

Aquifer Performance Test (APT) has been conducted in three exploratory wells in order to determine the aquifer parameters. APT has been conducted at constant discharge, and drawdown has been measured at regular intervals. Also the residual drawdown has been measured periodically during recovery. The time-drawdown data has been plotted by using Cooper-Jacob's Straight Line method and using Theis's Recovery Method and transmissivity values are approximated. T value has been calculated for each well and enumerated in Table 2.4. From the table it can be seen that T value ranges from 0.56 to 169 m2/day. Storativity value indicates that the aquifer is under semi-confined to unconfined conditions.

**Table 2.4: Details of CGWB Exploratory Well Details**

| Sl. No. | Location | Depth/ Casing | Zones in m | SWL in mbgl | Q (LPS) | DD (m) | T (m2/day) | S |
|---|---|---|---|---|---|---|---|---|
| 1 | Aralgodu | 159.4 / 23.75 | | 15.06 | 0.73 | 36.73 | 0.56 | 1.29 |
| 2 | Avinahalli | 184.85 / 37 | | 6.34 | Negligible | - | - | - |
| 3 | Gauthampura EW | 191 / 50.50 | | 7.81 | 6.2 | 15.88 | 16 | 14.5 |
| 4 | Gauthampura OW | 172.5 / 52.90 | | 8.34 | 10.2 | 11.93 | 23 | 24.55 |
| 5 | Jambani EW | 131.95 / 48.50 | | 5.06 | 18.9 | 14.25 | 35 | 19.5 |
| 6 | Jambani OW | 140.10 / 48.50 | | 5.78 | 12 | 9.98 | 169 | 32.3 |
| 7 | Sagara EW | 70.95 / 26.70 | 23,32,36,44,62 | 4.5 | 6.48 | 8.45 | 34.18 | 46.01 |
| 8 | Sagara OW | 157.45 / 22.60 | | 4.29 | 6.54 | 10.24 | 27.28 | 38.32 |
| 9 | Tumri | 200.1 | 31,32,74,75,86, 87,135,136 | 8.9 | 0.31 | - | - | - |

## 2.7 Hydrogeochemical Data

### 2.7.1 Water Quality Sampling, Number of Samples and Analysis Mechanism

Groundwater quality of an area is a function of physical and chemical parameters that are greatly influenced by geochemical characteristics of the formations and anthropogenic activities. The concentration of the major ions and other dissolved ions in ground water are function of the availability of the constituents in the aquifer matrices and their solubility. Quality of ground water is as much demanding as its quantity. Suitability of ground water for drinking and irrigational purpose is important for its safe and effective use. In Sagarataluk, both irrigation and domestic requirement are mostly depended on groundwater.

Groundwater quality studies have been done based on the samples collected from the study area during May/June-2022. A total number of 36 samples (22 DW+14BW) were collected for analysis. Water samples were collected and stored in 01 litre capacity clean high-density polyethylene bottles with poly-seal caps. Before collection of samples, bottles were properly washed and were rinsed by the water to be sampled. The hand-pumps were pumped for sufficient duration before collecting ground water sample so that the stagnant water, if any, is completely removed.

These water samples were analysed in chemical laboratory of CGWB SWR-Banglore. Besides these, available previous year data of chemical analysis of ground water were also studied to have an understanding of ground water chemistry of the area. From the chemical data it can be observed that pH of the analysed samples vary from 6.18 to 9.35 indicating that waters are slightly acidic to slightly alkaline.The prominent hydro chemical facies has been identified from Hill-Piper diagram (fig. 2.7 & 2.8). From the diagram, it can be observed that majority of the analysed samples comes under 'Calcium Bicarbonate Type' facies for both phreatic and fractured aquifers. Analytical results of ground water samples are given in Annexure III.

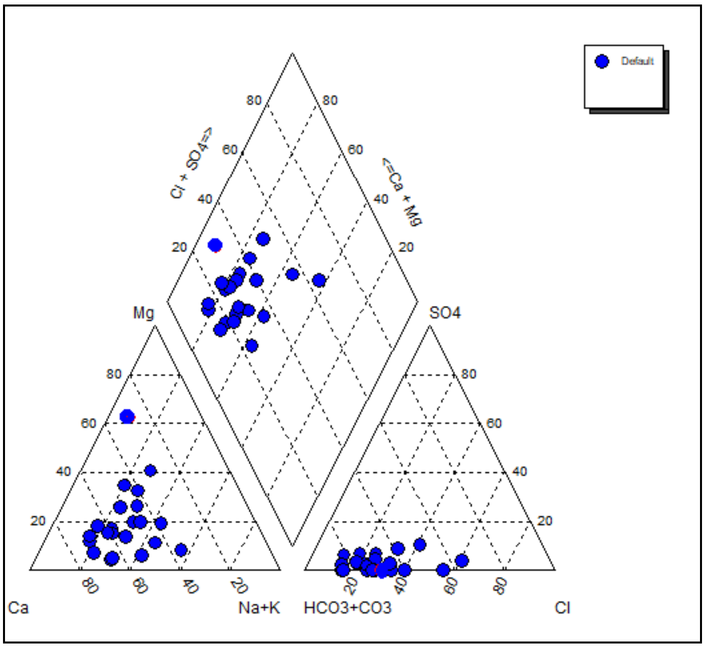


**Fig. 2.7: Hill-Piper diagram for dug well samples collected from Sagara Taluk**

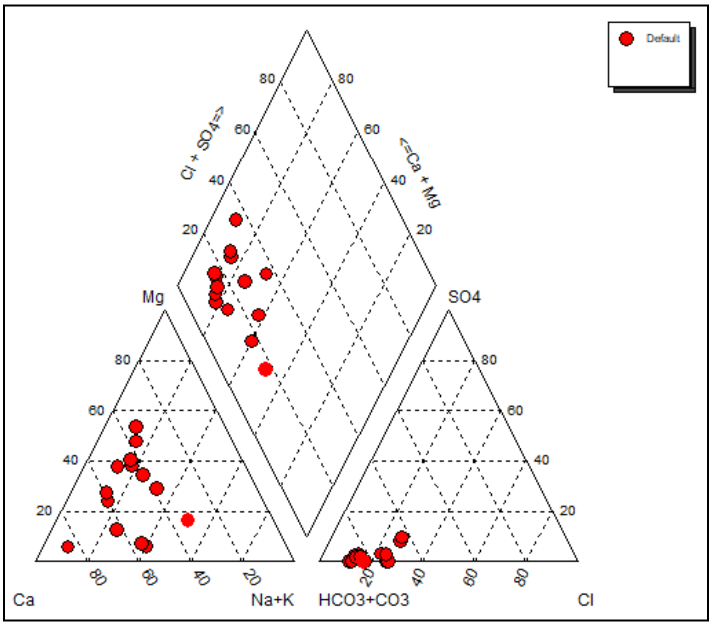


**Fig. 2.8: Hill-Piper diagram for bore well samples collected from Sagara Taluk**

Quality of irrigation water varies significantly based on its dissolved salts. The salts may originate from dissolution or weathering of rocks and soil. From the analysis data it can be seen that EC values ranges from 54µS/cm (Baikodu) to 487 µS/cm (Jambani)@ 25°, which is well within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. The results obtained from chemical analysis were plotted in USSL diagram as shown in figure 2.9 and 2.10. From the figure, it can be observed that all samples have low SAR value and come under low sodium as well as low to moderate- salinity hazard zone. Therefore, groundwater from both dug wells and bore wells in the taluk is suitable for irrigation purposes.

From the Chemical data, it can be observed that the presence of fluoride concentration is aove the desirable limit in water samples collected from Tumani (1.15 mg/L). The sample is collected from domestic bore well. Presence of fluoride is suspected in the taluk where granitoid rocks are present. Therefore, detailed investigation has to be done in order to decipher the mobilization mechanisms, spatial and temporal variation in concentration of fluoride in the taluk.

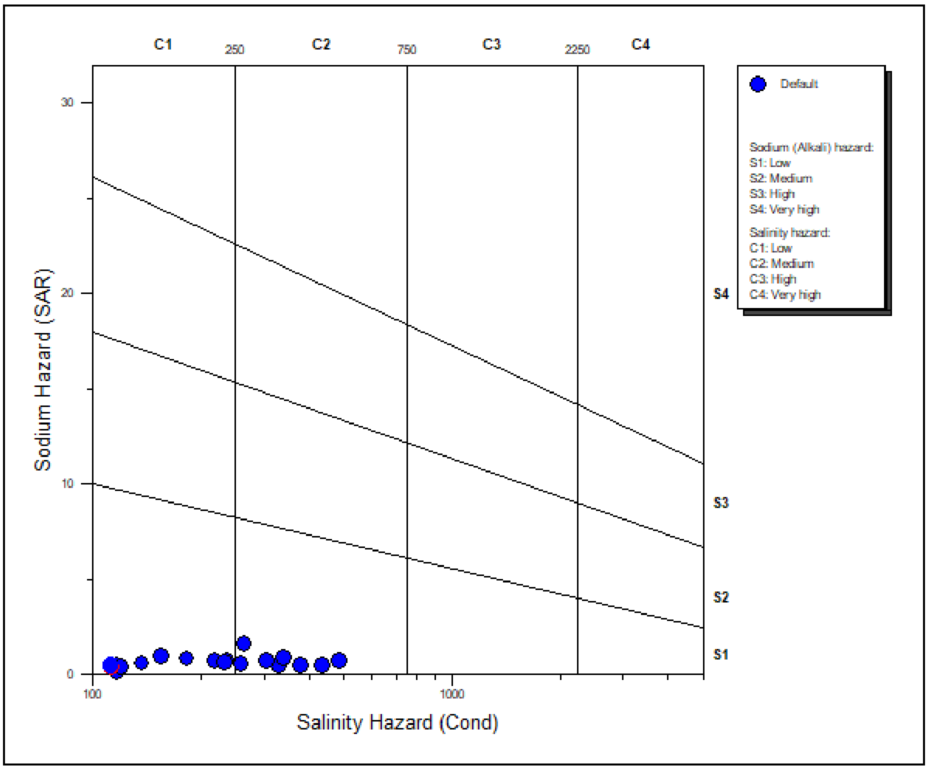


**Fig. 2.9: US Salinity diagram for dug well samples collected from Sagara Taluk**

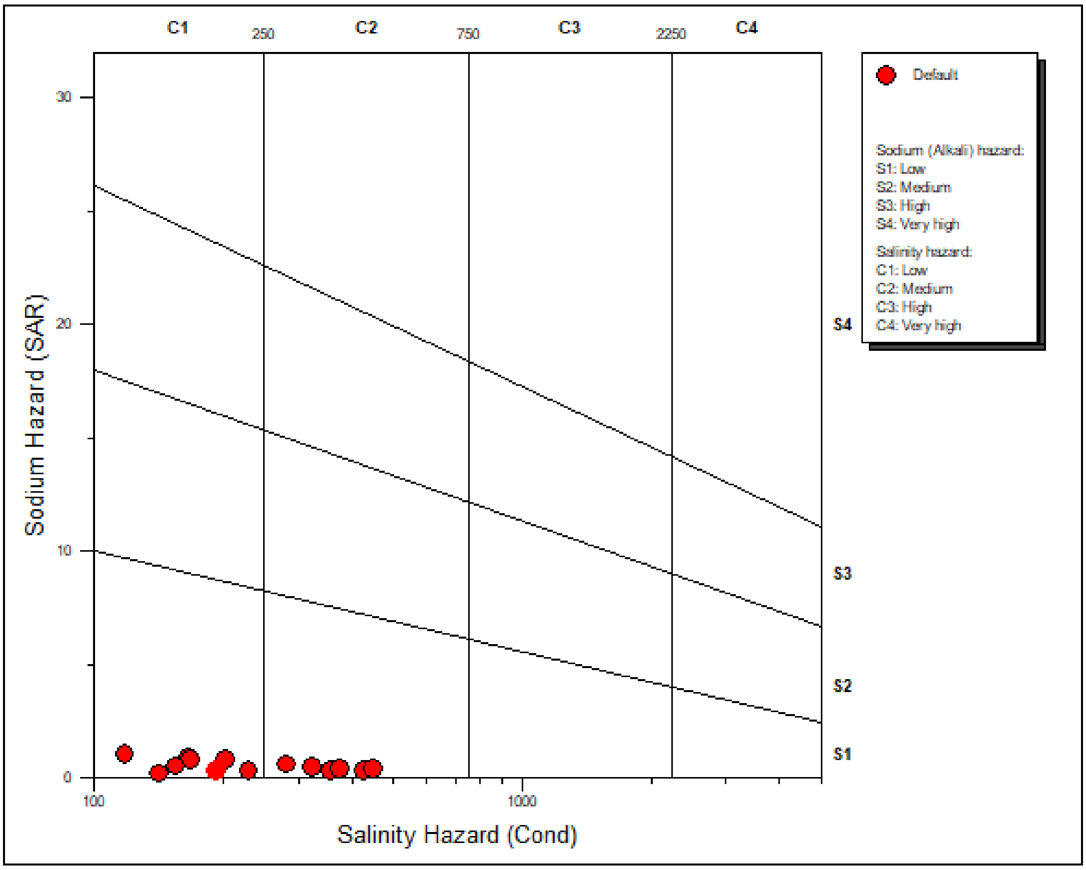


**Fig. 2.10: US Salinity diagram for bore well samples collected from Sagara Taluk**

# 3. Data Interpretation, Integration and Aquifer Mapping

## 3.1 Hydrogeology

The study area comprises of rock formations belonging to Archaean to Recent age. Numerous quartz veins and reefs occurs in the older schistose rocks and granite gneiss. The Laterites are developed in the northern part of the taluk over the schists and phyllite and in some palces, over granite-gneisses with an approximate thickness of few centimetres to 40.00 m. The alluvium deposits are restricted along the riverbanks. Main aquifers in the study area are the weaker weathered and fractured zones of schistose and gneissic rocks. It together covers an area of 1436.2 sq. km (74%) of the total area of the taluk. A table showing area covered under different lithounits are given below (Table 3.1). The gneissic-granitic complex does not possess primary porosity. Secondary porosity like joints, fissures and faults present in these formation forms the aquifer. Ground water occurs under phreatic condition, which generally occurs within the depth range of 13.00 to 30.00 m bgl. The sustained yield of dugwells ranges from negligible to 30 $m^3$/day. The fracture zones that occur at various depth zones within the depth of 200.10 m bgl are expected to be saturated with ground water. It is found that the water bearing characteristics of schists are more or less similar to that of gneisses and granites. But the weathered zones of schists may not yield as granites, because of their compact and clayey nature. Laterite overlying the schists and gneissic-granites in moderate thickness acts as an aquifer locally. Alluvium occurring along the riverbanks with a thickness of few cm to 3.00 meters, holds the bank storage. Ground water in these aquifer materials generally occurs under unconfined to semi-confined conditions. The ground water is being exploited from within the depth range of 13.00 to 30.00 m bgl through dug wells and 30.00 to 200.00 m bgl through dug-cum-bore wells and bore wells.

