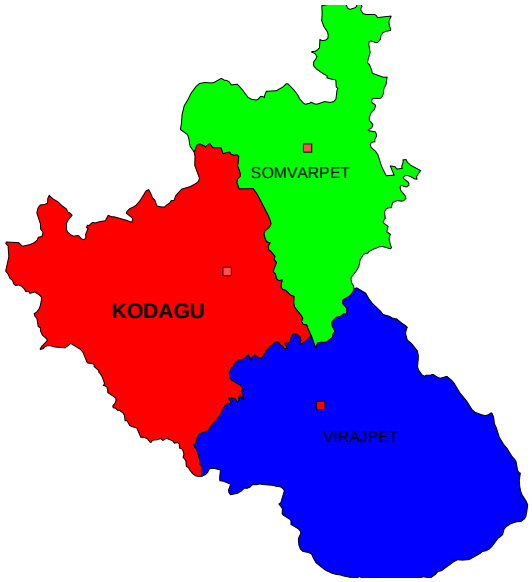
जल वर्ष 2007 Water Year 2007

स्वच्छ सुरक्षित जल – सुन्दर खुशहाल कल

CONSERVE WATER - SAVE LIFE

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER INFORMATION BOOKLET
KODAGU DISTRICT, KARNATAKA STATE



SOUTH WESTERN REGION
BENGALURU
JANUARY 2013

जल वर्ष 2007 Water Year 2007

स्वच्छ सुरक्षित जल – सुन्दर खुशहाल कल

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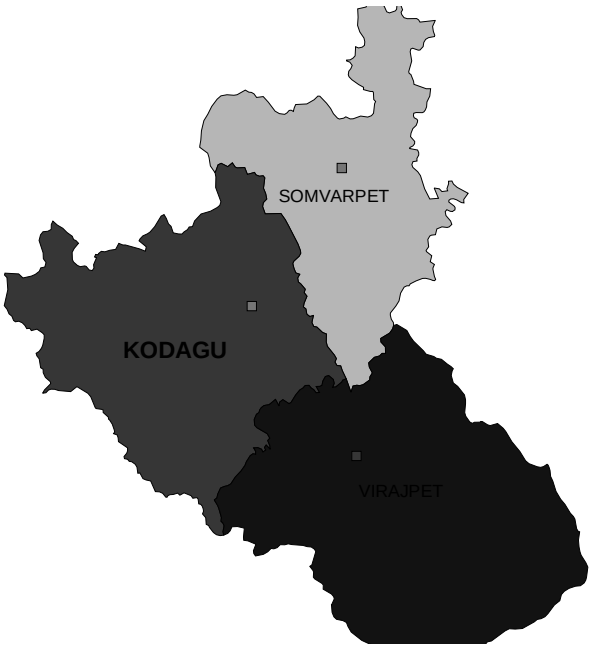


SOUTH WESTERN REGION
BANGALORE
JANUARY 2013

सुशील गुप्ता
अध्यक्ष
केन्द्रीय भूमि जल बोर्ड,
जल संसाधन मंत्रालय,
भारत सरकार,
भूजल भवन, एन एच. - 4,
फरीदाबाद.

Sushil Gupta
Chairman
Central Ground Water Board,
Ministry of Water Resources,
Government of India,
Bhujal Bhawan, NH-IV,
Faridabad.

FOREWORD

Groundwater is an essential component of the environment and economy. It sustains the flow in our rivers and plays an important role in maintaining the fragile ecosystems. The groundwater dependence of agrarian states like Karnataka is high. Recent studies indicate that 26 percent of the area of Karnataka State is under over exploited category and number of blocks is under critical category. In view of the growing concerns of sustainability of ground water sources, immediate attention is required to augment groundwater resources in stressed areas. Irrigated agriculture in the state is putting additional stress on the groundwater system and needs proper management of the resources.

Central Ground Water Board is providing all technical input for effective management of ground water resources in the state. The groundwater scenario compiled on administrative divisions gives a better perspective for planning various ground water management measures by local administrative bodies. With this objective, Central Ground Water Board is publishing the revised groundwater information booklet for all the districts of the state.

I do appreciate the efforts of Dr. K.Md.Najeeb, Regional Director and his fleet of dedicated Scientists of South Western Region, Bangalore for bringing out this booklet. I am sure these brochures will provide a portrait of the groundwater resources in each district for planning effective management measures by the administrators, planners and the stake holders.

Sushil Gupta
CHAIRMAN

PREFACE

Ground water contributes to about eighty percent of the drinking water requirements in the rural areas, fifty percent of the urban water requirements and more than fifty percent of the irrigation requirements of the nation. Central Ground Water Board has decided to bring out district level ground water information booklets highlighting the ground water scenario, its resource potential, quality aspects, recharge – discharge relationship, vulnerability area etc., for all the districts of the country. As part of this, Central Ground Water Board, South Western Region, Bangalore, is preparing such booklets for all the 30 districts of Karnataka state, incorporating the data up to the period 2011-12.

The Kodagu district Ground Water Information Booklet has been prepared based on the information available and data collected from various state and central government organisations by several hydro-scientists of Central Ground Water Board with utmost care and dedication. This booklet has been prepared by Dr S.Srinivasa Vittala, Asst Hydrogeologist, and under the guidance of Dr K.R.Sooryanarayana, Scientist-D, Central Ground Water Board, South Western Region, Bangalore. The figures were prepared by Sri.J.Sivaramakrishnan, Assistant Hydrogeologist. The efforts of Report processing section in finalising and bringing out the report in this format are commendable.

I take this opportunity to congratulate them for the diligent and careful compilation and observation in the form of this booklet, which will certainly serve as a guiding document for further work and help the planners, administrators, academicians, hydrogeologists and engineers to plan and manage the water resources in a better way in the district.

(Dr. K.Md.Najeeb)
Regional Director

KODAGU DISTRICT AT A GLANCE

Sl.No.	Items	Statistics	
1	**General Information**		
	i) Geographical area (sq. km)	4,102	
	ii) Administrative Divisions		
	Number of Taluks	3 (Madikeri, Somvarpet & Virajpet)	
	No. of Panchayat /Villages :	98/291	
	iii) Population (As on 2011 Census)	554,762	
	iv) Annual normal rain fall (1971-2011)	2,598 mm	
2	**Geomorphology**		
	Major Physiographic Units	Malnad area of Western Ghats. The district forms a part of Western Ghats with high range mountains running north – south. The whole district area, except for a narrow elongated strip, is mountainous. The highest peak of the district is Tadiondamol (1908 m amsl). The table land of Madikeri maintains an average altitude of about 1166 m amsl and slopes down a little to reach 910 m amsl near Kushalnagar.	
	Major Drainages	Drained by 6 perennial rivers namely East flowing Cauvery and West flowing Netravati, Payasyani, Ariyakodavu, Kuppam and Velapattanam	
3	**Land use (sq. km)**		
	Forest area	1345.97	
	Net area sown	1474.53	
4	**Major soil types**	Reddish brown forest soil, Yellowish grey to greyish sandy loam soils and mixed soils.	
5	**Area under principal crops in ha**	**Crop**	**Area**
		Coffee	83205
		Tea	490
		Rubber	1926
		Cashew	2198
		Coconut	1370
		Areca nut	1505
		Palm	903
		Pepper	15975
		Ginger	4550
		Cardamom	11957
		Banana	520
		Orange	1085

