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

Turuvekere Taluk, Tumkur District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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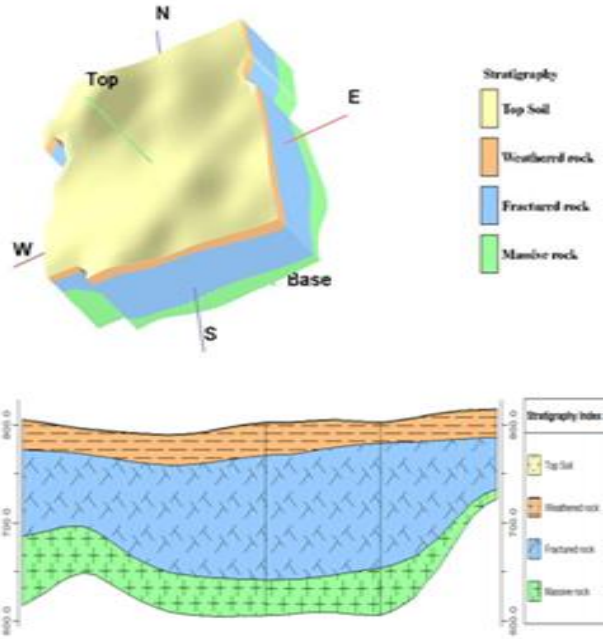
Bengaluru

AQUIFER MAPS AND MANAGEMENT PLAN, TURUVEKERE TALUK, TUMKUR DISTRICT, KARNATAKA STATE

(AAP – 2021-2022)



By

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AUGUST-2022

AQUIFER MAPS AND MANAGEMENT PLAN, TURUVEKERE TALUK, TUMKUR DISTRICT, KARNATAKA STATE

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AQUIFER MAPS AND MANAGEMENT PLAN, **TURUVEKERE** TALUK, **TUMKUR** DISTRICT, KARNATAKA STATE

1 SALIENT INFORMATION

Name of the taluk	: Turuvekere
District	: Tumkur
State	: Karnataka
Area	: 785 sq.km.
Population	: 1,68,994
Annual Normal Rainfall	:722.2

1.1 Study Area

Aquifer Mapping Studies have been carried out in Turuvekere taluk, Tumkur district of Karnataka, covering an area of 785 sq.kms under National Aquifer Mapping Project. The Turuvekere taluk is located between North Latitudes 13°04'42.73" and 13°05'36.89" and East Longitudes between 76°33'12.79" to 76°55'02.98". The study area is bounded on the north-east by Gubbi & north-west by Tiptur taluk, south by Nagamangala taluk of Mandya district and on the south-east by Kunigal taluk of Tumkur district. Location map of Turuvekere taluk of Tumkur district is presented in **Fig-1.** Turuvekere is taluk head quarter. There are 243 villages and 27 Gram panchayats and 4 hoblies in this taluk.

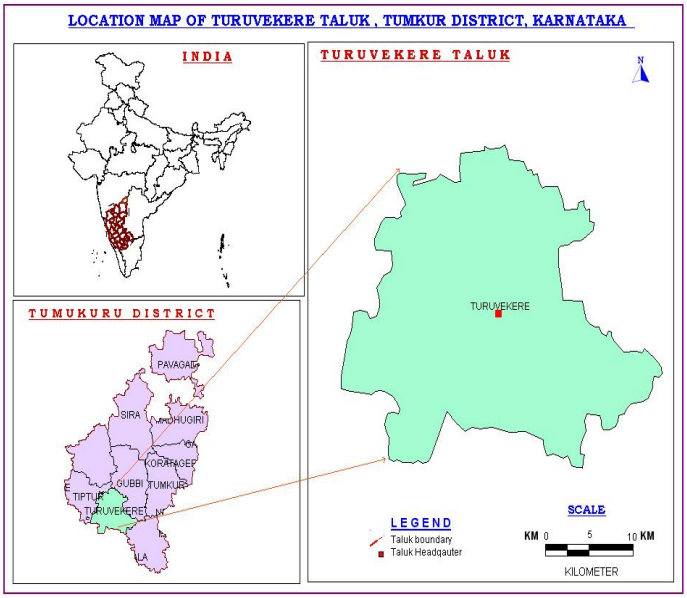

Fig-1: Location map of Turuvekere taluk of Tumkur district

1.2 Population

According to 2011 census, the population in Turuvekere taluk is 1,68,994 out of which 83,950 is male and 85, 044 is female. The taluk has an overall population density of 215.27 persons per sq.km. The decadal variation in population from 2001-2011 is -3.04 % in Turuvekere taluk.

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
168994	83950	85044	6.30	152177	16817	-3.04	2.9	3.9

Source: District at a glance 2016-17, Govt. of Karnataka

1.3 Rainfall and Climate

Turuvekere taluk enjoys semi-arid climate. Dryness and hot weather prevails in major part of the year. The area falls under Central Dry agro-climatic zone of Karnataka state and is categorized as drought prone. The climate of the taluk is quite agreeable and free from extremes. The year is usually divided into four seasons: summer from March to May; rainy season or south-west monsoon season from June to September; post-monsoon season covering the months of October and November and dry or winter Season from December to February.