**Table 3.1: Percentage area showing different lithounits of the study area**

| Lithology | Area (Sq. Km) | Percentage Area (%) |
|---|---|---|
| Graywacke | 2.93 | 0.15 |
| Laterite | 195.25 | 10.05 |
| Meta-Rhyolite/G Gneiss/Quartzite | 484.2 | 24.93 |
| Argillite/Phyllite | 282 | 14.52 |
| Mafic and Ultramafuc Rocks | 17.2 | 0.89 |
| Schistose Rocks /Ambhibolite | 952 | 49.02 |
| Bif/Quartz Vein/Reef | 8.42 | 0.43 |
| **Total** | **1942** | **100.00** |

## 3.2 Aquifer Disposition

Aquifer disposition of the district has been studied through prepared sections based on the lithologs obtained through exploratory drilling done by CGWB and field observations. Based on this, detailed aquifer geometry on regional scale has been established in the study area. Principal aquifers in the area have been delineated by grouping the weathered/phreatic zone and fractured zones as aquifers. The fracture zones encountered at different depths are grouped into an aquifer system based on its lateral continuity.

The weathered formation and fractured crystalline metamorphic rocks in the taluk are by large forms the aquifer system. A map showing depth to weathering of the formation is given in fig. 3.1. Thickness of weathering varies from 10 to 57 m bgl. On the basis of drilling data, it can be observed that fractures in crystalline rocks are not isotropic and in many places, with limited subsurface extension. Further, schistose aquifers in the western part of the taluk are poorly yielding as compared to the gneissic and laterite aquifers present in the rest of the taluk. The disposition of fractures, their attitudes, fracture density and vertical permeability are the major controlling factors responsible for the availability of groundwater yield.

### 3.2.1 Hydrogeological Cross-Section

The aquifer geometry and disposition of the taluk has been studied based on lithologs of exploratory bore holes as well as field observations. Hydrogeological cross-sections were prepared along A-A’, B-B’ and C-C’ (fig. 3.2). The aquifer zones in the area have been found to occur under phreatic condition at shallow depth, primarily in the weathered formation, followed by semi – confined condition in fractured & jointed formation below the weathering zone. Geological formations occurring in the district are Granitic Gneiss; various grades of schists and phyllites; and laterites which covers major part of the district, a small portion of mafic and ultramafic rocks occurin the north-eastern part and the crystalline rocks are intruded by pegmatite and quartz veins in many part of the taluk.

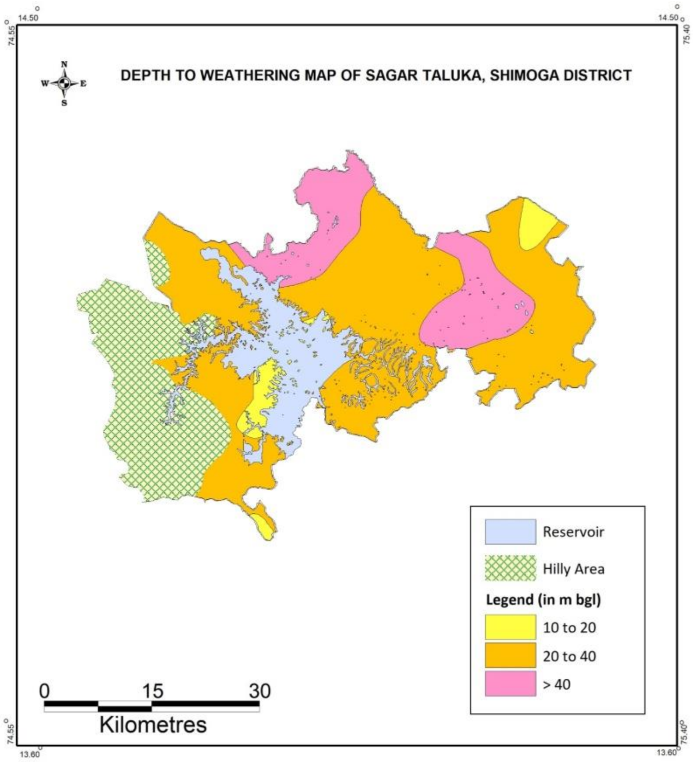


**Fig. 3.1: Depth to weathering map of Sagara taluk**

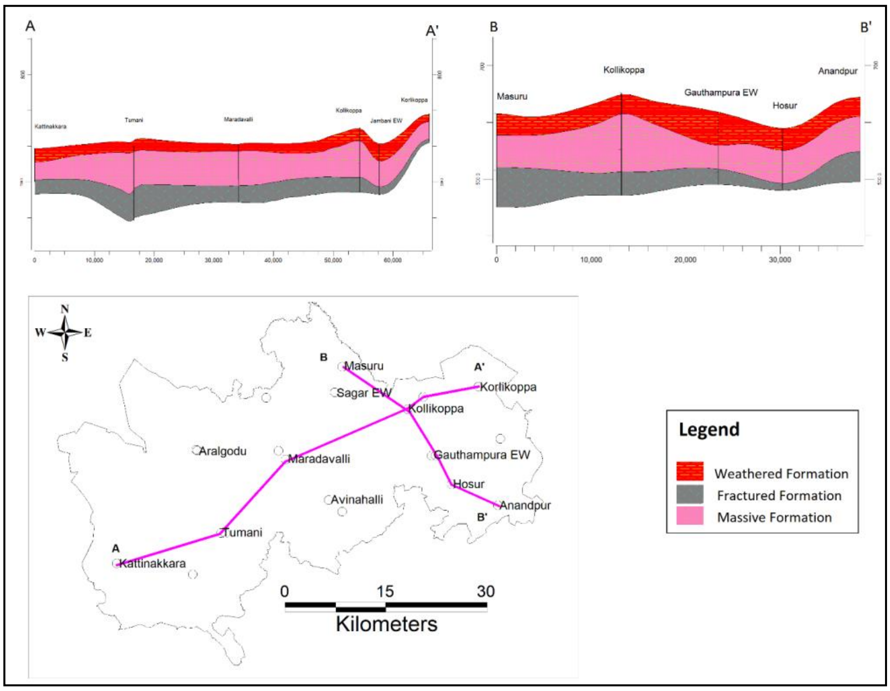


**Fig. 3.2: Hydrogeological section taken along A-A' and B-B' of Sagara taluk**

Hydrogeological fence of the study area has been prepared and is shown in fig.3.3. It is to be noted that the yield of wells tapping the fractured formation is site specific and exclusively depend upon the availability of interconnected productive fractures. Fracture density in higher on the eastern part of the taluk while, it is limited in the western part. Therefore, it is obvious that wells tapping the fractured formation in eastern part of the taluk is more yielding than those constructed in the western part.

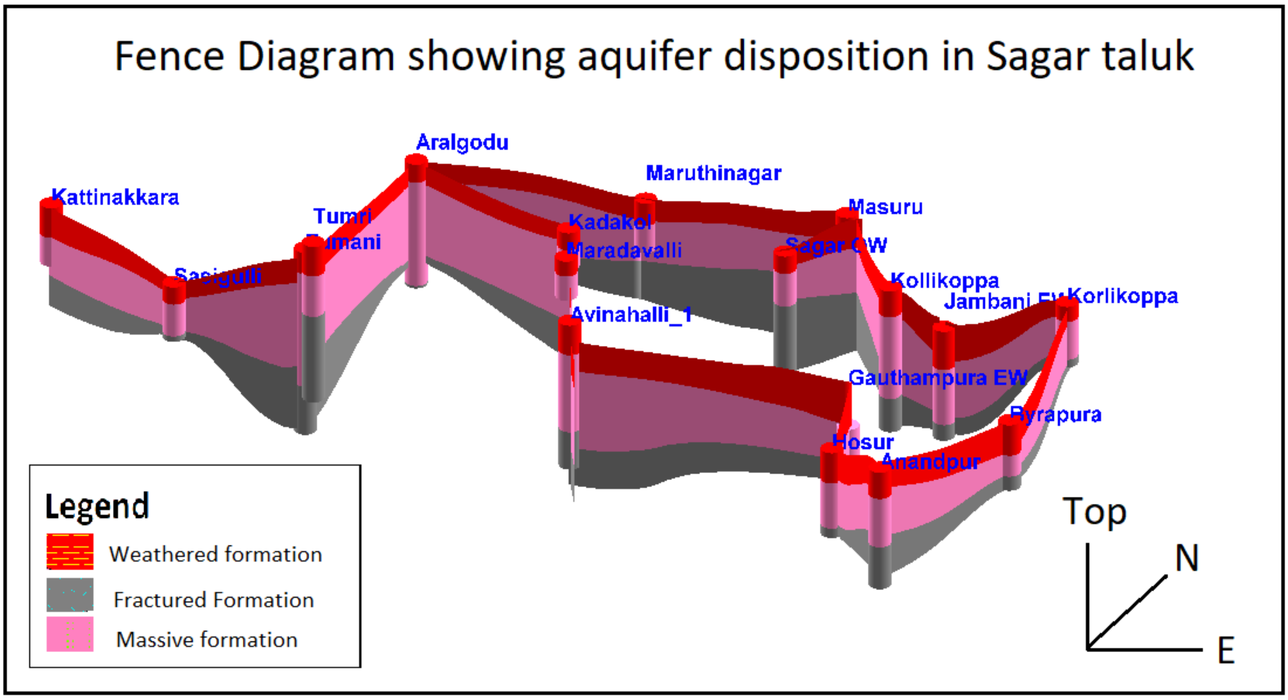


**Fig. 3.3: Fence Diagramshowing aquifer disposition inSagarataluk**

### 3.2.2 3D Aquifer Disposition

Aquifer disposition of Sagara taluk in 3-D has been generated based on the available borehole data and the result obtained is given in fig. 3.4. From the 3-D disposition, the two types of aquifer system in the taluk can be well demarcated. The phreatic aquifer system is constituted by weathered formation. It is also to be noted that the second aquifer is under semi confined to confined condition in the taluk. The weathering thickness in the taluk is also variable.

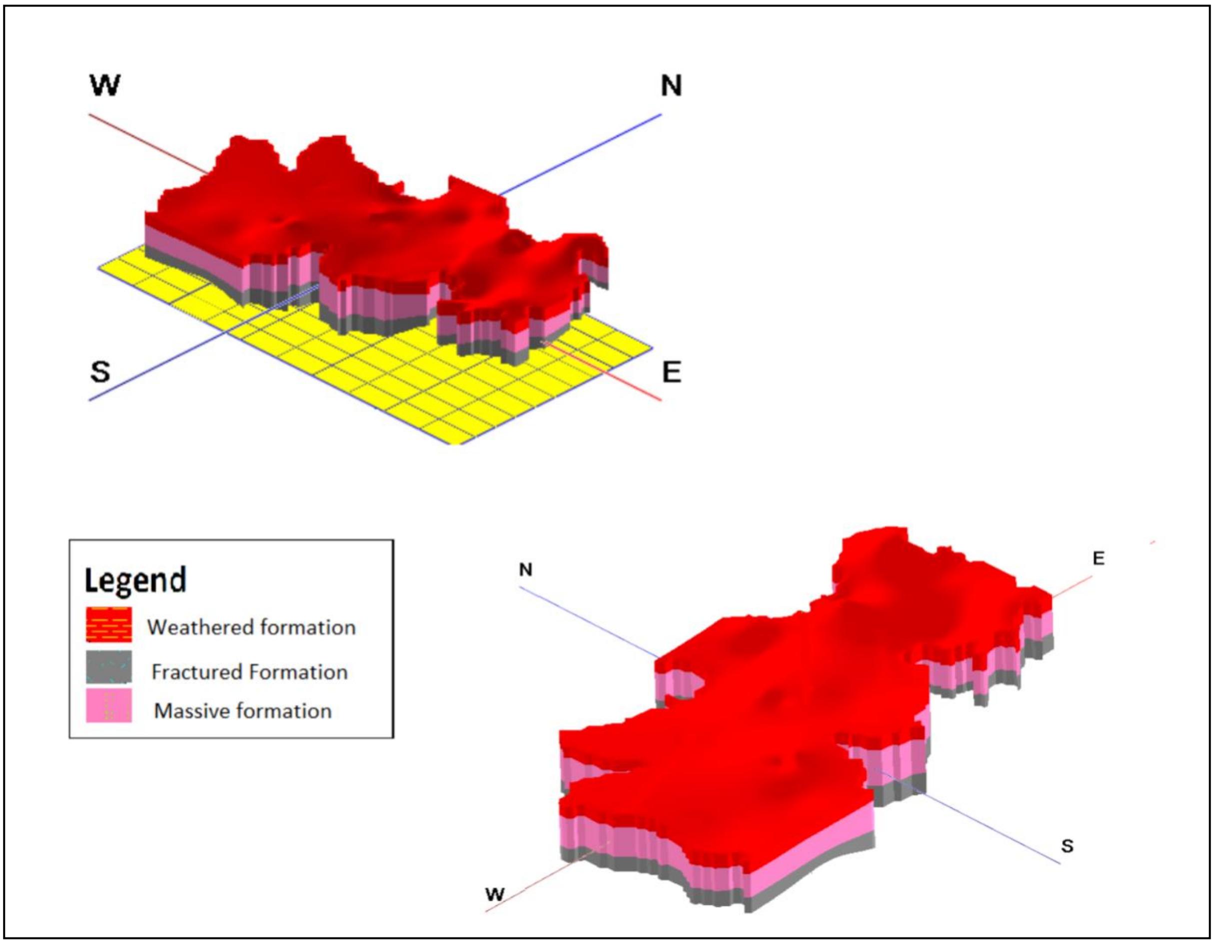


**Fig. 3.4: 3D aquifer disposition in Sagara taluk**

### 3.2.3 Ground Water in Aquifer – I & Aquifer-II

There are two aquifer system exists in the area, both of which are genetically related and therefore groundwater in both the aquifers are hydraulically connected. In the weathered formation, groundwater is under water table condition. However, in deep fractured aquifer, groundwater occurs in semi-confined to confined condition. It is to be noted that, the yield and potentiality of fractured aquifers are area specific and is controlled by the extent of fracture density.

