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Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

BILGI TALUK,

BAGALKOT DISTRICT, KARNATAKA

दक्षिण पश्चिमी क्षेत्र, बैंगलोर

South Western Region, Bengaluru

AQUIFER MANAGEMENT PLAN OF BILGI TALUK, BAGALKOT DISTRICT, KARNATAKA STATE

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AQUIFER MANAGEMENT PLAN OF BILGI TALUK, BAGALKOT DISTRICT, KARNATAKA STATE

1. SALIENT FEATURES

Name of the taluk : Bilgi

District : Bagalkot

State : Karnataka

Area : 783 sq.km.

Population : 1,60,294 (2011)

Annual Normal Rainfall : 716 mm

Bilgi taluk is located in northern part of Bagalkot district, Karnataka State covering an area of 783 sq. kms and is a part of Krishna river basin located at longitudes $16^0$03': 16^0 32' and east latitude of $75^0$73': 76^0'49" falling in survey of India toposheet numbers 47P/7, 47P/8, 47P/11. It is surrounded by Vijayapura and Basavana Bagewadi taluks of Bijapur district towards north, Bagalkot taluk of Bagalkot district towards south and east, Mudhol and Jamakhandi taluks of Bagalkot towards west. The location map of the taluk is in **Fig. 1**.

Bilgi town is the taluk head quarters. There are two revenue hoblies which cover 63 inhabitated villages, 24 grama panchayats and one town panchayat (Bilgi). The taluk is well connected with good network of roads with NH-218 Hubli-Humnabad passes through Bilgi. State highways passing through Bagalkot connects Siddapur- Teggi- Girisagar and Budni with NH 218. District roads and broad gauge railway line (Gadag-Hotgi) forming good net work transport system.

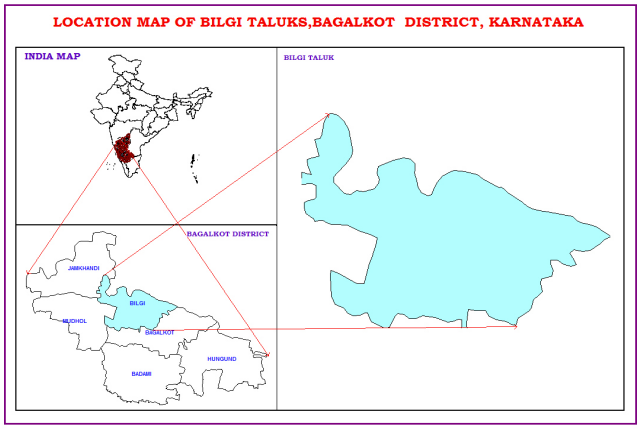

Fig. 1: Location map Bilgi taluk, Bagalkot district

1.2 Population

As per 2011 census, the total population in Bilgi taluk is 1,60,294 (80147 males and 80147 Females) of which about 1,42,502 (88.90 %) constitutes the rural population. 18.83 % (30181) of scheduled caste and 10.08 % scheduled tribe. The Taluk has an overall population density of 205 persons per sq.km. The decadal change is 12.9 % growth rate is 14.4%.

1.3 Rainfall

Bilgi taluk enjoys semi-arid climate. Dryness and hot weather prevails in major part of the year. The area falls under Northern Dry agro-climatic zone of Karnataka state and is categorized as drought prone.

The climate of the study area 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.

There is one rain gauge station located in Bilgi taluk **(Table 1).** The data in respect of this station from the year 1981 to 2010 is analysed and presented in **Table 2**. The data pertaining to the gauge is of long term nature and are well maintained. It is presumed that they are representative of the taluk and the same is used for analysis. Normal annual rainfall in Bilgi taluk for the period 1981 to 2010 is 716 mm.

Table 1: Rain gauge and its location in Bilgi taluk

Station	Latitude	Longitude	Altitude
Bilgi	16.53	75.33	589.6

Statistical analysis

Computations were carried out for the 30 year blocks of 1981- 2010 on Mean, Standard deviation and coefficient of variation of each month pre monsoon, monsoon, post monsoon and annual and are shown in **Table 2**.

The mean monthly rainfall at Bilgi taluk is ranging between 2mm during January and February to 132mm during September. The CV percent for premonsoon, monsoon and post monsoon season is 83, 43 & 57 percent respectively. Annual CV at this station works out to be 43 percent.

Assessment of Drought

Rainfall data of Bilgi taluk has been analysed for 105 years using IMD method to assess the drought condition in Bilgi taluk. The results of the classification are listed in the **Table 3**. It is

observed that the Bilgi taluk has experienced alternating no drought to severe drought conditions over the years.

