



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

Madikeri Taluk, Kodagu District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

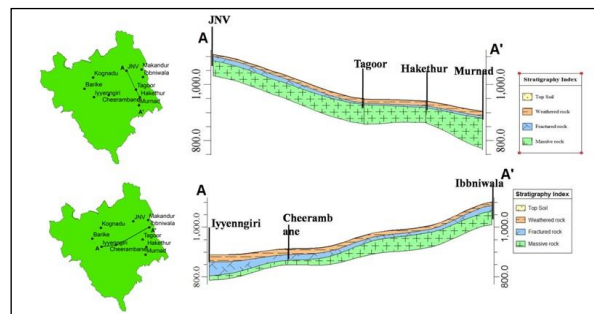
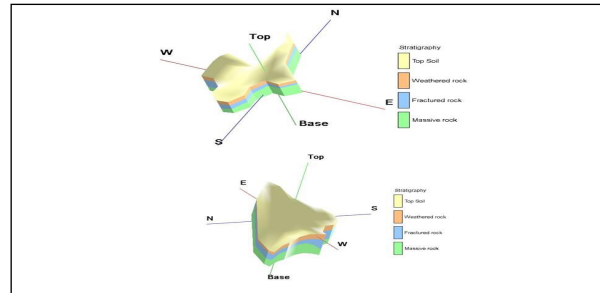
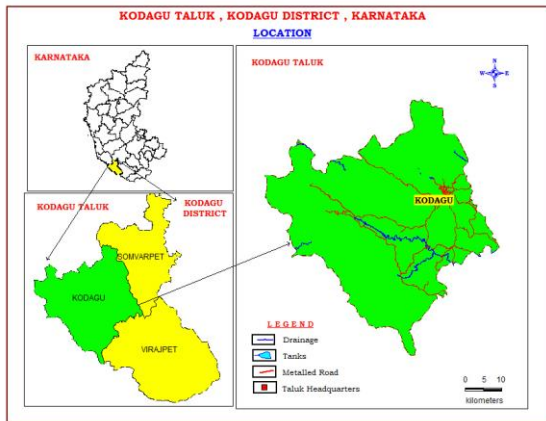
भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास
एवं गंगा संरक्षण विभाग
केन्द्रीय भूमिजल बोर्ड
दक्षिण पश्चिमी क्षेत्र,
बंगलुरु



Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development &
Ganga Rejuvenation
Central Ground Water Board
South Western Region, Bengaluru

AQUIFER MAPS AND MANAGEMENT PLAN, MADIKERI TALUK, KODAGU DISTRICT, KARNATAKA STATE

(AAP: – 2022-2023)



By

Abdul Rajik Khan, Assistant Hydrogeologist, CGWB, SWR, Bengaluru

AQUIFER MAPS AND MANAGEMENT PLAN, MADIKERI TALUK, KODAGU DISTRICT, KARNATAKA STATE

Contents

1.0	SALIENT INFORMATION	1
1.1	Study Area	1
1.2	Population	2
1.3	Data Gap Analysis	3
1.4	Rainfall and Climate	4
1.5	Agriculture & Irrigation.....	6
1.6	Geomorphology, Physiography & Drainage.....	8
1.7	Geology and Soil.....	9
1.8	Hydrogeology	10
1.9	Groundwater resource availability and extraction	10
1.10	Existing and future water demands (as per GWRA-2020 and 2022).....	11
1.11	Water level behavior	12
2.	AQUIFER DISPOSITION.....	19
2.1	Aquifer Types	19
2.2	3 D aquifer disposition and Cross-Sections	23
	Hydrogeological Cross Sections	24
3.	Groundwater resource, extraction, contamination and other issues.....	26
3.1	Comparison of Groundwater availability and draft scenario in Madikeri taluk.....	26
3.2	Chemical Quality of Groundwater and Contamination	26
4.	GROUNDWATER RESOURCE ENHANCEMENT AND PROPOSED MANAGEMENT STRATEGY.....	31
4.1	Resource Enhancement by Supply Side Interventions.....	31
4.1.1	Strategic Action Plan	33
4.1.2	Benefits of Artificial recharge scheme.....	33
4.2	Resource Savings by Demand Side Interventions	33
4.2.1	Water Use Efficiency by Micro Irrigation Practices.....	33
4.2.	Groundwater Development Plan.....	34
4.3.	Regulation and Control.....	34
4.4.	Other interventions proposed.....	35
5	SUMMARY AND RECOMMENDATIONS.....	35

AQUIFER MAPS AND MANAGEMENT PLAN, MADIKERI TALUK, KODAGU DISTRICT, KARNATAKA STATE

1.0 SALIENT INFORMATION

Name of the taluk	: Madikeri
District	: Kodagu
State	: Karnataka
Area	: 1446 sq.km.
Population (Census 2011)	: 1,46,583
Normal annual Rainfall	: 3316 mm

1.1 Study Area

Aquifer Mapping Studies have been carried out in Madikeri taluk, Kodagu district, Karnataka state under National Aquifer Mapping Project. The Taluk is covering an area of 1446 sq.kms. The Geographical extent of Madikeri taluk is located between North Latitudes 12°32'00.96'' to 12°12'57.85'' and East Longitudes between 75° 47' 59.16'' to 75°26'41.01''. The taluk is covered in parts of Survey of India Toposheet Nos. 48P/11, P/12 and P/15. Madikeri taluk is bounded on the East by somwarpet taluk, on the North by Dakshin Kannada, on the South by Virajpet taluk, on the West by Kerala. Taluk administration of Madikeri is divided into 4 Hoblies and 26 Gram panchayats. Madikeri town is taluk Headquarter. There are 67 villages resent in this taluk. Location map of Madikeri taluk of Kodagu district is presented in Fig-1.

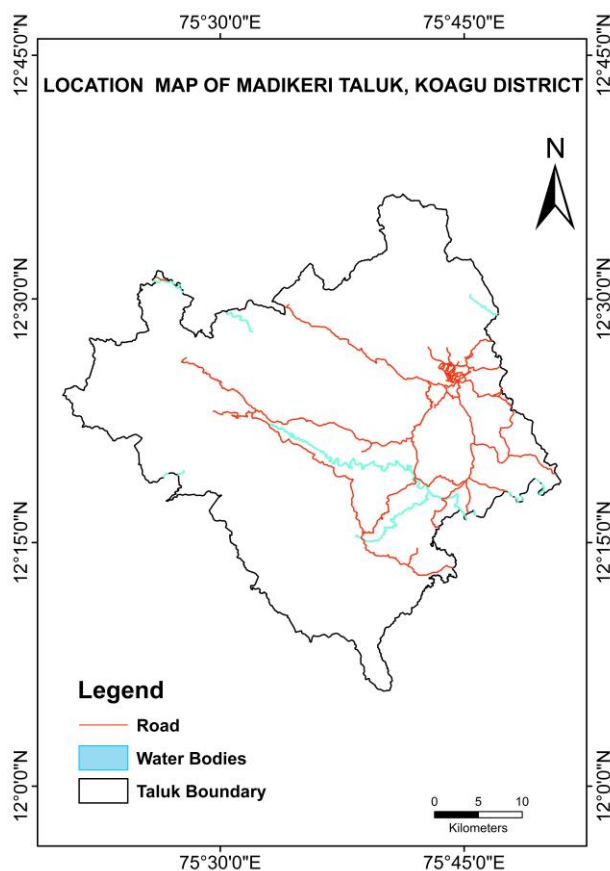


Figure 1 Location map of Madikeri taluk of Kodagu district

1.2 Population

According to 2011 census, the human population in Madikeri taluk is 1,46,583, in which 1,13,202 constitute the rural population and 33,381 is the urban population. The taluk has an overall population density of 98 persons per sq.km. The decadal variation in population from 2001-2011 is 3.12% in Madikeri taluk. The population details are given in table-1.

Table 1 Population details

Total	Male	Female	%Share of the district Population	Rural Population	Urban Population	Decadal change in Population	Decadal change in rural Population	Decadal change in urban Population
1,46,583	72966	73617	26.4	113202	33381	3.12	3.26	2.65

Source: District at a glance 2018-19, Govt. of Karnataka

1.3 Data Gap Analysis

During the aquifer mapping period, existing data of CGWB i.e. exploration, depth to water level, water quality, geophysical logging and groundwater resource data have been collected and compiled. In addition to this, bore well data & water level data have been collected from Ground Water Directorate, Govt.of Karnataka. As per the guidelines of data gap analysis for aquifer mapping, three monitoring wells have to identify to fill the data gap in the taluk after integrating Central Ground Water Board and State Ground Water Directorate monitoring wells data. Dug wells 28 Nos. are available to monitor the first phreatic aquifer and 09 bore wells are available to know the aquifer characters of semi-confined aquifer system. Ground water quality monitoring is being done through 21 Nos. of established dug wells for first phreatic aquifer and through 01 Nos. of bore wells drilled by CGWB for the Semiconfined aquifer in order to assess the groundwater quality for drinking and irrigation purposes. Additional 20 Nos. of bore wells has to be identified (in Semi-confined Aquifer) through Field survey to assess the Groundwater quality for drinking and irrigation purposes. Four numbers of Exploratory wells drilled in Pre-NAQUIM period. Total 09 Nos. of wells through Field survey has to be identified to complete the gaps in the data. Location of ground water observation wells and exploration wells are presented in Figure 2 & 3.

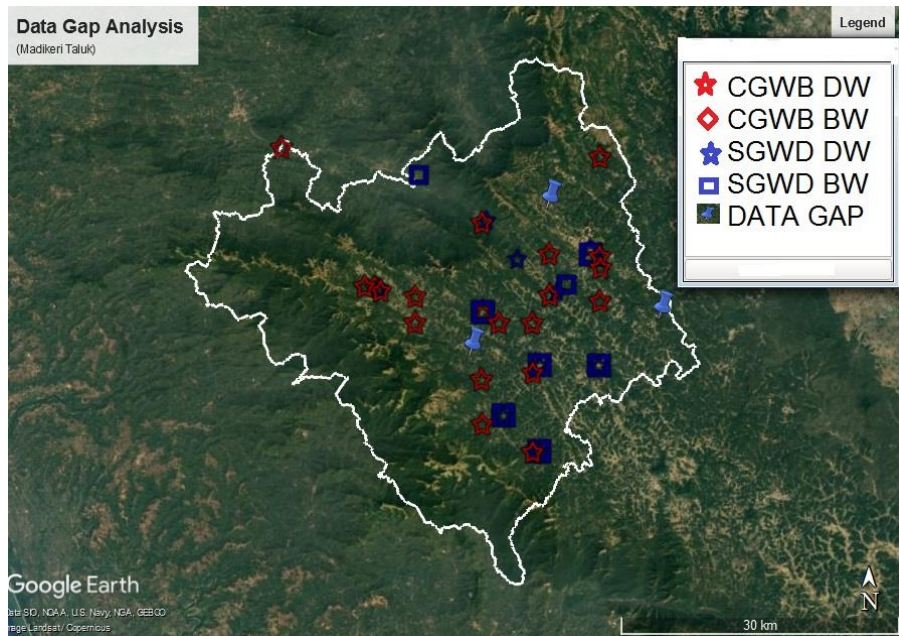


Figure 2 Location map of GW Monitoring wells

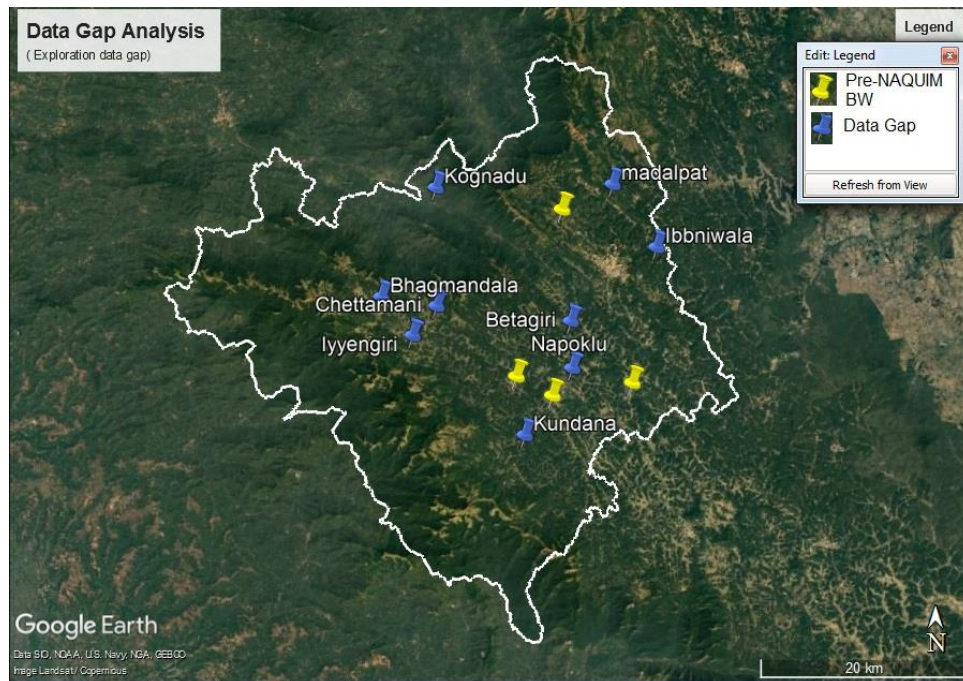


Figure 3 Location map of Exploration wells

1.4 Rainfall and Climate

The annual rainfall data from 2013 to 2022 of the Madikeri taluk is given in Table.2. The Monthly rainfall analysis for the period from 2013 to 2022 is shown in Table.3.