### 3.2.4 Ground Water Dynamics

The successful bore holes constructed in the district is 06, and flow dynamics are deciphered based on Aquifer Performance Test (APT) conducted in three exploratory wells. APT was conducted at constant discharge, and drawdown has been measured at regular intervals. Also the residual drawdown has been measured periodically during recovery. The time-drawdown data has been plotted by using Cooper-Jacob's Straight Line method and using Theis's Recovery Method and transmissivity values are approximated. Storativity values are calculated from the time-drawdown data in some locations were observation wells are also constructed. From the data it can be observed that EW's in Jambani and Sagara is having relatively high specific capacity owing to nominal drawdown Jambani well is having T value of 169 m2/day . The deep aquifer from which pumping has been done seems to be sustainable but are poorly yielding. Therefore, regulated pumping may be practiced in order to avoid steep draw drown and consequent drying up of the pumping well. Based on the pumping test data, a yield prospect map of fractured aquifer has been prepared and given in fig. 3.5.

## 3.3 Ground Water Exploration

Groundwater exploration studies have generated baseline data in Sagarataluk. Exploratory drilling has been done down to depth upto 200.10 m (Tumri) in order to decipher the characteristics of aquifer system. However, the deep boreholes constructed in Aralgodu, Avinahalli, Tumri does not yielded any potential water bearing fractures underneath. Thus no deep regional potential fractures are encountered and groundwater development shall be restricted to the phreatic zones in these areas of western part of the taluk. Lithologs of CGWB and State Govt. agencies were compiled, correlated and hydrogeological sections, fence diagram, 3 D aquifer disposition of the district has been prepared.

## 3.4 Ground Water Quality

The groundwater quality of the samples collected from both dug wells and bore wells show that all major parameters values are within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. pH of the analysed samples vary from 6.18 to 9.35 indicating that waters are slightly acidic to slightly alkaline.EC values ranges from 54 µS/cm (Baikodu) to 487 µS/cm (Jambani) @ 25°, which is well within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. All samples have low SAR value and come under low to low-moderate salinity hazard zone indicating suitable for irrigation purposes. From the Chemical data, it can be observed that the presence of fluoride concentration is aove the desirable limit in water samples collected from Tumani (1.15 mg/L). The sample is collected from domestic bore well. Presence of fluoride is suspected in the taluk where granitoid rocks are present. Therefore, detailed investigation has to be done in order to decipher the mobilization mechanisms, spatial and temporal variation in concentration of fluoride in the taluk.

## 3.5 Aquifer Characterization

Aquifer characterization down to depth of 200.10 m bgl has been done carried out by preparation of hydrogeological section, fence diagram and 3D sections. It can be observed that the phreatic aquifer is having regional cover except in the western part of the district, where the Sahyadri hill ranges exists. Yield map prepared, indicates that aquifer in the eastern part of the district is more productive and sustainable. Potential fractured aquifer system in the taluk is constituted by granitoid gneisses and high grade metamorphic rocks. Potential sub-surface fractures encountered in bore holes constructed in these area clubbed with high vertical permeability and low-moderate slope allows the area to be suitable for recharge purposes (both natural and AR).

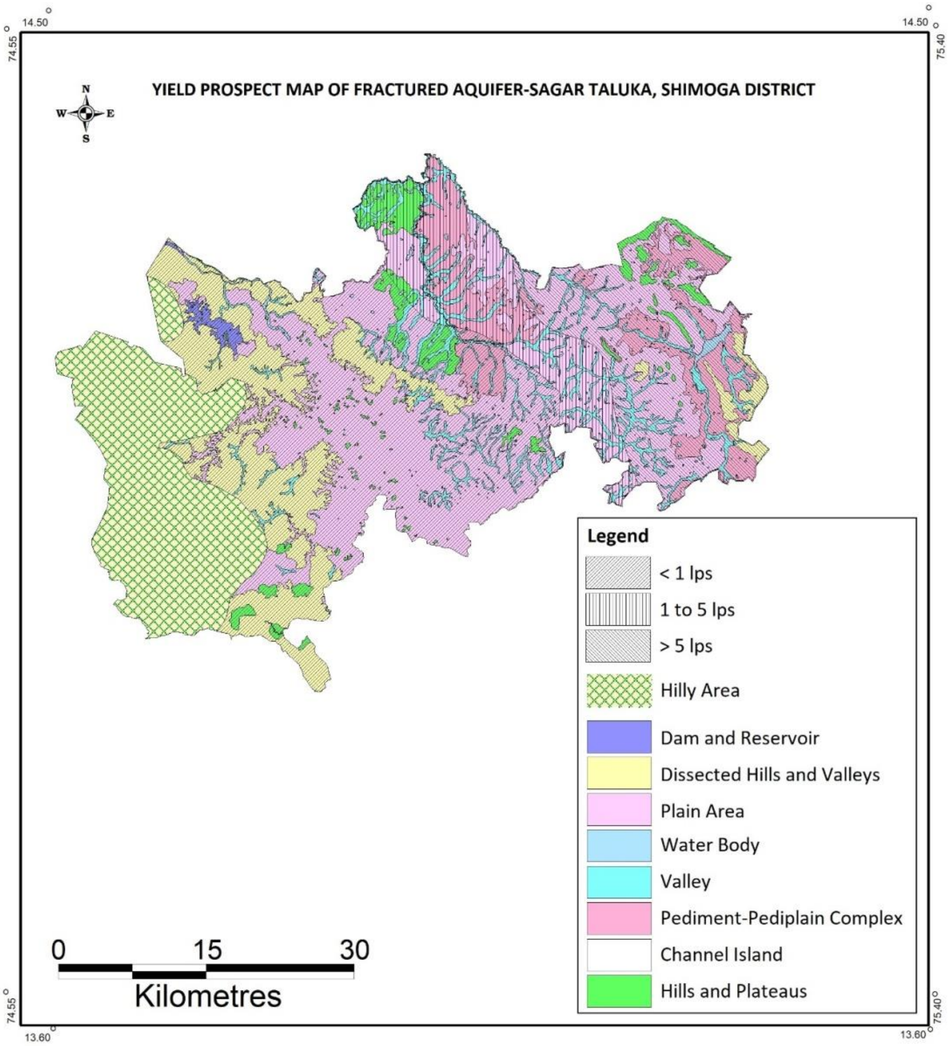


**Fig. 3.5: Yield map of fractured aquifer in Sagara taluk**

## 3.6 Aquifer Map

Aquifer map of the district is generated for both phreatic and fractured aquifer system. By integrating the yield potential, EC, water level contour, lithology etc. a thematic layer has been prepared, which describes the aquifer characteristics of the taluk. The maps are given under fig.3.6 and 3.7 respectively.

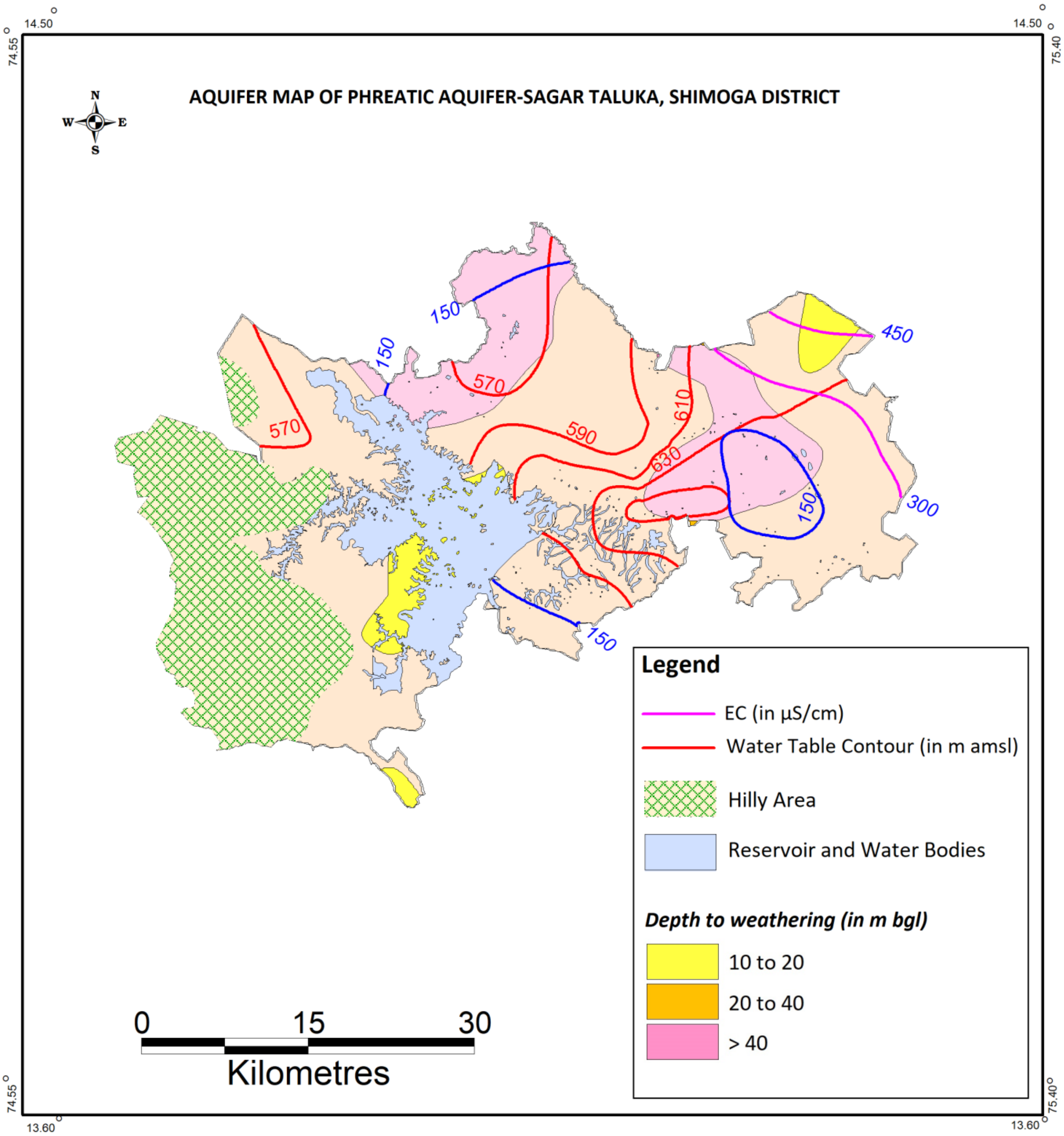


**Fig. 3.6: Aquifer map of phreatic aquifer system in Sagara taluk**

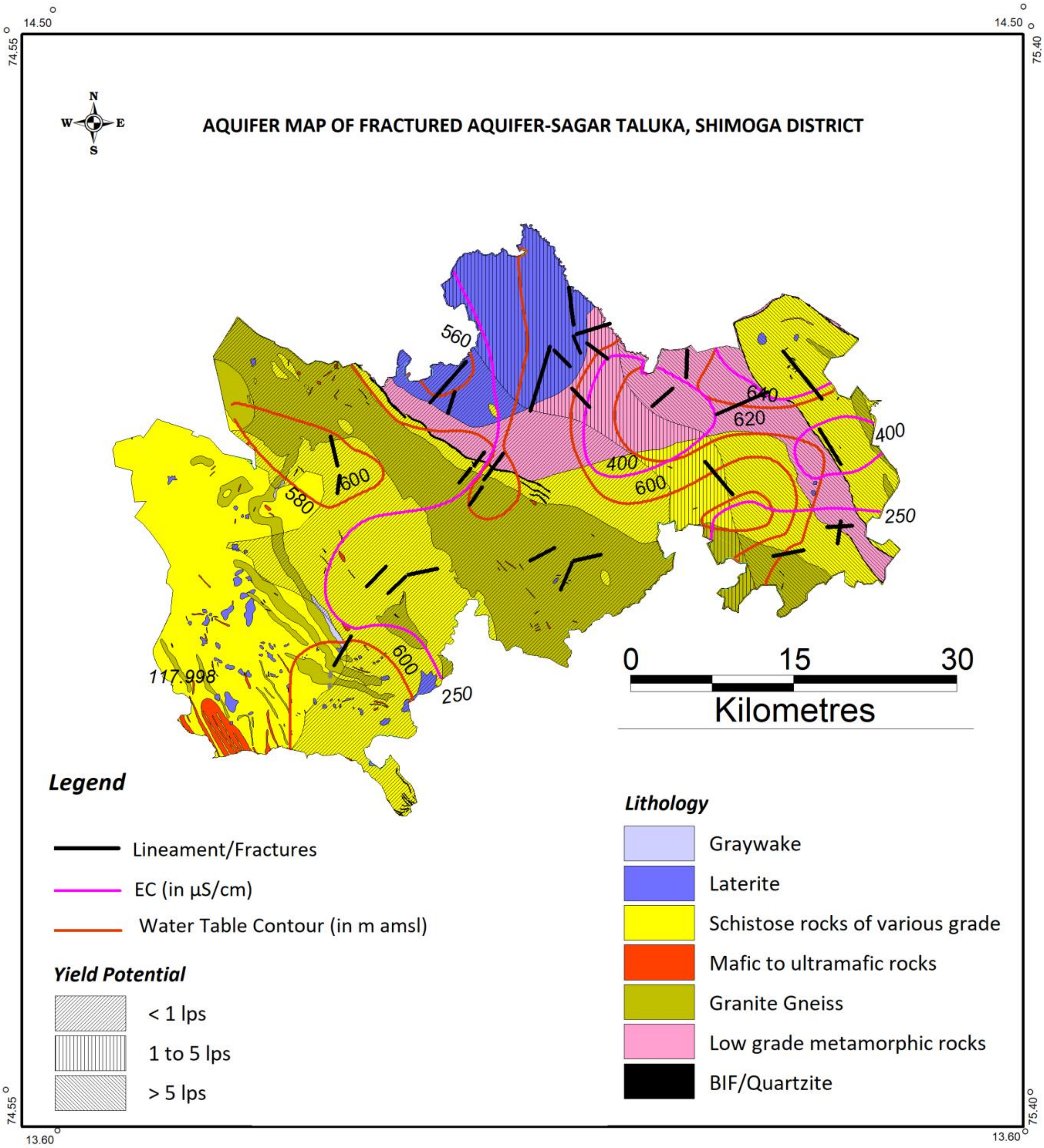


**Fig. 3.7: Aquifer map of fractured aquifer system in Sagara taluk**

# 4. Ground Water Resources

## 4.1 Dynamic Resources

Dynamic groundwater resource assessment of Karnataka State has been jointly carried out by Minor Irrigation and Groundwater Development Department, Govt. of Karnataka and Central Ground Water Board, Ministry of Jal Shakti, Govt. of India, as on March 2022. Dynamic resource of the study area has been estimated by using the norms prescribed under GEC-15. As per GWRE-2022, the annual net resource of the taluk is 189.88 MCM. Irrigation consumes about 93.86% of total groundwater requirement in the taluk. Domestic and industrial use accounts for the rest 6.14% requirement. A table showing resource position and allocation to various sectors as per GWRE-2020 and GWRE-20222 assessment are given in Table 4.1.

