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

Nagamangala Taluk, Mandya District, Karnataka

दक्षिण पश्चिमी क्षेत्र, बेंगलुरु

South Western Region, Bengaluru

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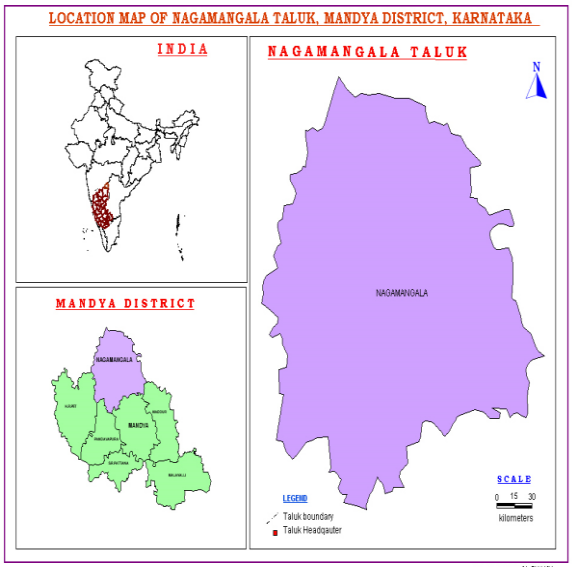
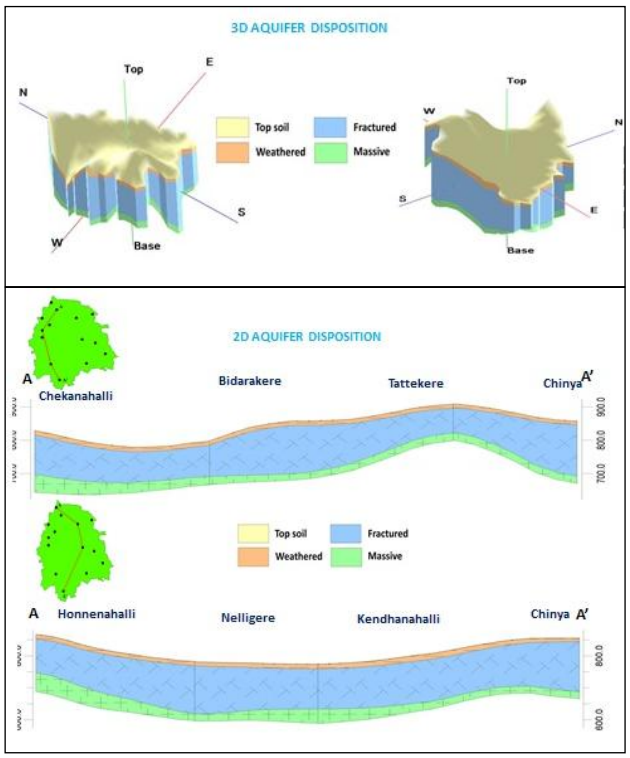
AQUIFER MAPS AND MANAGEMENT PLAN, NAGAMANGALA TALUK, MANDYA DISTRICT, KARNATAKA STATE

(AAP – 2021-2022)





By

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AUGUST 2022

AQUIFER MAPS AND MANAGEMENT PLAN, NAGAMANGALA TALUK, MANDYA DISTRICT, KARNATAKA STATE

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AQUIFER MAPS AND MANAGEMENT PLAN, NAGAMANGALA TALUK, MANDYA DISTRICT, KARNATAKA STATE

1 SALIENT INFORMATION

Name of the taluk: **NAGAMANGALA**

District: **MANDYA**; State: Karnataka

Area: 1035 sq.km.

Population: 187879

Annual Normal Rainfall: 809 mm

1.1 Aquifer management study area

Aquifer mapping studies was carried out in Nagamangala Taluk, Mandya district of Karnataka, covering an area of 1035 sq.kms under National Aquifer Mapping. Nagamangala Taluk of Mandya district is located between north latitude 12°46'46.81" and 12°55'33.01" & east longitude 76°35'46.80" and 76°53'36.43" and is covered in parts of Survey of India Toposheet Nos. 57C/12,16 and 57D/9,10,13,14 and 57D/9,10,13,14. It is bounded by Turuvekere taluk of Tumkur district to the North, Kunigal taluk of Tumkur district to the East, Channarayapatna and Holenarasipur taluk of Hassan district to the West and Krishnarajpet taluk, Pandavapura taluk, Mandya taluk and Maddur taluk of Mandya District in South. Location map of Nagamangala taluk is given in **Fig.1.**

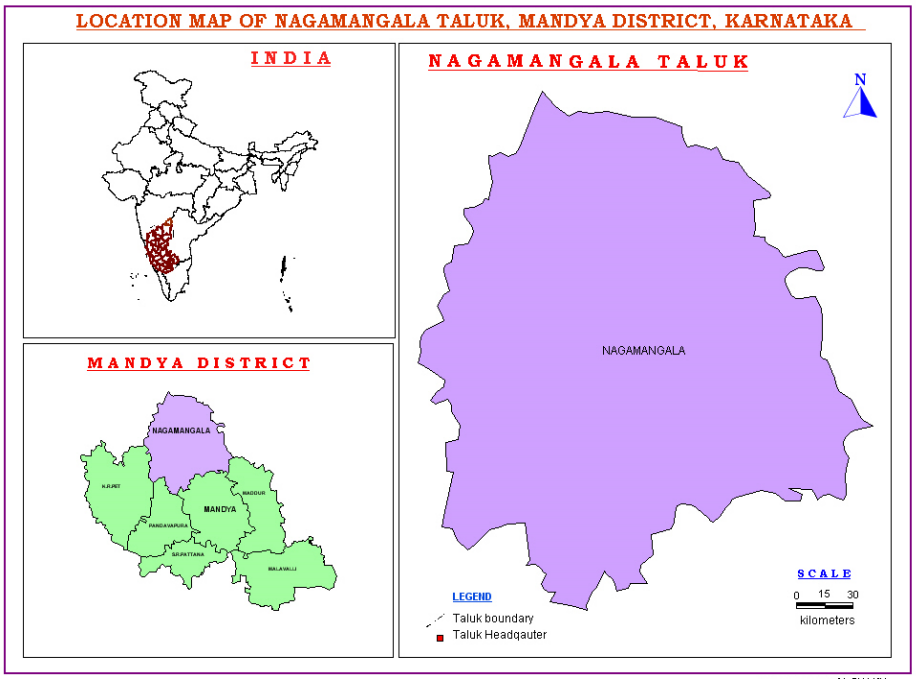

Fig. 1: Location Map

Nagamangala town is the taluk headquarter and Pourasabha of Nagamangala Taluk. There are 5 Hoblis, 27 gram-panchayat and 367 villages in Nagamangala Taluk. It is situated 119.3 km eastern side of Bangalore. The travel distance between Bangalore to Nagamangala may be higher and vary due to curvature of the road. The connection of Bangalore to Nagamangala is through Mandya-Koppa road and through Bellur cross. It is belong to Mysore division.