		Chilly Vegetable Paddy Maize	900 832 36106 2382
6	**Irrigation by different sources** Dug wells Bore wells Tanks/ Ponds Canals Lift Other Sources	**Area (Ha)** 18 10 98 2234 85 468	**Number** 122 88 - - -
	Net Irrigated Area (ha)	**2913**	
7	NUMBER OF GROUND WATER MONITORING STATIONS OF CGWB (AS ON 31-03-2007) Number Dug wells Number of Piezometers	 24 6	
8	**Predominant geological formations**		
	Recent to sub-Recent	Alluvium & Colluvium	
	Pleistocene	Laterites	
	~~ **U n c o n f o r m i t y**	~~~~~~~~~~~~~~~~~~~~~~~~~	
	Late Proterozoic	Basic and Ultra mafic dykes Pegmatite and quartz veins	
	Archaean	Amphibolites Granite gneisses Charnockites	
9	**Hydrogeology**		
	Major Water Bearing Formations -		
	Shallow aquifers of alluvium along the stream courses and weathered zones of Granites and gneisses occur between the depths of 2 to 25 m bgl.		
	Deeper aquifers of jointed and fractured Granite and gneisses occur between the depths of 25 to 150 m bgl.		
	Pre-monsoon Water Levels during 2011	0.90 – 14.65 m bgl	
	Post-monsoon Water Levels during 2011	0.71 – 13.71 m bgl	

	Long term water level trends (2002-2011) in m/year:	Pre-monsoon	Twenty are having rising trends in the range between 0.015 and 1.076 m/year and five stations showing falling trends in the range between 0.015 to 0.169 m/year.
		Post-monsoon	Nineteen are having rising trends in the range between 0.002 and 0.361 m/year and six stations showing falling trend in range between 0.004 to 0.369 m/year.
10	**Ground water exploration by C.G.W.B. (as on 31-03-2012)**		
	No of wells drilled		EW: 13, OW: 10, PZ: 6
	Depth range (m)		60 – 201 m bgl
	Discharge (litres / second)		1.0 – 15.0 Litres / second
	Transmissivity (m2/day)		$1 – 50\ m^2$ / day
11.	**Ground water quality**		
	Presence of chemical constituent more than the permissible limit		Chemical quality of Ground water is suitable for all purposes in Major parts of the district.
	Type of water		Low sodium type
12.	**Dynamic Ground Water Resources** (mcm) (2009)		
	Net Annual Ground Water Availability		240.29 mcm
	Net annual Ground Water Draft		51.90 mcm
	Stage of Ground Water development as on March 2009 (%)		22.10% (SAFE)
13.	**Awareness and Training Activity**		
	Mass Awareness Programmes Organised		Nil
	Water Management Training Programmes organised:		Nil
14.	**Efforts of artificial recharge & rain water harvesting:**		
	Projects completed by CGWB (No and amount spent)		Nil
	Projects under technical guidance of C.G.W.B (numbers)		Nil
15.	**Ground water control and regulation**		
	Number of OE Blocks Number of Critical blocks Number of blocks notified		Nil Nil Nil

16.	**Major ground water problems and issues**	Groundwater development has reached 30% for the district as a whole and the district falls in the 'safe' category. As groundwater level, in general, is not declining, revitalising by cleaning and deepening the dug wells will help in augmenting the yield. Adopting watershed treatment is a good option to control in augmenting the natural recharge.

KODAGU DISTRICT

1.0 INTRODUCTION

1.1 GENERAL

Kodagu district located in the southwestern part of Karnataka state falls in the high precipitation zone with picturesque topography occupying the eastern and western slopes of the Western Ghats. Closed with primeval forest or glassy glades and broken by a few cultivated villages, it has mountainous configuration, which presents a grand panorama, verdant valleys, ravines, fast flowing streams, lofty peaks and awe-inspiring spurs. The terrain and climatic conditions here are somewhat unique and nature has bestowed the district with an abundance of forest wealth. It enjoys typical tropical climate. In the economy of the State and the country Kodagu enjoys a distinct place in view of its international reputation as a prominent coffee-producing center. Cardamom, pepper and oranges of Kodagu are also quite famous. So also, the honey produced in Kodagu has a reputation for its taste and nutritive value. In conformity with the general pattern prevalent in the hilly regions, in Kodagu also the population density is low and small clusters of houses amidst rich vegetation, that is, scattered houses and homesteads, characterize the settlement pattern. The total population in the district is around 554,762 (as per 2011 census), out of which male and female were 274,725 and 280,037 respectively. There was change of 1.13 percent in the population compared to population as per 2001 census. With regards to Sex Ratio, it stood at 1019 per 1000 male compared to 2001 census figure of 995.

Cauvery, one amongst the seven most sacred rivers of the country, is the main and the largest river of the district.

1.2 Location

Kodagu district with an area of 4,102 Km^2 is the smallest district in the state of Karnataka. Located in the southwestern part of Karnataka state between North latitude 11^O 56' and 11^O 52' and East longitude 75^O 22' and 76^O 12', it falls in the high precipitation zone with picturesque topography occupying the eastern and western slopes of the Western Ghats. It is bounded by, Hassan district on the north, by Mysore district on the east, by Dakshin Kannada district on the west and Kasargod district of Kerala state on the south. In the north a narrow strip of landscape measuring about 20 km in length and 10 km breadth projects into Hassan district. A map showing administrative set-up of the district is given as **Figure 1**.

1.3 Administrative set up

The district comprises of three taluks namely Madikeri, Somvarpet and Virajpet having geographical areas 1449, 999 and 1654 sq. km respectively. The taluks are named after taluk headquartes. Madikeri is the district headquarters of Kodagu district. It is about 262 kms away from Bangalore.

1.4 Communication

The district is well connected by highways and other main roads. The Bangalore – Mangalore Highway (SH 88) and Mysore - Cannanore Highway (SH- 88A) passes through the district. Fairly good network of roads exists connecting taluk headquarters with district headquarters and hoblis to various taluk headquarters. Mercara town is well connected with all the important places of the state. It is about 262 km from Bangalore (State Capital), 128 km from Mysore and 130 km from Mangalore. The nearest Railway stations are Hassan and Mysore. Nearest Airport is located at a distance of about 130 km at Mangalore.