Table 2: Statistical Analysis of Rainfall Data of Bilgi Taluk, Bagalkot District (1981 to 2010)

Normal Rainfall (mm)	JAN	FEB	MAR	APR	MAY	PRE MONSOON	JUN	JUL	AUG	SEP	SOUTH WEST MONSOON	OCT	NOV	DEC	NORTH EAST MONSOON	ANNUAL RAINFALL
	2	2	11	16	45	77	103	57	63	132	356	116	21	9	145	716
STDEV	7	7	39	14	44	64	75	34	49	79	151	74	28	19	82	311
CV%	287	411	356	82	98	83	72	60	77	59	43	64	134	223	57	43

Table 3: Classification of drought and its periodicity (IMD, 1971)

% Deviation (Di)		>0	0 to -25	-25 to -50	50 to 75	<-75	Probability of drought occurrences
Category		No drought	Mild (Normal)	Moderate	Severe	Acute	
		Years					
Taluk	Bilgi	68	20	13	4	0	Once in 6 years

The details of the drought assessment are discussed as herein under. Out of 105 years of analysis in Bilgi taluk, “No Drought” condition is experienced in 68years, “Mild Drought” condition is experienced in 20 years and “Moderate Drought” condition experienced in 13 years. Further it is observed that “Severe Drought” condition is experienced in 4 years i.e., during 1905, 1923, 1985 and 2003 in Bilgi taluk. Based on occurrence and frequency of past drought events, the probability of occurrence of various intensities of drought at each station has been studied. It has been observed that the frequency of occurrence of drought is **once in 6 years** at Bilgi taluk.

1.4 Agriculture & Irrigation

The land use pattern of the taluk is presented in the **Table-4** and is shown in **Fig. 2.**

Table-4: Land use pattern

Geographical area (Ha)	Area under forest (Ha)	Land put to non agricultural use (Ha)	Uncultivable land (Ha)	Fallow land (Ha)	Area sown (Ha)		
					Net sown area	Area sown more than once	Total sown/cropped area
78169	11761	4331	4517	18208	39185	9254	48439

Source: District at a glance 2016-2017, Govt of Karnataka

Principal crops

Sugar cane cultivated in 15221 ha is the principal crop of the taluk, followed by cereals - Jowar - 10000 ha, Maize 4697 and Bengal gram with an area of 4500 ha, which are normally rain fed crops. Overall food crops and pulses are the major crops grown during Rabi season. Vegetables and paddy crops are the Kharif crops. The principal crops and area grown are in the below **Table-5**.

Table-5: Principal crops in Bilgi Taluk

Crops	Major Cereals (Ha)				Pulses (Ha)				Fruits (Ha)	Vegetables Ha	Oil seeds (Ha)		
	Jowar	Maize	Bajra	wheat	Bengal gram	Green gram	Turdal	Others			Sun Flower	Ground nuts	others
	10000	4687	2915	2500	4500	617	779		519	1195	813	2950	
Total	20102				6066						4378		
	Total Food Grains 26168 ha								**-**	**-**	**Total Oilseeds 4378 ha**		
	Commercial crops												
	cotton				**Sugar cane**								
	350				**15221**								