1.2 Population

According to 2011 census, the population of Nagamangala Taluk is 1,87,897. Out of the total population 93,682 constitute the male population and 94,215 is the female population. The urban population is 17,776 and rural one is 17,0121. Decadal change in population from 2001-2011 is 1.5% in Nagamangala Taluk. Decadal change in rural and urban population is 2.63 % and 10.74 % respectively. The total numbers of families in the Taluk are 44,954. The density of population is 181 persons per square km.

1.3 Rainfall

Nagamangala taluk has semi-arid climate. Dry and hot weather prevails in major part of the year. The area falls under Southern Dry Agro-climatic Zone of Karnataka state and is categorized as drought prone. The year is usually divided into four seasons namely summer from March to May; rainy season or south-west monsoon season from June to September; post-monsoon season covering the months of October and November and dry or winter Season from December to February. Rainfall generally decreases from west to east. April and May are regarded as the summer months with maximum temperature around 35 degree Celsius and minimum temperature is around 21 degree Celsius.

There are 5 rain gauge stations in Nagamangala Taluk, the rainfall data in respect of these stations from the year 1981 to 2010 is analyzed. The data pertaining to these gauges is of long-term nature and are well maintained. It is presumed that they are representative of the taluks and the same is used for analysis. Normal annual rainfall in the taluk for the period 1981 to 2010 is 651 mm.

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

The mean monthly rainfall at Nagamangala Taluk is ranging between 4 mm during February to 183 mm during October. The CV percent for pre-monsoon, monsoon and post monsoon season is 62, 26 & 43 percent respectively. Annual CV at this station works out to be 20 percent.

Table-1: Statistical Analysis of Rainfall Data of Nagamangala taluk, Mandya district (1981 to 2010)

STATION		JAN	FEB	MAR	APR	MAY	PRE MONSOON	JUN	JUL	AUG	SEP	SOUTH WEST MONSOON	OCT	NOV	DEC	NORTH EAST MONSOON	RAINFALL
	Normal Rainfall	6	4	24	43	110	187	63	57	98	156	374	183	65	14	262	822

Nagamangala	**(mm)**															
	STDEV	20	13	53	40	69	84	51	53	87	94	152	114	50	25	130	222
	CV%	240	178	195	70	99	62	37	38	49	53	26	55	124	184	43	20

Annual Rainfall (2015-2019)

Computation were carried out for the annual rain fall for the year 2015-2019, the annual rainfall for the year 2015,2016,2017,2018 and 2019 is 800,367,862,410 and 1083 mm respectively.

The annual rainfall from 2015-2019 for month and monsoon season is below **(Table-2).**

Table 2: Analysis of Annual Rainfall Data of Nagamangala Taluk, Mandya District, Karnataka for the Period 2015 to 2019

ANNUAL RAINFALL (2015-2019)																
Year	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**PRE MONSOON**	**JUN**	**JUL**	**AUG**	**SEP**	**SOUTH WEST MONSOON**	**OCT**	**NOV**	**DEC**	**NORTH EAST MONSOON**	**L RAINFALL**
2015	0	0	1	56	225	282	34	19	86	185	324	52	140	2	194	800
2016	2	0	0	0	54	56	55	129	42	41	267	13	2	29	44	367
2017	0	0	6	38	289	334	4	2	113	203	322	178	13	15	206	862
2018	0	0	14	2	156	172	63	0	11	87	161	61	16	0	77	410
2019	0	0	0	15.2	150.8	166	39.2	42	267	108	456.2	379	16	66	461	1083

1.4 Agriculture & Irrigation

Agriculture is the main occupation in Nagamangala Taluk, since 90.53% of the total population constitutes the rural population. The amount of rainfall and its distribution throughout the season contributes to the cropping pattern in the area. There are two agricultural seasons namely Kharif (June – October) and Rabi season (Mid October – Mid February). Most of the agriculture is through canal and bore-well.Ground water is a major source of irrigation. Major Kharif crops are paddy, maize, ragi, jowar, and vegetables. Main crops of Rabi season are pulses, and oilseeds. Among the commercial crops, paddy, ragi and sugarcane are grown. Fruits and vegetables are also grown in the area (**Table 3**).

Table 3: Area wise crops grown in Nagamangala Taluk

Year	**Paddy**	**Jowar**	**Maize**	**Ragi**	**Pulses**	**Sugarcane**	**Oil seeds**	**Total fruits**	**Total vegetables**	**Total Food Grains**
	Area under cultivation (in ha)									

2015 - 16	999	792	7	16292	8662	211	781	311	1940	26787

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

During the year 2015-16, percentage of gross sown area of total geographical area is 35 % and net sown area was 28.58 % in Nagamangala Taluk (**Table 4** and **Fig 2**). Irrigation practices by different sources in the Taluk are presented in **Table 5**.

Table 4: Land use pattern of Nagamangala Taluk

Year	Total Geographical Area (ha)	Area under Forest (ha)	Area not available for cultivation (ha)	Other uncultivated land(ha)	Total fallow land (ha)	Net sown area(ha)	Area sown more than once(ha)
2015-16	103885	2516	17319	27714	29645	29691	6865

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

Table 5: Irrigation practice in Nagamangala Taluk

Source of irrigation	No. of irrigation source	Net area irrigated (ha)	Gross area irrigated (ha)
Canals	7	3338	4250
Tanks	136	941	1265
Wells	2590	350	480
Tube/ Bore wells	5607	1625	1985
Lift Irrigation	0	-	-
Other Sources	-	75	75
Total	**8340**	**6329**	**8055**

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

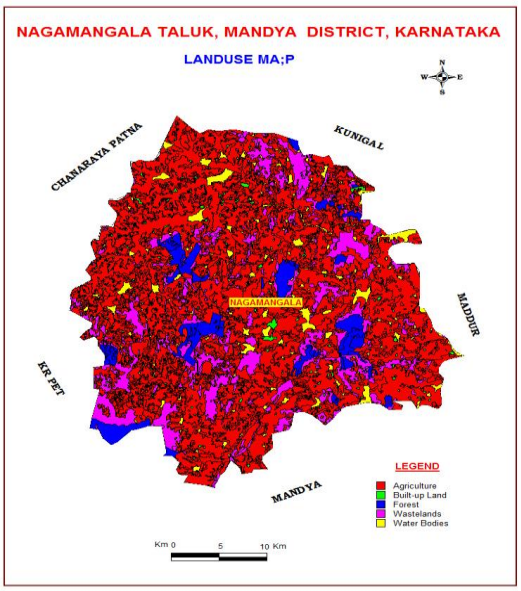

Fig. 2: Land use map

1.5 Geomorphology, Physiography & Drainage

Geomorphologically, Nagamangala taluk belongs to Southern Maidan region which is characterized by plain area with highly undulating terrain topography. The hills are mostly in the central part of the taluk with a general slope in the westerly direction. There are piedmont zones in mostly in western side in between which are scattered unevenly (**Fig. 3)**.

The Taluk lies in Cauvery basin and Lokapavani river sub basin, which is a tributary to the Cauvery river. They exhibit dendritic to sub-dendritic drainage pattern (**Fig.4**.) Lokapavani river originated from Honakere and flow through the Arighatta hill before converging with Cauvery about 3km away from Srirangapatna. It is perennial in nature.