1.5 Drainage

The district is drained by 6 perennial rivers namely westernly flowing Netrawati, Payasyani, Ariyakodavu, Kuppam and Velapattanam and easternly flowing Cauvery river. The major perennial tributaries to Cauvery are Harangi, Hemavati, Chikle, Kokkabe, Laxmantirth and Kabini. Cauvery is the main and the largest river of the district. It has its origin in the Brahamgiri Mountains at a place called Talakaveri. The length of river Cauvery from its source to the place where it leaves Kodagu district is about 80 km. The drainage map of the district is presented as **Figure 2**. Based on the drainage densities the district is divided into 4 zones, viz. areas having (i) drainage density less than 1, (ii) 1 to 2, (iii) 2-3 and (iv) >3 km /km^2. It is observed that the drainage density and the ground slope in the plateau areas with a minimum surface runoff and moderate to good rate of water infiltration have enough scope for natural recharge of ground water regime. Rest of the area offers less scope for infiltration as compared to plateau area. Kodagu district is not in any way reputed for lakes and tanks. Now, the Harangi project is completed and a large artificial lake, namely the Harangi Reservoir, has been formed in the eastern sector near Igoor village of Somwarpet taluk. There are numerous springs in the valleys and there is always adequate supply of water for drinking and other purposes.

1.6 Crops and Irrigation Practices

The net sown area comprises 36% of the total geographical area. While paddy is grown in favourable areas, Coffee, Tea, Plantain and Areca nut are the main horticulture crops. About 2% of the net sown area is irrigated and of this a mere 10% is irrigated by ground water. Plantation crops constitute the very life-blood of the district economy in that the very name of the district, particularly its anglicized form, Coorg is almost a bye word for coffee and oranges. Cardamom and pepper are also crops of considerable importance. Coffee is the most important plantation crop. It is a common practice for the coffee planters to grow oranges inter-mixed with coffee in their estates. Although paddy is grown extensively, annually only one crop is raised and it is done usually under rain-fed conditions. In certain tracts sugarcane is also raised to a little extent and used for preparing gur.

Fig-1

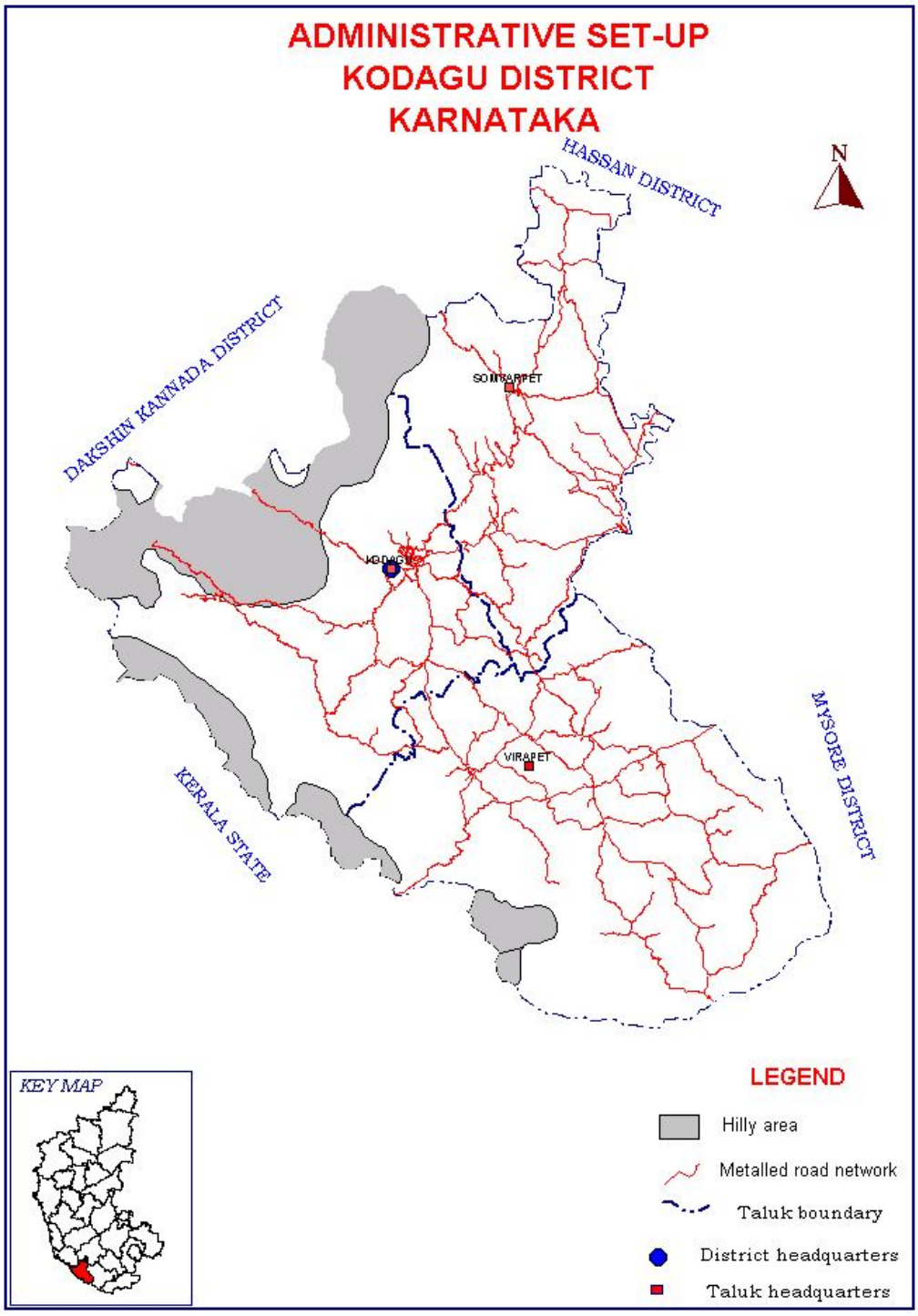
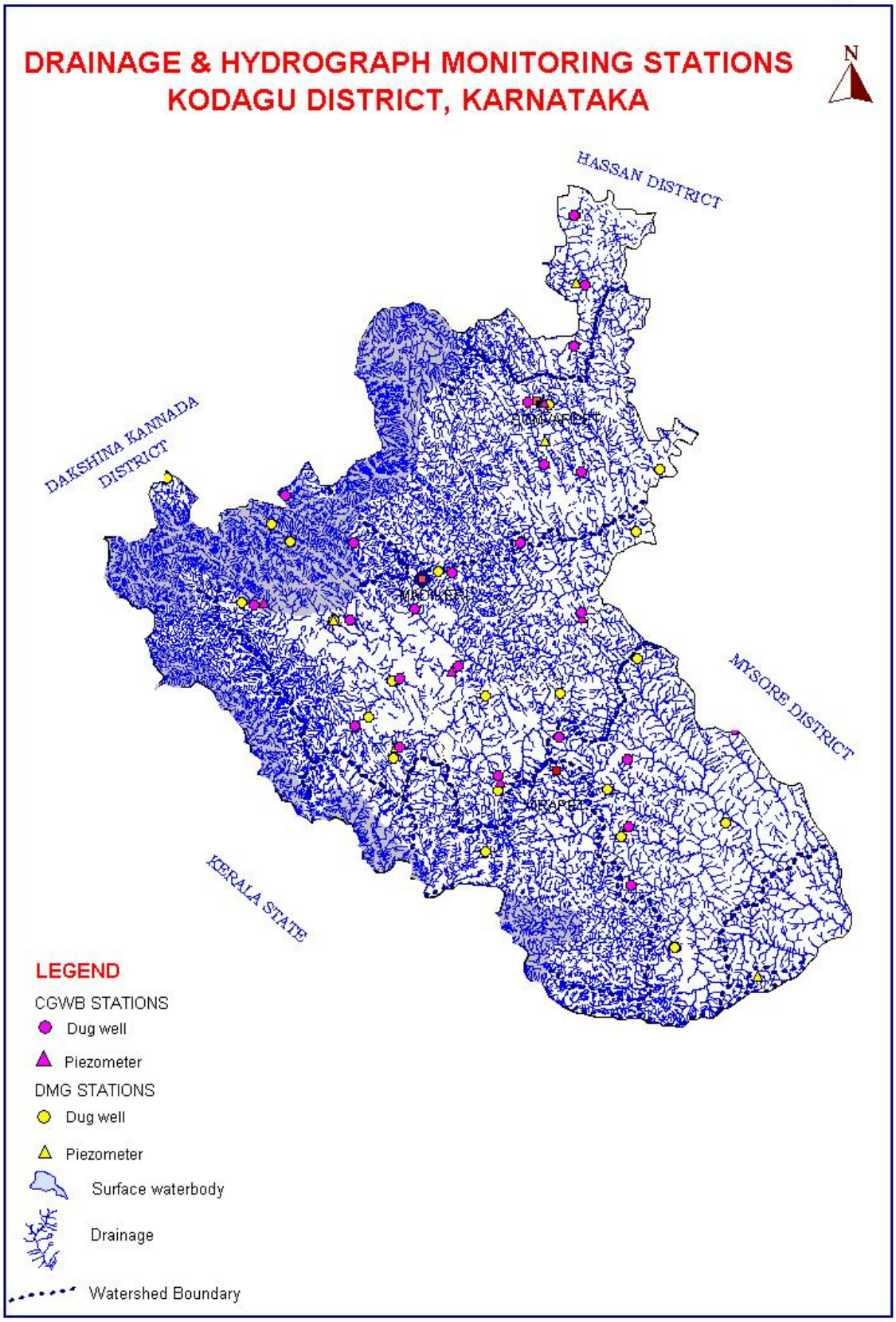