The annual rainfall data from 2009 to 2019 of the Turuvekere taluk is given in Table.2, Statistical Analysis of Rainfall Data of Turuvekerei taluk, (1990 to 2019) (Table 2b) and Monthly rainfall data of Turuvekere taluk are given (Table 2c)

Table-2a Actual Annual Rainfall of Turuvekere taluk from 2009 to 2019

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Rainfall (mm)	933.6	1180.8	766	381	317	754.3	750	347	1003	909	1023.8

Table-2b: Statistical Analysis of Rainfall Data of Turuvekere taluk, (1990 to 2019)

Stataion Turuvekere	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**PRE**	**JUN**	**JUL**	**AUG**	**SEP**	**SW**	**OCT**	**NOV**	**DEC**	**NE**	**ANNUAL**
NRM	1.8	4.6	7.7	42.5	88.5	145.0	65.5	51.2	112.3	133.0	362.0	160.8	49.1	5.3	215.2	722.2
STDEV	5.8	11.0	15.9	40.8	74.1	98.1	59.3	36.6	64.2	94.4	144.9	83.0	46.6	11.5	88.1	233.8
CV%	330.4	239.4	206.6	96.0	83.7	67.6	90.5	71.4	57.1	71.0	40.0	51.6	95.0	218.0	40.9	32.4

Table 2c: Monthly rainfall data of Turuvekere taluk

Year	JAN	FEB	MAR	APR	MAY	PRE	JUN	JUL	AUG	SEPT	SWM	OCT	NOV	DEC	NEM	ANNUAL
2009	0	0	2.6	44	153	199.6	47	57	215	237	556	102	76	0	178	933.6
2010	0	0	0	124	148	272	164.8	97.2	126.8	148	536.8	181	191	0	372	1180.8
2011	0	23	0	109	194	326	23	82	82	34	221	132	87	0	219	766
2012	0	0	0	68	50	118	20	35	96	11	162	29	72	0	101	381
2013	0	16	0	38	0	54	20	35	96	11	162	29	72	0	101	317
2014	0	0	38.3	26	153	217.3	64	43	103	83	293	235	9	0	244	754.3
2015	0	0	12	92	51	155	47	10	146	199	402	101	89	3	193	750
2016	3	0	0	0	95	98	59	102	37	22	220	6	0	23	29	347
2017	3	0	32	52	216	303	50	16	145	362	573	125	0	2	127	1003
2018	0	0	24	29	248	301	213	45	70	99	427	141	33	7	181	909
2019	0	37	0	33.4	110.6	181	107.8	39	175	252	573.8	233	6	30	269	1023.8

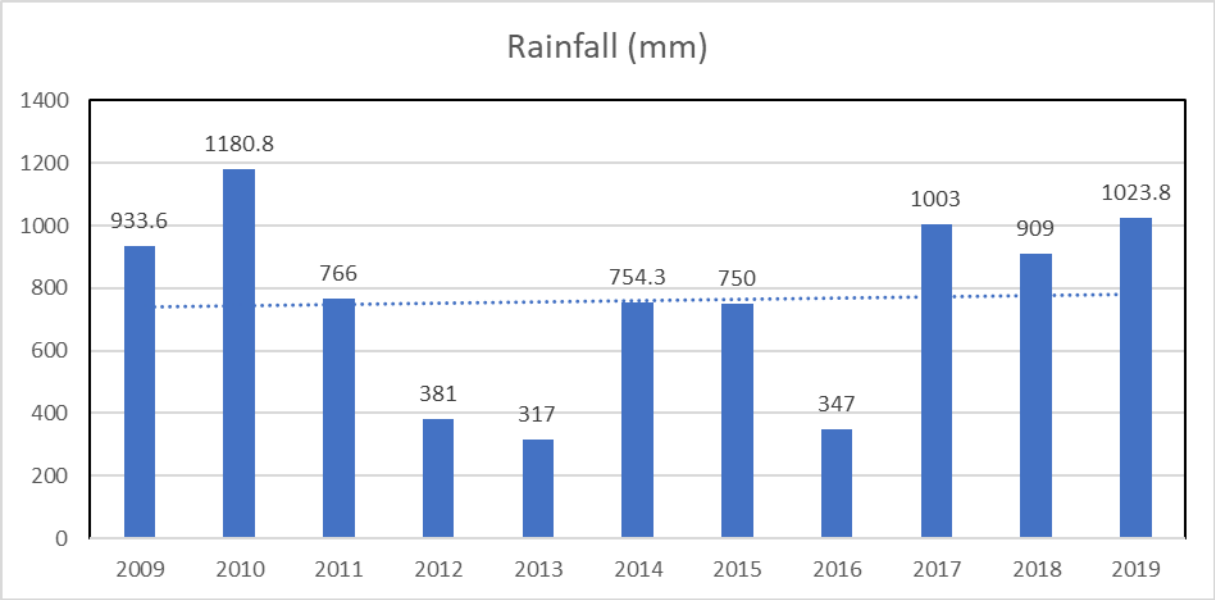

Fig.2: Rainfall Trend Analysis

1.4 Agriculture & Irrigation

Agriculture is the main occupation in Turuvekere taluk. Major crops are Paddy, Maize, Tur, Pulses, Tobacco, Fruits and Vegetables. Water intensive crops like Paddy and Tobacco are grown in Turuvekere Taluk **(Table.3a).**

Table-3a: Cropping pattern in Turuvekere taluk 2016-2017 (Ha)