Table 2 Actual Annual Rainfall of Madikeri taluk from 2013 to 2022

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rainfall (mm)	2453	3301	2964	2869	2943	5018	3806	3488	3522	4214.2

(Source: Directorate of Economic and Statistics)

Table 3 Monthly rainfall data of Madikeri taluk

Year	JAN	FEB	MAR	APR	MAY	PRE	JUN	JUL	AUG	SEP	SW M	OCT	NOV	DE C	NE M	ANN .
2013	0	33	110	5	0	148	391	567	732	350	2040	100	165	0	26 5	2453
2014	0	0	0	66	181	247	319	1144	847	661	2971	64	19	0	83	3301
2015	0	0	1	81	185	267	109 8	712	421	274	2505	129	63	0	19 2	2964
2016	0	0	6	35	157	198	799	762	653	307	2521	73	49	28	15 0	2869
2017	35. 6	0.4	22.9	90.5	193. 5	342. 9	577	715	728	415	2435	116	34	15	16 5	2943
2018	0.3	1.8	55	100	376	533. 1	117 6	1542	1439	100	4257	170	39	18	22 7	5018
2019	01	08	13	81	54	157	325	771	1429	636	3161	386	59	43	48 8	3806
2020	02	02	10	108	221	343	514	660	1045	611	2830	249	46	21	31 6	3488
2021	47. 1	17. 2	8.4	132. 8	341. 1	546. 6	607	936.3	442	351	2336 .3	365	257	16	63 8	3522
2022	0	2.8	40	141. 1	316	497	325	1726. 9	1071. 4	283. 3	3406 .6	228.8	65.9	13	30 7.7	4214 .2

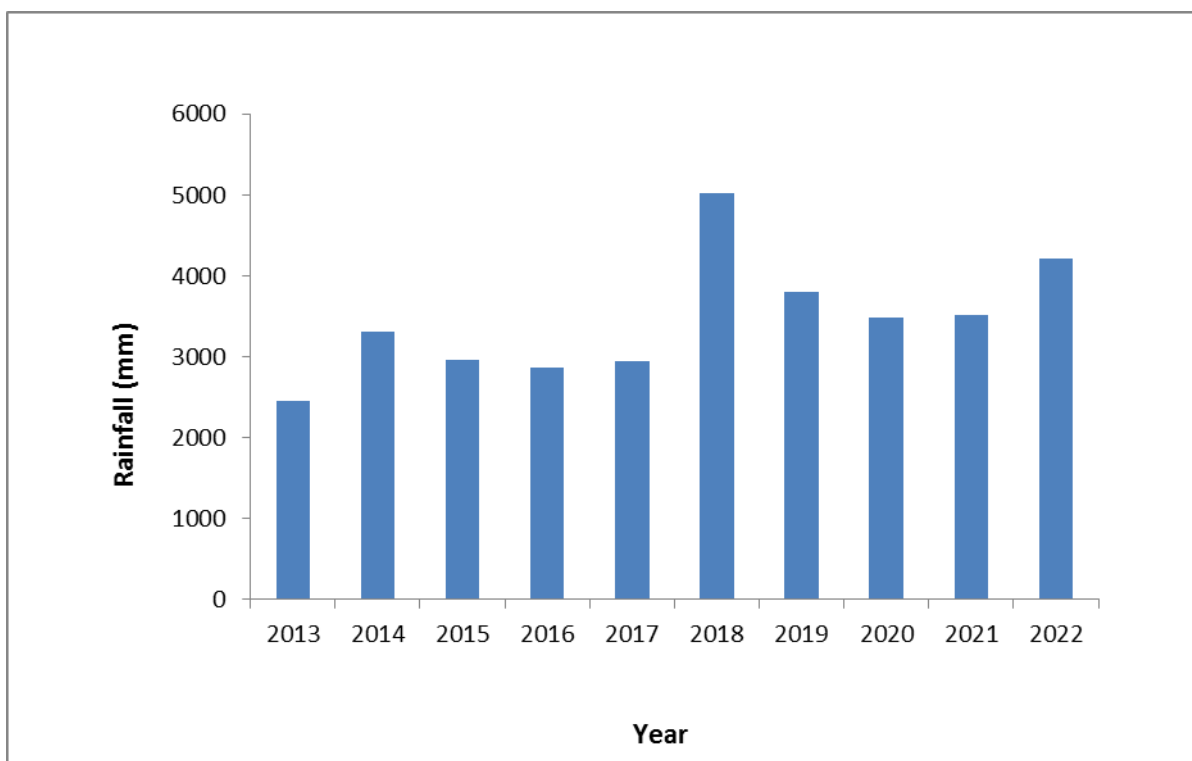


Figure 4 Rainfall Trend Analysis

1.5 Agriculture & Irrigation

Agriculture is the main occupation in Madikeri taluk. Major crops are Paddy, Fruits and Vegetables. Water intensive crops Paddy is grown in Madikeri Taluk (Table.4). Under Plantation coffee plant is grown more in taluk and water dependent.

Table 4 Cropping pattern in Madikeri taluk 2018-2019 (Ha)

Year	Paddy	Jowar	Ragi	Maize	Wheat	Food grain	Fruits	Oil seeds	Sugarcane	Cotton
	Area under cultivation (in ha)									
2018-2019	5613	0	0	0	-	5613	4026	48	-	0

About 32.75% of the Geographical area is covered by forest. It is observed that net sown area accounts 34.45 % and area sown more than once is 3.52% of total geographical area in Madikeri taluk. Area not available for cultivation, the other uncultivable land and Fallow land cover 12.40%, 18.62% and 1.75% respectively of total geographical area. The details of land use and details of irrigation are given in Table-5 and Table-6 respectively. The land use pattern is given in Fig-5.

Table 5 Details of land use in Madikeri taluk 2018-2019 (Ha)

Taluk	Total Geographical Area	Area under Forest	Area not available for cultivation	Other Uncultivable land	Fallow land	Net sown area	Area sown more than once	Gross sown area
MADIKERI	145045	47514	17996	27015	2543	49977	5111	55088
% of the area	-	32.75	12.40	18.62	1.75	34.45	3.52	37.97

Source: District at a glance 2018-19, Govt. of Karnataka

Table 6 Irrigation details in Madikeri taluk (in ha)

Source of Irrigation	Length in Km/ No of Structure	Gross irrigated area	Net area irrigated (Ha.)	% of area
Canals	2 (Km)	0	0	0
Tanks	205	0	0	0
Wells	0	0	0	0
Bore wells/ Tube wells	0	0	0	0
Lift Irrigation	4	0	0	-
Other Sources		13	11	100
Total			11	

Source: District at a glance 2018-19, Govt. of Karnataka

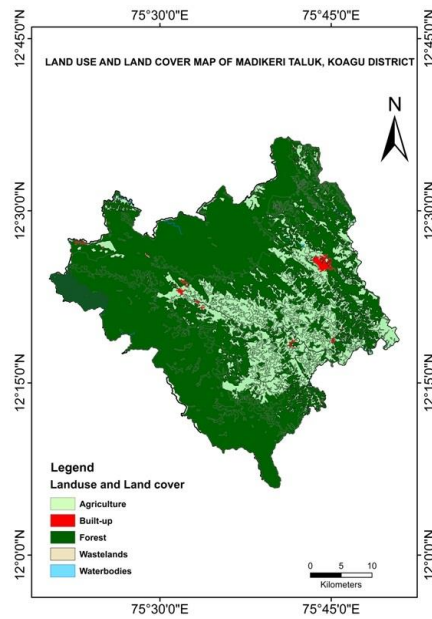


Figure 5 Land use Map

1.6 Geomorphology, Physiography & Drainage

The geomorphology of the Madikeri is formed by hilly area covered all over the taluk except central and south eastern part, which is covered by piedmont zone and plains. Madikeri taluk also shows reservoir, river/ stream and tanks etc. The general topographic elevation in the taluk varies from 1281 m in the North-eastern to 286 m amsl in the North-western part of the taluk. The differential altitude is significant because, it is likely to cause irregular ground water flow patterns on the micro scale (Fig.-6). Topography is dominantly controlled by geological structures. The entire Madikeri taluk falls in Cauvery river basin. The taluk is drained by 1st to 4th order streams. The drainage system is well developed in the taluk. The Drainage pattern is dendritic to sub-dendritic (Fig.-7).

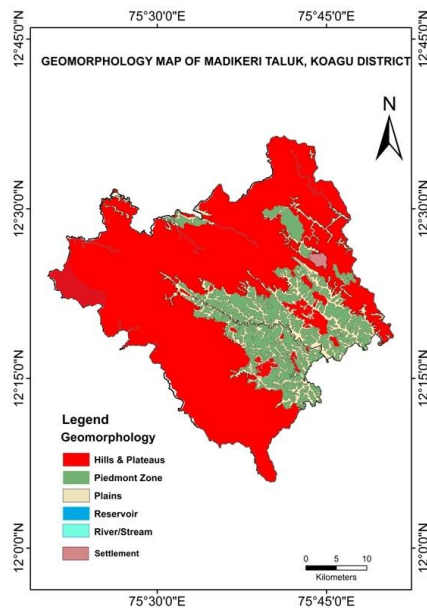


Figure 6 Geomorphology Map

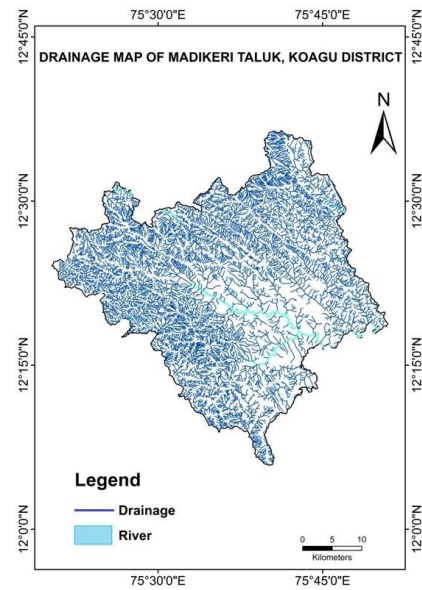


Figure 7 Drainage Map

1.7 Geology and Soil

Geologically, the taluk is mainly composed of metamorphic rocks of Pre-Cambrian age either exposed at the surface or covered with a thin mantle of residual and transported soils. The rock formation in the taluk falls into two groups, Banded Gneissic Complex and Charnockite formation (Fig-8). In Banded Gneissic Complex, Schist patches are found. The identification of stream pattern in the taluk is helpful in identification and interpretation of many geological features. The soil type of Madikeri taluk can broadly be classified into Clayey soils and Clayey Skeletal soils. These soils vary in depth and texture, depending on the parent rock type, physiographic settings and climatic conditions. It is less permeable compare to the sandy soil. It is having good moisture holding capacity and is fertile (Fig-9).

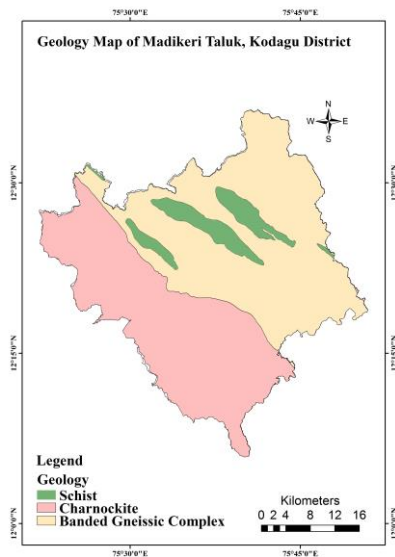


Figure 8 Geology Map

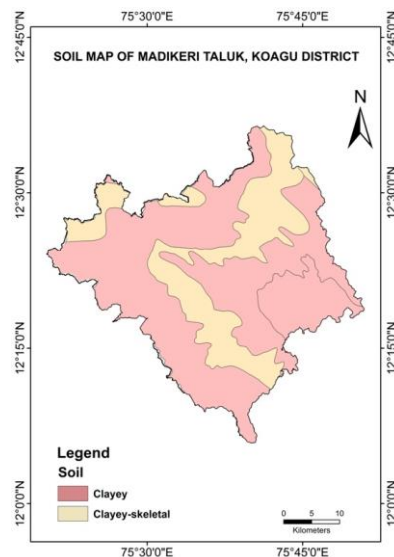


Figure 9 Soil Map

1.8 Hydrogeology

Hydrogeologically, the area forms a part of hard rock terrain comprising of Granite gneiss, Charnockites and Schist (Figure 10). The flat and low-lying areas are covered by a thick mantle of fertile soil, while the elevated portions and hills are capped by laterites. The alluvium is found along the river course, contains silt, sand and gravel in varying proportions. The Groundwater occurs under phreatic conditions in weathered zones of Granite gneiss and Charnockite, and under semiconfined to confined conditions in fractures (Secondary porosity) of these rocks at deeper level. Yield ranges from Negligible to 8.22 lps.

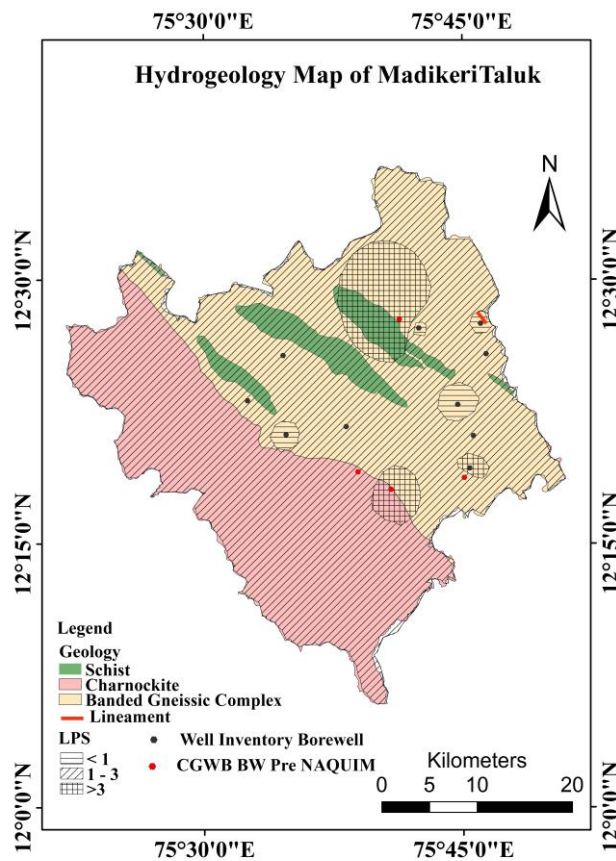


Figure 10 Hydrogeology Map of Madikeri Taluk

1.9 Groundwater resource availability and extraction

As per Groundwater resource estimation 2022 Table 7, the data on Groundwater resources shows that the net Groundwater availability is 5667.59 Ham. The existing gross Groundwater for irrigation is 1697.9 Ham. The existing gross Groundwater for domestic and industrial is 1881.59 Ham. The existing gross Groundwater draft is 2064.15 Ham. The stage of Groundwater development is 36.42 % and falling under 'Safe' category.