ADMINISTRATIVE SET-UP
KODAGU DISTRICT
KARNATAKA
N
HASSAN DISTRICT
DAKSHIN KANNADA DISTRICT
SOMWARPET
KODAGU
VIRAJPET
KERALA STATE
MYSORE DISTRICT
KEY MAP
LEGEND
Hilly area
Metalled road network
Taluk boundary
District headquarters
Taluk headquarters

Fig-2


DRAINAGE & HYDROGRAPH MONITORING STATIONS
KODAGU DISTRICT, KARNATAKA
N
HASSAN DISTRICT
DAKSHINA KANNADA DISTRICT
MYSORE DISTRICT
KERALA STATE
MADIKERI
VIRAJPET
LEGEND
CGWB STATIONS
Dug well
Piezometer
DMG STATIONS
Dug well
Piezometer
Surface waterbody
Drainage
Watershed Boundary

1.7 Activities carried out by CGWB

Central Ground Water Board has carried out Systematic Hydrogeological surveys, Reappraisal Hydrogeological surveys and Groundwater Exploration in the district. The hydrogeological investigations and groundwater exploration have revealed the existence of potential zones within 200 meters depth in granitic and gneissic formations. Besides, CGWB maintains a good network of observation wells (NHS) in the district, which are monitored periodically to keep a close vigil in water level variations.

2.0 RAINFALL AND CLIMATE

The district enjoys typical tropical climate characterized by slight to medium humidity due to proximity to coast (about 32 Km). It is known to be quite pleasant and healthy, characterized by high humidity, heavy rainfall and cool summer. A major part of the year consists of rainy season as the monsoon period starting in June lasts till the ends of September. Even during the post monsoon months of October and November certain parts of the district receive a significant amount of rainfall. Because of the cloudy weather, the day would be quite sultry during October and it is only during the second half of the November that the weather becomes brighter. The period from December to February is the cold season marked by a bright weather, foggy mornings and cool nights. The day temperature begins to rise sharply during March and marks the commencement of the summer season, which lasts till the end of May. The highest maximum temperature recorded at Madikeri is $35^{O}C$ on the 11th of May 1902 and the lowest minimum temperature ever recorded is $8.9^{O}C$ on the 20th of February 1936.

The southwest monsoon sets in usually during the early part of June. Generally, June, July and August are the months of heavy rainfall and the precipitation in July is incessant and very heavy. The average annual rainfall for the district (2001-2010) is 2581 mm. The Seasonal & Annual Nornmal Rainfall for the period 2001-2010 Kodagu District, Karanataka is given in **Table 2** and The district and taluk wise rainfall for the year 2011, Kodagu district, Karnataka is given is **Table 3.** The number of rainy days ranges between 85 and 153, with an average of about 118 rainy days in a year.

The amount of rainfall and the number of rainy days varies considerably within the district. The analysis of the last 10 years data reveals that the highest rainfall (Average 3222 mm) has occurred in Madikeri taluk located in the Western part of the district which is thickly forested and the lowest (Average 2132 mm) in Somvarpet, taluk which is in northern part of the district having less forest cover and adjacent to Maidan (Plain) region. The orographic influence on rainfall is clear from the spatial distribution. Therefore, the rainfall is found to go on decreasing as one proceeds from the western part of the district to the eastern part.

Table: 2 Seasonal & Annual Nornmal Rainfall for the period 2001-2010 Kodagu District, Karanataka

Station	Pre-Monsoon	SW Monsoon	NE Monsoon	Annual
	Rainfall (mm)			
Madikeri	241	2678	303	3222
Somwarpet	209	1682	241	2132
Virajpet	296	1774	318	2388