Crop	Paddy	Maize	Bajra	Jowar	Ragi	Wheat	Pulses	Fruits	Vege tables	Oil seeds	Sugar cane	Cotton	Coconuts	Total crop
Area(ha)	408	06	0		19631	0	4518	7009	742	162	0	0	0	32476
Area %	1.25	0.02	0		60.44		13.91	21.58	2.31	0.49				100

Source: District at a glance 2016-17, Govt. of Karnataka

It is observed that net sown area accounts for 64,846 (Ha) and area sown more than once is 10199 (Ha) of total geographical area 122500 (Ha) in Turuvekere taluk **(Table-3b).** Area under Forest is 10090 (Ha). Area not available for cultivation and Fallow land cover 22512 (Ha) and 15217 (Ha) of total geographical area respectively. 2,605 (Ha) of net area is irrigated from surface water and 25882 (Ha) is irrigated from Groundwater **(Table.3c).**

Table-3b: Details of land use in Turuvekere taluk 2016-2017 (Ha)

Total Geographical Area	Area under Forest	Area not available for cultivation	Fallow land	Net sown area	Area sown more than once	Gross sown area
122500	10090	22512	15217	64846	10199	75045
% of the area	8.23	18.37	12.42	52.93	8.32	61.26

Source: District at a glance 2016-17, Govt. of Karnataka

Table-3c: Irrigation details in Turuvekere taluk (in ha)

Source of Irrigation	Length in Km/No of structures	Gross area Irrigated (Ha)	Net area Irrigated (Ha)	% of area
Canals	-	-	-	-
Tanks	162	2605	2605	8.37
Wells	6543	218	218	0.70
Bore/Tube wells	36002	28279	25664	82.51
Lift Irrigation	-	-	-	-
Other Sources		2618	2618	8.42
Total	42707	31102	28487	100