**Table 4.1: Showing resource, as per GWRE-2022**

| Year | Assessment Unit | Assessment Unit Type | Annual Extractable GW Resource (Ham) | GW Extraction for Irrigation (Ham) | GW Extraction for Industry (Ham) | GW Extraction for Domestic (Ham) | Total Extraction (Ham) |
|---|---|---|---|---|---|---|---|
| **2022** | Sagara | Taluk | 18988.87 | 4668.17 | 3.42 | 301.55 | 4973.14 |
| **2020** | Sagara | Taluk | 18914.57 | 3877.43 | 0.00 | 476.16 | 4353.58 |

| Total Extraction (Ham) | Annual GW Allocation for for Domestic Use as on 2025 (Ham) | Net Ground Water Availability for future use (Ham) | SOE (%) | Categorization |
|---|---|---|---|---|
| 4973.14 | 305.0 | 12113.4 | 29.10 | safe |
| 4353.58 | 496.32 | 14541.30 | 23.02 | safe |

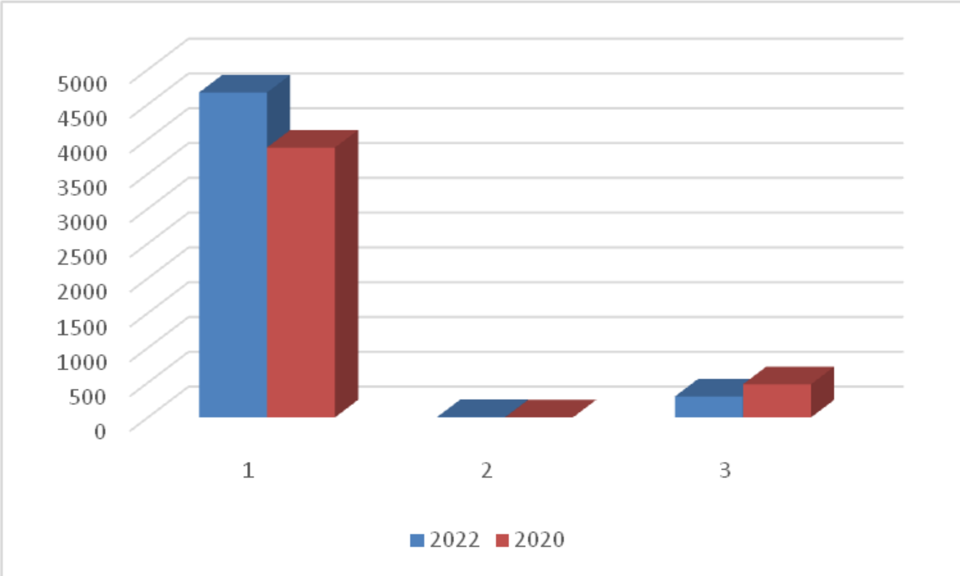


**Fig. 4.1: Graph showing change in groundwater extraction, as per GWRE-2020 & 2022**

From table 4.1 and corresponding fig. 4.1, it is clear that, from GWRE-2020 to 2022, SOE has increased by about 6%, however, the availability of resource has marked fractional increase. Irrigation demand has increase by about 4.8% in the last two assessment years. This may be due to the increase in number of groundwater abstraction structures in the taluk owing to the increased requirement. However, demand for domestic use has dropped fractionally. This may be due to the increase inpiped supply water to individual households implemented in the taluk under various Govt. interventions.

# 5. Ground Water Related Issues

## 5.1 Identification of issues

Issues related to groundwater in the study area are basically focused on the aspect of quantity, quality and sustainability. Because of its geological and geomorphologic characteristics, the groundwater resource in the district is unevenly distributed. The eastern part is having potential fractured aquifer and therefore rich in groundwater resource. On the flip side, middle and western part of taluk is water scarce due to the poor yield potential of fractured aquifer system. Aquifer in the middle and western part of the taluk is also less sustainable which is evident from the higher drawdown on pumping and slow recuperation. Major groundwater issues in the district are detailed below:

## 5.2 Increase in groundwater demand in agriculture and irrigation sector

Agriculture and irrigation in the district is mostly dependent on tanks and ponds. However, from agriculture statistics, and minor irrigation census data and GWRE-2020 & 2022, it can be observed that demand for groundwater for agriculture and irrigation is steeply increasing. On comparing resource for the last two assessment years, it can be seen that the irrigation extraction is raised by 6%. It is also to be noted that there is a fractional rise in groundwater requirement for industrial sector also and this may also be increased in the coming years.

## 5.3 Low yield potential in western and middle part of the taluk

Due to the presence of highly compact low grade metamorphic rocks, groundwater yield potential of aquifers in these areas are poor. Ground water is limited to the top weathered residuum or in the shallow or deep seated potential fractures, cracks/joints. These fractures are not regionally extensive and yield of wells tapping these fractures is less. Further, moderate to steep slope in these area cause wastage of rainwater as runoff in very short span of time, and does not allowing water to recharge. Existing bore well data in in these terrain shows that yield of the wells are 0.73 lps (Aralgodu), 0.1 lps (Avinahalli), 0.31 lps (Tumri). with lower specific capacity. Therefore the potentiality of the aquifers is limited which causes water scarcity in southern and south-eastern part of the district especially during lean period.

# 6. Management Strategies

## 6.1 Introduction

Management plan for groundwater resource of the taluk is made in order to address the issues detailed in Chapter-V. The plan has been prepared by considering both supply side and demand side interventions. It is observed from the field survey that groundwater demand for irrigation practices in the district are increasing. Lithology, fracture configuration and geomorphology in the taluk have a strong impact on the distribution of groundwater resource in the district.

Hydrogeologically, taluk is bestowed with two aquifer system, both of which are genetically related and therefore groundwater in both the aquifers are hydraulically connected. In the weathered formation, groundwater is under water table condition. However, in deep fractured aquifer, groundwater occurs in semi-confined to confined condition. It is to be noted that, the yield and potentiality of fractured aquifers are area specific and is controlled by the extent of fracture density. By considering this variation in groundwater resource potential, management plans are made in such a way that sustainable groundwater development is recommended in the eastern parts and demand- supply interventions in the middle and western parts of the taluk. Supply side management plans for irrigation sectoris discussed in sections 6.2 and 6.3. Also supply side interventions through AR structures are discussed under section 6.3. Demand side management through crop diversification is incorporated in section 6.2. Other demand side interventions such as micro irrigation practices has been discussed under 6.4.

## 6.2 Management Plan for Irrigation Sector

Cereals such as paddy, maize and plantation crops such as arecanut, cashew etc constitute major part of the gross cropped area of Sagara district. It is to be noted that the non-food crops which can generate high income for farmers and requires less water resource for cultivation, is less cultivated in the district. Crop seasons in the district are kharif, rabi and summer. The gross irrigated area in the taluk is 24943 ha and net irrigated area is 20490 ha. Gross irrigated area constitutes 143262 ha, and 68.91%of gross cropped area has so far been covered under irrigation by all means. Agriculture in the district by and large is the traditional kharif cultivation depending primarily on monsoon rainfall while rabi cultivation is practiced where irrigation facilities are available. Irrigation in the district is done through sources of irrigation such as tanks/ponds, tubewells, dugwells, canals.

**Table 6.1: Resource required for additional area brought under irrigation**

| Block | Cultivable area/Net sown area | Net Irrigated Area (ha) | Cultivable waste land (ha) | Additional irrigation Water Requirement (Delta factor:50 cm) for Pulses/oilseeds (ham) |
|---|---|---|---|---|
| Sagara | 26048 | 20490 | 5558 | 2779 |

The additional area available for cultivation (5558 ha) is proposed for pulses and oil seeds based on its lower water requirement. Water requirement for pulses and oilseeds are taken as 50 cm, which is less as compared to requirement for cereals crops. Thus volume of additional water required to extend irrigation to the remaining area has been calculated from crop water requirement taking delta factor 0.5 m (Table 6.1). To bring the cultivable waste land under assured irrigation through ground water, an additional 2779 ham resource is required.

As per the Dynamic Resource of Ground Water Resource Assessment, 2022, total annual extractable ground water resource in Sagara taluk is 18988.87ham with SOE of 29.10%. Considering the safe limit of development, at 60% of SOD, the additional resource available is estimated to be 5867.56 ham. The additional resource can therefore be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc. Since the additional resource calculated is well within the limit of additional resource available, the entire cultivable waste land can be brought into assured irrigation through groundwater resource. Even if the cropping intensity is doubled (5558 ha) in the additional cultivable area, the additional resource caters fully, for less water intensive crops.

The additional irrigation potential may be created through construction of open dug wells and shallow/medium depth bore wells. The unit draft of dug well is taken as 1 ham/year and for SBW/MDBW is considered 1.5 ham/year based on the norms taken for GWRE-2022. The requirement of additional abstraction structures has been estimated (Table 6.2). It can be observed that additional number of 1667 dug wells and 741 bore wells are required to be constructed for the proposed irrigation potential to be created. However, installation of proposed structures should always be implemented in phase-wise as per the actual site specific feasibility. Proposed structures can bring additional 5558 ha irrigation potential in the district which accounts for about 27% net irrigated area of the taluk.

**Table 6.2: Number of feasible tube wells in order to achieve additional irrigation potential**

| Volume of water available for future Irrigation development (ham) within 'safe' limit | Additional resource required for future irrigation (ham) within safe limit | Actual additional resource available 3 = (Lowest of 1 and 2) | Unit draft of DW (ham) | Unit draft of SBW/ MDBW (ham) | Required no. of DW (Considering 60% of total abstraction structures) | Required no. of SBW/ MDBW (Considering 40% of total abstraction structures) |
|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 5867.56 | 2779 | 2779 | 1 | 1.5 | 1667 | 741 |

## 6.3 Artificial Recharge to groundwater

Artificial recharge is recommended in various parts of the taluk by considering the variation in yield potential of aquifer systems. Basic requirements for recharging the aquifer are availability of surplus rainwater and availability of storage space in the aquifer system. Central Ground Water Board has published "Master Plan for Artificial Recharge to Ground Water in India" as on 2020. The Master Plan broadly identified areas which needs urgent attention. Based on this, recharge plan has been proposed considering variations in terrain type of identified areas.

Identification of the area suitable for artificial recharge has been done based on depth of post- monsoon water level and ground water level trend. Using GIS tools, post-monsoon (November, 2019) depth-to-water level map and long-term (2007-2017) trend of ground water level map has been superimposed over administrative boundary in order to identify feasible areas for recharge. Using the prepared map, feasible areas are identified, subject to fulfilling the below mentioned conditions

a) Areas showing water levels between 3 and 6 m bgl and declining trend of > 10 cm/yr;

b) Areas with depth to water level between 6 and 9 m bgl and declining trend;

c) Areas with depth to water level > 9 m bgl with or without declining trend.

An area of 1571 sq km has been identified in Sagarataluk as suitable area for recharge. The available storage column/space (post-monsoon) for has been calculated by computation of average depth of unsaturated zone below 3 m water level in post monsoon time. Total volume of available storage space is calculated by multiplying storage area by specific yield. Considering the efficiency of the structure as 75%, the total water required to fill the storage space has been assessed.

By considering local hydrogeological conditions and groundwater potential in the taluk, various types of artificial recharge / conservation structure possible for augmentation and conservation of ground water resources has been proposed. Apart from these, existing village ponds and dug wells may be considered as cost-effective recharge structures. However, actual field condition, availability of suitable area are to be considered in order to implement recharge system. Proposed number and capacity of recharge structures in the district is given in table 6.3. A map showing tentative location of the proposed artificial recharge structures is given in fig. 6.1. The location details of the same is tabled in table 6.4.