The surface water availability is calculated out to be **81.322 MCM.**

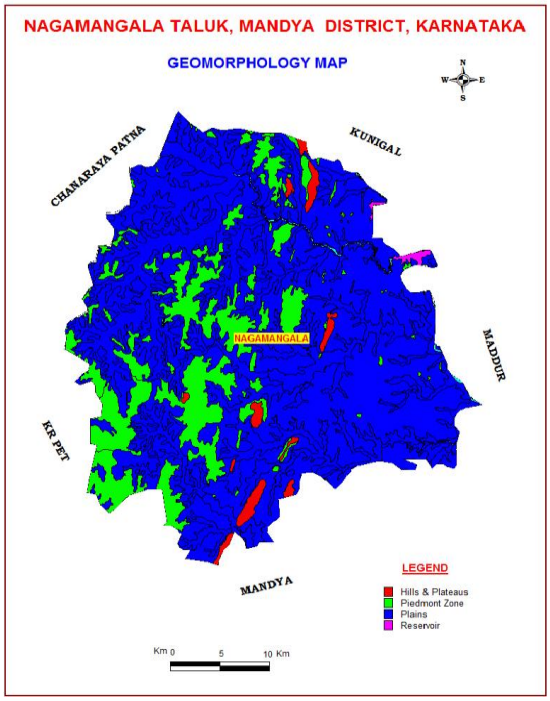

Fig. 3: Geomorphology map

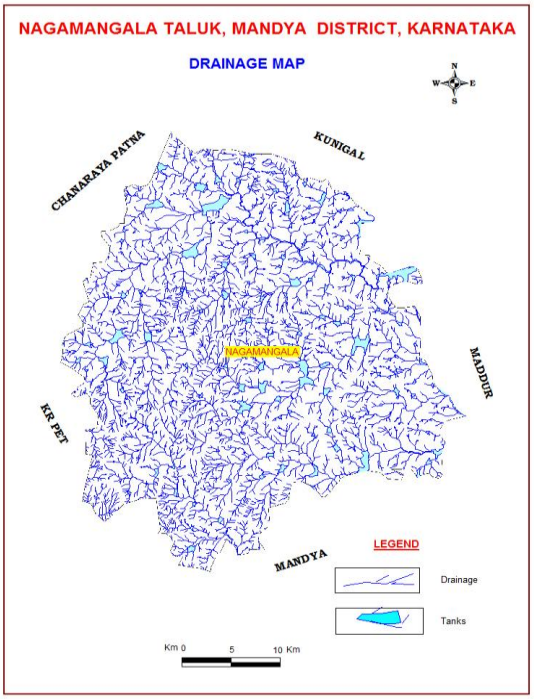

Fig. 4: Drainage map

1.6 Soil

The Taluk is mainly covered by clayey soil and varieties of clayey soil like mixed and skeletal variety **(Fig. 5).** Soil is derived from granite and gneiss with occasionally patches of schist in taluk. Soils range from red sandy loam to red clay loam, very thin in ridge and in higher elevation and comparatively thick in valley portion. Red sandy loam are altered product of Granite gniesses, shallow to medium in depth intermixed with quartzite and gravelly material whereas the red clayey loam are altered product of schist.

Water holding capacity is low. Infiltration rate of red loamy and red soil are 2 to 12 cm/hrs to 1 to 3 cm/hrs respectively. The soil in taluk are thin gravelly and underlain with Murram zone containing weathered zone.

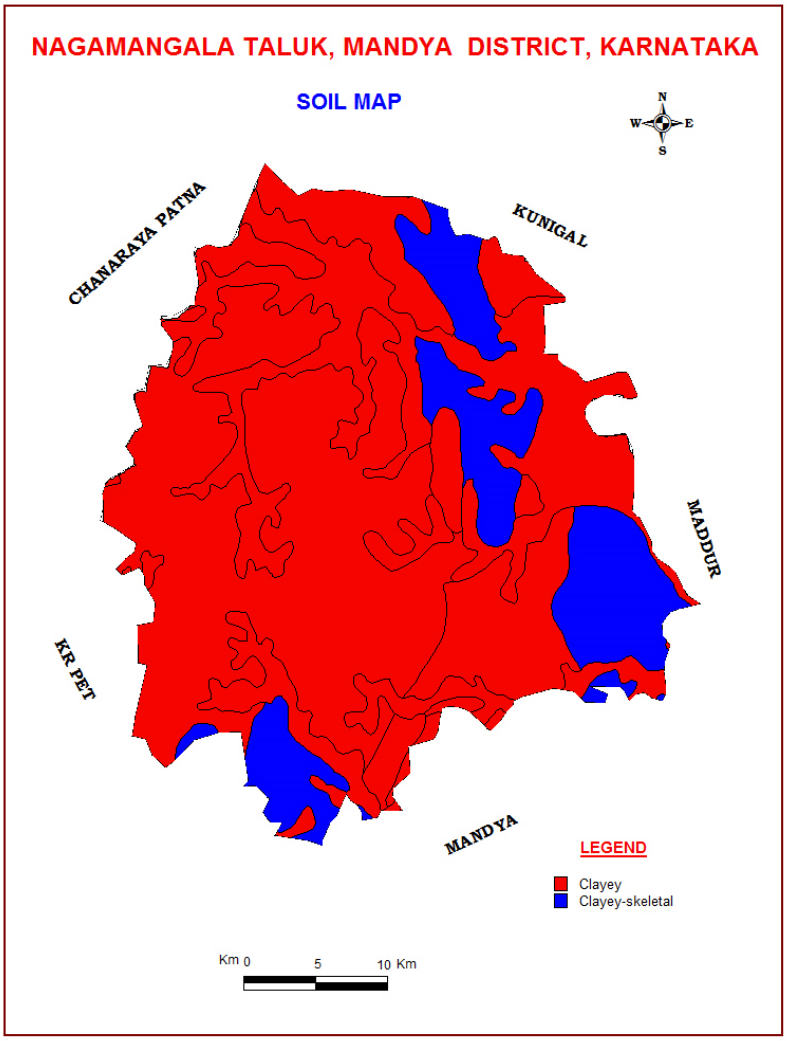

Fig. 5: Soil map

1.7 Ground water resource availability and extraction

Aquifer wise total ground water resources up to 200 m depth is given in **Table-6** below.

Table-6: Total Ground Water Resources (2017) (Ham)

Taluk	Annual replenishable GE resources (in ham)	Fresh In-storage GW resources		Total availability of fresh GW resources
		Phreatic (in ham)	Fractured (Down to 260m) (in ham)	Dynamic + phreatic in-storage + fractured (in ham)
Nagamangala	20823	4500	1799	27122

1.8 Existing and future water demands (as per GEC-2017)

Year	Existing Gross GW extraction for Irrigation (ham)	Existing Gross GW extraction for domestic and industrial water supply (ham)	Allocation for domestic and industrial use for the next 25 years (ham)	Net GW availability for future Irrigation development (ham)

2017	12499	415	521	8469
2020	13486.13	491.82	567.06	8777.44

1.9 Water level behavior

(a) Depth to water level

Aquifer – I

- Pre-monsoon: 2 – 20 mbgl **(Fig-6)**
- Post-monsoon: 2 – 10 mbgl **(Fig-7)**

Aquifer – II

- Pre-monsoon: 6.92– 38.62 mbgl
- Post-monsoon: 0.45 mbgl

(b) Seasonal water level fluctuation

Aquifer – I

Range from 2 m bgl to 10 mbgl

Aquifer – II

Rise range from 0.691 to 0.7635 mbgl & Fall range from 0.097 to 0.852 mbgl.