Table 7 Dynamic Groundwater Resources (2022) (Ham)

Net Annual Groundwater Availability	Existing Gross Groundwater Draft For Irrigation	Existing Gross GW Draft For Domestic And Industrial Water Supply	Existing Gross Groundwater Draft For All Uses	Allocation For Domestic And Industrial Use For Next 25 Years	Net Ground Water Availability For Future Irrigation Development	Existing Stage Of Groundwater Development (%)	Category
5667.59	1697.9	1881.59	2064.15	211.28	3575.86	36.42	Safe

Aquifer wise total Groundwater resources down to 200 m depth is given in **Table-8** below as per 2022 estimation.

Table 8 Total Groundwater Resources (2022) (Ham)

Taluk	Annual replenishable GW resources	Fresh In-storage GW resources		Total availability of fresh GW resources
Madikeri		Phreatic	Fractured (Down to 200m)	Dynamic + phreatic in-storage + fractured
	5667.59	110318	8633	124618.59

(Note- Annual replenishable GW resources is taken from GWRA-2022 and Fresh In-storage GW resources is taken from GEC-2017)

1.10 Existing and future water demands (as per GWRA-2020 and 2022)

The details of Groundwater resources for Madikeri taluk as on 2020 and 2022 is shown in **Table.9 and Table.10**. It is observed that the stage of Groundwater extraction is 17.23 % to 36.42% from 2020 to 2022.

Table 9 Present Dynamic Groundwater Resource (2020)

Net Annual Groundwater Availability	Existing Gross Groundwater Draft For Irrigation	Existing Gross GW Draft For Domestic And Industrial Water Supply	Existing Gross Groundwater Draft For All Uses	Allocation For Domestic And Industrial Use For Next 25 Years	Net Ground Water Availability For Future Irrigation Development	Existing Stage Of Groundwater Development (%)	Category
14172.33	1877.33	564.32	2441.65	772.49	115222	17.23	Safe

Table 10 Dynamic Groundwater Resources (2022) (Ham)

Net Annual Groundwater Availability	Existing Gross Groundwater Draft For Irrigation	Existing Gross GW Draft For Domestic And Industrial Water Supply	Existing Gross Groundwater Draft For All Uses	Allocation For Domestic And Industrial Use For Next 25 Years	Net Ground Water Availability For Future Irrigation Development	Existing Stage Of Groundwater Development (%)	Category
5667.59	1697.9	1881.59	2064.15	211.28	3575.86	36.42	Safe

1.11 Water level behavior

The water level data have been monitored from the representative dug wells and bore wells under NHS monitoring for pre-monsoon seasons and Post monsoon during 2022 in Aquifer I and Aquifer II. During Pre monsoon season water level ranges from 0.93 to 18.6 mbgl in Aquifer- I (Phreatic aquifer) (Fig- 11) and water level ranges from 8.33 to 26.7 mbgl in Aquifer- II (Confined/ Semi confined aquifer) (Fig-14). During Post monsoon season water level ranges from 0.15 to 15.55 mbgl in Aquifer- I (Phreatic aquifer) (Fig-12) and water level ranges from 3.02 to 20.91 mbgl in Aquifer- II (Confined/ Semi confined aquifer) (Fig-15). Decadal Average water level ranges for Pre Monsoon from 1.25 to 14.8 mbgl (Fig-17). Decadal Average water level ranges for Post Monsoon from 1.33 to 11.34 mbgl (Fig-18).

Seasonal Water level Fluctuation:

Seasonal water level fluctuation In Aquifer- I shows raise in water level between 0.13 to 5.53 meter and fall of water level 0.10 to 1.24 meter (**Fig-13**). In Aquifer- II water level raises 0.24 to 12.86 meter and fall of water level 0.0 to 0.8 meter (**Fig-16**). Raise in water level is observed in major part of area and fall of water level observed in patches in west and South-west part of taluk.

Decadal Water level Fluctuation (2012-2021 with respect to 2022):

Decadal water level fluctuation, In Pre- Monsoon shows raise in water level between 0.21 to 2.69 meter and fall of water level 0.45 to 4.5 meter (**Fig-19**). In Post-Monsoon water level raises 0.04 to 1.35 meter and fall of water level 0.52 to 3.57 meter (**Fig-20**). In Pre-Monsoon fall of water level is observed in North-East part of taluk. In post-Monsoon fall of water level is observed in all part of taluk except some center part of taluk.

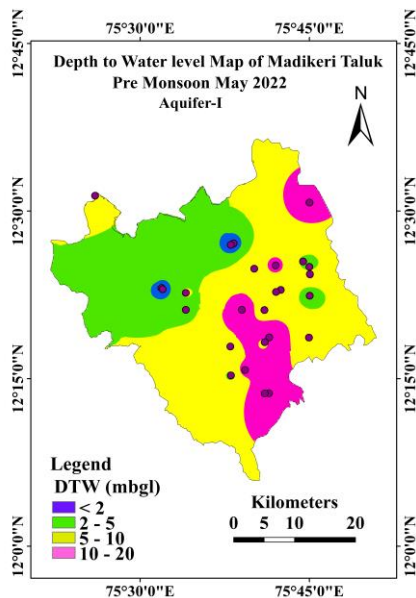


Figure 11 Pre Monsoon Depth to Water level Map

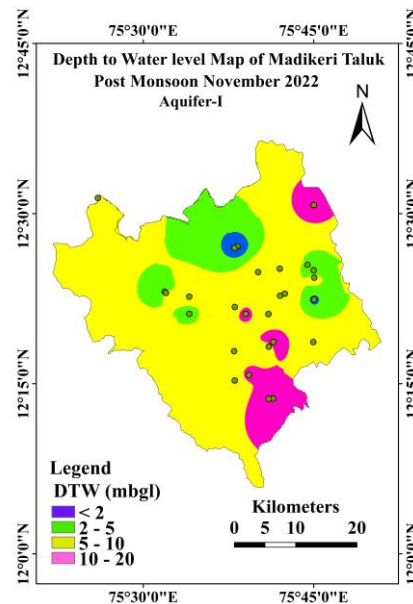


Figure 12 : Post Monsoon Depth to Water level Map

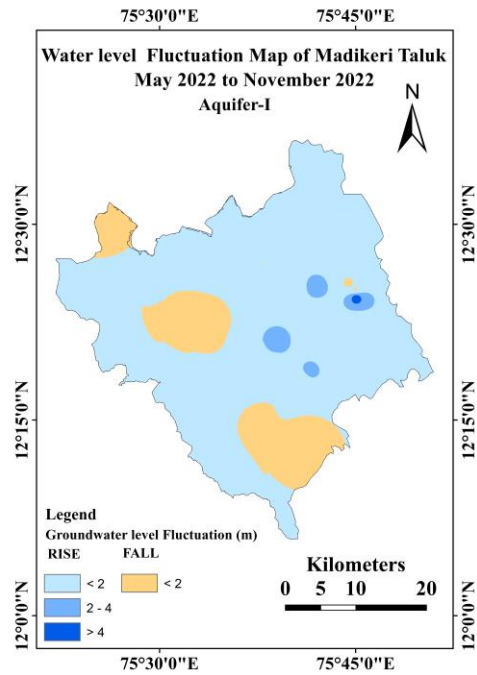


Figure 13 Water level Fluctuation Map (Aquifer- I)

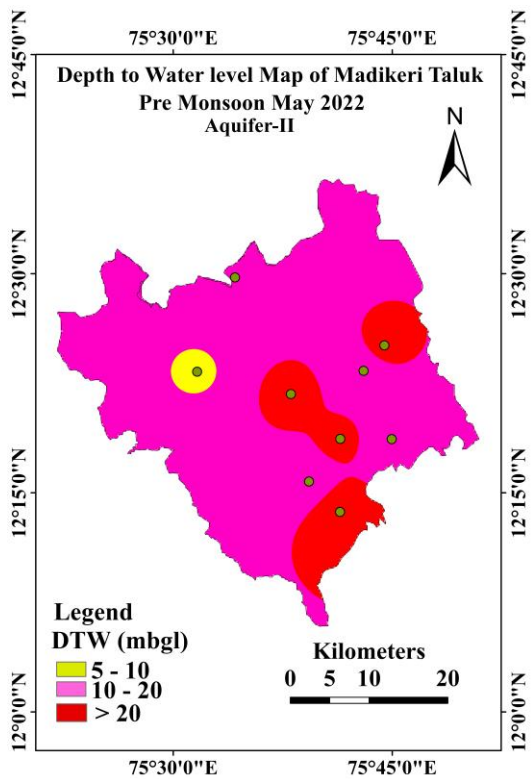


Figure 14 Pre Monsoon Depth to Water level Map

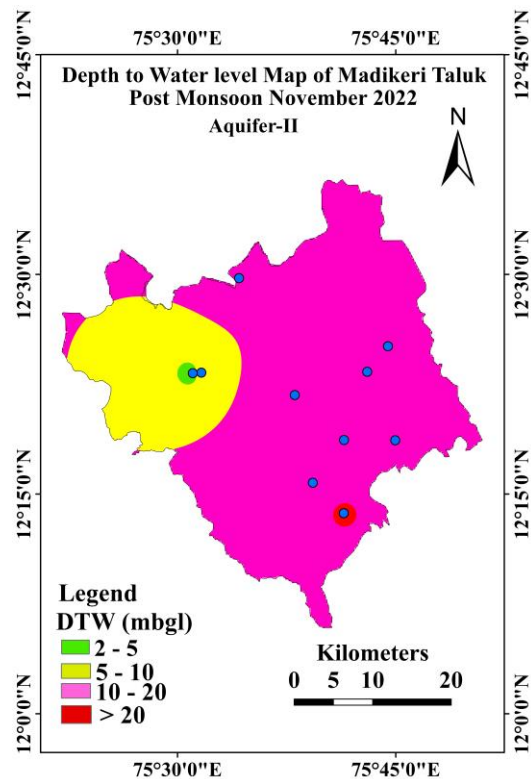


Figure 15 Post Monsoon Depth to Water level Map

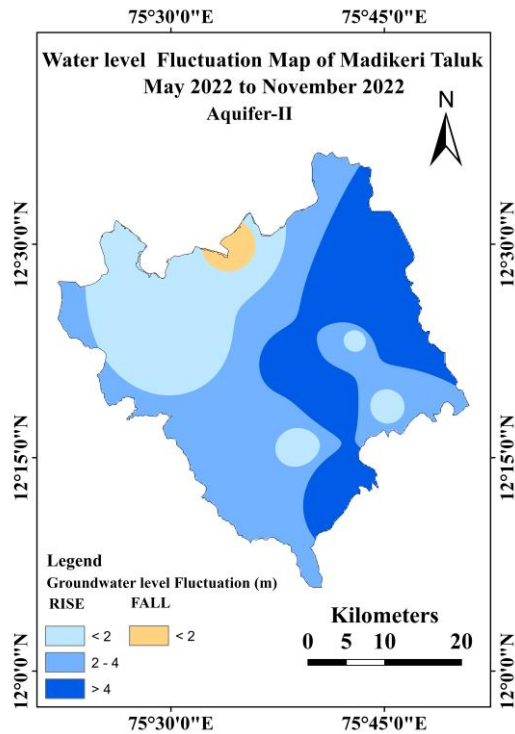


Figure 16 Water level Fluctuation Map (Aquifer- II)