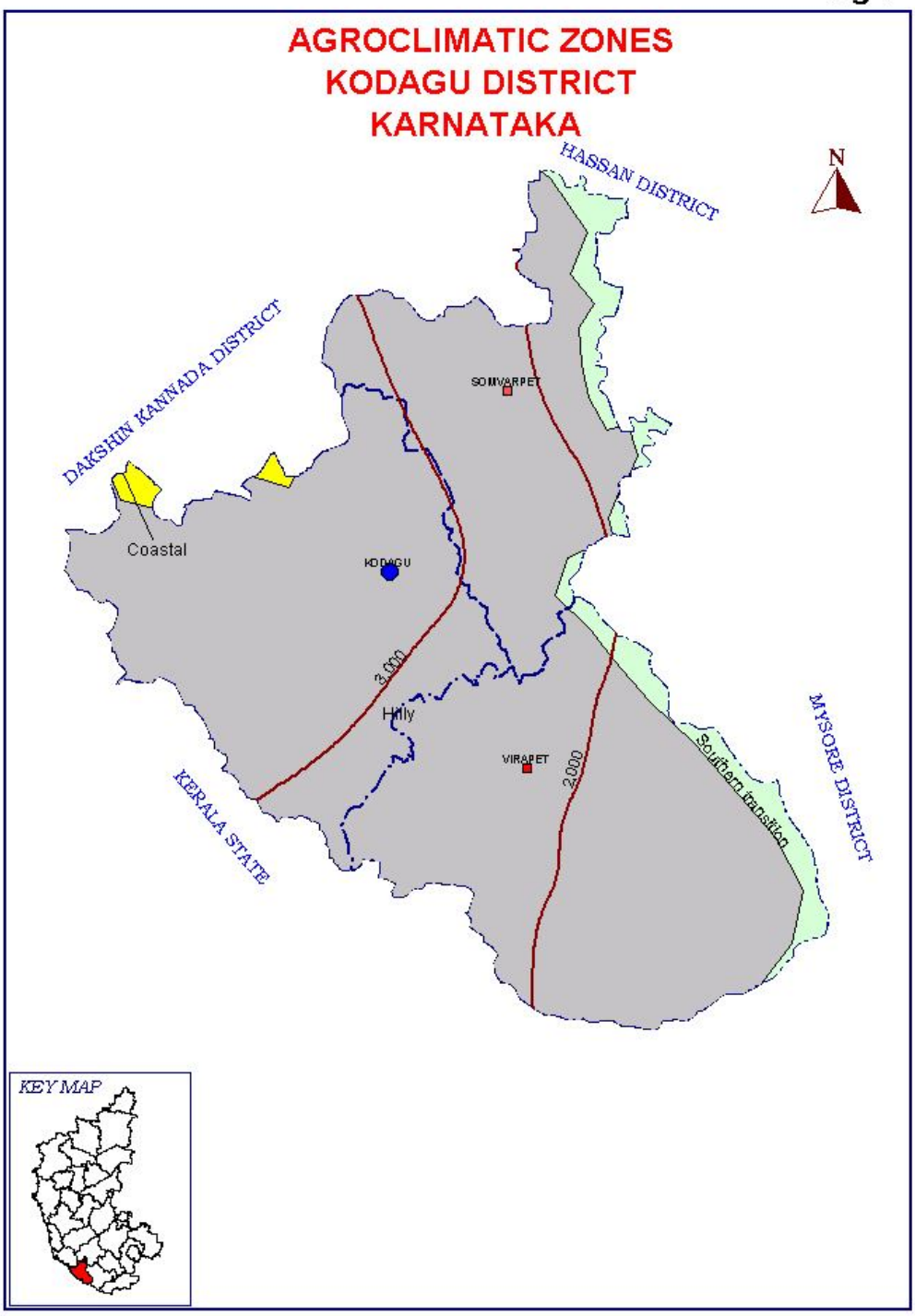
Table: 3 District and taluk wise rainfall for the year 2011, Kodagu district, Karnataka.

DISTRICT AND TALUK WISE RAINFALL FOR THE YEAR 2011, KODAGU DISTRICT, KARNATAKA																	
	DISTRICTS/ TALUKS	JAN	FEB	MAR	APR	MAY	PRE	JUN	JUL	AUG	SEPT	SWM	OCT	NOV	DEC	NEM	ANNUAL
		Rainfall (mm)															
	KODAGU	**0**	**8**	**5**	**119**	**76**	**208**	**648**	**591**	**564**	**364**	**2166**	**188**	**81**	**0**	**269**	**2643**
1	MADIKERI	0	12	1	99	72	184	778	853	866	544	3041	151	56	0	207	3432
2	SOMWARPET	0	11	12	89	114	226	359	363	404	209	1335	273	152	0	425	1986
3	VIRAJPET	0	0	3	169	42	214	806	556	421	339	2122	140	34	0	174	2510

3.0 GEOMORPHOLOGY AND SOIL TYPES

The district forms a part of Western Ghats with high range mountains running north – south. Situated on the eastern and western slopes of the Western Ghats, clothed with lush greenery of forests and plantations, and broken by a few cultivated valleys, Kodagu is a picturesque highland. Its physical features are varied. The high hilltops are generally grassy with valley of dense mixed jungles and cardamom plantations. Low hill areas are generally under cultivation with teak plantation or dense mixed jungle. From this main range seven long and elongated ridges run from west to east. These chains of hill range have an elevation ranging from 1000 to 1700 metres amsl. The whole district area, except for a narrow elongated strip, is mountainous (**Figure 3**). The landscape in northeastern and eastern portion is different and resembles that of the adjoining Mysore district. The highest peak of the district is Tadiondamol (1908 m amsl). The table land of Madikeri maintains an average altitude of about 1166 m amsl and slopes down a little to reach 910 m amsl near Kushalnagar.

Fig-3


AGROCLIMATIC ZONES
KODAGU DISTRICT
KARNATAKA
N
HASSAN DISTRICT
DAKSHIN KANNADA DISTRICT
SOMVARPET
Coastal
KODAGU
3,000
Hilly
VIRAPET
2,000
Southern transition
MYSORE DISTRICT
KERALA STATE
KEY MAP

The soils of the district are of a heterogeneous profile and consist of lateritic debris found in different stages of weathering and laterization. The valleys and slopes have fertile read loamy soils that are suitable for cultivation. In the eastern zone dark clay soils are predominant. These get water logged during monsoon and deep cracks appear during the summer months. In the central zone loamy soils are predominant. In the central zone loamy soils are predominant. In the western zone, the soil is highly leached and being lateritic in content, tends to be quite shallow.

4.0 GROUND WATER SCENARIO

4.1 HYDROGEOLOGY

Hydrogeologically, the area forms a part of hard rock terrain comprising of granites, gneisses, charnockites and amphibolites (**Figure 4**). Pegmatite veins and dolerite dykes are common intrusives in the area, especially in the eastern and southern sectors of the district. Dolerite dykes occur as detached boulders at places and as intrusives in granitic formations. 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 ground water occurs under phreatic conditions in weathered zones of granites and gneiss, and under semi-confined to confined conditions in joints and fractures of these rocks at deeper level. Weathering of granites and gneisses, has given rise to thick sandy residuum down to the depth of 2.0 and 25.0 m. bgl and it forms an important phreatic aquifer. Fractured granites and gneisses form prolific deeper aquifers in some parts of the district.

4.1.1 OCCURRENCE OF GROUND WATER

Ground water in the district generally occurs under unconfined to semi-confined conditions. In the shallower zones it is under phreatic conditions and in deeper zones it is under semi-confined conditions. The ground water is being exploited from the depth range of 10.00 to 20.00 m bgl through dug wells and from the depth range of 30.00 to 100.00 m bgl through dug-cum-bore wells and bore wells. The ground water exploration has proved the presence of prolific aquifers below the depth of 100 m. The Hydrogeological details of the area are presented in **Figure 4**.