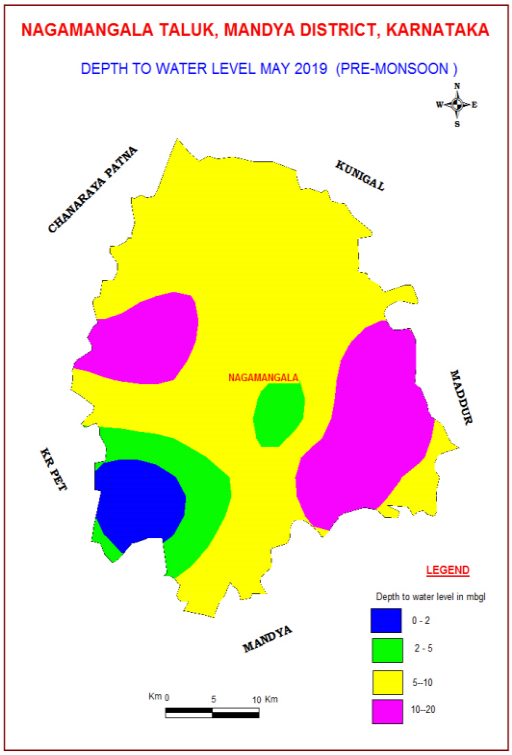

Fig 6: Pre monsoon water level map

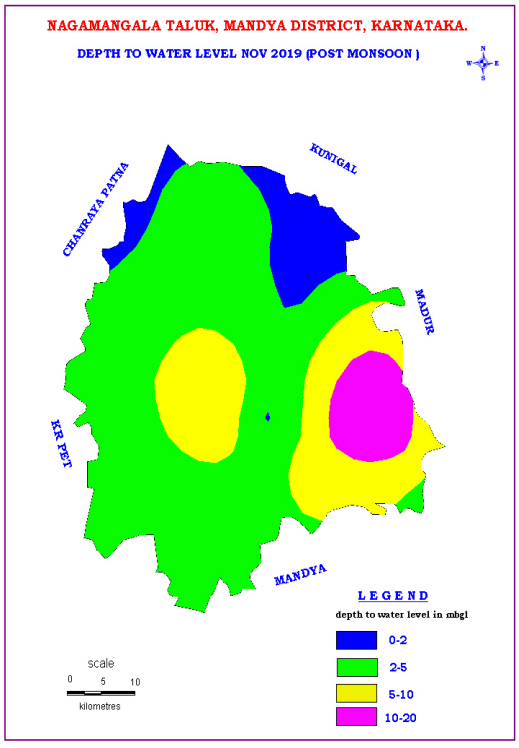

Fig 7: Post monsoon water level map

Table-7: Depth to water level for Pre-monsoon and Post-monsoon

Sr. No	Village	Source	Pre-monsoon Depth to water May-2019 (mbgl)	Post-monsoon Depth to water Nov-2019 (mbgl)	Water level Fluctuation
Aquifer-I					
1	Anjabhuvanahalli	Dug Well	2.30	1.20	1.1
2	Bindiganavale	Dug Well	8.88	4.28	4.6
3	Devalapura	Dug Well	14.15	14.15	0
4	Karadahalli	Dug Well	14.77	6.92	7.85
5	Mudlu Koppalu	Dug Well	19.46	18.46	1
6	Nagamangala2	Dug Well	1.81	1.77	0.04
7	Nelligere	Dug Well	3.87	1.63	2.24
8	Tirumala Sagara Chatra	Dug Well	7.10	4.48	2.62
Aquifer-II					
9	Nagamangala	Borewell	9.92	0.45	0.58

Above **Fig 6** showing depth to water level pre monsoon, in which shallow water level range from 0-2 mbgl is located in small area in South western part of taluk and deeper water level covered in western and Southern east part of taluk range from 10-20 mbgl. **Fig-7** showing post monsoon depth to water level, shallow area cover in some North part of taluk, range from 0-2 mbgl and deeper water level covered in some eastern part of taluk, range from 10-20 mbgl.

2 AQUIFER DISPOSITION

Granite occupy nearly 80% of the eastern part whereas Dharwarian schist and basalt occurs in the rest 20% in the some central and eastern part of the Taluk **(Fig 8).** The gneisses comprise of migmatites associated with biotites and hornblendes. The granites are grey in colour and are fine to coarse grain in nature. Ground water occurs under water table to semi confined condition depending upon disposition of aquifer which is mainly granite and schist. Ground water occur under water table to semi confined condition in granite whereas in schist groundwater occur in weathered, jointed and fractured zone under water table condition.

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

Majority of the dug well in granitic gneiss ranges in depth from 10.3m to 21.2m having a weathered zone from 3m to 18m. Water level lies in the range of 1.91m to 14.77 m.

Pumping test of 500 minutes conducted on open well in Nagamangala have revealed that the discharge ranges between 0.1 to 5.94 lps with a drawdown of 34.64 m and unit area specific capacity of 19.37 lpm/m/m2.

2.1 Aquifer Types:

In Nagamangala Taluk, there are mainly two types of aquifer systems

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

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

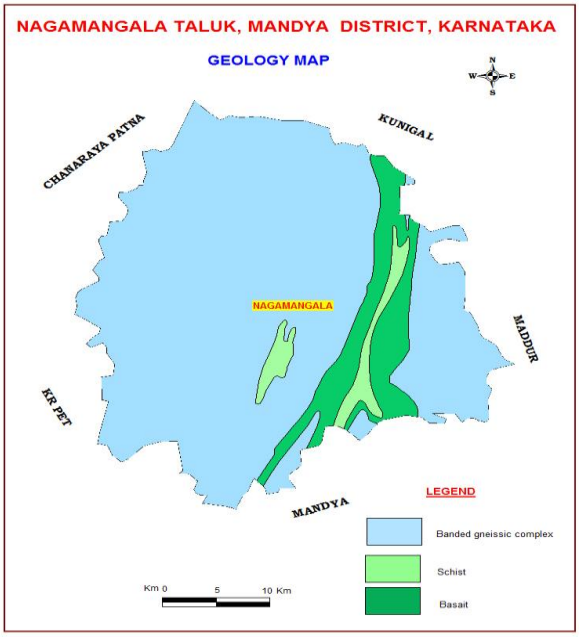

Fig 8: Geology Map

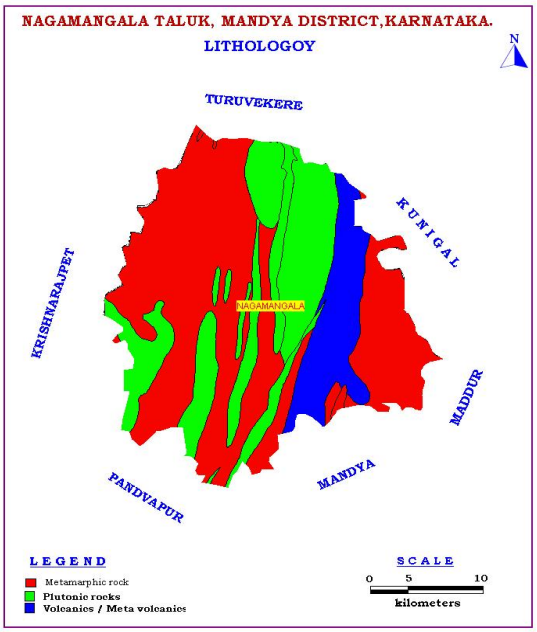

Fig 9: Lithology Map

Fig 9, showing the lithology of Nagamangala taluk, Metamorphic rock basically cover more in the taluk, generally in Eastern & Western part of taluk. Plutonic rocks spread from western to central part of taluk & Volcanic and meta-volcanics in between the central and eastern part of taluk.