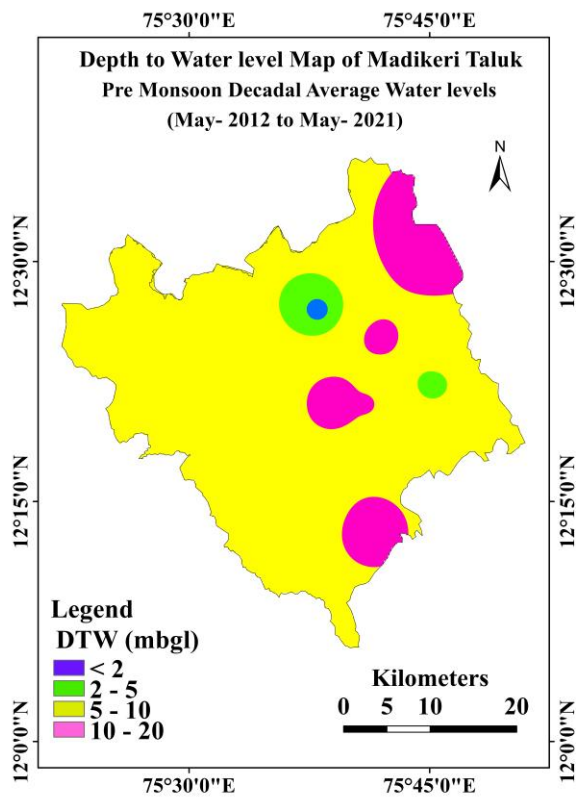


Figure 17 Pre Monsoon Decadal Water level Map

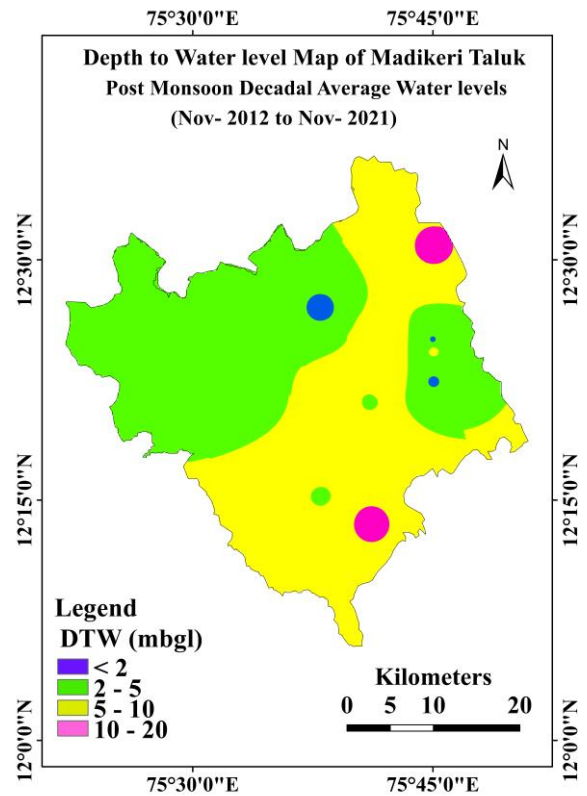


Figure 18 Post Monsoon Decadal Water level Map

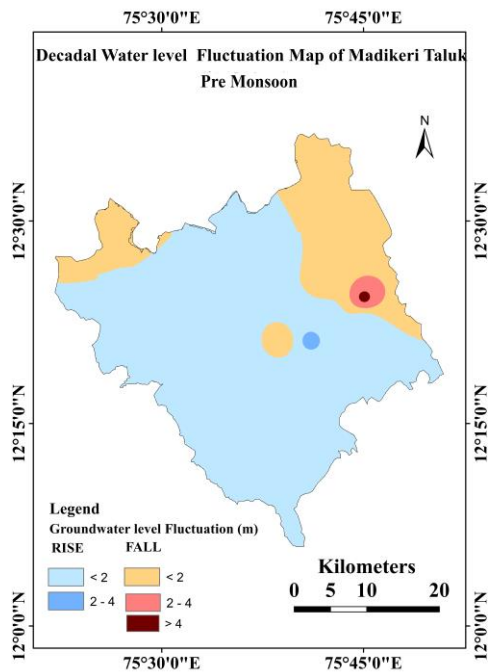


Figure 19 Pre Monsoon Decadal Fluctuation Map

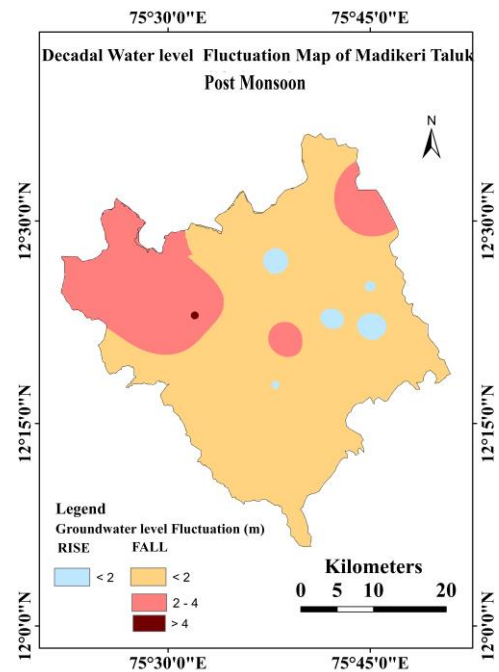


Figure 20 Post Monsoon Decadal Fluctuation Map

Table 11 Depth to water level of Pre and Post-monsoon (2022), CGWB

Sl No.	Site_type	Location name	May 22 WL (mbgl)	Nov 22 WL (mbgl)	Fluctuation (meter)
1	Dug well	Ayyangeri	3.93	4.05	-0.12
2	Bore well	Bhagamandala	-	3.02	-
3	Dug well	Benguru 50 okallu	13.95	11.05	2.9
4	Dug well	Bettagiri	7.6	5.75	1.85
5	Dug well	Bhagmandala1	-	6.5	-
6	Dug well	Cheerambane	9.2	8.9	0.3
7	Dug well	Chettimani	5.26	6.0	-0.74
8	Dug well	Cheyyandane	11.87	12.0	0.13
9	Dug well	Devarakolli	0.93	1.03	-0.1
10	Dug well	Heravanadu	6.85	6.28	0.57
11	Dug well	Kakabe	4.12	4.9	0.3
12	Dug well	Katakeri	12.13	8.8	3.33
13	Dug well	Khagodu	1.46	1.24	0.22
14	Dug well	Madikeri A	1.18	1.41	-0.23
15	Dug well	Mekari	15.25	14.63	0.62
16	Dug well	Napoklu	7.84	7.29	0.55
17	Dug well	Neerkolli	12.03	6.5	5.53
18	Dug well	Nelaje	9.6	8.8	0.8
19	Dug well	Nilwagilu	5.35	2.9	2.63
20	Dug well	Peraje	5.83	6.35	-0.52

Table 12 Depth to water level of Pre and Post-monsoon (2022) (Ground Water Dept., Govt. of Karnataka)

Sl No	Site_type	Location name	May 22 WL (mbgl)	Nov 22 WL (mbgl)	Fluctuation (meter)
1	Dug well	Madikeri	4.76	5.17	-0.41
2	Dug well	Devarakolli	1.17	0.14	1.03
3	Dug well	Appangala	7.00	6.85	0.15
4	Dug well	Cheerambane	9.17	8.99	0.18
5	Dug well	Bhagmandala	2.80	2.95	-0.15
6	Dug well	Napoklu	18.60	15.55	3.05
7	Dug well	Kunjila	11.17	11.07	0.1
8	Dug well	Cheyyandane	10.75	11.99	-1.24
9	Dug well	Murnad	6.15	5.73	0.42
10	Bore well	Sampaje	13.27	14.07	-0.8
11	Bore well	Kunjila	13.55	13.31	0.24
12	Bore well	Madikeri	24.46	11.60	12.86
13	Bore well	Murnad	12.05	11.02	1.03
14	Bore well	Napoklu	23.08	16.11	6.97
15	Bore well	Appangala	11.25	10.50	0.75
16	Bore well	Bhagamandala	8.33	8.05	0.28
17	Bore well	Cherambane	24.05	19.37	4.68
18	Bore well	Cheyyandane	26.70	20.91	5.79

Table 13 Decadal Average Pre Monsoon and Fluctuation Water level (2012-2021 w.r.t 2022), CGWB

Sl.No	Site Type	Location	Mean WL (mbgl)	MAY 22 WL (mbgl)	Fluctutation (meter)
1	Dug well	Ayyangeri	5.42	3.93	1.49
2	Dug well	Ballamavathu	11.7	11.1	0.6
3	Dug well	Benguru 50 Okallu	12.8	13.95	-1.15
4	Dug well	Bettagiri	10.29	7.6	2.69
5	Dug well	Chattahalli	11.95	10.9	1.05
6	Dug well	Cheerambane	10.9	9.2	1.7
7	Dug well	Cheyyandane	12.22	11.87	0.35
8	Dug well	Devarakolli	1.25	0.93	0.32
9	Dug well	Heravanadu	8.82	6.85	1.97
10	Dug well	Kakkabe	5.31	4.12	1.19
11	Dug well	Katakeri	11.5	12.13	-0.63
12	Dug well	Ketagal 7th Main	11.77	10.2	1.57
13	Dug well	Khagodu	3.21	1.46	1.75
14	Dug well	Mekari	14.8	15.25	-0.45

15	Dug well	Napoklu	8.24	7.84	0.4
16	Dug well	Neerkolli	7.53	12.03	-4.5
17	Dug well	Nelaje	9.81	9.6	0.21
18	Dug well	Nilwagilu	7.76	5.35	2.41
19	Dug well	Peraje	5.09	5.83	-0.74
20	Dug well	Suntikoppa	4.87	4.22	0.65

Table 14 Decadal Average Post Monsoon and Fluctuation Water level (2012-2021 w.r.t 2022), CGWB

Sl. No	Site Type	Location	Mean WL (mbgl)	November 2022 WL (mbgl)	Fluctuation (meter)
1	Dug well	Ayyangeri	3.53	4.05	-0.52
2	Dug well	Ballamavathu	10.26	10.15	0.11
3	Dug well	Benguru 50 okallu	7.48	11.05	-3.57
4	Dug well	Bettagiri	4.70	5.75	-1.05
5	Dug well	Chattahalli	10.51	9.72	0.79
6	Dug well	Cheerambane	8.94	8.9	0.04
7	Dug well	Cheyyandane	11.34	12	-0.66
8	Dug well	Devarakolli	1.33	1.03	0.30
9	Dug well	Heravanadu	6.93	6.28	0.65
10	Dug well	Kakkabe	4.57	4.9	-0.33
11	Dug well	Katakeri	7.30	8.8	-1.50
12	Dug well	Ketagal 7th main	6.59	8.8	-2.21
13	Dug well	Khagodu	1.71	1.24	0.47
14	Dug well	Mekari	11.17	14.63	-3.46
15	Dug well	Napoklu	5.70	7.29	-1.59
16	Dug well	Neerkolli	5.54	6.5	-0.96
17	Dug well	Nelaje	8.86	8.8	0.06
18	Dug well	Nilwagilu	4.25	2.9	1.35
19	Dug well	Peraje	2.79	6.35	-3.56
20	Dug well	Suntikoppa	4.14	4	0.14

2. AQUIFER DISPOSITION

2.1 Aquifer Types

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

In Madikeri, there are mainly two types of aquifer systems;

Aquifer-I (Phreatic aquifer)

Depth of weathered zone ranges from 6.1 mbgl to 30.5 mbgl (**Fig-21**) and (**Fig-22**). Major part of the weathering zone is ranges from 10.0 to 20.0 m followed by 20.0 to 30.0 meter. Due to Weathering of Granite gneiss formed thick sandy residuum, which forms phreatic aquifer. Whereas Charnockite, due to shallow weathering with tight joints with wider spacing render as poor phreatic aquifer.

The perusal of the map for aquifer thickness indicates that it ranges from 1 to 28 m, however aquifer thickness of 10 to 20 m is observed in major part of the area (about 70%). The aquifer thickness of 20 to 28 m is observed in 10% of the areas.. The less thickness areas are spread over 20% mostly in the central parts of the area.

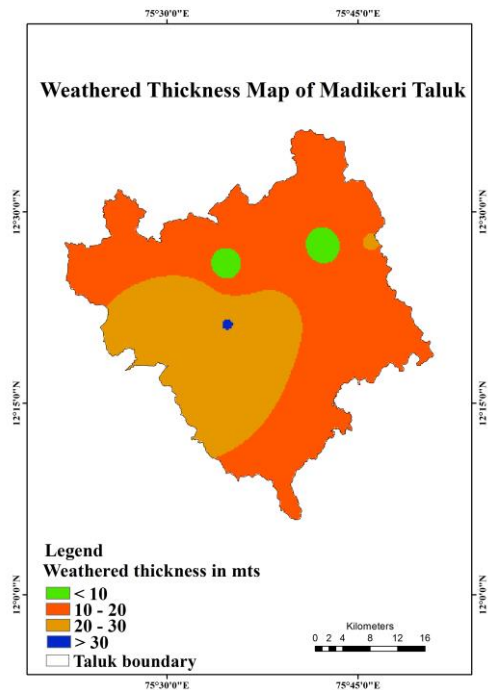


Figure 21 Weathered Thickness Map

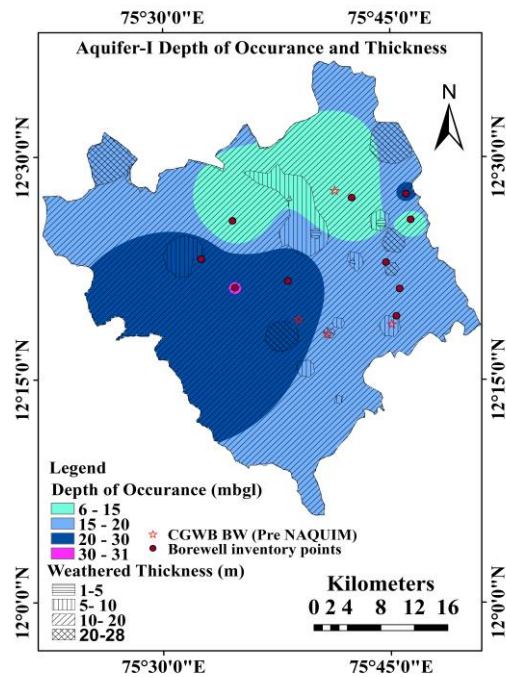


Figure 22 Depth of Occurrence and Thickness Map (Aquifer-I)

Aquifer-II (Fractured aquifer)

In Madikeri taluk, Banded gneissic complex, Charnockite and Schist are the main water bearing formations (Fig-8). Ground water occurs within the weathered and fractured Granite Gneissic, Charnockite and Schist under water table condition and semi-confined condition. In Madikeri taluk bore wells were drilled from a minimum depth of 61 mbgl to a maximum of 200.00 mbgl. Ground water exploration reveals that aquifer-II fractured formation was encountered between the depths of 18.3 to 91.5 mbgl (**Fig-23**). Major part of the areas (90%) occupied by fracture formation between 18-50 mbgl. However 50-91 mbgl fracture formation (10%) occupied in patches. Fracture Thickness ranges from 0 to 1 meter in all over taluk (based on well inventory data). Yield ranges from Negligible to 8.22 lps. The basic characteristics of each aquifer are summarized Table-15 and Table-16. The 3D aquifer disposition models, 2D aquifer sections and 3D aquifer fence diagrams have been prepared based on Exploration data and borewell inventory data and it presented in Fig-24, Fig-25 and Fig-26.

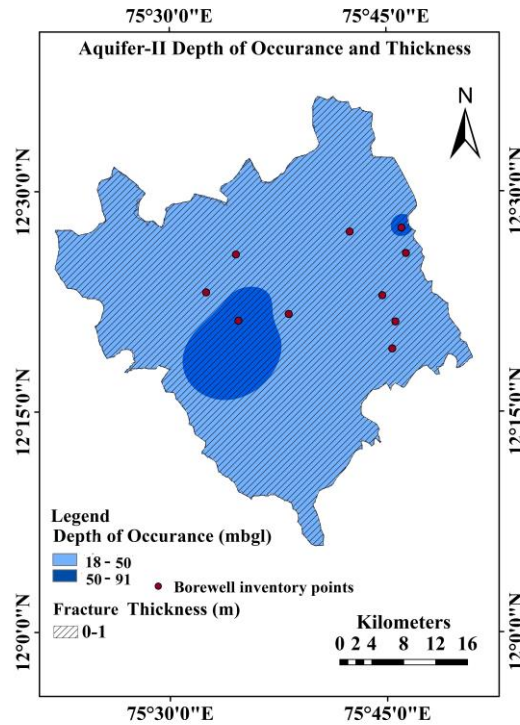


Figure 23 Depth of Occurrence and Thickness Map (Aquifer-II)

Table 15 Details of Groundwater Exploration (Pre-NAQUIM)

Sl.No	Location	Lat & Long	Depth (m bgl)	Casing (m)	Lithology	SWL (mbgl)	Q (lps)	T (m ² /day)
1	Yemmadu EW	12.318056 75.648611	200	24.25	Granite Gneiss	14.74	1.3	04
2	Galibidu EW	12.462500 75.688889	94	22.75	Granite Gneiss	4.33	4.27	17
3	Galibidu OW 1	12.462500 75.688889	79.6	24.7	Granite Gneiss	3.73	8.22	37
4	Galibidu OW 2	12.462500 75.688889	79.6	27.9	Granite Gneiss	5.315	4.82	52
5	Napoklu EW	12.301389 75.680556	106	21.8	Granite Gneiss	8.29	3.0	17
6	Napoklu OW 1	12.301389 75.680556	106	26.8	Granite Gneiss	8.83	4.27	20
7	Napoklu OW 2	12.301389 75.680556	77	20.15	Granite Gneiss	7.34	3.28	02
8	Murnad EW	12.312500 75.751389	182	26.3	Charnockites	17.21	1.45	04

Table 16 Details of Bore well inventory data

Sl.No	Location	Lat &Long	Depth (m bgl)	Casing (m)	Lithology	Fracture (m)	Q (lps)
1	Ibbniwala	12.429612 75.772536	91.5	13.725	Granite Gneiss	36.6	1.41
2	Makandur	12.458505 75.767369	85.4	21.35	Granite Gneiss	54.9	0.8
3	JNV	12.454126 75.707681	76.25	6.1	Granite Gneiss	21.35	0.39
4	Tagoor	12.381705 75.745149	91.5	15.25	Granite Gneiss	18.3	0.14
5	Murnad	12.321445 75.756491	147.925	16.775	Granite Gneiss	24.4	4.57
6	Hakethur	12.352001 75.760145	67.1	18.3	Granite Gneiss	24.4	1.41
7	Kognadu	12.428313 75.576533	48.8	6.1	Granite Gneiss	36.6	1.41
8	Cheerambane	12.360799 75.637278	61	24.4	Granite Gneiss	45.75	1.41
9	Barike	12.385476 75.542012	91.5	24.4	Charnockite	24.4	1.41
10	Iyyengiri	12.353262 75.579226	106.75	30.5	Charnockite	91.5	0.8

2.2 3 D aquifer disposition and Cross-Sections

Aquifer disposition

The disposition of Aquifer-I and Aquifer-II followed by massive formation can be observed in the 3-D aquifer disposition. The depth of the top soil is in the range of 0 to 1 m bgl, followed by weathered aquifer observed upto 30.5 m, which is followed by fractured aquifer which is disposed from 30.5 to 91.5 m bgl depth followed by massive formation devoid of any ground water (Fig.-24).