Source: District at a glance 2016-2017, Govt of Karnataka

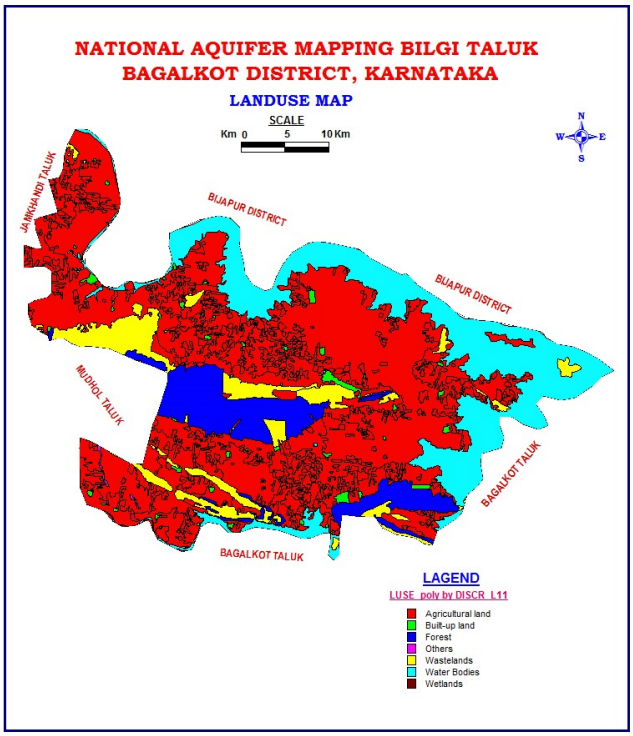

Fig 2: Land use map

Irrigation Practices

In Bilgi taluk, both surface water and ground water irrigation is practiced. One lift irrigation scheme is existing in Bilgi near Sonna Village of Bilgi Taluk in backwaters of Almatti Reservoir which utilise 0.23 TMC water and irrigation potential of 906 ha and irrigate parts of bilgi taluk. (Source: http://www.kbjnl.karnataka.gov.in/kbjnlenglish/). Ground water is the main source of irrigation with net irrigated area of 20294 ha. The details of surface water and ground water irrigation are given in **Table-6**.

Table 6: Details of irrigation in Bilgi taluk

Sl.No.	Source		No. / Length (km)	Net area Irrigated (ha)	Gross area irrigated (ha)
1	Surface water	Canals	20	3314	3314
		Tanks	3	0	0
		Lift Irrigation	1	207	207
2	Ground water	Dug Wells	445	596	628
		Tube wells	5169	20294	22195
3	Other Sources	-	-	9944	11029
4		Total		34355	37373

Source: District at a glance 2016-2017, Govt of Karnataka

1.5 Geomorphology, Physiography & Drainage

Geomorphologically, taluk falls in Northern maidan region. The western part of the taluk is bound by the Western Ghats range of hills which is followed by a narrow piedmont landform towards the east. Further east is Maidan plain land which is characterised by rugged and undulating topography. The other important landforms, which are seen in the region, are reservoirs of the Almatti dam, flood plains of the river Krishna, and Ghataprabha river **(Fig-3).**

Drainage

Bilgi taluk is part of Krishna river basin. The taluk is drained by the Krishna river and Ghataprabha river which is a tributary of Krishna river. The Krishna forms the northern boundary of the Bilgi taluk and Ghataprabha forms the southern boundary of the taluk. Towards south east of the river is the reservoir of the Almatti dam **(Fig.4).** Around 666 sq.km is falling in command area of the upper Krishna irrigation project.

1.6 Geology

Bilgi taluk is underlain by Banded gneissic complex, Granites, Meta sedimentaries, Basalts. The meta sedimentary rocks are collectively known as the Kaladgi series. In Bilgi taluk it is represented by Limestones which cover around 50% of the area **(Fig-5)**.

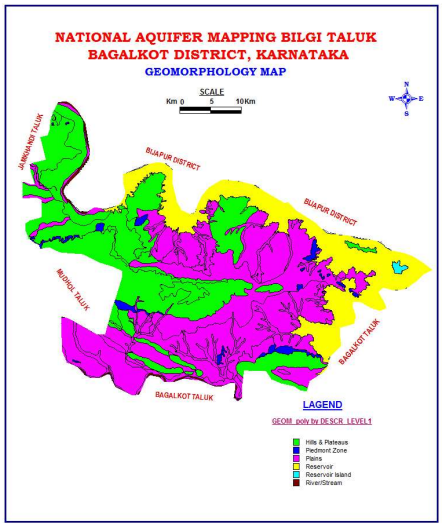

Fig 3. Geomorphology map

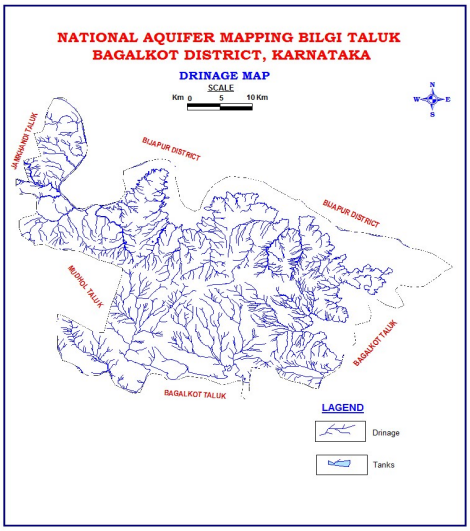

Fig 4. Drainage map

1.7 Soil

The soils are derived from Lime stones, Basalts and Granites. The soils are hard and poor in general and consist of clay, loam, moderate and deep black cotton soils derived from basalt, dark grey clayey and calcareous soil from limestone, clayey soil from Gneiss loam soil from granites **(Fig-6).**