Table-8: Details of Ground Water Exploration

S. No	Location	Long	Lat	Depth m bgl	Casing (m)	Lithology	SWL (mbgl)	Q (lps)	T (m^2/day)
1	Karadahalli-EW	76.8052	12.7722	202.3	31.5	SC	28.71	0.02	-
2	Chinya-EW	76.6978	12.7033	202.3	10	GR	60.5	0.43	-
3	Nelligere-EW (Karyabylu)	76.7661	12.9623	202.3	12	BG	36.1	0.01	-
4	Bindiganavile-EW	76.6305	12.8815	202.3	12	BG	65.7	4.36	-
5	Bindiganavile-OW1	76.63	12.8814	202.3	18	BG	62.5	8.4	-

6	**Bindiganavile-OW2**	76.6299	12.8812	202.3	12	BG	87.18	0.7	-
7	**Biderakere**	76.631	12.911	80	12.000	ARCN, GRGN	8.29	0.13	-
8	**Devalapura EW**	76.881	12.811	77.65	6.300	ARCN, GRGN	4.049	2.8	18
9	**Devalapura OW**	76.881	12.811	81.8	12.600	ARCN, GRGN	4.631	2	25
10	**Hatana I I**	76.831	12.978	82.85	16.400	ARCN, GRGN	8.4	0.75	11.6
11	**Kadabahalli**	76.631	12.961	89.1	18.650	ARCN, GRGN	18.909	1.19	7
12	**Tattekere**	76.664	12.769	90	12.350	ARCN, GRGN	19.601	1.82	16.2
13	**Honnenahalli EW**	76.668	13.027	183.87	15.200	GR GN	-	2.44	-
14	**Dhandebala**	76.841	12.858	200.23	14.550	GR GN	-	4.01	-
15	**Kendhanahalli EW**	76.789	12.872	189.95	15.400	GR	-	2.81	-
16	**Chakenahalli EW**	76.689	12.997	203.79	13.850	GR	-	0.13	-
17	**Koochalli EW**	76.660	12.933	196.15	12.550	GR	-	5.94	-
18	**Koochalli OW**	76.660	12.933	112.11	12.000	GR	-	0.01	-

Table-9 Basic characteristics of each aquifer

Aquifers	**Weathered Zone (Aq.-I)**	**Fractured Zone (Aq.-II)**
Prominent Lithology	Weathered Gniess/Schist	Fractured Gniess/Schist
Thickness range (mbgl)	31.5	200
Depth range of occurrence of fractures (mbgl)	6.3-31.5	12-187.5
Range of yield potential (lps)	Poor yield	0.1-5.94
Specific Yield	2%	0.2%
T (m^2/day)	-	7-25
Quality Suitability for Domestic &Irrigation	Suitable	Suitable