4.1.2 DEPTH TO WATER LEVEL

Out of 24 National Hydrograph Stations (NHS) located in Kodagu district, the depth to water levels in the NHS (dug wells) recorded during May-2011 were in the range of 0.90 – 14.65 m bgl. The depths to water levels in the national hydrograph stations (dug wells) recorded during November 2011 were in the range of 0.71 to 13.71 m bgl.

The pre-monsoon and post-monsoon depths located water levels are depicted in **Figure 5** and **Figure 6**. It is observed that major parts of the district has moderate to moderately deep-water levels between 2 to 10 m both during pre- and post-monsoon periods.

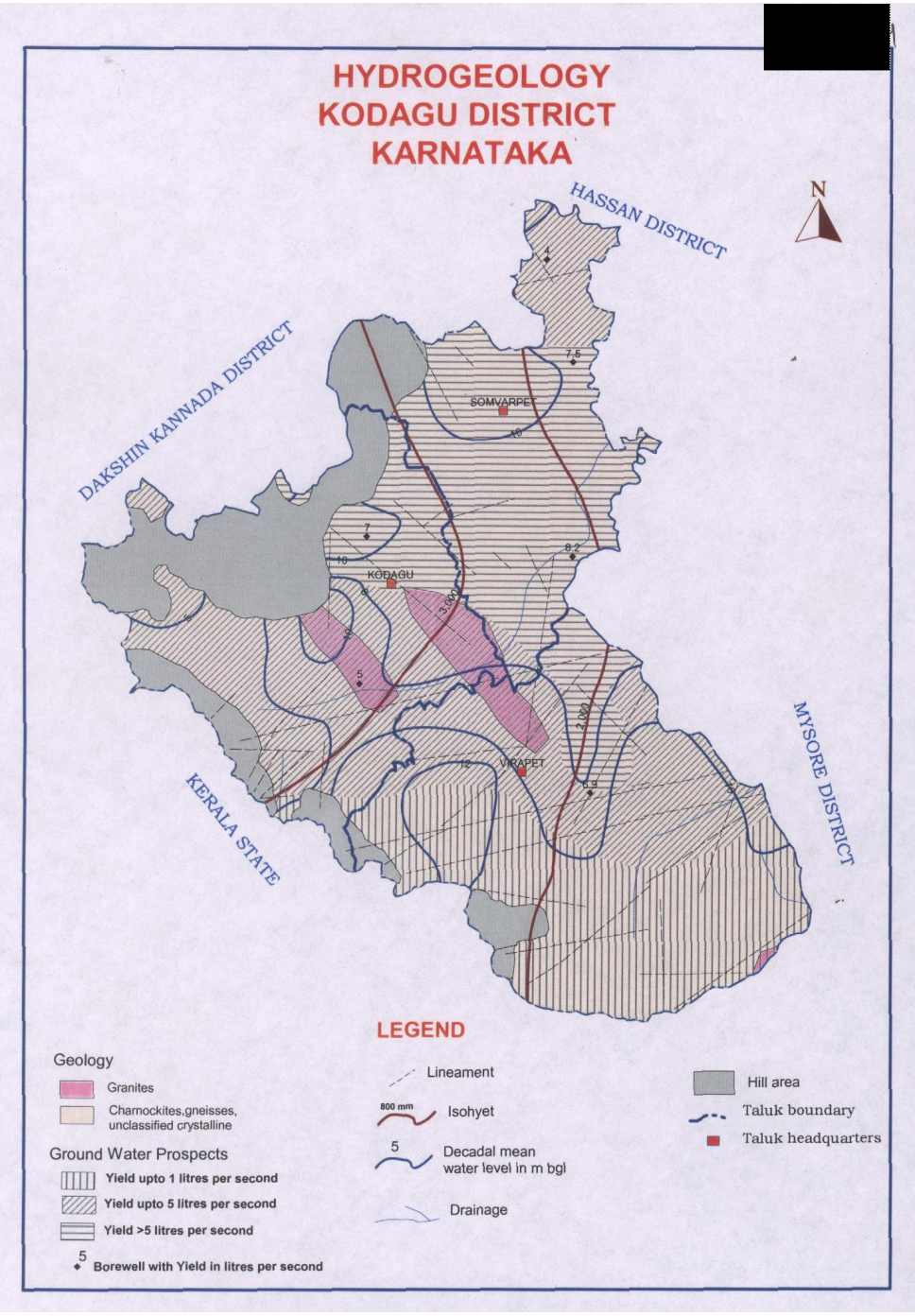


Fig. 5

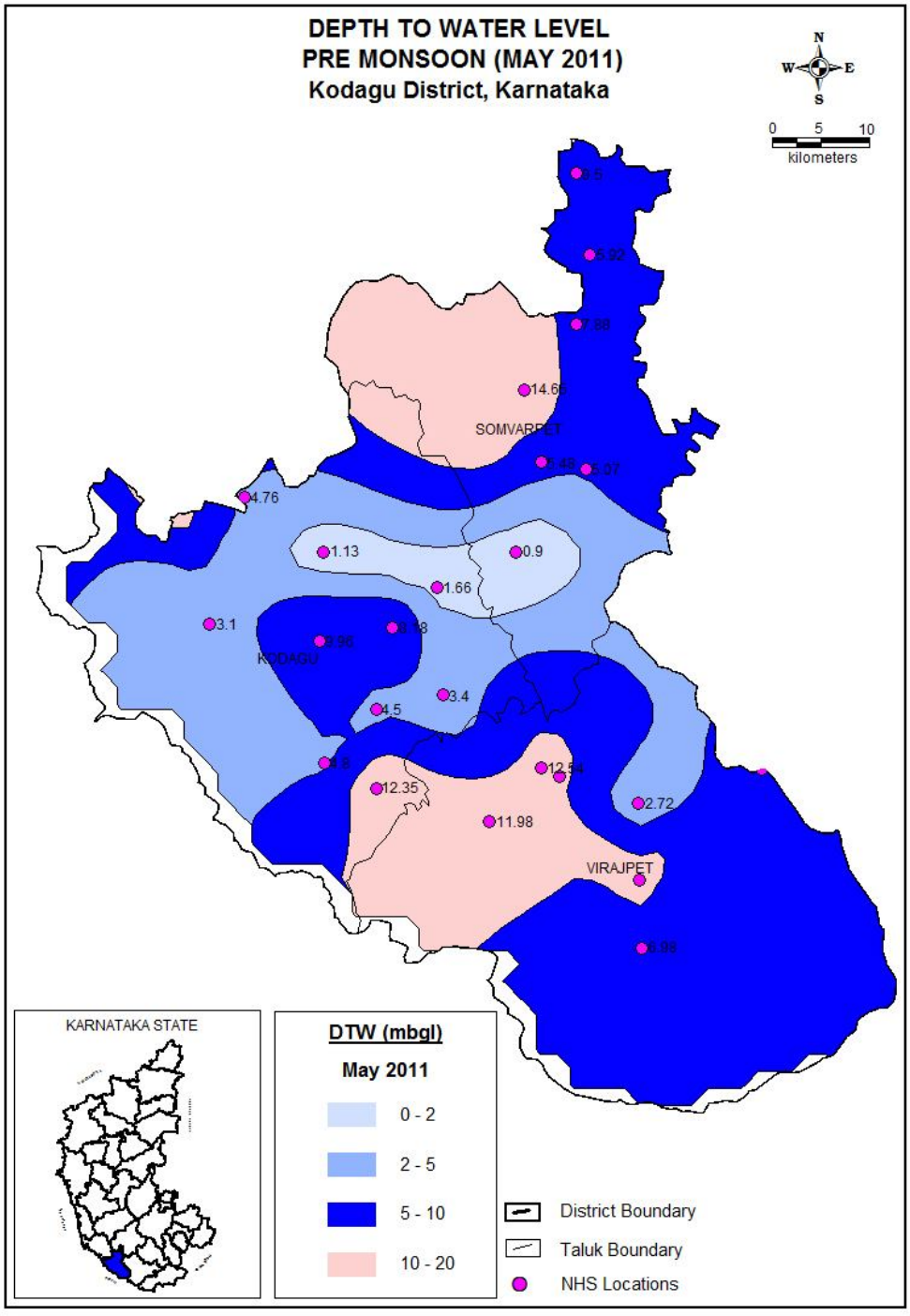
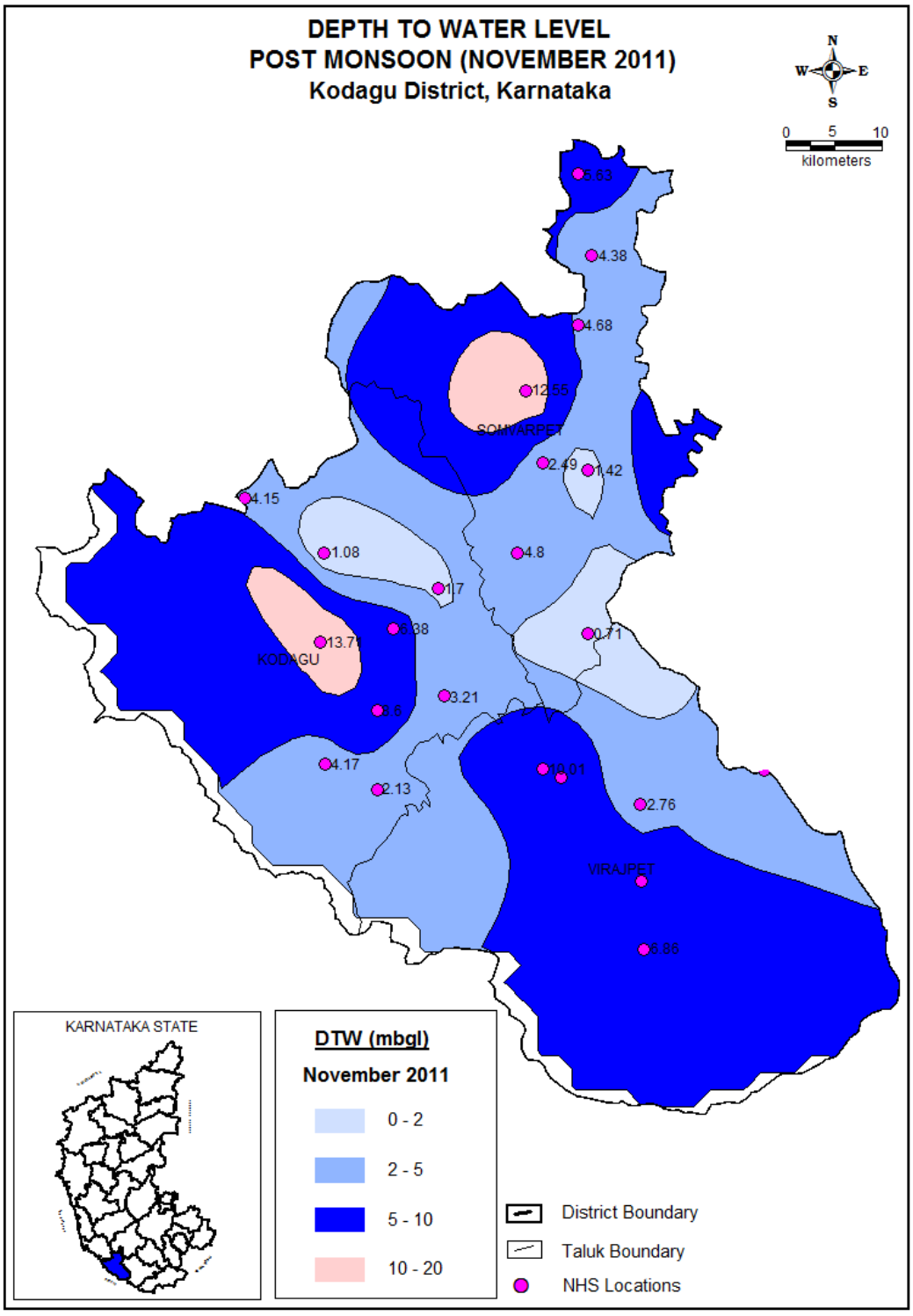

DEPTH TO WATER LEVEL
PRE MONSOON (MAY 2011)
Kodagu District, Karnataka
N
W
E
S
0 5 10
kilometers
14.66
SOMVARPET
4.76
1.13
0.9
1.66
3.1
KODAGU
3.4
4.5
12.54
12.35
2.72
11.98
VIRAJPET
KARNATAKA STATE
DTW (mbgl)
May 2011
0 - 2
2 - 5
5 - 10
10 - 20
District Boundary
Taluk Boundary
NHS Locations

Fig. 6


DEPTH TO WATER LEVEL
POST MONSOON (NOVEMBER 2011)
Kodagu District, Karnataka
N
W
E
S
0 5 10
kilometers
5.63
4.38
4.68
12.55
SOMVARPET
2.49
1.42
4.15
1.08
4.8
1.7
6.38
13.71
KODAGU
0.71
3.21
8.6
4.17
2.13
0.01
2.76
VIRAJPET
6.86
KARNATAKA STATE
DTW (mbgl)
November 2011
0 - 2
2 - 5
5 - 10
10 - 20
District Boundary
Taluk Boundary
NHS Locations

4.1.3 SEASONAL WATER LEVEL FLUCTUATION

Consequent upon seasonal rainfall, the water levels record a rise, indicating the build up of storage in ground water reservoir. During the non-monsoon period, this gets depleted due to exploitation and natural discharge. Therefore, the water levels, in general show, a receding trend from December to May. The seasonal water level fluctuation for the year 2011 is available for 21 dug well national hydrograph network stations.

4.1.4 LONG-TERM WATER LEVEL TREND

Out of pre-monsoon water level trend data available for 25 national hydrograph network stations for the period from 2002 to 2011, twenty are having rising trends in the range between 0.015 and 1.076 m/year. Out of these twenty national hydrograph stations, 12 national hydrograph network stations are showing rise of more than 0.1 m/year. In remaining hydrograph stations the water levels show falling trend in the range between 0.015 to 0.087 m/year. The water levels (five stations) are showing falling trends in the range between 0.015 to 0.169 m/year and of these, three stations have shown a fall of more than 0.1 m/year.