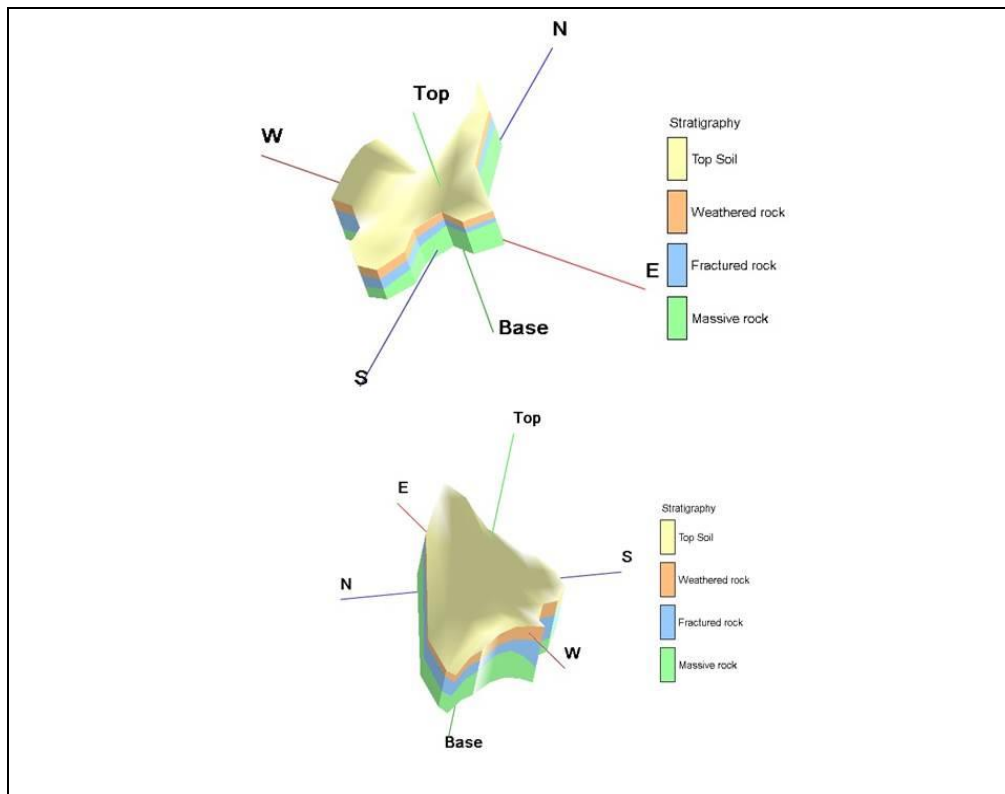


Figure 24 3D aquifer Disposition

Hydrogeological Cross Sections

Hydrogeological cross section A-A' (**Fig.-25**) represents north west – south east direction and data of well inventory borewell have been utilised. It can be clearly seen from the north west – south east direction i.e., from JNV to Murnad, the thickness of Aquifer-II (deeper aquifer) is decreasing. On the contrary, the thickness of Aquifer-I (shallow aquifer) is increasing. The maximum depth of Aquifer-II is attained at JNV location.

Hydrogeological cross section A-A' (**Fig.-25**) represents east – west direction and data of well inventory borewell have been utilised. It can be clearly seen from the section that the thickness of Aquifer-II is maximum in initial part of the section near Iyyengiri and cheerambane as we move towards east part Aquifer –II thickness is decreasing. In aquifer – I disposition is also decreasing from Iyyengiri to Ibbniwala.

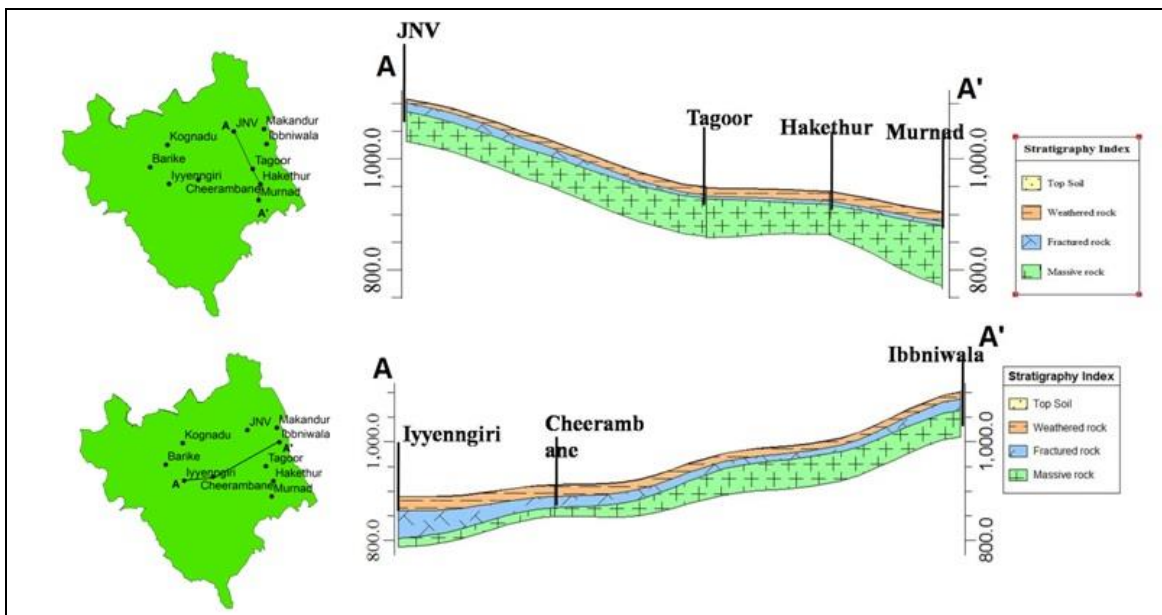


Figure 25 Cross sections in different directions

Aquifer Fence diagram

The fence diagram indicating the disposition of various aquifers is presented in **Fig.-26**. The Fence diagram shows Aquifer Disposition from different direction. The top soil is followed by weathered formation (up to 30.5 meter). Fracture formation ranges from 30.5 meter to 91.5 meter. It is followed by massive formation.

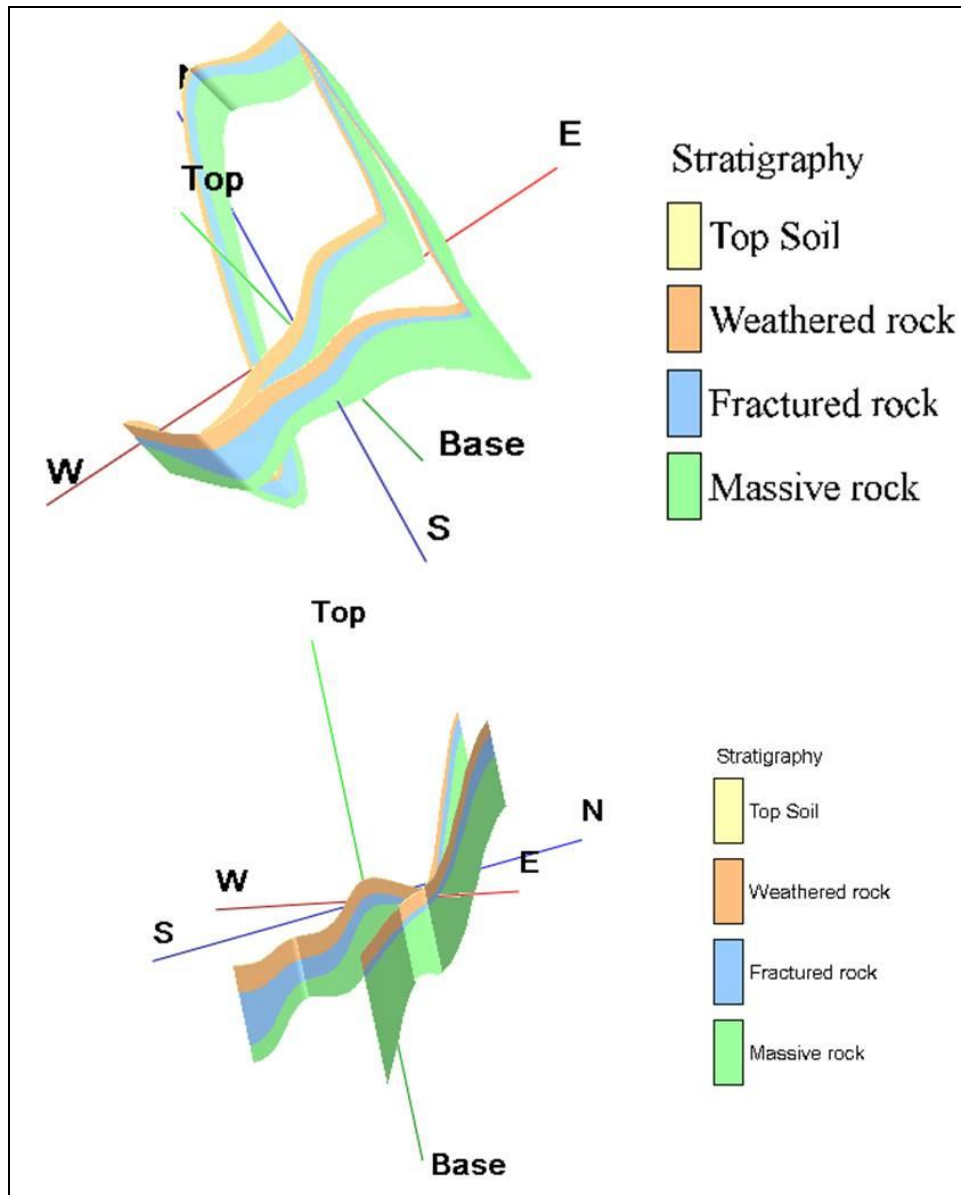


Figure 26 3D Aquifer Fence Diagram

3. Groundwater resource, extraction, contamination and other issues

3.1 Comparison of Groundwater availability and draft scenario in Madikeri taluk

The Dynamic Groundwater Resource 2022 and as on 2020 have summarized and presented in Table-17. It is observed that the ground water availability in 2022 is decreased compare to 2020. Groundwater draft in 2022 is less compare to 2020. Stage of Groundwater development is 36.42%. As Madikeri taluk is 'safe' category, there is scope to develop the Groundwater resources in this taluk through additional wells in feasible areas. In view of the prevailing practice of abstraction structures, bore wells are the preferred structures in the area.

Table 17 Total Groundwater Resources (2022) (Ham)

Taluk	GW availability (in ham)	GW draft (in ham)	Stage of GW development	GW availability (in ham)	GW draft (in ham)	Stage of GW development
	2022			2020		
Madikeri	5667.59	2064.15	36.42	14172.33	2441.65	17.23

3.2 Chemical Quality of Groundwater and Contamination

The water samples were collected for both Aquifer-I and Aquifer-II in different parts of Madikeri taluk and analysed in CGWB, Bangalore laboratory. Interpretation from Chemical Analysis results in Madikeri taluk is mentioned as under: (**Table-18 & Table-19**) .Electrical Conductivity (EC) In general, ranges from 40 to 440 μ /mhos/cm in the aquifer-I at 25°C (**Fig-27**) and range from 60 to 420 μ /mhos/cm in the aquifer-II (**Fig-30**). Electrical Conductivity values in Groundwater Samples (Aquifer-I and Aquifer-II) are fresh as EC values is less than 750 μ /mhos/cm. Fluoride concentration in Groundwater samples ranges between 0.01 and 0.57 mg/l in the aquifer-I (**Fig-28**) and ranges between 0.04 and 1.01 mg/l in the aquifer-II (**Fig-31**). Fluoride concentration is in Madikeri Taluk is within the Permissible limit (1.5 mg/l). Nitrate concentration in ground water ranges from 0.07 and 45.60 mg/l in the Aquifer –I (**Fig-29**) and ranges from 0.17 and 31.1 mg/l in the Aquifer –II (**Fig-32**). Nitrate Concentration is in Neerkoli Samples (One location) above permissible limit.