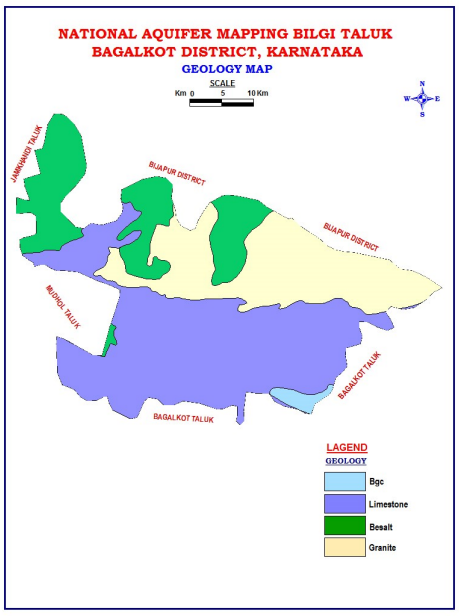

Fig 5. Geology map

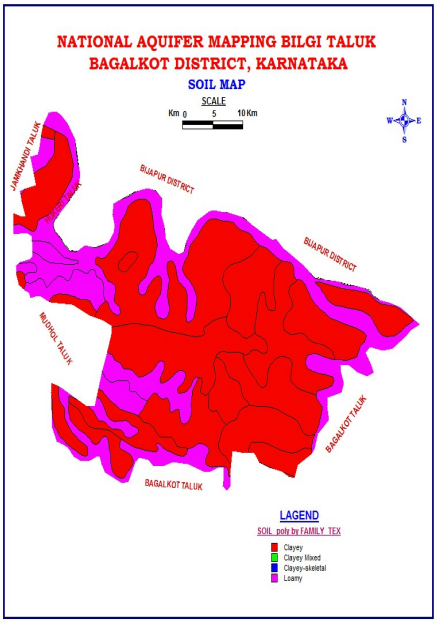

Fig 6. Soil map

1.8 Ground water resource availability and extraction

Aquifer wise the Ground water resource availability up to 200m depth as per Resource Estimation 2017 is as in the **Table 7**.

Table 7: Ground water resource availability (ham)

Year	Annual replenishable GW resources	Fresh In-storage GW		Total availability of fresh GW resources
		Phreatic	Fractured (Down to 200m)	Dynamic +phreatic in-Storage + fractured
2017	3328	6753	1803	8556

As per the estimation **(GEC 2017)** the ground water draft (extraction) for irrigation worked out to be 1199 ham with stage of ground water development of 49%.

1.9. Existing and future water demands

As per GEC (2017) existing ground water draft for irrigation, industrial & domestic (all use) is 1625 ham and allocation for domestic and industrial use is 795 ham and 1430 ham is for future irrigation purpose.

1.10 Water level behaviour

The depth to water levels during pre and post monsoon and the rate of fluctuation of water level are in the **Table 8** and **Figures 7 to 12**.

Item	Table 8: Depth to Water level in Bilgi taluk					
	Pre monsoon		Post monsoon		Water level fluctuation	
	Aquifer I	Aquifer II	Aquifer I	Aquifer II	Aquifer I	Aquifer II
Range	5.00- 20.00	10.00 - 41.00	2.00 -10.00	10.00 - 40.00	0.00 - 9.00	0.00 - 4.00
Average	15.56	25.00	7.75	35.00	7.81	7.51