**Table 6.3: Type, capacity and no. of proposed recharge structures in suitable area types**

| TypeofStructure | No. of proposed structures | StorageCapacity (MCM) | Total Recharge capacity (MCM) |
|---|---|---|---|
| Sub surface dyke | 4 | 5.42 | 21.69 |
| PercolationTank | 130 | 0.56 | 72.30 |
| CheckDam | 263 | 0.137 | 36.15 |
| Filter Beds | 35 | 0.41 | 14.46 |
| Total recharge capacity (MCM) | | | 144.6 |
| Volume of water to be recharged (MCM) | | | 108.46 |
| Additional irrigation potential created (lakh hectare) | | | 0.131 |

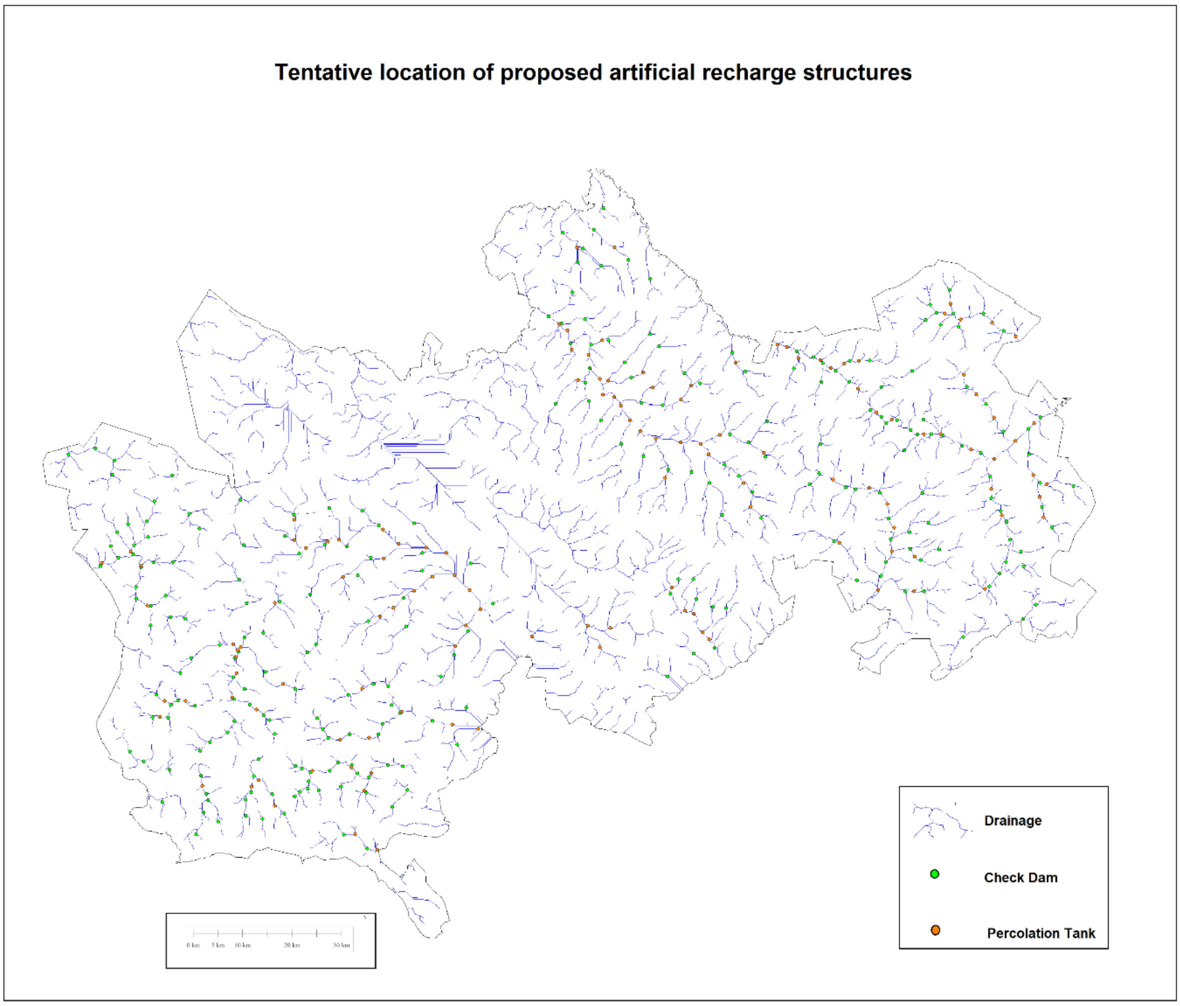


**Fig. 6.1: Tentative location of the proposed artificial recharge structures**

## 6.4 Micro Irrigation Practices

Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plan is one of the focus area in order to ensure 'Per drop-More crop'. Under the scheme, in Sagara taluk, total of 8838 ha irrigation potential will be created by installing drips and sprinklers (District Irrigation Plan-Shimoga). The scheme will be implemented in phase-wise.

**Table 6.4: Location details of proposed AR structures**

| Site | Latitude | Longitude | Site | Latitude | Longitude |
|---|---|---|---|---|---|
| CD-1 | 13° 56' 32.8503" N | 74° 42' 10.5152" E | CD-133 | 14° 11' 11.8503" N | 75° 09' 33.8152" E |
| CD-2 | 13° 57' 32.8503" N | 74° 43' 38.8152" E | CD-134 | 14° 11' 27.3003" N | 75° 09' 08.8152" E |
| CD-3 | 13° 56' 51.8503" N | 74° 43' 50.8152" E | CD-135 | 14° 12' 19.4967" N | 75° 09' 33.4839" E |
| CD-4 | 13° 56' 36.8503" N | 74° 43' 55.6152" E | CD-136 | 14° 12' 56.4003" N | 75° 10' 43.8152" E |
| CD-5 | 13° 56' 08.8503" N | 74° 43' 45.4152" E | CD-137 | 14° 13' 19.8503" N | 75° 09' 06.8152" E |
| CD-6 | 13° 55' 47.6503" N | 74° 44' 18.8152" E | CD-138 | 14° 13' 19.0503" N | 75° 08' 21.8152" E |
| CD-7 | 13° 55' 18.9003" N | 74° 43' 28.0152" E | CD-139 | 14° 12' 30.8503" N | 75° 08' 19.8152" E |
| CD-8 | 13° 57' 46.0003" N | 74° 42' 26.7652" E | CD-140 | 14° 12' 30.8503" N | 75° 07' 16.6152" E |
| CD-9 | 13° 58' 05.0503" N | 74° 41' 27.8152" E | CD-141 | 14° 13' 13.8503" N | 75° 07' 19.4152" E |
| CD-10 | 13° 58' 27.8503" N | 74° 40' 56.6652" E | CD-142 | 14° 12' 56.8503" N | 75° 07' 48.8152" E |
| CD-11 | 13° 58' 28.8503" N | 74° 43' 37.8152" E | CD-143 | 14° 13' 27.8503" N | 75° 06' 58.8152" E |
| CD-12 | 13° 58' 48.7503" N | 74° 43' 59.6652" E | CD-144 | 14° 13' 40.8503" N | 75° 06' 20.8152" E |
| CD-13 | 13° 59' 10.8503" N | 74° 44' 39.8152" E | CD-145 | 14° 13' 01.8503" N | 75° 06' 14.0652" E |
| CD-14 | 13° 59' 36.8503" N | 74° 44' 55.8152" E | CD-146 | 14° 08' 54.8503" N | 75° 13' 41.8152" E |
| CD-15 | 13° 57' 31.8503" N | 74° 45' 39.8152" E | CD-147 | 14° 08' 05.8503" N | 75° 13' 44.4152" E |
| CD-16 | 13° 56' 54.8503" N | 74° 45' 33.6652" E | CD-148 | 14° 07' 35.8503" N | 75° 14' 06.3152" E |
| CD-17 | 13° 56' 37.9183" N | 74° 45' 20.8152" E | CD-149 | 14° 07' 11.8503" N | 75° 14' 20.2152" E |
| CD-18 | 13° 56' 00.9003" N | 74° 45' 21.8152" E | CD-150 | 14° 06' 30.8503" N | 75° 14' 27.8152" E |
| CD-19 | 13° 55' 53.8003" N | 74° 46' 00.1152" E | CD-151 | 14° 06' 03.6503" N | 75° 14' 52.8152" E |
| CD-20 | 13° 56' 05.8912" N | 74° 46' 49.7246" E | CD-152 | 14° 05' 40.8503" N | 75° 14' 17.8152" E |
| CD-21 | 13° 56' 50.6503" N | 74° 46' 21.6152" E | CD-153 | 14° 05' 29.8503" N | 75° 14' 58.8652" E |
| CD-22 | 13° 58' 10.8003" N | 74° 45' 50.8152" E | CD-154 | 14° 05' 13.8503" N | 75° 14' 03.8152" E |
| CD-23 | 13° 56' 45.8503" N | 74° 47' 13.8152" E | CD-155 | 14° 04' 44.8503" N | 75° 13' 40.6152" E |
| CD-24 | 13° 56' 55.8503" N | 74° 47' 25.8152" E | CD-156 | 14° 04' 33.9503" N | 75° 11' 10.8152" E |
| CD-25 | 13° 57' 02.8503" N | 74° 47' 43.2152" E | CD-157 | 14° 04' 33.1503" N | 75° 10' 28.7652" E |
| CD-26 | 13° 57' 19.8503" N | 74° 47' 44.8152" E | CD-158 | 14° 05' 44.8503" N | 75° 11' 03.8152" E |
| CD-27 | 13° 57' 40.5003" N | 74° 47' 49.8652" E | CD-159 | 14° 06' 08.5503" N | 75° 11' 45.8152" E |
| CD-28 | 13° 57' 48.8503" N | 74° 47' 29.8152" E | CD-160 | 14° 06' 09.8503" N | 75° 10' 40.0152" E |
| CD-29 | 13° 57' 54.8503" N | 74° 47' 14.8152" E | CD-161 | 14° 06' 48.2503" N | 75° 10' 37.8152" E |
| CD-30 | 13° 56' 58.8503" N | 74° 48' 08.3152" E | CD-162 | 14° 07' 09.3503" N | 75° 11' 20.8152" E |
| CD-31 | 13° 55' 18.2503" N | 74° 49' 05.8152" E | CD-163 | 14° 08' 17.0503" N | 75° 11' 06.8152" E |
| CD-32 | 13° 54' 46.4003" N | 74° 49' 58.8152" E | CD-164 | 14° 06' 27.6503" N | 75° 07' 45.9652" E |
| CD-33 | 13° 56' 54.0503" N | 74° 49' 56.8152" E | CD-165 | 14° 04' 58.8503" N | 75° 08' 37.8152" E |
| CD-34 | 13° 57' 07.8503" N | 74° 48' 58.9152" E | CD-166 | 14° 05' 08.8503" N | 75° 09' 32.3152" E |
| CD-35 | 13° 57' 37.8503" N | 74° 49' 36.8152" E | CD-167 | 14° 05' 40.8503" N | 75° 09' 44.0152" E |
| CD-36 | 13° 57' 29.1503" N | 74° 50' 02.8152" E | CD-168 | 14° 06' 31.8503" N | 75° 09' 54.8652" E |
| CD-37 | 13° 57' 56.8503" N | 74° 49' 23.4152" E | CD-169 | 14° 07' 18.8503" N | 75° 09' 49.6152" E |
| CD-38 | 13° 58' 02.6503" N | 74° 48' 52.8152" E | CD-170 | 14° 08' 18.0503" N | 75° 09' 29.8152" E |
| CD-39 | 13° 57' 43.9003" N | 74° 48' 32.8152" E | CD-171 | 14° 08' 25.8003" N | 75° 08' 34.8152" E |
| CD-40 | 13° 57' 56.8503" N | 74° 50' 45.8152" E | CD-172 | 14° 08' 30.4503" N | 75° 08' 11.8152" E |
| CD-41 | 13° 57' 53.8503" N | 74° 51' 20.8152" E | CD-173 | 14° 09' 02.8503" N | 75° 07' 11.3152" E |
| CD-42 | 13° 56' 59.8503" N | 74° 51' 30.8152" E | CD-174 | 14° 08' 38.2003" N | 75° 06' 49.8152" E |
| CD-43 | 13° 56' 21.8875" N | 74° 50' 56.8152" E | CD-175 | 14° 10' 09.3503" N | 75° 07' 14.8152" E |