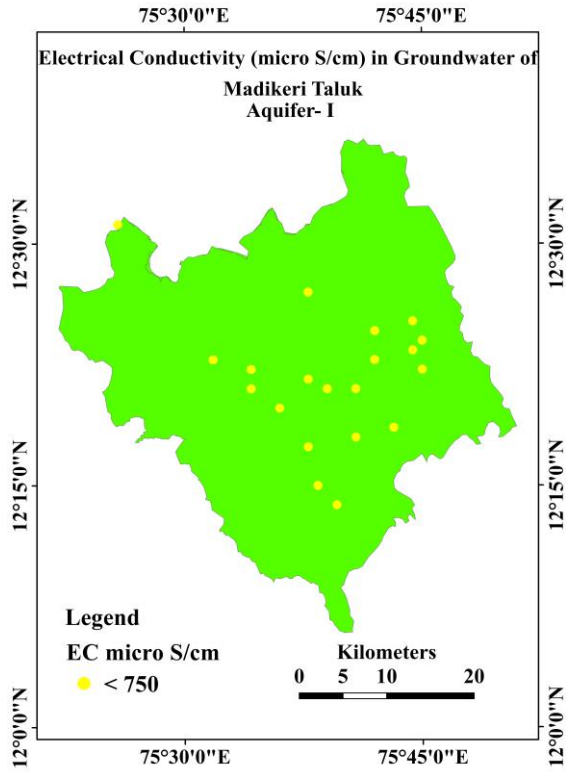


Figure 27 EC Distribution Map

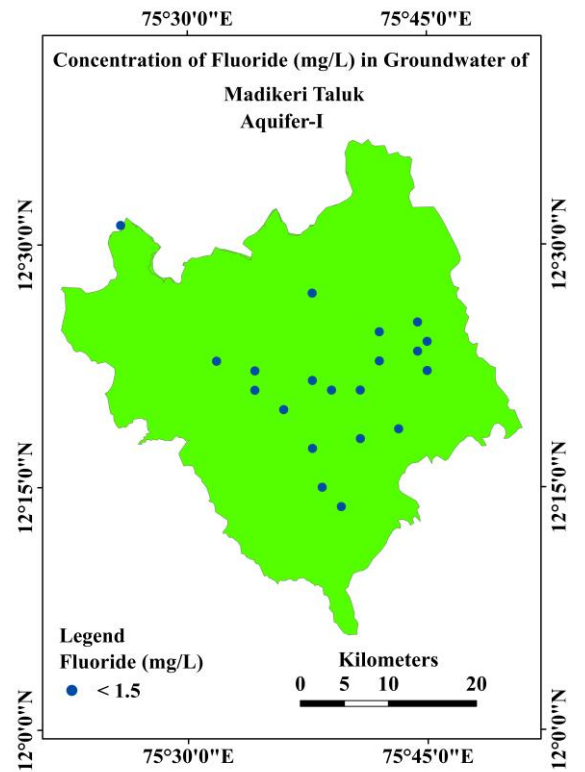


Figure 28 Fluoride Distribution Map

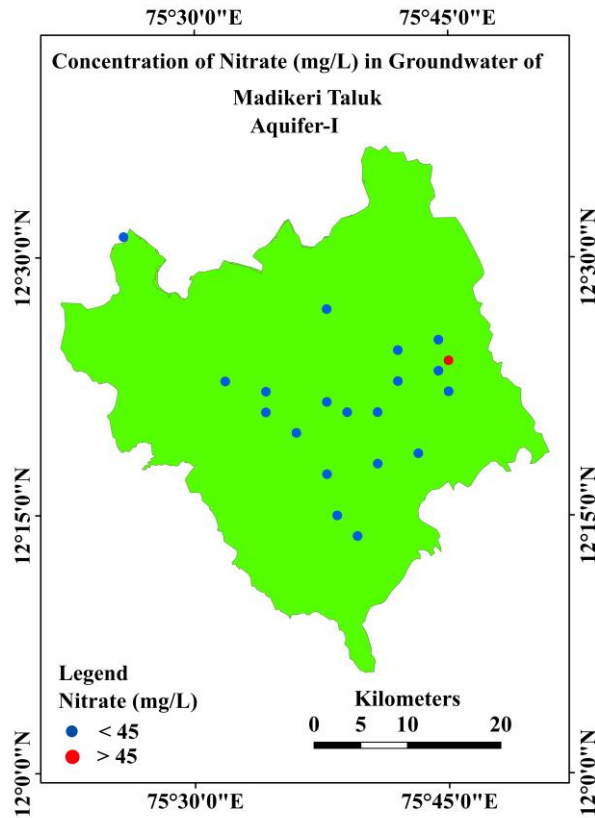


Figure 29 Nitrate Distribution Map

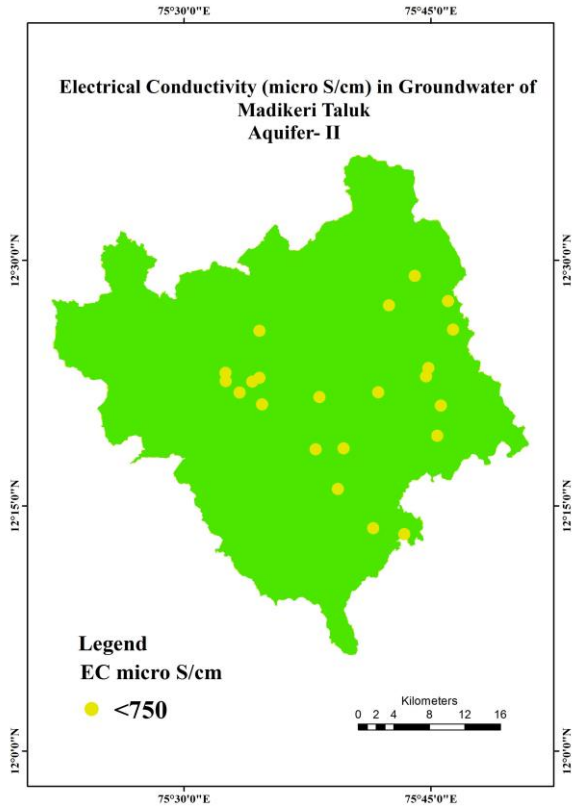


Figure 30 EC Distribution Map

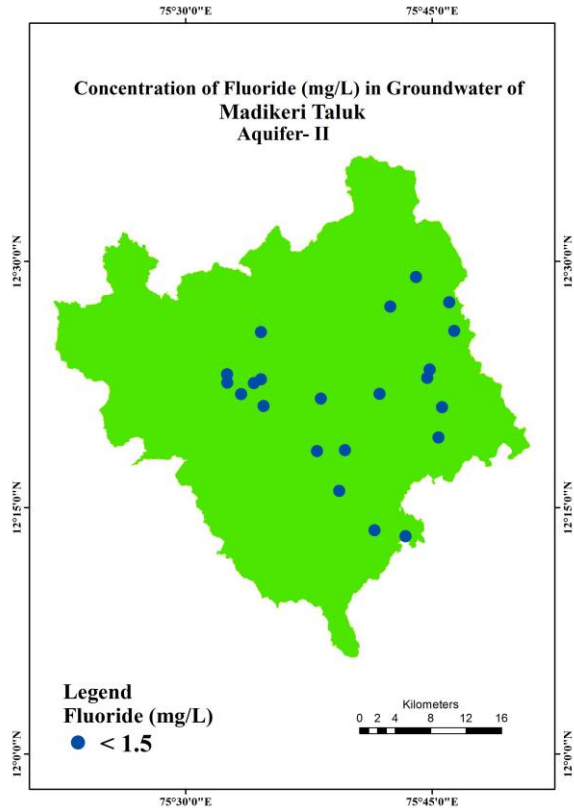


Figure 31 Fluoride Distribution Map

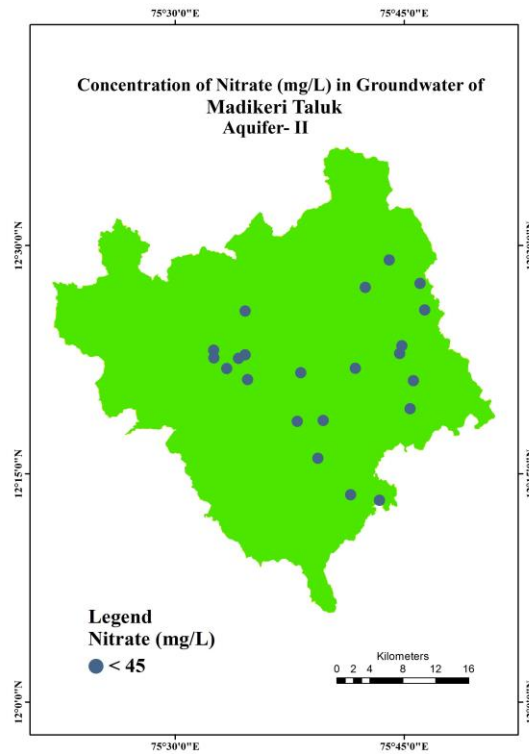


Figure 32 Nitrate Distribution Map

Table 18 Water quality parameters (Aquifer-I)

Sl. No.	Location	Type of sample	EC (micro S/cm)	F (mg/L)	NO3 (mg/L)
1	Marandoda	DW	150	0.13	2.77
2	Kakkabe	DW	80	0.11	6.41
3	Nelaje	DW	160	0.14	4.53
4	Napoklu	DW	150	0.06	7.24
5	Hoodur	DW	80	0.07	31.41
6	Murnad	DW	90	0.01	8.15
7	Khegodu	DW	160	0.02	14.2
8	Mekari	DW	150	0.03	10.5
9	Neerkolli	DW	440	0.02	45.6
10	Mercara	DW	220	0.14	13.10
11	Katakeri	DW	150	0.19	0.30
12	Devarakolli	DW	70	0.17	0.10
13	Peraje	DW	80	0.12	5.5
14	Heravanad	DW	40	0.03	0.9
15	Bettagiri	DW	160	0.42	0.07
16	Benguru 50 Okallu	DW	140	0.57	2.6
17	Cheerambane	DW	120	0.3	28.1
18	Chattamani	DW	230	0.11	24.1
19	Bhagamandala	DW	40	0	1.1
20	Ayyangeri	DW	50	0	2.9
21	Ballamavathu	DW	100	0.03	6.6

Table 19 Water quality parameters (Aquifer-II)

Sl. No.	Location	Type of sample	EC (micro S/cm)	F (mg/l)	NO ₃ (mg/l)
1	Ibbniwalawadi	BW	160	0.11	20.3
2	Makandur	BW	180	0	10.0
3	Mandalatti	BW	60	0	0.92
4	JNV	BW	90	0.04	0.61
5	Mekari	BW	180	0.52	0.4
6	Tagoor	BW	280	0.81	0.39
7	Murnad	BW	250	1.01	31.1
8	Hakethur	BW	90	0.67	11.3
9	Kognadu	BW	60	0	5.7
10	Chettamani	BW	220	0.92	0.73
11	Bettigiri	BW	140	0.33	1.28
12	Cheerambane	BW	280	0.97	1.27
13	Neeroke	BW	110	0.78	0.36
14	Barike	BW	100	0.57	1.2
15	Bhagmandala	BW	100	0.65	6.7
16	Korangala	BW	110	0.94	0.48
17	Iyyengiri	BW	250	0.37	1.80
18	Nelaji	BW	210	0.52	1.82
19	Chonakeri	BW	250	0.28	0.51
20	Kunda	BW	230	0.31	0.17
21	Nariyanada	BW	240	0.76	0.4
22	Poddamani	BW	420	0.29	0.49

4. GROUNDWATER RESOURCE ENHANCEMENT AND PROPOSED MANAGEMENT STRATEGY

4.1 Resource Enhancement by Supply Side Interventions

Recharge dry **phreatic aquifer (Aq-I)** in the taluk, through construction of artificial recharge structures, viz; check dams, percolation tanks & Sub surface dyke (Table-20). The choice of recharge structures should be site specific and such structures need to be constructed in areas as feasible for artificial recharge.

Table 20 Quantity of non-committed surface runoff & expected recharge through AR structures

Artificial Recharge Structures Proposed	Madikeri taluk
Non committed monsoon runoff available (MCM)	46.626
Total no. of existing Artificial Recharge Structures	292
Number of Check Dams	238
Number of Percolation Tanks	42
Number of Sub surface dyke	1
Tentative total cost of the project (Rs. in lakhs)	3257.624 Lakhs
Excepted recharge (MCM)	34.969
Additional Irrigation Potential (MCM)	42

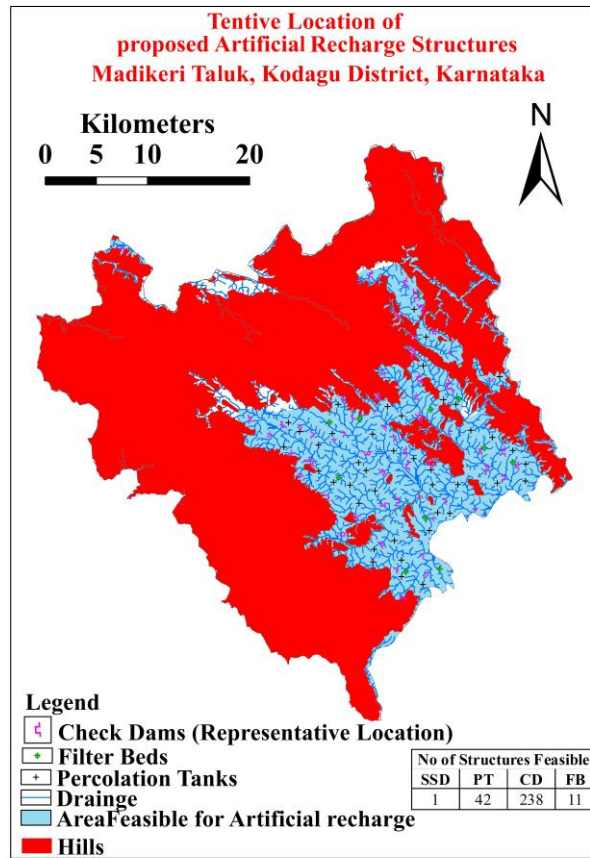


Figure 33 Tentative location of representative Artificial Recharge Structures

Table 21 Improvement in GW availability due to Recharge, Madikeri taluk

Taluk	Net annual ground water availability	Existing gross ground water draft for all uses	Existing stage of ground water development	Expected recharge from proposed artificial recharge structures	Expected improvement in stage of ground water development after the implementation of the project	Expected improvement in overall stage of ground water development
—	HAM	HAM	%	HAM	%	%
Madikeri	5667.59	2064.15	36.42	3496.9	22.52	13.9

After implementation of Artificial Recharge structures for GW recharge, the annual Groundwater availability will increase from 5667.59 to 9164.49 ham and the expected improvement in stage of development is 13.9% from 36.42% to 22.52% (Table-21).