A. Depth to water level Aquifer I:

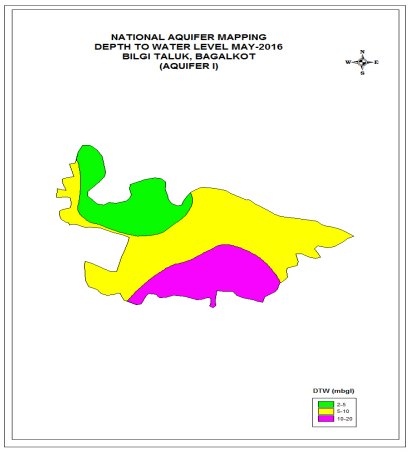

Fig 7. Pre-monsoon DTW Map Aquifer- I

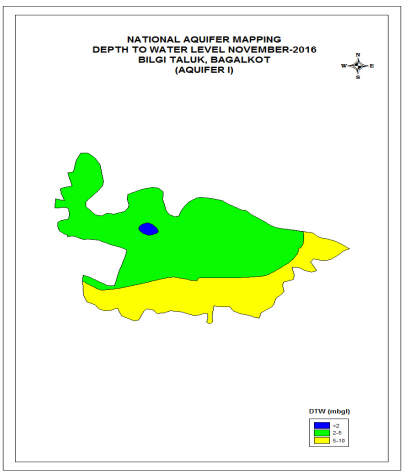

Fig 8. Post-monsoon DTW map Aquifer-I

B. Depth to water level Aquifer II:

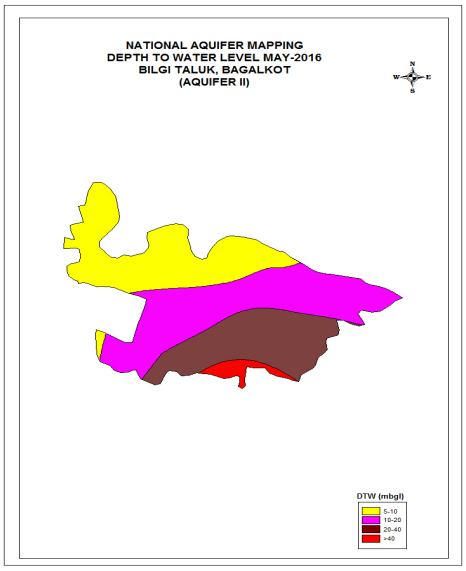

Fig 9. Pre-monsoon DTW Map Aquifer- II

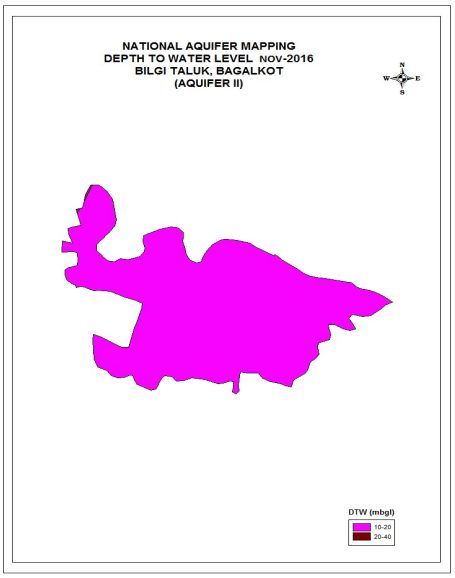

Fig 10. Post-monsoon DTW map Aquifer-II

C. Water level fluctuation

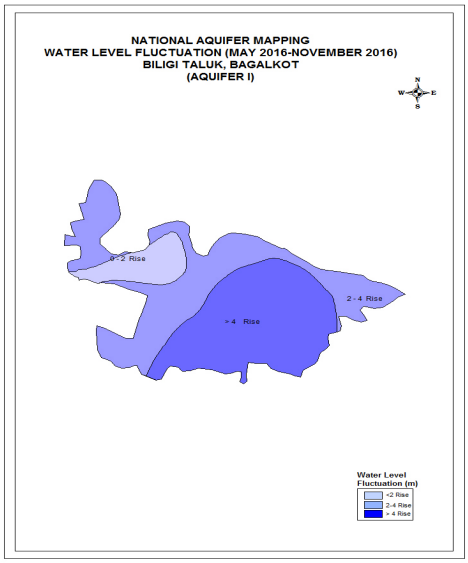

Fig 11. W/L Fluctuation map Aquifer- I

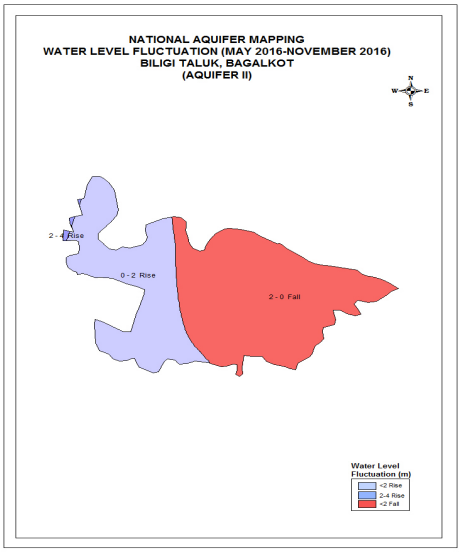

Fig 12. W/L Fluctuation map Aquifer II

2. AQUIFER DISPOSITION

The data collected during Geophysical investigation, Ground water exploration were made use to delineate the aquifer system, geometry and the extension of aquifer in terms of both lateral and vertical extent. The details of ground water exploration are in **Table-9**.

Table 9: Details of Ground water Exploration in Bilgi taluk

Sl. No.	Details	No/Range
1	No of wells drilled	6
2	Depth range in 'm'	80.00 to 200
3	Depth of Casing in 'm'	24.5 -30.50
4	Discharge in lps	0.4 to 6.71
5	SWL in m	2.65 to 21.60
6	Transmissivity m^2/day	0.17 to 12.65

2.1 Number of aquifers

Based on the Ground water exploration data In Bilgi taluk, there are mainly two types of aquifer systems;

i. **Aquifer-I- (Phreatic aquifer)** comprising Weathered Lime stone / Basalt / granite.

ii. **Aquifer-II- (Fractured multi-aquifer system)** comprising Fractured Lime stone / Basalt / granite.