| Site | Latitude | Longitude | Site | Latitude | Longitude |
|---|---|---|---|---|---|
| CD-44 | 13° 59' 18.8503" N | 74° 48' 17.8152" E | CD-176 | 14° 09' 40.8503" N | 75° 05' 08.8152" E |
| CD-45 | 13° 58' 58.3003" N | 74° 48' 29.8152" E | CD-177 | 14° 11' 00.8503" N | 75° 05' 12.8152" E |
| CD-46 | 13° 59' 44.0003" N | 74° 48' 04.8152" E | CD-178 | 14° 10' 13.0503" N | 75° 04' 29.8152" E |
| CD-47 | 13° 59' 07.3003" N | 74° 49' 18.8152" E | CD-179 | 14° 10' 31.3003" N | 75° 03' 47.8152" E |
| CD-48 | 13° 59' 06.8503" N | 74° 50' 24.8152" E | CD-180 | 14° 12' 55.5003" N | 75° 04' 22.8152" E |
| CD-49 | 13° 59' 30.8503" N | 74° 50' 33.8152" E | CD-181 | 14° 13' 37.8503" N | 75° 03' 52.8152" E |
| CD-50 | 13° 59' 55.9085" N | 74° 51' 14.7411" E | CD-182 | 14° 12' 28.0503" N | 75° 02' 39.8152" E |
| CD-51 | 13° 59' 45.8503" N | 74° 41' 48.4152" E | CD-183 | 14° 12' 50.8503" N | 75° 02' 03.8152" E |
| CD-52 | 13° 59' 44.8503" N | 74° 42' 24.1652" E | CD-184 | 14° 11' 37.8503" N | 75° 01' 13.8152" E |
| CD-53 | 14° 00' 13.8503" N | 74° 42' 30.9652" E | CD-185 | 14° 11' 43.4003" N | 75° 00' 25.8652" E |
| CD-54 | 14° 00' 37.8503" N | 74° 41' 56.8152" E | CD-186 | 14° 13' 52.8503" N | 75° 01' 05.8152" E |
| CD-55 | 14° 00' 24.4503" N | 74° 42' 46.8152" E | CD-187 | 14° 14' 19.8503" N | 75° 00' 45.8152" E |
| CD-56 | 14° 00' 11.8503" N | 74° 43' 25.8152" E | CD-188 | 14° 13' 15.8503" N | 74° 59' 46.8652" E |
| CD-57 | 13° 59' 07.9503" N | 74° 46' 27.8152" E | CD-189 | 14° 12' 41.8503" N | 75° 00' 02.8152" E |
| CD-58 | 13° 59' 39.8503" N | 74° 46' 14.8152" E | CD-190 | 14° 17' 09.8003" N | 74° 59' 55.6152" E |
| CD-59 | 13° 59' 50.8503" N | 74° 46' 02.3152" E | CD-191 | 14° 18' 18.8503" N | 74° 58' 36.8152" E |
| CD-60 | 14° 00' 14.8503" N | 74° 45' 30.3152" E | CD-192 | 14° 16' 55.8503" N | 74° 58' 53.8152" E |
| CD-61 | 14° 00' 27.4003" N | 74° 44' 54.8152" E | CD-193 | 14° 17' 04.8503" N | 74° 58' 00.2152" E |
| CD-62 | 14° 01' 17.6503" N | 74° 44' 52.8152" E | CD-194 | 14° 14' 54.5503" N | 74° 58' 15.8152" E |
| CD-63 | 14° 00' 50.3503" N | 74° 45' 18.8152" E | CD-195 | 14° 15' 00.0503" N | 74° 56' 52.8152" E |
| CD-64 | 14° 02' 00.8503" N | 74° 44' 56.2152" E | CD-196 | 14° 14' 45.3003" N | 74° 57' 22.8152" E |
| CD-65 | 14° 02' 01.0503" N | 74° 43' 16.8152" E | CD-197 | 14° 13' 55.8503" N | 74° 58' 30.8152" E |
| CD-66 | 14° 01' 26.8503" N | 74° 42' 51.8152" E | CD-198 | 14° 14' 06.8003" N | 74° 59' 10.6152" E |
| CD-67 | 14° 02' 30.8589" N | 74° 44' 22.0580" E | CD-199 | 14° 13' 02.8503" N | 74° 58' 27.8152" E |
| CD-68 | 14° 02' 15.8503" N | 74° 45' 04.6152" E | CD-200 | 14° 13' 58.8503" N | 74° 57' 43.6652" E |
| CD-69 | 14° 02' 47.8003" N | 74° 45' 18.1652" E | CD-201 | 14° 12' 29.8503" N | 74° 58' 17.3152" E |
| CD-70 | 14° 01' 29.2503" N | 74° 46' 06.8152" E | CD-202 | 14° 08' 19.8503" N | 75° 04' 38.6152" E |
| CD-71 | 14° 00' 49.8503" N | 74° 47' 14.8152" E | CD-203 | 14° 07' 20.8503" N | 75° 04' 59.1652" E |
| CD-72 | 14° 00' 37.2503" N | 74° 49' 15.8152" E | CD-204 | 14° 08' 56.8503" N | 75° 04' 07.8152" E |
| CD-73 | 14° 01' 01.9749" N | 74° 50' 13.2414" E | CD-205 | 14° 09' 22.4003" N | 75° 03' 34.8152" E |
| CD-74 | 14° 00' 13.8503" N | 74° 50' 54.8152" E | CD-206 | 14° 07' 27.8503" N | 75° 03' 29.8152" E |
| CD-75 | 14° 00' 56.8503" N | 74° 50' 46.8152" E | CD-207 | 14° 08' 40.8503" N | 75° 03' 00.8152" E |
| CD-76 | 14° 02' 32.8503" N | 74° 48' 02.7152" E | CD-208 | 14° 09' 05.8503" N | 75° 02' 19.7652" E |
| CD-77 | 14° 02' 13.8503" N | 74° 47' 42.8152" E | CD-209 | 14° 09' 11.8503" N | 75° 01' 26.8152" E |
| CD-78 | 14° 03' 30.6503" N | 74° 43' 02.8152" E | CD-210 | 14° 09' 41.8503" N | 75° 00' 29.6652" E |
| CD-79 | 14° 03' 34.2003" N | 74° 42' 29.8152" E | CD-211 | 14° 10' 09.8503" N | 74° 59' 39.6152" E |
| CD-80 | 14° 04' 00.4003" N | 74° 41' 44.8152" E | CD-212 | 14° 11' 03.8503" N | 74° 58' 53.2652" E |
| CD-81 | 14° 04' 23.2503" N | 74° 42' 18.8152" E | CD-213 | 14° 11' 47.7003" N | 74° 58' 25.2652" E |
| CD-82 | 14° 03' 15.8503" N | 74° 41' 44.3152" E | CD-214 | 14° 04' 25.8503" N | 74° 47' 48.8152" E |
| CD-83 | 14° 04' 16.8503" N | 74° 41' 11.8152" E | CD-215 | 14° 04' 09.9503" N | 74° 46' 38.8152" E |
| CD-84 | 14° 04' 42.8503" N | 74° 41' 10.8152" E | CD-216 | 14° 04' 59.8503" N | 74° 45' 06.8152" E |
| CD-85 | 14° 05' 40.8503" N | 74° 42' 35.8152" E | CD-217 | 14° 06' 19.3003" N | 74° 45' 16.8152" E |
| CD-86 | 14° 05' 39.8503" N | 74° 41' 50.8152" E | CD-218 | 14° 03' 25.4003" N | 74° 50' 01.6652" E |
| CD-87 | 14° 05' 28.8503" N | 74° 41' 22.7152" E | CD-219 | 14° 03' 13.0003" N | 74° 51' 27.8152" E |
| CD-88 | 14° 05' 49.8003" N | 74° 40' 30.8152" E | CD-220 | 14° 01' 19.3503" N | 74° 52' 46.8152" E |
| CD-89 | 14° 05' 30.8503" N | 74° 39' 49.6152" E | CD-221 | 13° 59' 37.8503" N | 74° 52' 27.8152" E |

| Site | Latitude | Longitude | Site | Latitude | Longitude |
|---|---|---|---|---|---|
| CD-90 | 14° 05' 57.8503" N | 74° 41' 04.8152" E | CD-222 | 14° 00' 07.8503" N | 74° 53' 44.9652" E |
| CD-91 | 14° 06' 47.8503" N | 74° 40' 27.7652" E | CD-223 | 14° 02' 07.8503" N | 74° 53' 17.8152" E |
| CD-92 | 14° 07' 05.8503" N | 74° 40' 53.1152" E | CD-224 | 14° 04' 18.3503" N | 74° 51' 21.8152" E |
| CD-93 | 14° 06' 18.0503" N | 74° 41' 06.8152" E | CD-225 | 14° 05' 09.8503" N | 74° 49' 37.8652" E |
| CD-94 | 14° 06' 36.8503" N | 74° 41' 37.8152" E | CD-226 | 14° 05' 49.8503" N | 74° 50' 07.8152" E |
| CD-95 | 14° 07' 12.8503" N | 74° 41' 35.7652" E | CD-227 | 14° 05' 59.3503" N | 74° 47' 23.8152" E |
| CD-96 | 14° 06' 16.8503" N | 74° 40' 13.3152" E | CD-228 | 14° 06' 39.8503" N | 74° 46' 50.8152" E |
| CD-97 | 14° 09' 45.8503" N | 74° 38' 36.8152" E | CD-229 | 14° 07' 27.8503" N | 74° 47' 11.6152" E |
| CD-98 | 14° 09' 59.6503" N | 74° 39' 37.8152" E | CD-230 | 14° 06' 19.8503" N | 74° 48' 21.8152" E |
| CD-99 | 14° 09' 31.8503" N | 74° 40' 21.8152" E | CD-231 | 14° 07' 42.8503" N | 74° 48' 31.9652" E |
| CD-100 | 14° 08' 59.2003" N | 74° 40' 16.8152" E | CD-232 | 14° 08' 01.8503" N | 74° 45' 09.2652" E |
| CD-101 | 14° 07' 58.8503" N | 74° 41' 52.8152" E | CD-233 | 14° 02' 23.8503" N | 75° 03' 13.2152" E |
| CD-102 | 14° 06' 56.8503" N | 74° 43' 36.0152" E | CD-234 | 14° 03' 54.8503" N | 75° 03' 38.8152" E |
| CD-103 | 14° 07' 29.8503" N | 74° 43' 12.8152" E | CD-235 | 14° 03' 57.8503" N | 75° 03' 08.8152" E |
| CD-104 | 14° 15' 27.8503" N | 75° 11' 24.8152" E | CD-236 | 14° 04' 15.8503" N | 75° 02' 30.6652" E |
| CD-105 | 14° 14' 52.8503" N | 75° 11' 14.8152" E | CD-237 | 14° 05' 00.8503" N | 75° 02' 23.9652" E |
| CD-106 | 14° 15' 08.8503" N | 75° 11' 39.8152" E | CD-238 | 14° 05' 00.8503" N | 75° 01' 49.8152" E |
| CD-107 | 14° 16' 00.8503" N | 75° 12' 09.2152" E | CD-239 | 14° 04' 27.8503" N | 75° 01' 31.3652" E |
| CD-108 | 14° 15' 06.8503" N | 75° 12' 17.8152" E | CD-240 | 14° 01' 18.8503" N | 75° 01' 24.8152" E |
| CD-109 | 14° 14' 41.8503" N | 75° 11' 49.0652" E | CD-241 | 14° 02' 11.3503" N | 75° 02' 24.8152" E |
| CD-110 | 14° 14' 36.8503" N | 75° 12' 30.5152" E | CD-242 | 14° 08' 58.1003" N | 74° 42' 32.8152" E |
| CD-111 | 14° 15' 06.8503" N | 75° 13' 26.8152" E | CD-243 | 14° 03' 02.8503" N | 74° 53' 49.2652" E |
| CD-112 | 14° 14' 27.8503" N | 75° 14' 12.8152" E | CD-244 | 14° 05' 21.2003" N | 74° 52' 04.8152" E |
| CD-113 | 14° 06' 58.8503" N | 75° 16' 03.9152" E | CD-245 | 14° 07' 37.5503" N | 74° 49' 47.8152" E |
| CD-114 | 14° 07' 45.8503" N | 75° 15' 40.8152" E | CD-246 | 14° 06' 16.1003" N | 74° 49' 12.6652" E |
| CD-115 | 14° 08' 40.8503" N | 75° 15' 36.6652" E | CD-247 | 14° 02' 58.8503" N | 74° 46' 01.8152" E |
| CD-116 | 14° 08' 33.8503" N | 75° 16' 52.8152" E | CD-248 | 14° 04' 05.8503" N | 74° 45' 23.7652" E |
| CD-117 | 14° 09' 46.8503" N | 75° 15' 11.4652" E | CD-249 | 13° 58' 43.8503" N | 74° 53' 24.3152" E |
| CD-118 | 14° 10' 43.8503" N | 75° 15' 09.8152" E | CD-250 | 14° 07' 09.0503" N | 74° 51' 45.8152" E |
| CD-119 | 14° 11' 10.8503" N | 75° 15' 36.8152" E | CD-251 | 14° 07' 03.8503" N | 74° 50' 25.8152" E |
| CD-120 | 14° 10' 37.8503" N | 75° 14' 12.0152" E | CD-252 | 14° 02' 49.3003" N | 75° 12' 40.8152" E |
| CD-121 | 14° 11' 40.8503" N | 75° 13' 32.8152" E | CD-253 | 14° 03' 29.8503" N | 75° 14' 57.8152" E |
| CD-122 | 14° 12' 19.8503" N | 75° 12' 48.7152" E | CD-254 | 14° 04' 03.0003" N | 75° 15' 26.8152" E |
| CD-123 | 14° 09' 49.5503" N | 75° 13' 20.8152" E | CD-255 | 14° 05' 37.0503" N | 74° 53' 55.8152" E |
| CD-124 | 14° 10' 05.0503" N | 75° 12' 37.8152" E | CD-256 | 14° 04' 05.0003" N | 74° 54' 45.8152" E |
| CD-125 | 14° 10' 29.3503" N | 75° 11' 53.8152" E | CD-257 | 14° 19' 08.2503" N | 74° 58' 57.9152" E |
| CD-126 | 14° 11' 05.8503" N | 75° 11' 09.8652" E | CD-258 | 14° 16' 25.8503" N | 75° 00' 45.6152" E |
| CD-127 | 14° 10' 31.8503" N | 75° 11' 27.8152" E | CD-259 | 14° 18' 11.8503" N | 74° 57' 25.8152" E |
| CD-128 | 14° 10' 30.8503" N | 75° 10' 55.8152" E | CD-260 | 14° 17' 35.4003" N | 74° 58' 11.8152" E |
| CD-129 | 14° 09' 54.9003" N | 75° 10' 26.0152" E | CD-261 | 14° 15' 54.8503" N | 74° 57' 47.8152" E |
| CD-130 | 14° 10' 41.8503" N | 75° 10' 40.8152" E | CD-262 | 14° 11' 41.8503" N | 74° 57' 09.3152" E |
| CD-131 | 14° 11' 04.0503" N | 75° 10' 09.8152" E | CD-263 | 14° 06' 01.2503" N | 74° 52' 04.8152" E |
| CD-132 | 14° 10' 57.0503" N | 75° 09' 44.8152" E | PT-66 | 14° 14' 06.8003" N | 74° 58' 55.8152" E |
| PT-1 | 14° 06' 00.8503" N | 74° 52' 59.6152" E | PT-67 | 14° 14' 28.3003" N | 74° 57' 36.6152" E |
| PT-2 | 14° 05' 09.8503" N | 74° 53' 18.8152" E | PT-68 | 14° 14' 42.8503" N | 74° 57' 17.8152" E |
| PT-3 | 14° 03' 52.8503" N | 74° 54' 17.8152" E | PT-69 | 14° 17' 37.8503" N | 74° 57' 57.8152" E |