4.1.1 Strategic Action Plan

The provision for minimum protective irrigation can only improve the agricultural growth in the taluk which is dependent on rain. This objective can be achieved by utilizing the rain water more efficiently by harvesting structures like farm ponds, check-dams, barrages and other surface structures. The Strategic Action Plan, prepared for the taluk has included the irrigation infrastructure for major irrigation, minor irrigation, ground water recharge, harvesting of rain water, improvement of irrigation efficiency and strengthening the adoption of micro-irrigation. Considering the existing infrastructure in the taluk and considering the irrigation potential required to be created to meet the gap between demand and supply of all the sectors of water use, the Strategic Action Plans are developed under PMKSY project and the same is given below.

4.1.2 Benefits of Artificial recharge scheme

- These structures have proved in building-up of ground water levels and sustainability of ground water abstraction structures, mainly in bore wells.
- An increase in the area irrigated by ground water source is also observed in the area of influence.
- Such activities help in providing sustainable drinking water to the rural population. The qualitative result from farmer's perception indicate that, there is rising trend in ground water levels in the area of influence, productivity of crops enhanced and improvement in yield is observed in bore wells.

4.2 Resource Savings by Demand Side Interventions

4.2.1 Water Use Efficiency by Micro Irrigation Practices

Madikeri Taluk falls under Safe category with the stage of groundwater extraction of 36.42 %. However, Water Use Efficiency (WUE) practices like Drip irrigation needs to be strengthened. This ultimately enhances the area under irrigation potential.

4.2. Groundwater Development Plan

In Madikeir taluk, the present stage of ground water extraction (2022) is merely 36.42 % with net ground water availability for future use of 3787.14 ham and total extraction of 2064.15 ham. The ground water draft for irrigation purpose is estimated to be 1697.9 ham and there is further scope for developing the resource for irrigation as a part of development with appropriate scientific backing. The implementation of the plan should be based on site specific detailed hydrogeological and scientific surveys for pinpointing the sites for construction of additional abstraction structures. As per tentative estimates, 68 dug wells and 480 bore wells are recommended to be constructed in feasible areas which is likely to create about 685 hectares of additional irrigation potential (Table.22).

Table 22 Feasibility of Additional GW abstraction structures based on GWRA 2022 availability

Annual Extractable GW Resource (Ham)	5667.59
Total Extraction / Draft (Ham)	2064.15
Stage of GW Extraction (%)	36.42
GW Resources available to increase SOE to 60% (Ham)	3400.554
Balance GWR available to enhance SOE 60% (Ham)	1336.404
DW unit draft (Ham)	1.00
BW unit draft (Ham)	1.25
No. of DW feasible considering 10% of balance GWR with unit draft of 1 ham	134
No. of BWs feasible considering 90% of balance GWR with unit draft of 1.25 ham	1202
GW Resource to be developed through Dug well (ham) (50% taken of actual nos.)	68
GW Resource to be developed through Bore well (ham) (50% taken of actual nos.)	480
Additional Irrigation Potential created by Dug Wells (Ha)	85
Additional Irrigation Potential created by Bore Wells (Ha)	600
Total additional Irrigation Potential created by Bore wells and Dug wells (ha)	685

(Note- Hydrogeological and scientific intervention is needed for pinpointing the sites for construction of dug wells and Bore wells)

4.3. Regulation and Control

Madikeri taluk has been categorized as "Safe". However, the mandatory guidelines like rainwater harvesting and artificial recharge issued by Karnataka Ground Water Authority(KGWA) needs to be strictly implemented to avoid the taluk from safe category to semi critical or higher category in the future.

4.4. Other interventions proposed

- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- Excess nitrate concentration is found in ground water samples (One sample; Location- Neerkoli) require remedial measures viz. dilution of nitrate rich ground water through artificial recharge & water conservation.
- Roof top rain water harvesting

5 SUMMARY AND RECOMMENDATIONS

The main ground water issues are Low Ground Water Development, Limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, which are all inter-related or inter dependent and Inferior Ground Water Quality due to nitrate contamination major part of the area. The summary of ground water management plan of Madikeri taluk is given in Table-23.

Table 23 Summary of Management plan of Madikeri taluk

Madikeri taluk is Safe & present stage of Ground water extraction (2022)	36.42%
Net Annual Ground Water Availability (MCM)	56.67
Existing Gross Ground Water extraction for all uses(MCM)	20.64
Total GW Resources (Dynamic & Static upto the depth of 150 mbgl) (MCM)	00
Expected additional recharge from monsoon surplus runoff (MCM)	34.969
Change in Stage of GW development, %	36.42 to 22.52
Excess nitrate concentration	Dilution of nitrate rich ground water through artificial recharge & water conservation. Roof top rain water harvesting.
Water Use efficiency measures	Government to take initiative to encourage at least 70% farmers to adopt water use efficiency irrigations practices like dip & sprinkler irrigation

As per the resource estimation – 2022, Madikeri taluk falls under Safe category with the stage of Groundwater extraction is 36.42 %. However, there is need to formulate management strategy to tackle the water scarcity related issues in the taluk in the coming days to avoid water crisis in the

future. It is suggested to adopt a scientific and multi-pronged ground water management strategy covering supply side interventions, demand side interventions, ground water development interventions and groundwater quality protection aspects as mentioned in the management plan suggested above

Ground water resource enhancement by supply side interventions: Quantity of surface water available through non-committed surface run-off is estimated to be 4662.59 ham. This can be used to recharge the aquifer mainly through percolation tanks (42), check dams (238) and sub-surface dyke structures (1). The volume of water expected to be conserved/recharged is 3496.9 ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 32.57 Cr. The additional area which can be brought under assured ground water irrigation will be about 4200 hectares. However, the figures given are tentative and pre-field studies / DPR are recommended prior to implementation of these recharge structures.

Ground water resource enhancement by demand side interventions: The micro irrigation practices like drip and sprinkler irrigation are needs to be strengthened for irrigation. The micro irrigation water efficient methodology needs to be adopted for growing water intensive crop like Paddy. Implementation of efficient irrigation techniques will contribute in saving Groundwater. Artificial recharge structures like check dam, nala bund, percolation tank and roof top rainwater harvesting structures should also be incorporated in taluk.

By adopting the supply side and demand side management plan itself, the stage of groundwater extraction decreases to 22.52 % from 36.42% and the taluk falls under safe category.

Annexure-I: Tentative locations of Proposed Check Dams, Madikeri Taluk, Kodagu District

SI NO	Longitude	Latitude	Village	Gramapanchayat	Taluk
1	75.694441	12.206828	Chelavara	Nariyandada	Madikeri
2	75.692896	12.211234	Chelavara	Nariyandada	Madikeri
3	75.706912	12.213687	Karada	Nariyandada	Madikeri
4	75.716353	12.215284	Karada	Nariyandada	Madikeri
5	75.683177	12.220694	Chelavara	Nariyandada	Madikeri
6	75.710045	12.220952	Karada	Nariyandada	Madikeri
7	75.702751	12.221554	Nariyandada	Nariyandada	Madikeri
8	75.691200	12.224463	Nariyandada	Nariyandada	Madikeri
9	75.731437	12.225041	Podhawada	Nariyandada	Madikeri
10	75.704151	12.226553	Nariyandada	Nariyandada	Madikeri
11	75.716794	12.228491	Podhawada	Nariyandada	Madikeri
12	75.691064	12.231285	Nariyandada	Nariyandada	Madikeri
13	75.647490	12.232296	Yavakapadi	Kunijala	Madikeri
14	75.694926	12.234762	Nariyandada	Nariyandada	Madikeri
15	75.686599	12.235000	Kokeri	Konanjageri	Madikeri
16	75.679611	12.237195	Maradhoda	Kunijala	Madikeri
17	75.661124	12.237240	Maradhoda	Kunijala	Madikeri
18	75.724063	12.237719	Arepattu	Nariyandada	Madikeri
19	75.636955	12.241498	Yavakapadi	Kunijala	Madikeri
20	75.660359	12.242792	Maradhoda	Kunijala	Madikeri
21	75.687800	12.243108	Kokeri	Konanjageri	Madikeri
22	75.678110	12.244891	Kokeri	Konanjageri	Madikeri
23	75.713904	12.245189	Nariyandada	Nariyandada	Madikeri
24	75.703190	12.249577	Kokeri	Konanjageri	Madikeri
25	75.664626	12.250775	Kokeri	Konanjageri	Madikeri
26	75.686033	12.251450	Kokeri	Konanjageri	Madikeri
27	75.715383	12.251883	Bavali	Konanjageri	Madikeri
28	75.676420	12.254625	Kokeri	Konanjageri	Madikeri
29	75.621577	12.254632	Naladi	Kunijala	Madikeri
30	75.632088	12.255374	Kunjala	Kunijala	Madikeri
31	75.627612	12.255384	Naladi	Kunijala	Madikeri
32	75.668774	12.255789	Kokeri	Konanjageri	Madikeri
33	75.704375	12.256081	Bavali	Konanjageri	Madikeri
34	75.683437	12.258627	Kokeri	Konanjageri	Madikeri
35	75.672921	12.260325	Kokeri	Konanjageri	Madikeri
36	75.648533	12.261137	Kunjala	Kunijala	Madikeri
37	75.641252	12.262626	Kunjala	Kunijala	Madikeri

38	75.661131	12.263823	Kunjala	Kunijala	Madikeri
39	75.691625	12.264157	Kirundadu	Konanjageri	Madikeri
40	75.635418	12.264553	Kunjala	Kunijala	Madikeri
41	75.668072	12.267036	Kolakeri	Napoklu	Madikeri
42	75.654310	12.269868	Kunjala	Kunijala	Madikeri
43	75.658594	12.271006	Kunjala	Kunijala	Madikeri
44	75.669551	12.274449	Kolakeri	Napoklu	Madikeri
45	75.722603	12.276327	Konajageri	Konanjageri	Madikeri
46	75.685430	12.276805	Kaikadu	Konanjageri	Madikeri
47	75.654233	12.278314	Kolakeri	Napoklu	Madikeri
48	75.671999	12.280664	Kolakeri	Napoklu	Madikeri
49	75.733344	12.282878	Balamuri	Konanjageri	Madikeri
50	75.654733	12.283816	Kolakeri	Napoklu	Madikeri
51	75.746745	12.284733	M.Badaga	Kanturu Marnadu	Madikeri
52	75.761546	12.285905	Kiggalu	Kanturu Marnadu	Madikeri
53	75.713675	12.285921	Konajageri	Konanjageri	Madikeri
54	75.665688	12.286421	Kolakeri	Napoklu	Madikeri
55	75.632115	12.287218	Nelaji	Ballamavati	Madikeri
56	75.678591	12.289500	Kolakeri	Napoklu	Madikeri
57	75.647097	12.292662	Nelaji	Ballamavati	Madikeri
58	75.691895	12.293250	Bethu	Napoklu	Madikeri
59	75.735502	12.293339	Balamuri	Konanjageri	Madikeri
60	75.642849	12.294443	Nelaji	Ballamavati	Madikeri
61	75.711673	12.295989	Balamuri	Konanjageri	Madikeri
62	75.704954	12.296989	Bethu	Napoklu	Madikeri
63	75.758034	12.297435	M.Badaga	Kanturu Marnadu	Madikeri
64	75.629360	12.297467	Nelaji	Ballamavati	Madikeri
65	75.780427	12.297508	Kiggalu	Kanturu Marnadu	Madikeri
66	75.651139	12.298974	Nelaji	Ballamavati	Madikeri
67	75.642928	12.299293	Nelaji	Ballamavati	Madikeri
68	75.800702	12.301008	Sodluru Kattemadu	Maragodu	Madikeri
69	75.659051	12.301049	Napoklu	Napoklu	Madikeri
70	75.785101	12.301749	Aikola	Kanturu Marnadu	Madikeri
71	75.627910	12.301777	Nelaji	Ballamavati	Madikeri
72	75.773143	12.302613	Kiggalu	Kanturu Marnadu	Madikeri
73	75.625291	12.305515	Nelaji	Ballamavati	Madikeri
74	75.703811	12.306323	Bethu	Napoklu	Madikeri
75	75.714233	12.307084	Hodduru	Hodduru	Madikeri
76	75.661804	12.307322	Napoklu	Napoklu	Madikeri
77	75.750664	12.307915	M.Badaga	Kanturu Marnadu	Madikeri
78	75.679784	12.308894	Napoklu	Napoklu	Madikeri
79	75.799926	12.309265	Sodluru Kattemadu	Maragodu	Madikeri
80	75.674921	12.309863	Napoklu	Napoklu	Madikeri
81	75.643316	12.310282	Nelaji	Ballamavati	Madikeri

82	75.730011	12.311062	Hodduru	Hodduru	Madikeri
83	75.788984	12.311539	Aikola	Kanturu Marnadu	Madikeri
84	75.654516	12.311826	Napoklu	Napoklu	Madikeri
85	75.696535	12.312680	Bethu	Napoklu	Madikeri
86	75.743836	12.312938	Kodamburu	Kanturu Marnadu	Madikeri
87	75.712308	12.314936	Hodduru	Hodduru	Madikeri
88	75.623976	12.315142	Ballamavati	Ballamavati	Madikeri
89	75.694595	12.315173	Bethu	Napoklu	Madikeri
90	75.795383	12.315558	Sodluru Kattemadu	Maragodu	Madikeri
91	75.782153	12.315596	Aikola	Kanturu Marnadu	Madikeri
92	75.652702	12.316316	Yemmemadu	Yammemadu	Madikeri
93	75.639225	12.316722	Yemmemadu	Yammemadu	Madikeri
94	75.604327	12.316765	Peruru	Ballamavati	Madikeri
95	75.647895	12.317449	Yemmemadu	Yammemadu	Madikeri
96	75.775773	12.318007	Aikola	Kanturu Marnadu	Madikeri
97	75.678446	12.318085	Napoklu	Napoklu	Madikeri
98	75.812781	12.318242	Sodluru Kattemadu	Maragodu	Madikeri
99	75.771674	12.320411	Kanthuru	Kanturu Marnadu	Madikeri
100	75.738992	12.320799	Kodamburu	Kanturu Marnadu	Madikeri
101	75.761792	12.321485	Kanthuru	Kanturu Marnadu	Madikeri
102	75.782574	12.322282	Aikola	Kanturu Marnadu	Madikeri
103	75.699870	12.322433	Hodhavada	Hodduru	Madikeri
104	75.797613	12.322919	Sodluru Kattemadu	Maragodu	Madikeri
105	75.648822	12.322980	Yemmemadu	Yammemadu	Madikeri
106	75.722065	12.323907	Hodduru	Hodduru	Madikeri
107	75.643808	12.325085	Yemmemadu	Yammemadu	Madikeri
108	75.790089	12.325143	Hosakeri	Hosakeri	Madikeri
109	75.814362	12.325893	Sodluru Kattemadu	Maragodu	Madikeri
110	75.759677	12.326276	Kanthuru	Kanturu Marnadu	Madikeri
111	75.697158	12.327608	Paluru	Hodduru	Madikeri
112	75.768254	12.328235	Kanthuru	Kanturu Marnadu	Madikeri
113	75.613604	12.328417	Ballamavati	Ballamavati	Madikeri
114	75.819451	12.328645	Arekadu	Hosakeri	Madikeri
115	75.715269	12.330241	Hodhavada	Hodduru	Madikeri
116	75.676530	12.330339	Napoklu	Napoklu	Madikeri
117	75.808204	12.330772	Sodluru Kattemadu	Maragodu	Madikeri
118	75.642910	12.331069	Yemmemadu	Yammemadu	Madikeri
119	75.664611	12.334830	Kadiyatthuru	Bettageri	Madikeri
120	75.596164	12.334991	Doddapulikotu	Benguru	Madikeri
121	75.698346	12.335261	Paluru	Hodduru	Madikeri
122	75.802898	12.336171	Hosakeri	Hosakeri	Madikeri
123	75.766582	12.336425	Kanthuru	Kanturu Marnadu	Madikeri
124	75.787844	12.337112	Hosakeri	Hosakeri	Madikeri
125	75.602792	12.338996	Doddapulikotu	Benguru	Madikeri