Source: District at a glance 2016-17, Govt. of Karnataka

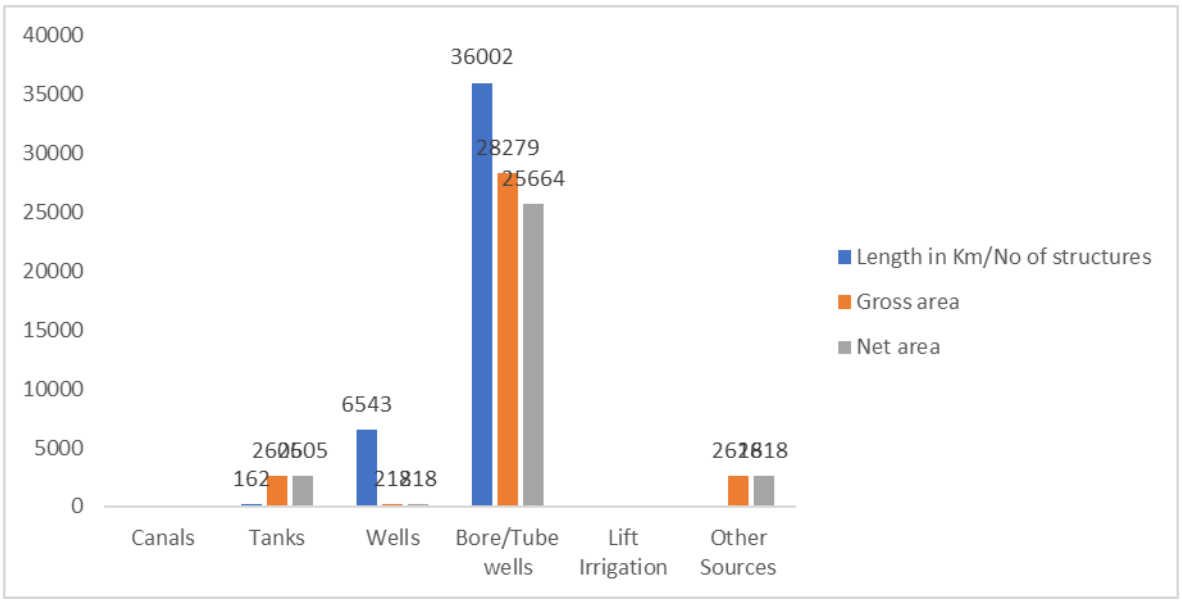

Fig. 3: Sources of Irrigation

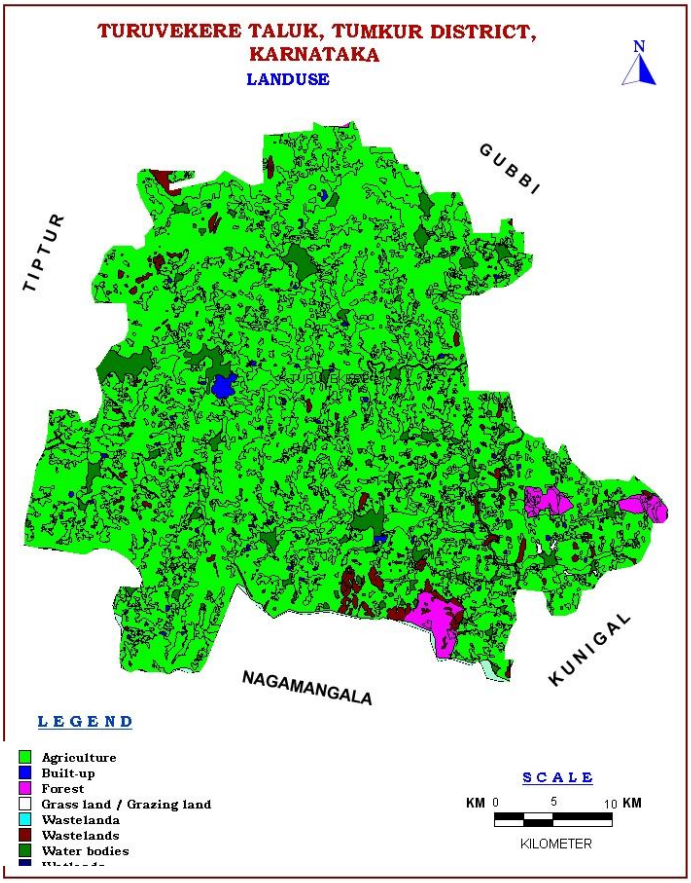

Fig. 4: Land use/land cover map

1.5 Geomorphology, Physiography & Drainage

The geomorphology of the Turuvekere is formed by plain region covered all over the taluk. The elevation varies from 754m to 846m in the taluk. The differential altitude is significant because, it is likely to cause irregular ground water flow patterns on the micro scale **(Fig.-5).** Topography is dominantly controlled by geological structures. The entire Turuvekere taluk falls in Krishna & Cauvery river basin. The Drainage pattern is dendritic to subdendritic **(Fig.-6).**

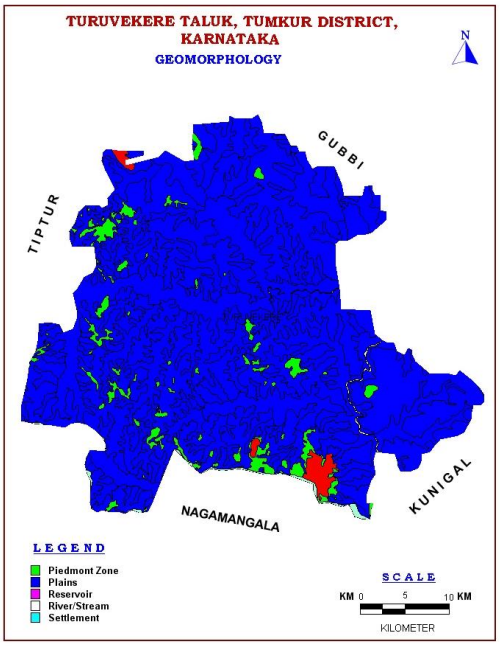

Fig-5: Geomorphology Map

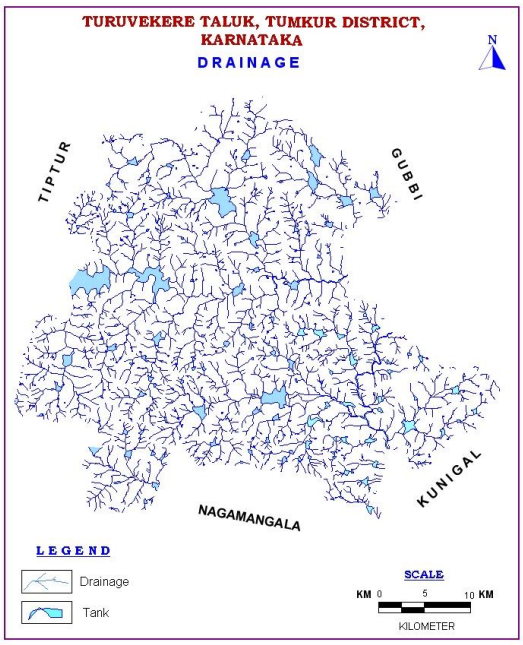

Fig-6: Drainage Map

1.6 Soil

The soils of Turuvekere taluk are mostly red sandy soil. These soils vary in depth and texture, depending on the parent rock type, physiographic settings and climatic conditions **(Fig.7)**.

Geologically, the rock formation in the taluk falls into two groups., Banded gneissic complex and schistose formation and Basalt also found in the southern margins of taluk **(Fig.8).**