| Site | Latitude | Longitude | Site | Latitude | Longitude |
|---|---|---|---|---|---|
| PT-4 | 14° 03' 15.0503" N | 74° 58' 22.8152" E | PT-70 | 14° 17' 37.8503" N | 74° 59' 23.8152" E |
| PT-5 | 14° 10' 09.8503" N | 75° 02' 40.8152" E | PT-71 | 14° 13' 14.8503" N | 75° 04' 00.7152" E |
| PT-6 | 13° 59' 19.8503" N | 74° 54' 12.8152" E | PT-72 | 14° 13' 55.8503" N | 75° 05' 35.8152" E |
| PT-7 | 13° 59' 28.8503" N | 74° 53' 13.8152" E | PT-73 | 14° 13' 50.8503" N | 75° 05' 57.8152" E |
| PT-8 | 14° 03' 09.8503" N | 74° 59' 14.8152" E | PT-74 | 14° 13' 24.8503" N | 75° 06' 23.8152" E |
| PT-9 | 14° 04' 34.8503" N | 74° 51' 45.8152" E | PT-75 | 14° 13' 20.8503" N | 75° 07' 14.8152" E |
| PT-10 | 14° 03' 42.4503" N | 75° 02' 24.8152" E | PT-76 | 14° 13' 03.3503" N | 75° 07' 37.8152" E |
| PT-11 | 14° 02' 43.8503" N | 75° 03' 00.2652" E | PT-77 | 14° 13' 13.0003" N | 75° 08' 08.8152" E |
| PT-12 | 14° 10' 12.8503" N | 75° 01' 54.8152" E | PT-78 | 14° 13' 18.8503" N | 75° 08' 41.8152" E |
| PT-13 | 14° 10' 21.8503" N | 75° 00' 58.3652" E | PT-79 | 14° 12' 15.8577" N | 75° 08' 40.7298" E |
| PT-14 | 14° 11' 03.8503" N | 74° 59' 58.8152" E | PT-80 | 14° 15' 06.9003" N | 75° 11' 58.8152" E |
| PT-15 | 14° 11' 36.8503" N | 74° 59' 38.8152" E | PT-81 | 14° 15' 29.8503" N | 75° 12' 11.3152" E |
| PT-16 | 14° 12' 01.8503" N | 74° 58' 57.8152" E | PT-82 | 14° 14' 53.5066" N | 75° 12' 34.5164" E |
| PT-17 | 14° 12' 37.8503" N | 74° 58' 50.6152" E | PT-83 | 14° 14' 45.8503" N | 75° 13' 46.8152" E |
| PT-18 | 14° 10' 30.4003" N | 75° 03' 24.8152" E | PT-84 | 14° 14' 14.8503" N | 75° 14' 40.8152" E |
| PT-19 | 13° 57' 43.8503" N | 74° 47' 53.8152" E | PT-85 | 14° 10' 56.6649" N | 75° 15' 22.6299" E |
| PT-20 | 13° 57' 51.8503" N | 74° 49' 22.8152" E | PT-86 | 14° 10' 16.8503" N | 75° 14' 39.8152" E |
| PT-21 | 13° 56' 58.7588" N | 74° 49' 51.7014" E | PT-87 | 14° 09' 35.8503" N | 75° 13' 51.8152" E |
| PT-22 | 13° 57' 38.8503" N | 74° 50' 08.6152" E | PT-88 | 14° 11' 09.8503" N | 75° 13' 50.4152" E |
| PT-23 | 13° 59' 58.8503" N | 74° 51' 17.8152" E | PT-89 | 14° 09' 57.0003" N | 75° 12' 58.8152" E |
| PT-24 | 14° 02' 03.8503" N | 74° 44' 58.8152" E | PT-90 | 14° 10' 31.8503" N | 75° 11' 48.8152" E |
| PT-25 | 14° 02' 18.8503" N | 74° 45' 02.8152" E | PT-91 | 14° 11' 21.4106" N | 75° 09' 22.2549" E |
| PT-26 | 14° 02' 25.8503" N | 74° 45' 09.8152" E | PT-92 | 14° 11' 05.7210" N | 75° 09' 57.5225" E |
| PT-27 | 14° 02' 32.8503" N | 74° 44' 52.8152" E | PT-93 | 14° 10' 31.8503" N | 75° 11' 10.3993" E |
| PT-28 | 14° 01' 26.8503" N | 74° 45' 00.6152" E | PT-94 | 14° 12' 02.8503" N | 75° 13' 10.6152" E |
| PT-29 | 14° 00' 30.8503" N | 74° 44' 50.8152" E | PT-95 | 14° 12' 47.8503" N | 75° 12' 41.8152" E |
| PT-30 | 14° 04' 06.8503" N | 74° 46' 27.8152" E | PT-96 | 14° 08' 58.8503" N | 75° 15' 20.9652" E |
| PT-31 | 14° 04' 00.8503" N | 74° 41' 36.8152" E | PT-97 | 14° 08' 08.8942" N | 75° 15' 34.9976" E |
| PT-32 | 14° 06' 03.8503" N | 74° 40' 58.8152" E | PT-98 | 14° 07' 26.8503" N | 75° 14' 08.6152" E |
| PT-33 | 14° 05' 37.8503" N | 74° 39' 52.8152" E | PT-99 | 14° 08' 26.8503" N | 75° 13' 44.8152" E |
| PT-34 | 14° 05' 31.8503" N | 74° 41' 21.8152" E | PT-100 | 14° 04' 39.0503" N | 75° 13' 29.8152" E |
| PT-35 | 14° 06' 11.8503" N | 74° 47' 38.8152" E | PT-101 | 14° 06' 04.8503" N | 75° 09' 57.8152" E |
| PT-36 | 14° 06' 26.8503" N | 74° 48' 28.8152" E | PT-102 | 14° 04' 36.0503" N | 75° 09' 25.8152" E |
| PT-37 | 14° 06' 30.8503" N | 74° 48' 54.8152" E | PT-103 | 14° 04' 33.8503" N | 75° 10' 47.8152" E |
| PT-38 | 14° 06' 12.8503" N | 74° 52' 13.8152" E | PT-104 | 14° 05' 52.8503" N | 75° 10' 49.9652" E |
| PT-39 | 14° 06' 30.6503" N | 74° 47' 12.8152" E | PT-105 | 14° 06' 24.1536" N | 75° 07' 57.4934" E |
| PT-40 | 14° 07' 16.8503" N | 74° 47' 12.8152" E | PT-106 | 14° 08' 48.0503" N | 75° 07' 42.8152" E |
| PT-41 | 14° 06' 54.4225" N | 74° 50' 35.2430" E | PT-107 | 14° 08' 29.5503" N | 75° 09' 05.8152" E |
| PT-42 | 14° 05' 47.8503" N | 74° 50' 36.8152" E | PT-108 | 14° 06' 58.8503" N | 75° 10' 02.6152" E |
| PT-43 | 14° 03' 35.8503" N | 74° 50' 27.8152" E | PT-109 | 14° 07' 52.9003" N | 75° 09' 47.3652" E |
| PT-44 | 14° 05' 05.8503" N | 74° 49' 03.8152" E | PT-110 | 14° 02' 25.8503" N | 74° 58' 50.8652" E |
| PT-45 | 14° 02' 28.8503" N | 74° 53' 20.8152" E | PT-111 | 14° 05' 07.3503" N | 74° 52' 27.8152" E |
| PT-46 | 14° 03' 15.8503" N | 74° 53' 44.8152" E | PT-112 | 14° 06' 21.8503" N | 74° 51' 10.8152" E |
| PT-47 | 14° 02' 49.8503" N | 74° 56' 15.3652" E | PT-113 | 13° 55' 18.8503" N | 74° 49' 31.8152" E |
| PT-48 | 14° 02' 59.8503" N | 75° 02' 45.8152" E | PT-114 | 13° 54' 43.8503" N | 74° 50' 21.8152" E |
| PT-49 | 14° 03' 48.8503" N | 75° 02' 04.8152" E | PT-115 | 13° 57' 07.8503" N | 74° 45' 35.1152" E |

| Site | Latitude | Longitude | Site | Latitude | Longitude |
|---|---|---|---|---|---|
| PT-50 | 14° 04' 41.8503" N | 75° 01' 34.8152" E | PT-116 | 13° 57' 22.4003" N | 74° 45' 50.8152" E |
| PT-51 | 14° 08' 40.2503" N | 75° 04' 18.8152" E | PT-117 | 13° 57' 09.1653" N | 74° 43' 42.8152" E |
| PT-52 | 14° 07' 46.8503" N | 75° 04' 34.8152" E | PT-118 | 13° 56' 24.3503" N | 74° 46' 27.8652" E |
| PT-53 | 14° 09' 46.8503" N | 75° 02' 58.8152" E | PT-119 | 14° 00' 23.2003" N | 74° 42' 15.8152" E |
| PT-54 | 14° 08' 52.8503" N | 75° 01' 19.8152" E | PT-120 | 13° 59' 46.0503" N | 74° 42' 05.8152" E |
| PT-55 | 14° 09' 48.8503" N | 75° 05' 04.8152" E | PT-121 | 14° 00' 23.3003" N | 74° 43' 03.8152" E |
| PT-56 | 14° 10' 38.8503" N | 75° 00' 22.8152" E | PT-122 | 14° 00' 03.4003" N | 74° 45' 45.8152" E |
| PT-57 | 14° 12' 22.8503" N | 75° 02' 18.8152" E | PT-123 | 14° 01' 01.8503" N | 74° 46' 46.8152" E |
| PT-58 | 14° 11' 51.0503" N | 75° 01' 55.8152" E | PT-124 | 13° 58' 54.8929" N | 74° 48' 56.9005" E |
| PT-59 | 14° 12' 18.0503" N | 75° 00' 51.8152" E | PT-125 | 13° 58' 58.8503" N | 74° 50' 02.8152" E |
| PT-60 | 14° 12' 33.8503" N | 74° 59' 09.6152" E | PT-126 | 14° 00' 51.6503" N | 74° 49' 47.8652" E |
| PT-61 | 14° 11' 56.8503" N | 74° 59' 23.0152" E | PT-127 | 14° 04' 35.8503" N | 74° 53' 52.8152" E |
| PT-62 | 14° 12' 52.2503" N | 75° 00' 28.8152" E | PT-128 | 14° 03' 55.8547" N | 74° 50' 59.1972" E |
| PT-63 | 14° 12' 35.6503" N | 74° 58' 00.8152" E | PT-129 | 14° 08' 37.8503" N | 75° 15' 51.8152" E |
| PT-64 | 14° 13' 44.8503" N | 74° 57' 45.8152" E | PT-130 | 14° 07' 22.8503" N | 75° 15' 43.8152" E |
| PT-65 | 14° 13' 32.8503" N | 74° 58' 25.0152" E | | | |


**Fig. 6.2: Field photograph showing drip irrigation system installed in an agriculture land**


**Fig. 6.3: Field photograph showing irrigation through a bore well cum storage pit in a plantation field**

# 7. SUMMARY

Sagara taluk with geographical area coverage of 1942 sq.km has been taken up for aquifer mapping study. The taluk comes under Sagara sub-division of Shimoga district with headquarter located at Sagara. The taluk is drained by Sharavathi River and its tributaries. The taluk forms part of the Malnad area and therefore, experiences a tropical humid climate. Trend and distribution of rainfall in the taluk indicate that maximum rainfall occurs in the month of July and August. Elevation of the hilly terrain ranges from 640 m to 529 m above mean sea level. Geomorphologically, most of the area is covered by plain table-land followed by the Sahayadri hill-valley system. Coming to land use pattern, majority of the area is under forest cover (66125 ha) and agricultural activities are limited to 28202 ha of land. The taluk comes under hilly agro-climatic zones- southern transition zone. The net sown area of the taluk is 29733 ha and cropping intensity is 125 %. In Sagara taluk, 57% of the net area is irrigated by tanks and ponds and groundwater constitute 20.83% of the net irrigated area.

Geologically, the area is covered by Pre-Cambrian metamorphic rocks of various grade, which are cut across by late stage intrusive at many places. Aquifer characterization down to depth of 200.10 m bgl has been done carried out by preparation of hydrogeological sections, fences, 3D disposition of the study area. There are two aquifer system exists in the area, both of which are genetically related and therefore groundwater in both the aquifers are hydraulically connected. They are the 1) weathered formation and 2) Fractured formation. In the weathered formation, groundwater is under water table condition. However, in deep fractured aquifer, groundwater occurs in semi-confined to confined condition.

Depth to water level map of phreatic aquifer shows that majority of the area has water level between 5 to 10 m bgl in phreatic aquifer system and 5 to 15 m bgl in deep aquifer system during both pre monsoon and post monsoonseasons. In the central part of the taluk, deep water levels are observed for both seasons. This may be due to the presence of comparatively poor yielding Banded Gneissic Complex lithounits constituting the aquifer present in this part, as well as clay-rich top soil which hinders the rate of recharge into the phreatic aquifers as well. Long term groundwater level trend over ten years (from 2010 to 2019) has been analysed by using data from established network monitoring stations in Sagara Taluk. A perusal of the data indicates that most of the stations record slightly falling trend of groundwater level over long term.

Sub-surface lithological information from the available drilling records of exploratory well of CGWB and information obtained during field study was compiled in order to conceptualize the aquifer geometry of the area. The exploratory bore wells drilled in Sagarataluk are having depths ranging from 70.95 to 200.10 m bgl. The discharge ranges between negligible to 18 lps. The yield cum recuperation tests conducted on the wells show that the general specific capacity ranges from 1.29 to 46.01 lpm/m/d.d. The transmissivity of aquifer material in general range from 0.56 to 34.18 m2/day.

Groundwater quality studies have been done based on the samples collected from the study area during May/June-2022. A total number of 36 samples (22 DW+14BW) were collected for analysis. A perusal of the hydrochemical data shows that pH of the analyzed samples vary from 6.18 to 9.35 indicating that waters are slightly acidic to slightly alkaline.The prominent hydro chemical faciesis 'Calcium Bicarbonate Type' for both phreatic and fractured aquifers. Quality data indicates that groundwater from both dug wells and bore wells is potable. USSL plot shows that groundwater in the taluk is suitable for irrigation purposes also.

Groundwater yield potential map is prepared based on exploratory well data, which indicates that aquifer in the eastern part of the district is more productive and sustainable. Potential fractured aquifer system in the taluk is constituted by granitoid gneisses and high grade metamorphic rocks. By integrating the various inferred characteristics of aquifer system such as yield potential, EC, water level contour etc. aquifer map for both phreatic and fractured aquifer system has been prepared.

As per GWRE-2022, the annual dynamic resource of the taluk is 189.88 MCM, with SOE of 29.10%, out of which irrigation consumes about 93.86% of total groundwater requirement in the taluk. Major groundwater issues identified in the taluk are increase in groundwater demand in agriculture and irrigation sector and lesser yield potential in western and middle part of the taluk.

Management plans are made in such a way that sustainable groundwater development is recommended in the eastern parts, where yield potential is high; and demand- supply interventions in the middle and western parts of the taluk, where yield potential is less. Supply side management plans are prepared for irrigation sectors and management through construction of recommended artificial recharge structures are also discussed. Demand side management through crop diversification and adoption of micro irrigation practices has also discussed.