2.2 3 D aquifer disposition and Cross-Sections

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

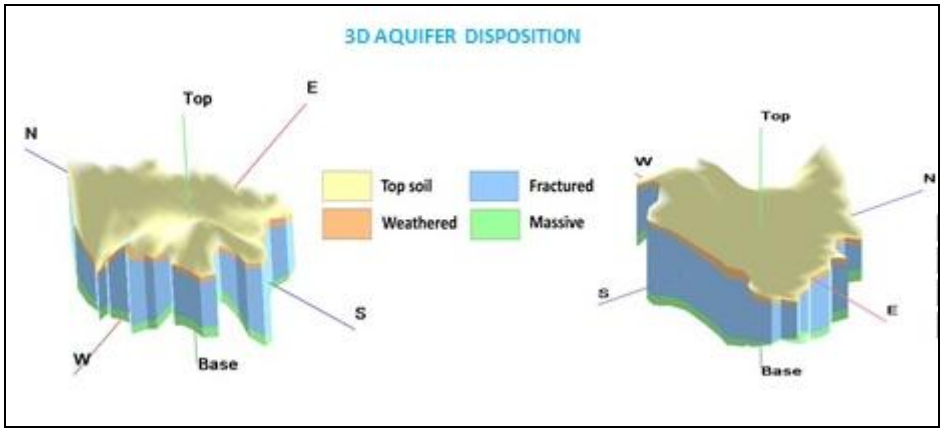

Fig:-10: 3D aquifer Disposition

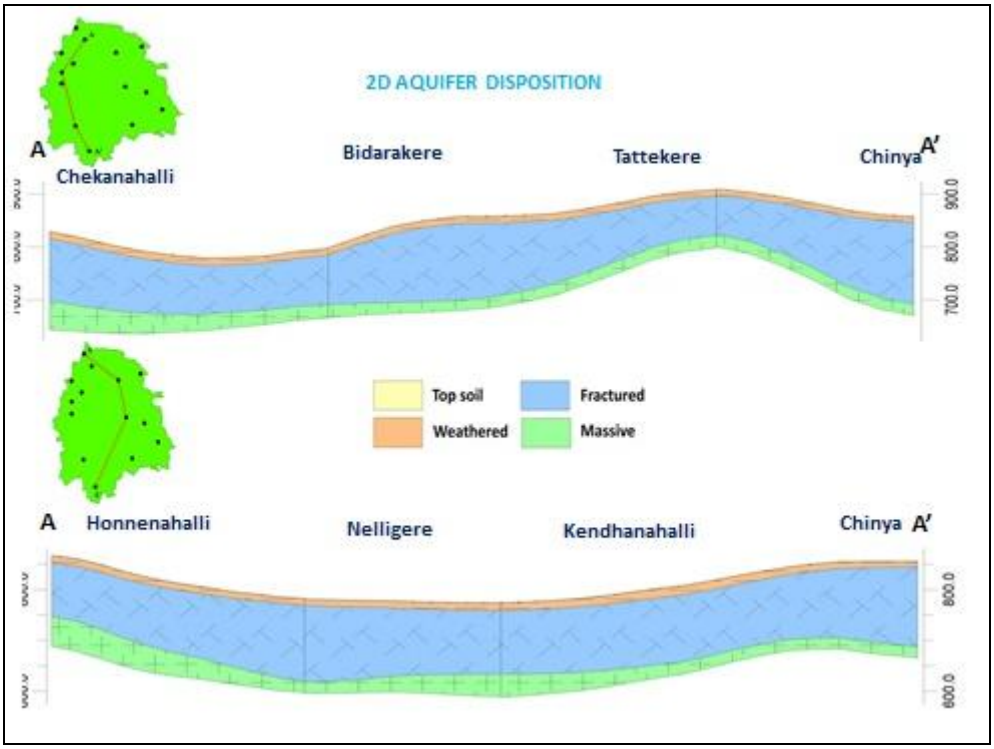

Fig-11: Cross sections in different directions

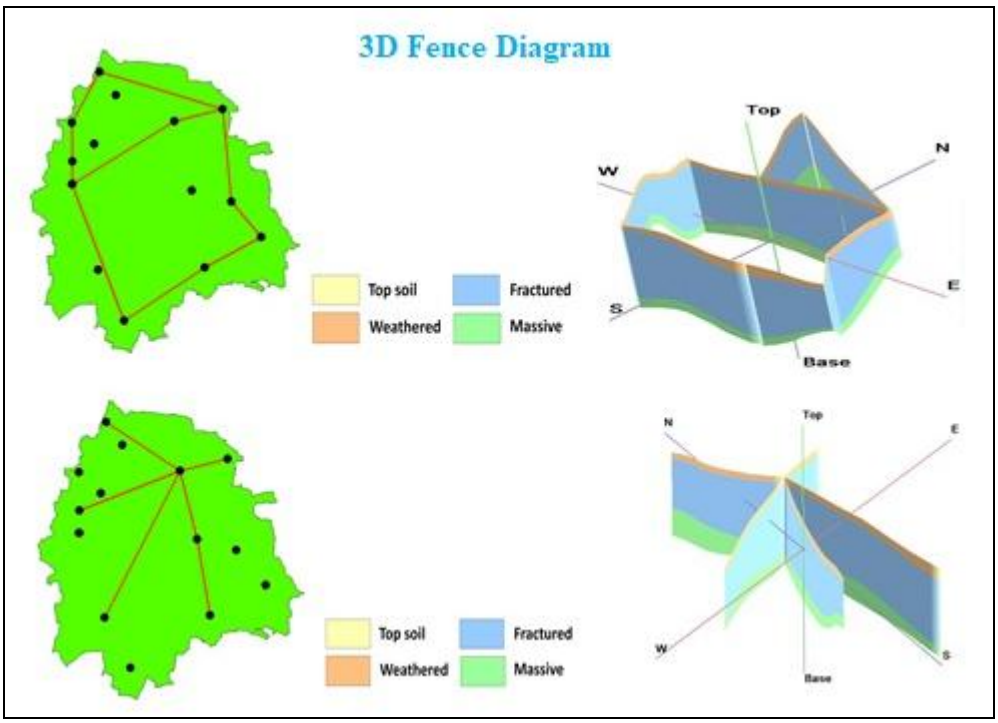

Fig-12: 3D Aquifer Fence Diagram

3 GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION AND OTHER ISSUES

3.1 Aquifer wise resource availability and extraction (2020)

Taluk	Annual Extract GW resource (ham)	Existing Gross GW extraction for Irrigation (ham)	Existing Gross GW extraction for domestic and industrial water supply (ham)	Existing Gross GW extraction for all uses (ham)	Allocation for domestic and industrial use for the next 25 years (ham)	Net GW availability for future Irrigation development (ham)	Stage of GW developm ent (%)	Category
Nagamangala	22453	13486.13	491.82	13977.95	567.01	8777.44	62.25	**Safe**

Comparison of ground water availability and draft scenario in Nagamangala taluk

Taluk	2013			2017			2020		
	GW Availability for Non command area	GW Draft for Non command area	Stage of GW withdrawal	GW Availability	GW Draft	Stage of GW withdrawal	GW Availability	GW Draft	Stage of GW withdrawal
Nagamangala	17130	10868	63	20823	12914	62	22453	13977.95	62.25

From the above comparison, it can be observed that the stage of ground water extraction has increased steadily from 2017 to 2020.

3.2 Chemical quality of ground water and contamination

The interpretation from Chemical Analysis results (Phreatic aquifer) of ground water samples in Nagamangala taluk is summarized below. The results are presented in **Table.10.**

(a) Aquifer – I: 7 samples were collected from NHS dug wells representing Aquifer – I in Nagamangala Taluk and chemical analysis result indicate that the

- **E.C**: EC value is in the ranges of 505 to 2270 m/mhos/cm at 25^{o}C. Highest value is observed in **Chinya** village. **(Fig-13)**
- **pH**: The value of pH ranges from 7.15 to 9.99.
- **Cl**: Cl ranges from 56.8 mg/l to 308.85 mg/l.
- **NO_3:** The value of NO_3 ranges from 16.2 to 133.98 mg/l. Highest value of 133.98 mg/l is found in **Chunchanagiri palya village** which is above the permissible limit as per BIS, 2012 drinking water standards. **(Fig-14)**
- **F:** The value of F ranges from 0.78-1.63mg/l. Highest value of 1.63 is found in **Bindiganavale** village which is above the permissible limit as per BIS, 2012. **(Fig-15)**

(b) Aquifer -II: 19 samples were collected from borewells and Hand pump which represented the aquifer II in Nagamangala Taluk.

- **E.C**: EC value in groundwater is in the ranges of 416 to 2070 m/mhos/cm at 25^{o}C. Highest value is observed in **Gondihally** village.
- **pH**: The value of pH ranges from 7.16 to 8.08.
- **Cl**: Cl ranges from 24.85 mg/l to 390.5 mg/l.
- **NO_3:** The value of NO_3 ranges from 3 to 87.03 mg/l. Highest value is observed in **Hatna** village which is above the permissible limit as per BIS, 2012 drinking water standards.
- **F:** The value of F ranges from 0.46-1.63mg/l. Highest value of 1.63 is found in **Bindiganavale** village and **Nilligere** village which is above the permissible limit as per BIS, 2012.

Table-10: Quality of ground water in Nagamangala taluk of Mandya district

S. No	Location	EC	NO3	F
1	**Chinya**	2270	89	-
2	**Hatna**	-	87	-
3	**Ranganathanagara**	-	56	-
4	**Chunchanagiri Pallaya**	-	134	-
5	**Nelligere**	-	49	-
6	**Cholasandra**	-	65	-