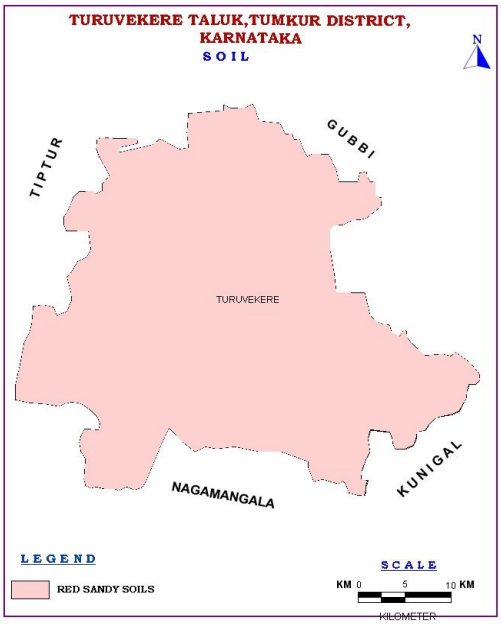

Fig-7: Soil Map

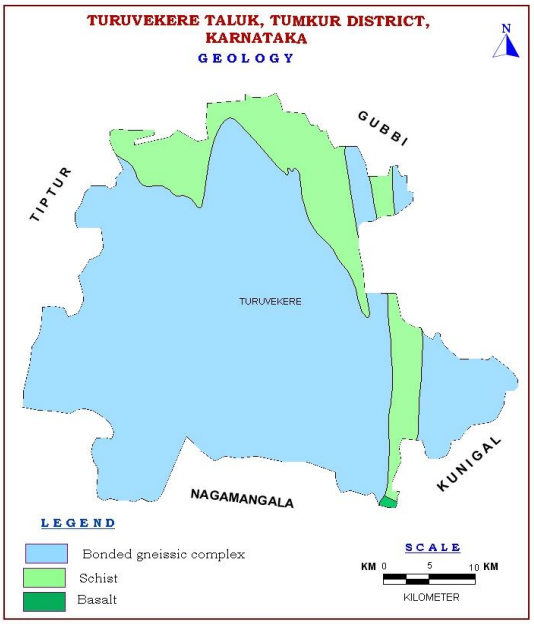

Fig. 8: Geology Map

1.7 Ground water resource availability and extraction

As per the ground water resource estimation 2020 **(Table 4b),** the data on ground water resources shows that the net annual ground water availability is 5890.88 ham. The existing gross groundwater for irrigation is 3377.70 ham. The stage of groundwater development is 59.74 and falling under **Safe** category

Aquifer wise total ground water resources up to 200 m depth is given in **Table-4a** below.

Table-4a: Total Ground Water Resources (2020) (Ham)

Taluk	Annual replenishable GW resources	Fresh In-storage GW resources		Total availability of fresh GW resources
		Phreatic	Fractured (Down to 200m)	Dynamic + phreatic in-storage + fractured
TURUVEKERE	5890.88	14409	1627	21,926.88

Table.4b Detail of Dynamic Ground Water resource, (2020 Figures in Ham)

Annual Extractable GW Resource (Ham)	GW Extraction for Irrigation Use (Ham)	GW Extraction for Industrial Use (Ham)	GW Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net GW Availability for future use (Ham)	Stage of GW Extraction (%)	Categorization (Over-Exploited/ Critical/ Semi-critical/ Safe/Saline)
5890.88	3377.70	0	141.60	3519.30	156.59	2689.88	59.74	Safe

1.8 Existing and Future Water Demands (as per GWRA-2017 and 2020)

The details of dynamic (Phreatic) ground water resources for Turuvekere taluk as on 2017 and 2020 is shown in **Table.5a** and **Table.5b** It is observed that the stage of ground water extraction is 58 % to 59.74 % from 2017 to 2020.

Table.5a Dynamic Ground Water Resource, (2017 Figures in Ham)

Net Annual Ground Water Availability	Existing Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Allocation For Domestic and Industrial Use for Next 25 Years	Net Ground Water Availability for Future Irrigation Develop-ment	Existing Stage of Ground Water Development	Category
5802	3238	120	3358	148	2750	58	SAFE

Table.5b Detail of Dynamic Ground Water resource, (2020 Figures in Ham)

Annual Extractable GW Resource (Ham)	GW Extraction for Irrigation Use (Ham)	GW Extraction for Industrial Use (Ham)	GW Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net GW Availability for future use (Ham)	Stage of GW Extraction (%)	Categorization (Over-Exploited/ Critical/ Semi-critical/ Safe/Saline)
5890.88	3377.70	0	141.60	3519.30	156.59	2689.88	59.74	Safe

1.9 Water level behavior

The water level data have been monitored from the representative dug wells and borewells under NHS monitoring programme for both pre and post monsoon seasons during 2019 in Aquifer I **(Table 6a).** During premonsoon season water level ranges from 4.45 to 8.42 mbgl, whereas in postmonsoon it is 0.54 mbgl. Whereas in Aquifer II, the water level ranges from 4.19 to 32.81 mbgl in premonsoon and 2.6 to 19.63 mbgl during post monsoon as per Ground water Department, Govt of Karnataka data. (Table 6b) and the maps shown in **Fig 9 and 10.**

Table 6a: Depth to water level of Pre and Post-monsoon (2019), CGWB

Sl.No.	SITE_TYPE	Location name	Depth of the Well (m bgl)	May-19	Nov-19
1	Dug well	Mayasandra	10.92	4.45	-
2	Borewell	Mayasandra1	69.00	17.69	9.40
3	Dugwell	Turuvekere	12.80	8.42	0.54
4	Bore well	Turuvekere1	50.00	19.55	13.28

Table 6b: Depth to water level of Pre and Post-monsoon (2019) (State GW Directorate, Govt. of Karnataka)

Sl. No	Well Type	Location name	Depth of well (m bgl)	May-19	Nov-19
1		Haridasanahalli	56		
2		Machenahalli	46	23.80	11.4
3		Mayasandra	159	16.82	7.2
4		Turuvekere	62.5	4.19	2.6
5		Vadavanaghatta	60	32.81	19.63

Fig-9: Post-monsoon Depth to Water Level

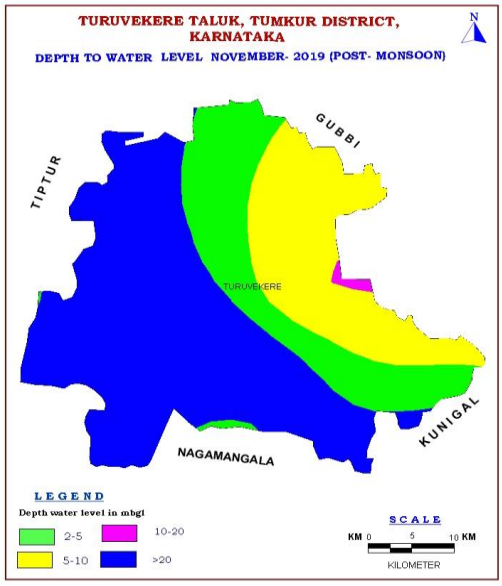

Fig-10: Post-monsoon Depth to Water Level

2 AQUIFER DISPOSITION

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

2.1 Aquifer Types

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

- **Aquifer-I (Phreatic aquifer)** comprising weathered Gneisses and schist.
- **Aquifer-II (Fractured aquifer)** comprising fractured Gneisses and schist.