**Annexure - I**

## Land-use Land-cover Details (in ha)

| Name of Taluk | Geographical area | Forest | Area under waste land | Land under other uses | Fallow Land | Net sown area | Area sown more than one time | Gross sown area |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Sagara** | 194009 | 66125 | 30416 | 67652 | 3713 | 26103 | 2099 | 28202 |

**Annexure - II**

## Details of Key wells Established in Sagara Taluk with Water Level

| Sl. No | Location | DW/BW | Latitude | Longitude | Elevation (m amsl) | Depth of Well | Diameter (m) | MP (m) | Pre M water level (mbgl) | Pre Mon WT (mamsl) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kargal | DW | 14.188 | 74.815 | 539.2 | 8.50 | 1.8 | 0.58 | 2.95 | 536 |
| 2 | Aralagodu | DW | 14.15 | 74.82 | 611 | 12.28 | 1.9 | 0.7 | 9.4 | 602 |
| 3 | Aralagodu | BW | 14.15 | 74.82 | 611 | 78.13 | 1.8 | 0.5 | 9.58 | 601 |
| 4 | Bhanakuli | DW | 14.11 | 74.75 | 596 | 8.65 | 1.6 | 0.65 | 6.82 | 589 |
| 5 | Kogaru | DW | 14.06 | 74.74 | 659 | 7.72 | 1.6 | 0.7 | 5.7 | 653 |
| 6 | Kattinakkara | DW | 13.99 | 74.71 | 596 | 14.42 | 1.8 | 0.6 | 10.5 | 586 |
| 7 | Kattinakkara | BW | 13.99 | 74.71 | 596 | 109.38 | 2.1 | 0.6 | 9.2 | 587 |
| 8 | Sasigulli | BW | 13.98 | 74.81 | 613 | 70.31 | 2.3 | 0.5 | 9.25 | 604 |
| 9 | Baikodu | DW | 13.99 | 74.81 | 604 | 12.24 | 1.65 | 0.72 | 9.25 | 595 |
| 10 | Hosahalli | DW | 14.05 | 74.87 | 598 | 16.63 | 1.8 | 1 | 14.1 | 584 |

| Sl. No | Location | DW/BW | Latitude | Longitude | Elevation (m amsl) | Depth of Well | Diameter (m) | MP (m) | Pre M water level (mbgl) | Pre Mon WT (mamsl) |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Tumani | BW | 14.03 | 74.85 | 608 | 234.38 | 2.2 | 0.45 | 16.13 | 592 |
| 12 | Hulidevarbana | DW | 14.02 | 75 | 608 | 10.05 | 1.8 | 0.75 | 7.29 | 601 |
| 13 | Avinahalli | BW | 14.06 | 75.02 | 609 | 93.75 | 1.8 | 0.58 | 16.59 | 592 |
| 14 | Karkikoppa | DW | 14.14 | 74.99 | 621 | 17.38 | 1.8 | 0.75 | 14.9 | 606 |
| 15 | Maradavalli | BW | 14.13 | 74.94 | 596 | 96.88 | 1.9 | 0.55 | 19.25 | 577 |
| 16 | Kadakol | BW | 14.14 | 74.93 | 611 | 93.75 | 2.1 | 0.38 | 18.61 | 592 |
| 17 | Maruthinagar | BW | 14.22 | 74.91 | 569 | 87.50 | 1.8 | 0.7 | 12.7 | 556 |
| 18 | Kagodu | DW | 14.26 | 74.98 | 588 | 6.35 | 1.7 | 0.7 | 4.62 | 583 |
| 19 | Masuru | BW | 14.26 | 75.02 | 599 | 118.75 | 1.6 | 0.4 | 8.5 | 591 |
| 20 | Chiknalluru | DW | 14.29 | 75.01 | 563 | 8.63 | 1.62 | 0.72 | 5.5 | 558 |
| 21 | Keladi | DW | 14.22 | 75.01 | 573 | 10.25 | 1.5 | 0.75 | 6.27 | 567 |
| 22 | Lingadahalli | DW | 14.21 | 75.08 | 622 | 13.20 | 2 | 0.75 | 11.65 | 610 |
| 23 | Kollikoppa | BW | 14.2 | 75.11 | 644 | 181.25 | 2.1 | 0.4 | 5.8 | 638 |
| 24 | Jambani | DW | 14.22 | 75.17 | 688 | 6.35 | 1.8 | 0.74 | 3.92 | 684 |
| 25 | Korlikoppa | BW | 14.23 | 75.21 | 670 | 78.13 | 1.7 | 0.6 | 17.38 | 653 |
| 26 | Koppa | DW | 14.19 | 75.13 | 653 | 10.55 | 1.4 | 0.9 | 8.97 | 644 |
| 27 | Byrapura | BW | 14.16 | 75.24 | 632 | 84.38 | 1.5 | 0.4 | 10.3 | 622 |
| 28 | Sanganakere | DW | 14.15 | 75.27 | 656 | 15.00 | 1.9 | 0.85 | 13.9 | 642 |

| Sl. No | Location | DW/BW | Latitude | Longitude | Elevation (m amsl) | Depth of Well | Diameter (m) | MP (m) | Pre M water level (mbgl) | Pre Mon WT (mamsl) |
|---|---|---|---|---|---|---|---|---|---|---|
| 29 | Goutampur | DW | 14.14 | 75.22 | 642 | 10.45 | 2.1 | 0.9 | 7.22 | 635 |
| 30 | Veerabadrapura | DW | 14.16 | 75.17 | 651 | 11.64 | 1.6 | 0.8 | 8.3 | 643 |
| 31 | Ullur | DW | 14.14 | 75.1 | 655 | 9.40 | 1.65 | 0.85 | 7.95 | 647 |
| 32 | Hosur | BW | 14.1 | 75.17 | 586 | 109.38 | 1.6 | 0.35 | 11.5 | 575 |
| 33 | Mumbalu | DW | 14.09 | 75.19 | 634 | 7.85 | 1.6 | 0.8 | 4.98 | 629 |
| 34 | Channakoppa | DW | 14.08 | 75.26 | 651 | 7.41 | 1.7 | 0.8 | 4.1 | 647 |
| 35 | Anandpur | BW | 14.07 | 75.23 | 640 | 150.00 | 1.56 | 0.57 | 6.75 | 633 |
| 36 | Iruvakki | DW | 14.04 | 75.19 | 674 | 12.45 | 1.4 | 0.9 | 7.92 | 666 |

**Annexure - III**

**Results of Chemical Analysis Groundwater Samples of SagaraTaluk**

| Sl. No. | Location | DW/BW | pH | EC | TH | Ca | Mg | Na | K | CO3 | HCO3 | Cl | SO4 | NO3 | F | PO4 | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kargal | DW | 6.65 | 113 | 45 | 14 | 2.42 | 6.19 | 0.92 | 0 | 42.7 | 14.2 | 5 | 2.13 | ND | ND | 7.79 |
| 2 | Aralagodu | DW | 7.23 | 117 | 60 | 16 | 20.57 | 4.23 | 1.76 | 0 | 54.9 | 14.2 | ND | ND | 0.05 | 0.06 | 27.52 |
| 3 | Aralagodu | BW | 7.55 | 193 | 80 | 14 | 10.9 | 6.12 | 0.9 | 0 | 86 | 17.75 | ND | ND | 0.49 | 24.25 | 54.02 |
| 4 | Bhanakuli | DW | 7.02 | 69 | 25 | 8 | 1.21 | 5.04 | 0.54 | 0 | 30.5 | 7 | ND | ND | 0.82 | 0.07 | 3.93 |
| 5 | Kogaru | DW | 6.72 | 70 | 25 | 8 | 1.21 | 3.46 | 0.98 | 0 | 18.3 | 9 | 3 | 5.3 | 0.55 | ND | 4.78 |
| 6 | Kattinakkara | DW | 7.38 | 117 | 35 | 10 | 2.4 | 6 | 2.47 | 0 | 36.6 | 14.2 | ND | 0.74 | ND | ND | 4.51 |
| 7 | Kattinakkara | BW | 7.01 | 166 | 50 | 18 | 1.21 | 15 | 0.7 | 0 | 85.4 | 10.65 | ND | ND | 0.44 | ND | 25.46 |

| Sl. No. | Location | DW/BW | pH | EC | TH | Ca | Mg | Na | K | CO3 | HCO3 | Cl | SO4 | NO3 | F | PO4 | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Sasigulli | BW | 6.03 | 142 | 80 | 30 | 1.21 | 3.93 | 0.2 | 0 | 71 | 17.75 | 7 | ND | 0.66 | ND | 20.47 |
| 9 | Baikodu | DW | 6.34 | 54 | 25 | 8 | 1.21 | 3.2 | 0.62 | 0 | 24.4 | 7.5 | ND | ND | ND | ND | 3.79 |
| 10 | Hosahalli | DW | 7.9 | 86 | 25 | 8 | 1.21 | 8.57 | 1.35 | 0 | 24.4 | 17.75 | ND | 2.92 | ND | ND | 5.29 |
| 11 | Tumani | BW | 6.94 | 324 | 140 | 30 | 15.73 | 12.93 | 2.75 | 0 | 187 | 14.2 | ND | ND | 1.15 | 0.02 | 34.65 |
| 12 | Hulidevarbana | DW | 7.52 | 155 | 45 | 12 | 3.63 | 15 | 1.16 | 0 | 73.2 | 12.5 | 2 | 6.96 | ND | ND | 10.65 |
| 13 | Avinahalli | BW | 7.33 | 357 | 150 | 34 | 15.73 | 8.38 | 3.54 | 0 | 185 | 17.75 | 5 | ND | 0.47 | 0.09 | 44.28 |
| 14 | Karkikoppa | DW | 7.82 | 330 | 140 | 48 | 4.84 | 13.11 | 2.21 | 0 | 176.9 | 17.75 | ND | 6.93 | ND | ND | 13.65 |
| 15 | Maradavalli | BW | 7.5 | 282 | 110 | 24 | 12.1 | 14.23 | 3.94 | 0 | 164.7 | 14.2 | 3 | ND | ND | ND | 51.3 |
| 16 | Kadakol | BW | 7.42 | 168 | 45 | 16 | 1.21 | 12 | 0.85 | 0 | 68 | 12 | 2 | ND | 0.62 | ND | 36.79 |
| 17 | Maruthinagar | BW | 7.22 | 203 | 70 | 16 | 7.26 | 15.17 | 0.54 | 0 | 85.4 | 21.3 | 10 | ND | 0.7 | 0.02 | 35.41 |
| 18 | Kagodu | DW | 6.42 | 219 | 80 | 30 | 1.21 | 14.46 | 2.8 | 0 | 109.8 | 21.3 | ND | 2.72 | 0.31 | ND | 10.34 |
| 19 | Masuru | BW | 8.19 | 375 | 165 | 34 | 19.36 | 11.35 | 6.58 | 0 | 211 | 17.75 | ND | 4.95 | ND | ND | 36.52 |
| 20 | Chiknalluru | DW | 6.42 | 183 | 50 | 18 | 1.21 | 13.38 | 5.51 | 0 | 67.1 | 20 | 2 | 4.61 | 0.63 | ND | 13.34 |
| 21 | Keladi | DW | 7.34 | 305 | 115 | 20 | 15.73 | 17.38 | 5.58 | 0 | 170.8 | 15.7 | 10 | 0.89 | 0.3 | ND | 12.87 |
| 22 | Lingadahalli | DW | 7.56 | 259 | 90 | 24 | 7.26 | 11.76 | 1.83 | 0 | 103.7 | 22.4 | 8 | 0.8 | 0.35 | 0.02 | 12.87 |
| 23 | Kollikoppa | BW | 7.32 | 427 | 175 | 50 | 12.1 | 8.49 | 12.09 | 0 | 225 | 21.3 | 3 | ND | 0.02 | 0.02 | 28.97 |
| 24 | Jambani | DW | 6.55 | 487 | 195 | 44 | 20.57 | 23 | 1.15 | 0 | 216 | 31.95 | 15 | 1.93 | 0.52 | 0.02 | 27.48 |
| 25 | Korlikoppa | BW | 6.74 | 155 | 60 | 20 | 2.42 | 9.01 | 0.77 | 0 | 63.2 | 13.3 | ND | 4.04 | 0.47 | 0.02 | 30.44 |
| 26 | Koppa | DW | 7.58 | 237 | 75 | 28 | 1.21 | 14.93 | 1.03 | 0 | 97.6 | 14.2 | 3 | 0.75 | 0.7 | 0.02 | 15.61 |
| 27 | Byrapura | BW | 7.18 | 450 | 205 | 32 | 30.25 | 12.8 | 0.94 | 0 | 236 | 24.85 | 4 | ND | 0.89 | 0.02 | 52.48 |

| Sl. No. | Location | DW/BW | pH | EC | TH | Ca | Mg | Na | K | CO3 | HCO3 | Cl | SO4 | NO3 | F | PO4 | Si |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | Sanganakere | DW | 6.18 | 437 | 180 | 60 | 7.26 | 14.58 | 4.49 | 0 | 221 | 21.3 | 4 | 10.17 | 0.4 | ND | 19.34 |
| 29 | Goutampur | DW | 6.62 | 264 | 55 | 18 | 2.42 | 27.38 | 9.72 | 0 | 48.8 | 49.7 | 4 | 25.9 | 0.3 | ND | 6.13 |
| 30 | Veerabadrapura | DW | 6.2 | 137 | 50 | 14 | 3.63 | 9.4 | 4.69 | 0 | 61 | 13.4 | 3 | 8.16 | 0.63 | ND | 15.04 |
| 31 | Ullur | DW | 9.35 | 234 | 90 | 20 | 9.68 | 13.69 | 3.05 | 0 | 134.2 | 14.2 | ND | ND | 0.44 | ND | 37.33 |
| 32 | Hosur | BW | 8.5 | 230 | 95 | 26 | 7.26 | 6.68 | 0.86 | 0 | 107 | 21 | 3 | ND | 0.24 | ND | 45.71 |
| 33 | Mumbalu | DW | 6.99 | 120 | 55 | 20 | 1.21 | 6.74 | 0.83 | 0 | 63 | 14.2 | ND | 2.95 | 0.48 | ND | 11.56 |
| 34 | Channakoppa | DW | 7.25 | 380 | 160 | 50 | 8.47 | 13.85 | 4.47 | 0 | 170.8 | 32 | 3 | 0.67 | 0.76 | ND | 20.78 |
| 35 | Anandpur | BW | 7.12 | 118 | 30 | 8 | 2.42 | 13.06 | 2.07 | 0 | 66 | 8 | ND | ND | 0.51 | ND | 56.31 |
| 36 | Iruvakki | DW | 6.84 | 340 | 120 | 30 | 10.89 | 21.32 | 3.92 | 0 | 130 | 28.4 | ND | 38.04 | 0.8 | ND | 11.38 |

*(All in mg/L except pH, EC, TH. ND: Not Detected)*