7	**Devalpura**	-	121	-
8	**Bindiganavile**	-	-	1.63
9	**Nelligere**	-	-	1.63

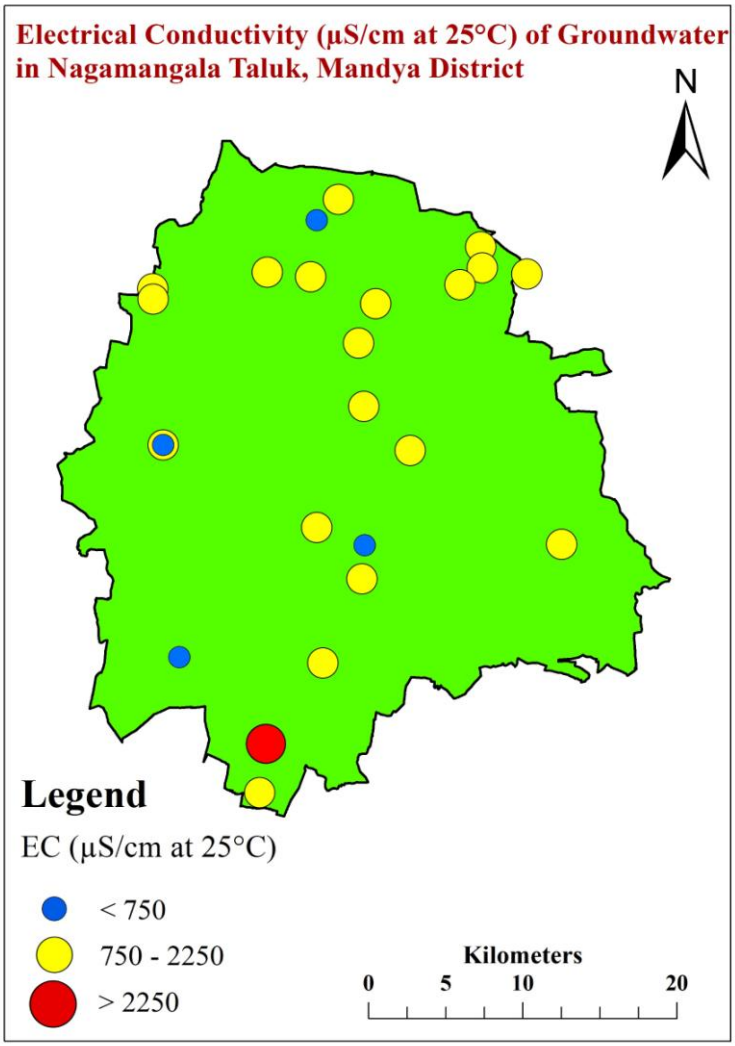

Fig-13 Distribution of Electrical Conductivity

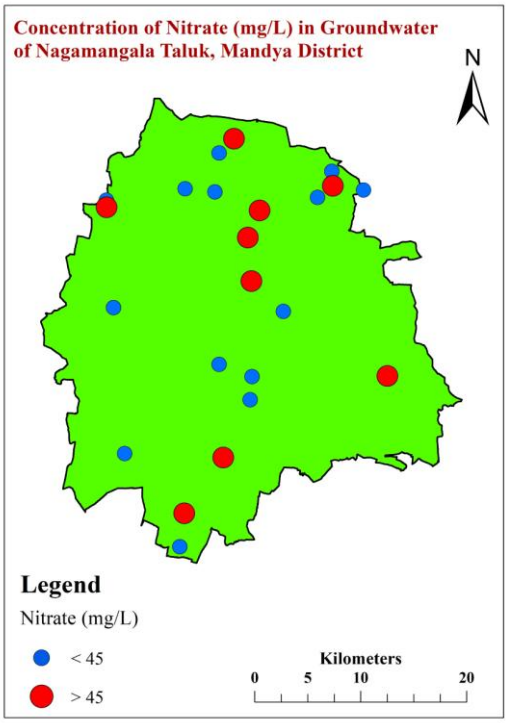

Fig-14 Distribution of Nitrate

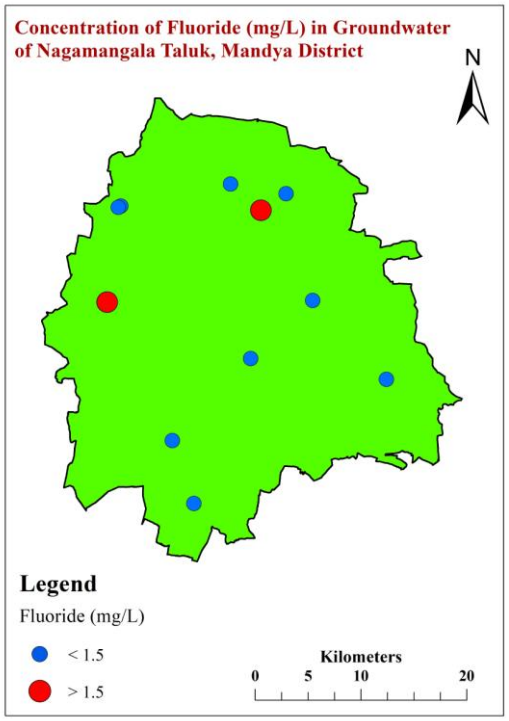

Fig-15 Distribution of Fluoride

In general, ground water quality in Nagamangala Taluk is good and potable except in some localized areas where nitrate, fluoride and salinity content are found to be greater than permissible limit. Ground water samples have been found suitable for agriculture & irrigation purposes.

4 GROUND WATER RESOURCE ENHANCEMENT

4.1 Supply side interventions

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

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

Non committed monsoon runoff available (MCM)	81.322
Artificial Recharge Structures Proposed	
Area feasible for artificial recharge structures (sq. km)	952
Number of Check Dams proposed	391
Number of Percolation Tanks proposed	73
Number of Sub surface dykes proposed	2
Tentative total cost of the project (Rs. in lakhs)	5414.309
Recharge capacity of sub surface dyke (MCM)	12.198
Recharge capacity of percolation tank (MCM)	40.661
Recharge capacity of Check dam (MCM)	20.330
Recharge capacity of filter bed (MCM)	8.132
Expected recharge (MCM)	**60.991**

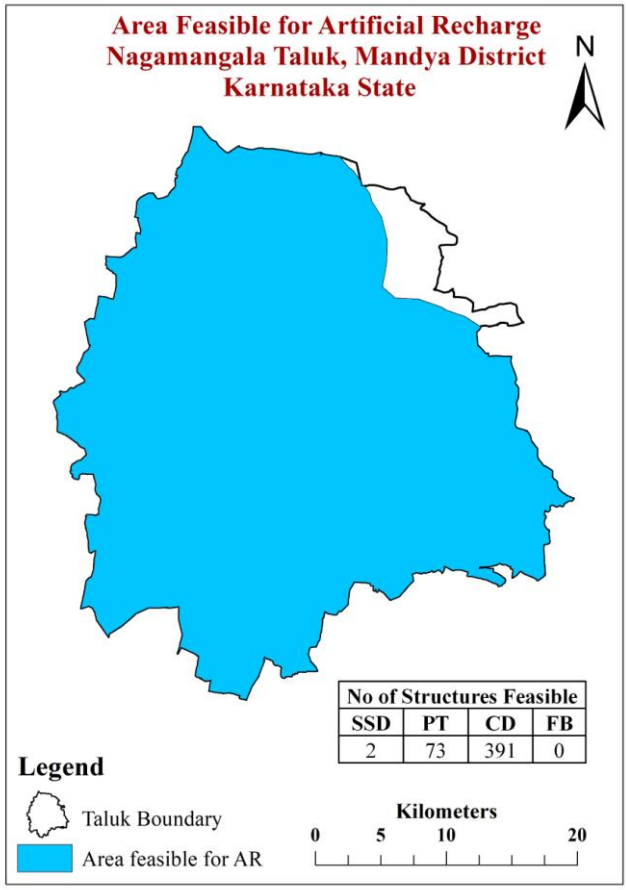

Fig-18 Area suitable for AR Structures

Table 12: Present ground water availability and draft scenario (2020) in Nagamangala Taluk and expected improvement in Stage of Ground Water Development in future, on implementation of artificial recharge schemes-