In Turuvekere taluk, Gneisses and Schists are the two major water bearing formations. Ground water occurs within the weathered and fractured formations semi-confined condition. The borewells were drilled by CGWB under exploratory programme reveals that the depth range of 32 to 200 m bgl. Weathering varies from 17.0 to 32.5 m bgl with yield ranges from 0.01 to 5.6 lps. Most potential fractures noticed between the depth of 30 to 180 m bgl.

The 3D aquifer disposition models, 2D aquifer sections and 3D aquifer fence diagrams have been prepared and presented in **Fig. 11a, b and c.**

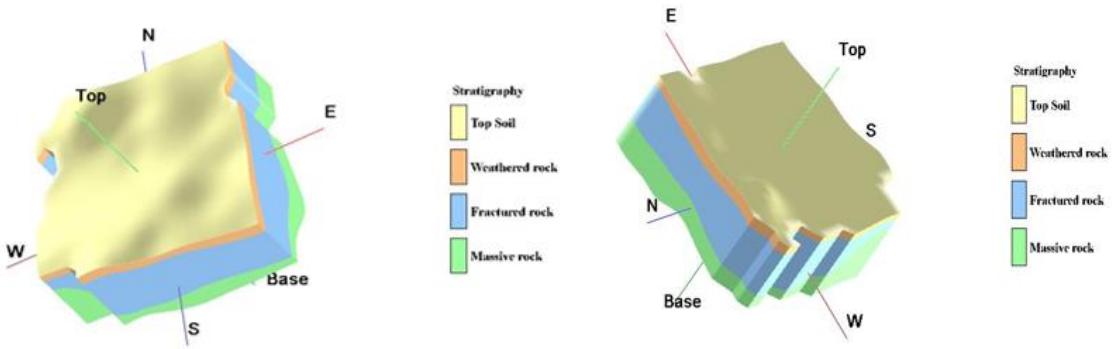

Fig-11a: 3D Aquifer Disposition

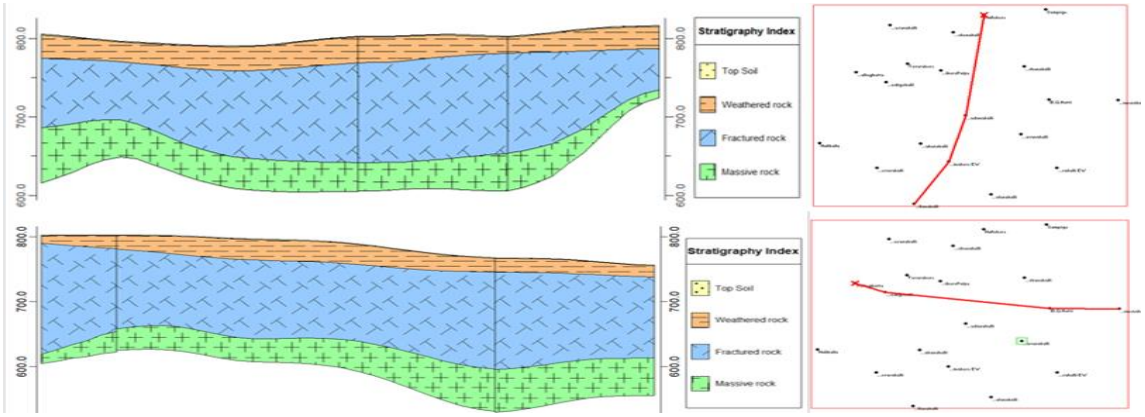

Fig-11b: 2D Cross sections in different directions

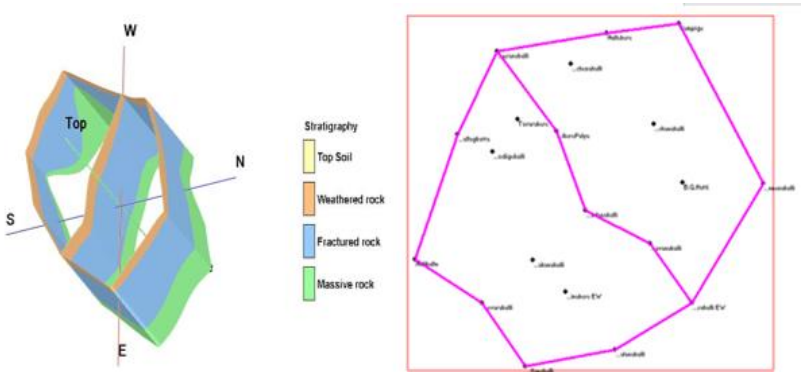

Fig-11c: 3D Aquifer Fence Diagram

3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

The main ground water issues are Limited Ground Water Potential / Limited Aquifer Thickness / Sustainability, declining water level trend which are all inter-related or inter dependent and Inferior ground water quality due to nitrate contamination in major part of the area.