3. GROUND WATER RESOURCE, EXTRACTION, CONTAMINATION

3.1 Aquifer wise resource availability and extraction

Aquifer wise ground water resource estimation in Bilgi taluk as on 2013 & 2017 indicating present and future scenario (2025), Stage of ground water development and categorisation is presented in the below **Table 10**.

Table 10: Ground water resource

Sl. No.	Resource details	As per 2013 Estimation	As per 2017 Estimation
1	Net Ground Water Availability in HAM	6105.58	3328
2	Existing Gross Ground Water Draft for Irrigation in HAM	1761.75	1199
3	Existing Gross Ground Water Draft for Domestic and Industrial	723.75	425
4	Existing Gross Ground Water Draft for all use in HAM	2485.5	1625
5	Allocation for Domestic And Industrial Use for next 25 years in	1194.82	790
6	Net Ground Water Availability for future Irrigation Development in HAM	3193.47	1431
7	Existing Stage of Ground Water Development in percentage	41	49
8	Categorization	Safe	safe

3.2 Chemical quality of ground water and contamination

The chemical quality of ground water in Bilgi taluk is assessed from the analysis results of 2 samples from dug wells (Aquifer-I). The variation range and average of the different chemical constituents are presented in the **Table 11**.

Table 11: Range and average of chemical constituents in Ground water

Location	PH	EC	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO4	NO_3	F
Badagandi	7.96	4950	780	64	39	782	1	NIL	421	986	576	182	1.80
Teggi	8.19	2960	460	48	29	322	255	NIL	372	326	528	210	1.30
Average	8.08	3955.00	620.00	56.00	34.03	552.00	128.01	0.00	396.63	655.83	552.00	196.05	1.55

The groundwater quality depends upon multiple aspects viz., rock types, irrigation practices adopted, release of effluents from various industries and due to over exploitation. Only two samples from Teggi and Baragundi were analysed. The EC ground water samples of the Taluk **(Fig.12a)** revealed that the ground water quality when compared with standards prescribed by BIS was in general found to be not potable. The pH is more than 7.0 and the ground water is alkaline in nature.

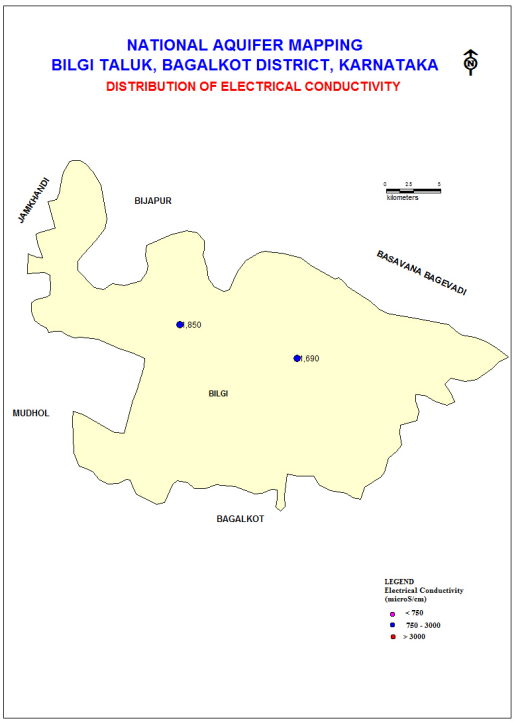

Fig 12a. Distribution of Electrical Conductivity- point location in Bilgi Taluk

Hardness:

Hardness in ground water is a major domestic water quality hazard. The hardness may be temporary or permanent depending upon salt content present. Both the forms of hardness reduce the cleaning ability of soaps and detergents. Higher hardness (>600 mg/l) is reported from Bilgi.