126	75.682904	12.339842	Paluru	Hodduru	Madikeri
127	75.763200	12.339921	Kanthuru	Kanturu Marnadu	Madikeri
128	75.613114	12.340887	B.Badaga	Benguru	Madikeri
129	75.781620	12.341018	Maragodu	Maragodu	Madikeri
130	75.564788	12.341019	Aiyyangeri	Aiyamgeri	Madikeri
131	75.579696	12.342483	Aiyyangeri	Aiyamgeri	Madikeri
132	75.760896	12.342959	Muttharumudi	Kanturu Marnadu	Madikeri
133	75.750011	12.343195	Muttharumudi	Kanturu Marnadu	Madikeri
134	75.624779	12.344158	Benguru	Benguru	Madikeri
135	75.658551	12.344415	Aivatthoklu	Bettageri	Madikeri
136	75.599170	12.345132	Doddapulikutu	Benguru	Madikeri
137	75.677201	12.345599	Kadiyatthuru	Bettageri	Madikeri
138	75.697886	12.345666	Paluru	Hodduru	Madikeri
139	75.610011	12.345871	B.Badaga	Benguru	Madikeri
140	75.689859	12.347242	Paluru	Hodduru	Madikeri
141	75.604499	12.347364	B.Badaga	Benguru	Madikeri
142	75.755802	12.347366	Muttharumudi	Kanturu Marnadu	Madikeri
143	75.571646	12.347435	Aiyyangeri	Aiyamgeri	Madikeri
144	75.634521	12.347581	Benguru	Benguru	Madikeri
145	75.628681	12.347594	Benguru	Benguru	Madikeri
146	75.556023	12.347706	Sannapulikutu	Aiyamgeri	Madikeri
147	75.619923	12.348954	B.Badaga	Benguru	Madikeri
148	75.657347	12.349502	Aivatthoklu	Bettageri	Madikeri
149	75.698872	12.350449	Bettageri	Bettageri	Madikeri
150	75.615644	12.350686	B.Badaga	Benguru	Madikeri
151	75.624990	12.351048	Benguru	Benguru	Madikeri
152	75.599184	12.351114	B.Badaga	Benguru	Madikeri
153	75.589603	12.351583	Doddapulikutu	Benguru	Madikeri
154	75.576370	12.351761	Aiyyangeri	Aiyamgeri	Madikeri
155	75.738085	12.352068	Bilageri	Hakathuru	Madikeri
156	75.643099	12.352537	Benguru	Benguru	Madikeri
157	75.695105	12.352611	Bettageri	Bettageri	Madikeri
158	75.717646	12.353127	Arvathoklu	Bettageri	Madikeri
159	75.594017	12.353219	B.Badaga	Benguru	Madikeri
160	75.621491	12.353353	B.Badaga	Benguru	Madikeri
161	75.610591	12.354526	B.Badaga	Benguru	Madikeri
162	75.618968	12.356612	B.Badaga	Benguru	Madikeri
163	75.764316	12.356997	Hadatthuru	Hakathuru	Madikeri
164	75.666037	12.357708	Karugunda	Bettageri	Madikeri
165	75.636298	12.357721	Benguru	Benguru	Madikeri
166	75.559331	12.358227	Sannapulikutu	Aiyamgeri	Madikeri
167	75.680221	12.358324	Bettageri	Bettageri	Madikeri
168	75.603982	12.358943	B.Badaga	Benguru	Madikeri
169	75.614886	12.359684	B.Badaga	Benguru	Madikeri

170	75.588405	12.359960	Berandetti	Kundacheri	Madikeri
171	75.663854	12.360704	Karugunda	Bettageri	Madikeri
172	75.728618	12.360706	Bilageri	Hakathuru	Madikeri
173	75.564935	12.361565	Sannapulikotu	Aiyamgeri	Madikeri
174	75.690938	12.361647	Bettageri	Bettageri	Madikeri
175	75.551915	12.361711	Korangala	Bhagamandala	Madikeri
176	75.740742	12.362253	Bilageri	Hakathuru	Madikeri
177	75.761403	12.362765	Hadatthuru	Hakathuru	Madikeri
178	75.722785	12.363737	Arvathoklu	Bettageri	Madikeri
179	75.683254	12.363963	Bettageri	Bettageri	Madikeri
180	75.612171	12.364284	B.Badaga	Benguru	Madikeri
181	75.583243	12.364457	Berandetti	Kundacheri	Madikeri
182	75.689488	12.365670	Bettageri	Bettageri	Madikeri
183	75.591916	12.365784	Berandetti	Kundacheri	Madikeri
184	75.559590	12.365882	Sannapulikotu	Aiyamgeri	Madikeri
185	75.681897	12.366455	Heravanadu	Bettageri	Madikeri
186	75.580207	12.367006	Singatur	Kundacheri	Madikeri
187	75.673917	12.367240	Karugunda	Bettageri	Madikeri
188	75.651314	12.367638	Karugunda	Bettageri	Madikeri
189	75.711991	12.367641	Arvathoklu	Bettageri	Madikeri
190	75.719003	12.368914	Arvathoklu	Bettageri	Madikeri
191	75.671883	12.371360	Karugunda	Bettageri	Madikeri
192	75.554735	12.371635	Korangala	Bhagamandala	Madikeri
193	75.677725	12.371729	Heravanadu	Bettageri	Madikeri
194	75.706752	12.374401	Arvathoklu	Bettageri	Madikeri
195	75.692295	12.374439	Heravanadu	Bettageri	Madikeri
196	75.714638	12.374668	Arvathoklu	Bettageri	Madikeri
197	75.678149	12.381508	Heravanadu	Bettageri	Madikeri
198	75.642786	12.383545	Kolagadalu	Made	Madikeri
199	75.708237	12.383680	Heravanadu	Bettageri	Madikeri
200	75.673195	12.385684	Avandhuru	Made	Madikeri
201	75.695591	12.387541	Heravanadu	Bettageri	Madikeri
202	75.733248	12.390095	Mekeri	Mekeri	Madikeri
203	75.693554	12.390130	Heravanadu	Bettageri	Madikeri
204	75.728086	12.393698	Mekeri	Mekeri	Madikeri
205	75.737977	12.394718	Mekeri	Mekeri	Madikeri
206	75.697267	12.395097	Heravanadu	Bettageri	Madikeri
207	75.775094	12.398448	Kadagadalu	Kadagadalu	Madikeri
208	75.683277	12.398911	Madhe	Made	Madikeri
209	75.696210	12.399775	Madhe	Made	Madikeri
210	75.729781	12.401319	Katakeri	Made	Madikeri
211	75.683133	12.402051	Madhe	Made	Madikeri
212	75.710676	12.402125	Heravanadu	Bettageri	Madikeri
213	75.694088	12.402771	Madhe	Made	Madikeri

214	75.678729	12.405053	Madhe	Made	Madikeri
215	75.728209	12.405189	Katakeri	Made	Madikeri
216	75.692425	12.406514	Madhe	Made	Madikeri
217	75.688017	12.408020	Madhe	Made	Madikeri
218	75.705828	12.409555	Katakeri	Made	Madikeri
219	75.740033	12.422710	Karnangeri	Madikeri	Madikeri
220	75.704929	12.424509	Katakeri	Made	Madikeri
221	75.732799	12.427883	Karnangeri	Madikeri	Madikeri
222	75.740362	12.429834	Karnangeri	Madikeri	Madikeri
223	75.728023	12.429867	Karaval Badaga	Madikeri	Madikeri
224	75.722942	12.433064	Karaval Badaga	Madikeri	Madikeri
225	75.705428	12.437999	Kalakeri Nidugane	Kalakeri Nidugane	Madikeri
226	75.724412	12.442194	Karaval Badaga	Madikeri	Madikeri
227	75.692986	12.457132	1st Monnangeri	Galibeedu	Madikeri
228	75.712711	12.463013	Galibeedu	Galibeedu	Madikeri
229	75.697495	12.463052	Galibeedu	Galibeedu	Madikeri
230	75.700262	12.473811	Galibeedu	Galibeedu	Madikeri
231	75.707875	12.475436	Galibeedu	Galibeedu	Madikeri
232	75.696016	12.479205	Galibeedu	Galibeedu	Madikeri
233	75.699692	12.486061	Galibeedu	Galibeedu	Madikeri
234	75.666615	12.491117	Galibeedu	Galibeedu	Madikeri
235	75.680946	12.496441	Galibeedu	Galibeedu	Madikeri
236	75.690832	12.500128	Kalooru	Galibeedu	Madikeri
237	75.452335	12.513428	Puthya Peraje	Peraje	Madikeri
238	75.443914	12.517049	Kundhalapadi Peraje	Peraje	Madikeri

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

Annexure -II: Tentative location of Proposed Percolation tanks, Madikeri taluk, Kodagu District

SI No	Longitude	Latitude	Village	Gramapanchayat	Taluk
1	75.714250	12.218342	Karada	Nariyandada	Madikeri
2	75.695150	12.225281	Nariyandada	Nariyandada	Madikeri
3	75.669408	12.238325	Maradhoda	Kunijala	Madikeri
4	75.695042	12.239924	Nariyandada	Nariyandada	Madikeri
5	75.670626	12.249585	Kokeri	Konanjageri	Madikeri
6	75.688834	12.257272	Kirundadu	Konanjageri	Madikeri
7	75.720196	12.266029	Konajageri	Konanjageri	Madikeri
8	75.738636	12.281232	Balamuri	Konanjageri	Madikeri
9	75.727775	12.281823	Balamuri	Konanjageri	Madikeri
10	75.656973	12.290297	Kolakeri	Napoklu	Madikeri

11	75.671406	12.301371	Napoklu	Napoklu	Madikeri
12	75.648898	12.306356	Nelaji	Ballamavati	Madikeri
13	75.723218	12.306544	Hodduru	Hodduru	Madikeri
14	75.746037	12.306647	M.Badaga	Kanturu Marnadu	Madikeri
15	75.781510	12.307833	Aikola	Kanturu Marnadu	Madikeri
16	75.634084	12.308963	Nelaji	Ballamavati	Madikeri
17	75.806917	12.309578	Sodluru Kattemadu	Maragodu	Madikeri
18	75.620795	12.318918	Ballamavati	Ballamavati	Madikeri
19	75.663470	12.319347	Napoklu	Napoklu	Madikeri
20	75.721893	12.319721	Hodduru	Hodduru	Madikeri
21	75.807147	12.324627	Sodluru Kattemadu	Maragodu	Madikeri
22	75.656772	12.326398	Yemmemadu	Yemmemadu	Madikeri
23	75.706420	12.329719	Hodhavada	Hodduru	Madikeri
24	75.795648	12.336599	Hosakeri	Hosakeri	Madikeri
25	75.688334	12.336656	Paluru	Hodduru	Madikeri
26	75.589494	12.340297	Doddapulikotu	Benguru	Madikeri
27	75.620682	12.341986	B.Badaga	Benguru	Madikeri
28	75.777128	12.348316	Hadatthuru	Hakathuru	Madikeri
29	75.669365	12.351478	Karugunda	Bettageri	Madikeri
30	75.633070	12.352066	Benguru	Benguru	Madikeri
31	75.603684	12.353921	B.Badaga	Benguru	Madikeri
32	75.757830	12.354651	Hadatthuru	Hakathuru	Madikeri
33	75.593645	12.361791	Berandetti	Kundacheri	Madikeri
34	75.695650	12.367585	Bettageri	Bettageri	Madikeri
35	75.682894	12.375842	Heravanadu	Bettageri	Madikeri
36	75.744401	12.377594	Kaggodlu	Mekeri	Madikeri
37	75.638533	12.377821	Kolagadalu	Made	Madikeri
38	75.733412	12.381691	Mekeri	Mekeri	Madikeri
39	75.783954	12.402003	Kadagadalu	Kadagadalu	Madikeri
40	75.715114	12.411793	Katakeri	Made	Madikeri
41	75.717851	12.437256	Karaval Badaga	Madikeri	Madikeri
42	75.707097	12.461672	Galibeedu	Galibeedu	Madikeri

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

Annexure-III: Tentative location of Proposed Filter Beds, Madikeri Taluk, Kodagu District

SI No	Longitude	Latitude	Village	Gramapanchayat	Taluk
1	75.698893	12.229748	Nariyandada	Nariyandada	Madikeri
2	75.729548	12.232156	Arepattu	Nariyandada	Madikeri
3	75.717069	12.277004	Konajageri	Konanjageri	Madikeri
4	75.638850	12.313166	Nelaji	Ballamavati	Madikeri
5	75.795571	12.326197	Hosakeri	Hosakeri	Madikeri
6	75.770003	12.339057	Kanthuru	Kanturu Marnadu	Madikeri
7	75.630539	12.362060	Benguru	Benguru	Madikeri
8	75.657447	12.365163	Karugunda	Bettageri	Madikeri
9	75.721812	12.373168	Arvathoklu	Bettageri	Madikeri
10	75.747116	12.382338	Kaggodlu	Mekeri	Madikeri
11	75.711261	12.475877	Galibeedu	Galibeedu	Madikeri

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