3.1 Comparison of Ground Water Resource and Extraction

The Dynamic Ground Water Resource 2017 and as on 2020 have already been summarised above and are shown in **Table 7a**. It is observed that the ground water availability in 2020 is more as compared to 2017 due to increase in rainfall and in water table.

Table 7a : Comparison of groundwater availability and draft scenario (in ham)

Taluk	March 2017			March 2020		
Turuvekere	**GW Availability** (in ham)	**GW Extraction** (in ham)	**Stage of GW Development** %	**GW Availability** (in ham)	**GW Extraction** (in ham)	**Stage of GW Development%**
	5802.07	3358	58%	5890.88	3519.30	60%

3.2 *Chemical Quality of Ground Water and Contamination*

The water samples were collected in different parts of Turuvekere taluk during NAQUIM studies in September 2021 the data is given below in **Table 8a**. The results of quality parameters shows that the EC ranges from 470 to 1905 while Nitrate varies from 0.91 to 103 mg/l **(Fig 12 a and 12 b).**

Table 8a: Water quality parameters
(NAQUIM Studies in September 2021)

Sl No	Location (Bore Wells)	PH	EC	Cl	NO3
			µS/cm		
1	Haridasanahalli	7.43	1403	184.6	10.98
2	Tavarakere	7.28	1035	142	12.21
3	Malaghatta	7.18	723	63.9	1.14
4	Machenahalli	7.24	834	88.75	2.91
5	Kodigehalli	7.23	1864	372.75	1.62
6	Arkanahalli	7.1	930	138.45	3.63
7	B.G.Hatti	7.79	926	110.05	32.07
8	Soravanahalli	7.2	1905	326	32.55
9	Madanahalli	7.62	882	71	16.47
10	Devanayakanahalli	7.83	752	42.6	10.71
11	Laxmidevarahalli	7.86	1037	117	1.86
12	Maillanahalli	7.41	1147	159.75	13.41
13	Chinchalanahalli	6.79	1300	241.4	47.28
14	Bytara Hosahalli	7.71	470	28.4	0.51

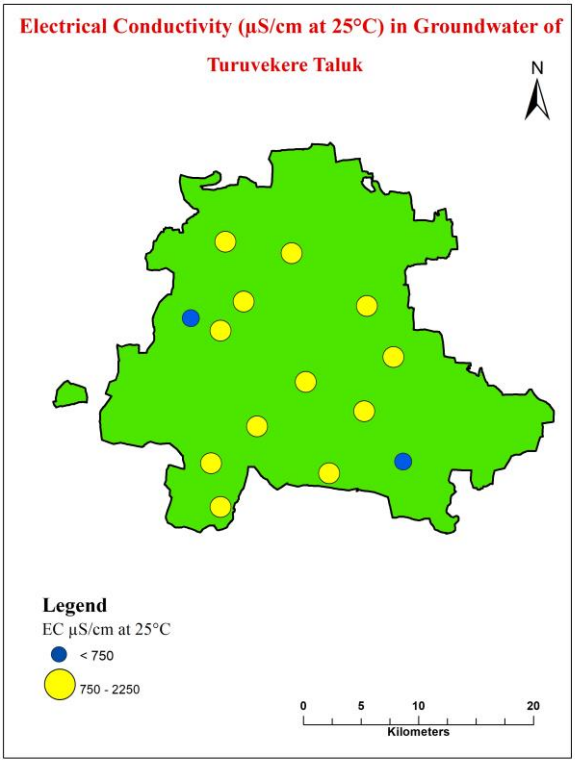

Fig.12 a: EC Map of Turuvekere Taluk

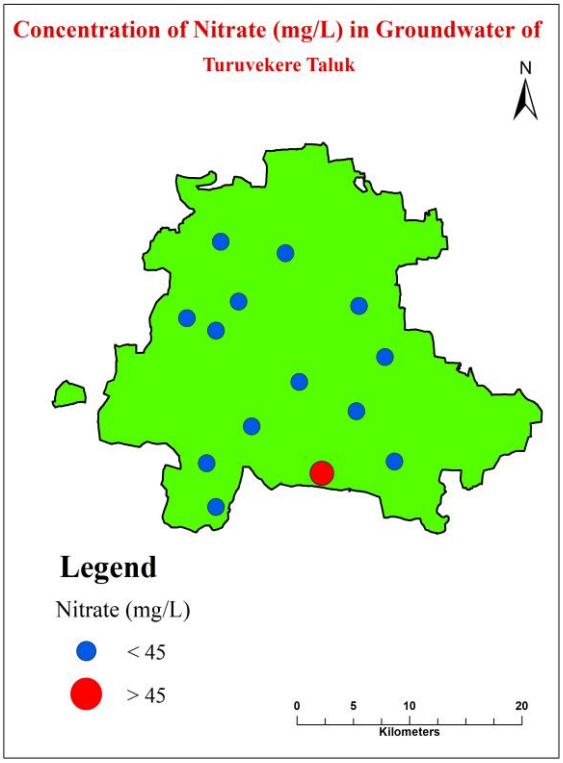

Fig. 12 b: Nitrate Map of Turuvekere Taluk

4 GROUND WATER RESOURCE ENHANCEMENT AND PROPOSED MANAGEMENT STRATEGY

4.1 Resource Enhancement by Supply Side Interventions

Recharge phreatic aquifer (Aquifer-I) in the taluk, through construction of artificial recharge structures, viz. Check dams, percolation tanks & subsurface dykes. The choice of recharge structures should be site specific and such structures need to be constructed in areas already identified as feasible for artificial recharge. Artificial Recharge Structures and Water Conservation Plans are proposed in the taluk through utilizing the uncommitted surface runoff of 1.936 MCM **(Table 9a).** By constructing 02 percolation ponds a 0.002 lakhs hectares of additional irrigation potential can be created. The existing 60.00 % of stage of ground water extraction would reduce to 58.304% **(Table 9b)**