Nitrate:

Presence of nitrate in ground water increases due to human activities on the surface especially near wells/ bore wells, like sewage disposal, animal dung pits, and use of nitrogen fertilizers. Higher concentration (>45 mg/l) of nitrate is reported in the Taluk **(Fig 12 b).**

Fluoride:

Excess fluoride is reported from Badagundi area **(Fig 12 c).**

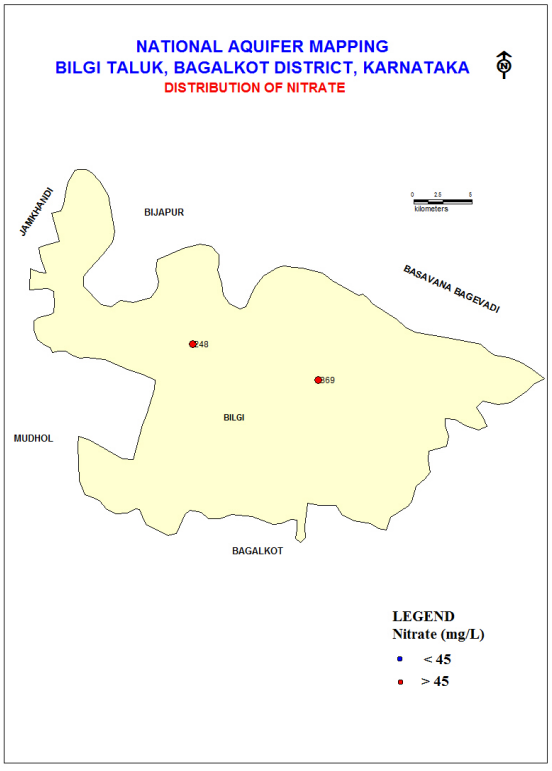

Fig 12 b. Point location of Nitrate in Bilgi taluk

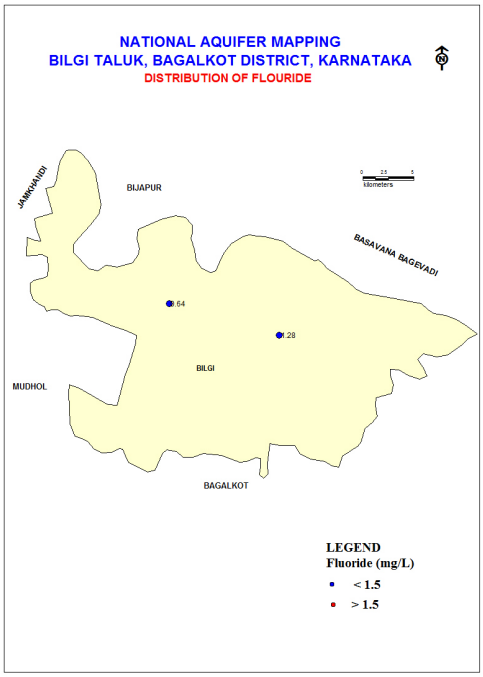

Fig 12 c. Point location of Fluoride in Bilgi taluk

3.2.1. Suitability of ground water for drinking purposes :

Assessed as per Indian Standard Drinking water specification (IS 10500:2012) for PH, TDS, Hardness, Calcium, Magnesium, Chloride, Nitrate and Fluoride ions. The analysis indicates that water is not potable and chemical constituents are not within the desirable/permissible for many constituents. The TDS is above permissible limit. Although calcium, magnesium and Chlorides are within permissible limit, the concentration of Nitrate and Fluoride are above permissible limits indicating that the groundwater is not suitable for drinking purposes **Table 12**. Alternatively surface water source maybe utilised for meeting the drinking water needs of the taluk.

Table 12:Suitablity of ground water for Drinking as per BIS standards 2012

Constituents	Permissible limit	Badagandi	Permissible Yes/No	Teggi	Permissible Yes/No
PH	6.5-8.5	7.96	Yes	8.19	Yes
TDS	1280	3168	No	1894.4	No
TH	600	780	No	460	Yes
Ca	200	64	Yes	48	Yes
Mg	30	39	Yes	29	No
Cl	1000	986	Yes	326	Yes
SO4	400	576	No	528	No
NO3	45	182	No	210	No
F	1.5	1.8	No	1.3	Yes

3.2.2. Suitability of ground water for irrigation purposes:

Assessed and generally it is good but at places the nitrate rich water is observed. The suitability of ground water for irrigation depends on various factors such as i) the total concentration of soluble salts, which is broadly related to the specific electrical conductance of water, ii) the relative proportion of sodium to calcium and magnesium, iii) the concentration of boron and iv) the relative proportion of bicarbonate to calcium and magnesium (Karanth, 1987). In the absence of analysis for boron in ground water samples, the other three criteria have been used to assess the suitability of ground water for irrigation. The analysis of two samples as per **Table 12** were utilised for evaluating irrigation suitability of ground water from Bilgi taluk.

Salinity Hazard

Classification based on amount of Total Dissolved Solids (Winslow and Kister (1956), USGS (1965) and Nordstrom (1987).