Taluk	Cumulative Annual Ground Water Availability	Existing Gross Ground Water Draft for All Uses	Existing Stage of Ground Water Development	Expected Recharge from Proposed Artificial Recharge Structures	Cumulative Ground Water Availability after Artificial Recharge Structure Implementation	Stage of Ground Water Development after Artificial Recharge Structure Implementation	Expected Improvement in Overall Stage of Ground Water Development
	HAM	**HAM**	**%**	**HAM**	**HAM**	**HAM**	**%**
Nagamangala	22453	13977.95	**62.25**	6099.1	28552.1	48.95	**13.3**

4.2 Demand side Interventions

4.2.1 Water Use Efficiency by Micro Irrigation Practices

It is observed that wells and bore wells are the source for 1975 ha of net irrigation in the taluk constituting about 31% of the irrigated area. Adoption of water use efficiency (WUE) techniques will contribute in ground water resource enhancement in the long run by way of saving of water. Efficient irrigation practices like Drip irrigation & sprinkler needs to be adopted by the farmers in the existing 1975 ha of net irrigated area by wells & bore wells. At present (2020), the irrigation draft is 13486.13 ham.

The water efficient methodology may be applied for growing sugarcane which is grown in 211 ha and is largely ground water dependent as compared to the other crops which are mainly grown during kharif. Efficient irrigation techniques will contribute in saving ground water by 60.13 ham considering 50% of the sugarcane area is dependent on ground water irrigation and thus will improve stage of development marginally by 0.16% from 62.25 to 62.09%. However, in long run the practice of Efficient irrigation techniques will add to the ground water resource in large extent. **(Table-13).**

Table 13: Improvement in GW availability (2020) due to saving by adopting water use efficiency

Net annual ground water availability	Existing gross ground water draft for all uses	Existing stage of ground water development	Sugarcane grown area	Sugarcane area considered for WUE (50%)	Saving due to adopting WUE measures @ 0.57 m in sugarcane grown area	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 ground water development
HAM	HAM	%	HA	HA	HAM	HAM	%	%
22453	13977.95	62.25	211	105.5	60.135	22513.14	0.16	62.09

4.2.2 Change in cropping pattern

Change in cropping pattern is necessary since cultivation of water intensive crops like sugarcane is prevalent in the taluk. Though only 211 hectares is covered under sugarcane and paddy is also prevalent in taluk, which covered 999 hectare in Nagamangla taluk which can effect groundwater availability. At present (2020), the stage of ground water extraction is @ 62.25% and taluk has been categorised as Safe, thus change in cropping pattern has not been suggested.

4.2.3 Other interventions proposed

- Periodical maintenance of artificial recharge structures should also be incorporated in the Recharge Plan.
- Excess nitrate & fluoride 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, Deeper Water Levels particularly in Aquifer-II in some parts of areas which are all inter-related or inter dependent and Inferior Ground Water Quality due to nitrate contamination major part of the area. The summary of ground water management plan of Nagamangala taluk is given in **Table-14.**

Table 14: Summary of Management plan of Nagamangala taluk

Stage of GW Extraction and Category (2020)	62.25 %, Safe
Annual Extractable GW Resource (Ham)	22453
Total Extraction (Ham)	13977.95
Total GW Resources (Dynamic & Static up to the depth of 200 mbgl) (Ham)	22513.14
Ground Water Draft for Irrigation (Ham)	13486.13
Ground Water Resource Enhancement by Supply side Interventions	
No of Proposed AR structures SSD PT CD	 2 73 391
Expected Additional Recharge to GW due to AR (Ham)	6099.1
Ground Water Resource Savings by Demand side Interventions	
Expected Saving due to adopting WUE measures in sugarcane area (Ham)	60.135
Change in Stage of GW development (%)	62.25 to 48.85
Ground Water Quality – Nitrate contamination	Improving quality by proper drainage of sewage and Limited usage of Nitrogenous fertilizers

As per the resource estimation – 2020, Nagamangala taluk falls under Safe category with the stage of ground water extraction is 62.25 %. However, there is need to formulate management strategy to tackle the water scarcity related issues in the taluk in the coming days to avoid water crisis in the future. It is suggested to adopt a scientific and multi-pronged ground water management strategy

covering supply side interventions, demand side interventions, ground water development interventions and ground water quality protection aspects as mentioned in the management plan suggested above

- **Ground water resource enhancement by supply side interventions**: Quantity of surface water available through non-committed surface run-off is estimated to be 81.322 MCM. This can be used to recharge the aquifer mainly through percolation tanks (73), check dams (391) and sub surface dyke structures (2). The volume of water expected to be conserved/recharged @75% efficiency is 6099.1 ham through these AR structures. The approximate cost estimate for construction of these AR structures is Rs. 54.14 Cr. The additional area which can be brought under assured ground water irrigation will be about 0.073 Lakh hectares.
- **Ground water resource enhancement by demand side interventions**: At present about 31 % of irrigation is by wells and bore wells (ground water). The micro irrigation practices like drip and sprinkler irrigation are comparatively less practiced in comparison with traditional surface flooding mode of irrigation. The micro irrigation water efficient methodology needs to be adopted for growing water intensive sugarcane crop which is grown in 211 ha and considering 50% area is dependent on ground water irrigation, efficient irrigation techniques will contribute in saving ground water by 60.13 ham @ 0.57 m and thus will improve stage of development marginally by 0.16% from 62.25 to 62.09%. However, in long run the practice of efficient irrigation techniques will add to the ground water resource in large extent..
- **Change in cropping pattern**: Farmers are facing inadequacy of groundwater for agriculture during summer. Change in cropping pattern is necessary since cultivation of water intensive crops like sugarcane is prevalent in the Taluk. Though only 211 hectares is covered under sugarcane and paddy is also prevalent in taluk, which covered 999 hectare in Nagamangala taluk which can effect groundwater availability. At present (2020), the stage of ground water extraction is @ 62.25% and taluk has been categorised as Safe, thus change in cropping pattern has not been suggested.
- **Advance Irrigation practices:** Out of the total irrigated area by various sources, about 47.08% (as on 2021 including data of CADA) is being irrigated by irrigation canal of Cauvery basin project and mostly by ground water. Bore wells are the main ground water abstraction structures. Water Use Efficiency (WUE) practices like drip irrigation and sprinkler are yet to pick-up in the taluk to the fullest extent which needs to be expanded. Presently, the ground water draft through irrigation is 13486. Ham (as on 2020). Implementation of efficient irrigation techniques will contribute in saving groundwater to considerable quantity. This ultimately enhances the area under irrigation potential.
- **Drinking water Supply:** In view of ground water contamination with mainly higher concentration Fluoride and Nitrate, drinking water supply from surface water needs to be explored/ ensured.

- **Regulation and control:** Taluk is categorized as **"Safe".** However, the mandatory guidelines like rainwater harvesting and artificial recharge issued by Karnataka Ground Water Authority needs to be strictly implemented in the taluk so that quality of ground water will improve in due course of time.
- **Participatory management:** Awareness programmes and practice of participatory approach needs to be strengthened with the involvement of all the stake holders for sustainable management.