Table 9a: Quantity of non-committed surface runoff & expected recharge through AR structures (As per Master Plan on Artificial Recharge in Karnataka, 2020)

Artificial Recharge Structures Proposed	TURUVEKERE
Non committed monsoon runoff available (MCM)	1.936
Number of Check Dams	0
Number of Percolation Tanks	02
Number of Subsurface dykes	0
Number of Filter beds	0
Tentative total cost of the project (Rs. in lakhs)	35.883
Expected recharge (MCM) @75%	1.452
Additional irrigation potential (in hectares)	200

Table 9b: Improvement in GW availability due to Recharge as per GWRA 2020

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	Cumulative annual ground water availability	Expected improvement in stage of ground water development after the implementation of the project	Expected improvement in overall stage of groundwater development
	HAM	HAM	%	HAM	HAM	%	%
Turuvekere	5890.88	3519.30	60.00	145.2	6036.08	1.696	58.304

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

Artificial recharge structures namely check dams and Nala bunds can be taken up on large scale in the over-exploited areas as a management plan to tackle falling ground water levels.

- 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.
- The cropping pattern has shown that farm households have resumed growing crops such as grapes which were not previously grown in the area.

4.2 Resource Savings by Demand Side Interventions

4.2.1 Water Use Efficiency by Micro Irrigation Practices

Turuvekere Taluk falls under Safe category with the stage of groundwater extraction of 59.74 %. However, Water Use Efficiency (WUE) practices like Drip irrigation needs to be strengthened to save irrigation water by way of precision farming mechanism. This ultimately enhances the area under irrigation potential.

4.3 Ground Water Development Plan

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

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 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 Turuvekere taluk is given in **Table- 10**.

Table 10 : Summary of Management plan

Stage of GW Extraction and Category (2020)	59.74%, Safe
Annual Extractable GW Resource (Ham)	5890.88
Total Extraction (Ham)	3519.30
Total GW Resources (Dynamic & Static up to the depth of 150 mbgl) (Ham)	21,926.88
Ground Water Draft for Irrigation (Ham)	**3377.70**
Ground Water Resource Enhancement by Supply side Interventions	
No of Proposed AR structures PT	 02
Expected Additional Recharge to GW due to AR (Ham)	145.2
Additional Irrigation Potential that can be created (Ha)	200
Total Estimated Expenditure (Rs. in Cr.)	0.35883
Change in Stage of GW Extraction (%)	60 to 58.304

- **Ground water resource enhancement:** Continuous drought, increase in agricultural activity, subjected to excessive ground water withdrawal leading to depletion of ground water level, reduction in yield and deterioration of ground water quality etc., suggests a need for proper ground water management and enhancement of storage capacity of aquifers, protection of ground water quality and proper utilization of ground water. To enhance the storage capacity of aquifers, the dewatered aquifers are to be recharged, for which the artificial recharge structures like Check dams, percolation tanks, point recharge structures etc have to be constructed.
- **Ground Water resource**: As per the resource estimation – 2020, Turuvekere taluk falls under Safe category with the stage of ground water extraction of 60.00%. However, there is need to formulate management strategy to tackle the water scarcity related issues in the taluk during the summer and scarcity of water during the future days.
- **Ground water resource enhancement**: Increase in agricultural activity, excessive ground water withdrawal, depletion of ground water levels, reduction in yield and ground water quality related issues etc., suggests the need for scientific ground water management, enhancement of storage capacity of the aquifers and protection of ground water quality.

- **Uantity of water available through non-committed surface run-off:** The surplus non-committed monsoon run off is estimated to be approximately 1.936MCM. This can be used to recharge the aquifer mainly through percolation tanks.

- **Advanced irrigation practices:** The important crops grown are Paddy, Ragi, Maize, gram, tur, groundnut, sunflower and sugarcane. Water Use Efficiency (WUE) practices like Drip needs and Micro irrigation to be strengthened to save irrigation water by way of precision farming mechanism. This ultimately enhances the area under irrigation potential.
- **Change in cropping pattern**: Farmers are facing inadequacy of groundwater for agriculture during summer and can opt for more rain-fed millets and water efficient Pulses for agricultural production.
- **Drinking water Supply**: In view of ground water contamination with mainly higher concentration Nitrate and fluoride, drinking water supply from surface water needs to be explored/ ensured.
- **Regulation and control:** Taluk is categorized as "Safe". However, the mandatory guidelines like rainwater harvesting and artificial recharge issued by Karnataka Ground Water Authority needs to be strictly implemented in the taluk, so that quality of ground water will improve in due course of time.
- **Participatory management**: Awareness programmes and practice of participatory approach needs to be strengthened with the involvement of all the stake holders for sustainable management.