Sodium Hazard

Excessive sodium content in water renders it unsuitable for irrigation in soils containing exchangeable Ca_2^+ and Mg_2^+ ions. The 'sodium hazard' in irrigation water is expressed by determining the Sodium Adsorption Ratio (SAR). Although the SAR value is found to be less than 26 required for using the water for irrigation, it is observed that in the samples sodium hazard is in medium to high category. Hence the ground water can be used for irrigating salt tolerant crops.

Residual Sodium Carbonate

In addition to total dissolved solids, the relative abundance of sodium with respect to alkaline earths and boron, the quantity of bicarbonate and carbonate in excess of alkaline earths also influence the suitability of water for irrigation purposes. This excess is denoted by 'Residual Sodium Carbonate' (RSC) and is determined by the formula (Richards (Ed.), 1954):

$$RSC = (HCO3- + CO3--) – (Ca2++ Mg2+)$$

where the concentrations are expressed in milli-equivalents/litre (epm). The RSC is found to be less than 2.5 and range from 0.5 to 1.3 rendering the water suitable for irrigation.

4. AQUIFER MANAGEMENT PLAN

Based on the field study and analysis of hydrogeological data following recommendations are made for management plan of aquifers and optimum yield of the available water resources in the Aquifer Mapping Study area of parts of Bilgi taluk, Bagalkot district.

4. 1 Ground water resource enhancement from artificial recharge

Continuous drought, increase in agricultural activity, subjected to excessive ground water withdrawal leading to depletion of ground water table, 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 **(Table-11)**.

4.2 Aquifer wise space available for recharge and proposed interventions

4.2.1 Quantity of water available through non-committed surface run off:

The surplus non-committed monsoon run off is calculated to be 7.76 MCM this can be used to recharge the aquifer through suitable recharge structures which augments the net ground water availability in the taluk. The area feasible for water conservation has been arrived from the Depth to Water Level data and Slope data. The details of types of structure/number for recharge are presented in the **Table-13**.

Table 13: Details of Artificial structures

Artificial Recharge Structures available/Proposed	Bilgi taluk	Resource available in MCM
Non committed monsoon run off available (MCM)	7.76	
Number of Check Dams	48	3
Number of Percolation Tanks	3	1.
Number of Point Recharge structures	5	0.
Tentative total cost of the project (Rs. in lakhs)	178	
Excepted recharge (MCM)	439	-
Expected rise in water level (m)	2.243	-
Cost Benefit Ratio (Rupees/ cu.m. of water harvested)	4.26	-

Thus, considering above source water for ground water recharge, the volume of water expected to be conserved or in the ground water resource enhancement is detailed in the below **Table-14**.

4.3 Other Interventions

Conjunctive Use in Water Logged areas: 165 sq.km of water logged due to intensive irrigation. It is suggested that conjunctive use of surface and ground water in these areas may be practiced.

Table 14: Expected improvement in stage of ground water development

After implementation of AR structures and inter-basin transfer project in Bilgi taluk

Sl. No.	Resource details	As per 2017 Estimation
1	Net Annual Ground Water Availability ham (2011) ham	3328
2	Existing Gross Ground Water Draft for All Uses (ham)	1625
3	Existing Stage of development	49
4	Expected Recharge from Implementing AR Structures & GW Recharge Schemes	439
	Additional Potential from Proposed AR (ham)	536
6	Cumulative Annual Dynamic Ground Water Availability after Implementing AR Structures, GW Recharge Schemes	3767
7	Stage of development after implementation of.AR structures	43 %
8	Expected improvement in overall stage of development	6 %

5. DEMAND SIDE INTERVENTIONS

5.1 Advanced irrigation practices

Major crops of Bilgi taluk are Jowar and Maize which are rain fed. Remaining crops like some of the pulses, Vegetables and fruits are depending upon the ground water source.

Micro Irrigation techniques are yet to pick up in the area, recommended to take up micro irrigation practices in the area. Considering 60% of the irrigated area by ground water is covered by WUE measures. The existing GW draft for irrigation is 1199 ham and about 30% of this can be saved for additional irrigation. The total saving works out to be 30% of the existing GW draft amounting to 360MCM.

6. SUMMARY

The summary of Management plan of Bilgi taluk is given in **Table-15**.

Table 15: Summary of Management Plan of Bilgi taluk

Bilgi taluk is Safe as GEC 2017	49 %
Net Annual Ground Water Availability (HAM)	3328
Existing Gross Ground Water Draft for all uses	1625
Total GW Resources (Dynamic & Static up to the depth of 250 mbgl) (MCM)	8556
Expected additional recharge from monsoon surplus runoff (MCM)	439
Change in Stage of GW development, %	49 to 43
Expected Saving due to adopting WUE measures (MCM)	360