Out of post-monsoon water level trend data available for 25 national hydrograph network stations for the period from 2002 to 2011, nineteen are having rising trends in the range between 0.002 and 0.361 m/year. Out of these nineteen national hydrograph stations, 8 national hydrograph network stations are showing rise of more than 0.1 m/year. In the remaining six hydrograph stations, the water levels are showing falling trends in the range between 0.004 to 0.396 m/year. The water levels (six stations), are showing falling trend range between 0.004 to 0.369 m/year of which only one station has shown a fall of more than 0.1 m/year.

4.1.5 AQUIFER SYSTEMS ENCOUNTERED IN THE AREA

The study of aquifer geometry and parameters have been attempted by Central Ground Water Board, South western Region, Bangalore, under its ground water exploration programme through drilling exploratory bore wells at selected places. The aquifer zones are weathered / fractured & jointed granites and gneisses, occurring at various depths from 15 to 201 m bgl.

The exploratory bore wells drilled in the district are having depths ranging from 94 to 201 m bgl. The discharge ranges from 1.0 to 16.0 lps. The yield-cum-recuperation tests conducted on the wells show that the general specific capacity ranges from 5.24 to 59.20 lpm /m /dd. The transmissivity of aquifer material in general range from 1 to 50 m2/day.

.2 GROUND WATER RESOURCES

Net annual ground water availability in the district is 24029.32 mcm, existing gross ground water draft for all uses is 5190.77 mcm, net ground water availability for future irrigation. The ground water development in the district is 22.10%. The entire district comes under '**safe**' category. Considering taluk wise,

the ground water development is about 16% in Madikeri taluk, 29% in Somwarpet taluk and about 21% in Virajpet taluk. The taluk wise groundwater resource (as on March 2009) is given in the **Table 4**.

Table-4 Taluk-wise groundwater resource of Kodagu district as on March 2009

TALUK	NET ANNUAL GROUND WATER AVAILABILITY	EXISTING GROSS GROUND WATER DRAFT FOR IRRIGATION	EXISTING GROSS GROUND WATER 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 DEVELOPMENT	STAGE OF GROUND WATER DEVELOPMENT (%)	CATEGORISATION
	Mcm	Mcm	Mcm	Mcm	Mcm	Mcm	%	10
	1	2	3	4	5	6	9	
MADIKERI	8633.17	963.63	452.78	1416.41	541.27	7128.27	16	SAFE
SOMVARPET	6884.72	1131.18	872.89	2004.07	1067.59	4685.95	29	SAFE
VIRAJPET	8511.43	1492.81	277.49	1770.29	338.12	6680.51	21	SAFE
TOTAL	**24029.32**	**3587.62**	**1603.16**	**5190.77**	**1946.98**	**18494.73**	**22.10**	**SAFE**

Salient features of taluk wise groundwater recharges to aquifer system in the district are depicted in the above table. The perusal of this table shows that, the annual utilizable ground water resource for year 2009 for the whole district is 18494.73 mcm. The maximum being 71.28 ham in Madikeri taluk, closely followed by 66.80 ham in Virajpet taluk and the least, 46.85 ham in Somawarpet taluk. The annual draft for domestic and industrial uses in Kodagu district, is 16.03 mcm and the draft for irrigation purposes is 35.87 mcm. It is further observed that the total ground water draft during the year 2009 was 51.91 mcm. It is also observed that highest draft is recorded in Somavarpet taluk (20.04 mcm) followed by Virajpet taluk (17.70 mcm) and the least in Madikeri taluk (14.16 ham). The talukwise stage of ground water development details computed for the district in the ground water estimation studies for the year 2009 is given in the above table and stage of ground water development is presented as **Figure 7**.

4.3 GROUND WATER QUALITY

Quality of groundwater in the district, in general, is good and potable. It is suitable for domestic and irrigation purposes. Water samples from NH Stations were analysed to decipher the shallow aquifer water quality and samples from exploratory bore wells represent water quality of deeper aquifer in the district. All the important parameters like EC, pH, TDS, fluoride of both, the shallow and the deep aquifer water are, in general, within the drinking water standards. Only, the nitrate and chloride are found in higher concentrations at few places. While considering the ground water quality in the district for irrigation purposes, it is found that the specific conductance ranges from 30 to 850 micro mhos per cm at 25^0C, chloride is in the range of 7 and 113 ppm. As per US salinity diagram, the

ground water falls under C1S1, i.e., low sodium water. Ground Water quality of the district is depicted in **Figure 8**.

4.4 GROUNDWATER VULNERABILITY AREA

Groundwater being a dynamic resource, getting recharged annually, primarily from the rainfall, is vulnerable to various developmental activities and is prone to deterioration in quality and quantity. The vulnerability is high in certain areas while in other areas it is comparatively stable. Based on it's susceptibility to various stress factors the district wise vulnerability map is prepared on a regional scale considering the following factors viz.

1. Area under high stage of ground water development falling in over exploited (generally with stage of development more than100%) and critical (generally stage of development within 85-100%) category as on March 2009.
2. Area having intensive cultivation/ area falling under canal command, thus prone to pollution from fertilisers/ insecticides or water logging.
3. Area having fluoride above maximum permissible limit of 1.5ppm
4. Area having nitrate above maximum permissible limit of 45ppm. (Even though nitrate is point source pollution due to anthropogenic activity and as such area cannot be demarcated, for the convenience of the user group, area having high incidence of pollution is marked. Within the marked area there may be points devoid of high nitrate and vice-versa.)
5. Industrial cluster as identified by Central Pollution Control Board, prone for pollution from industries.

In some of the districts parts of the area groundwater is vulnerable due to more than one of the above parameters, while in some others the entire district is free from vulnerability. In Kodagu district, the southern most part of the district (Virajapet Taluk) is most vulnerable due to Nitrate contamination and small portion in the north eastern direction (Somavarpet Taluk) is vulnerable due to intensive irrigation and application of fertilizers/pesticide contamination (Fig. 9).

UNIT AREA ANNUAL GROUNDWATER RECHARGE

Sustainability of groundwater resource depends mainly on two factors viz. Annual groundwater recharge and annual groundwater draft. The annual groundwater recharge depends on the quantity and intensity of rain fall, the infiltration characteristics of the soil, the depth to groundwater level, the slope of the area and the geomorphology. The groundwater recharge is assessed separately for the monsoon and non monsoon period due to rainfall as well as due to other sources. The annual groundwater recharge includes all the above.

The recharge from other sources includes return seepage from irrigated area, seepage from canals, seepage from water bodies, seepage from influent rivers etc. The recharge can be expressed in metres. In the state of Karnataka, the unit area recharge is grouped into four categories viz. 0.025-0.10m, 0.10-0.15m, 0.15-0.25m and 0.25-0.50m. In Kodagu district the unit area annual recharge is in the range of 0.025 to 0.10 in Kodagu & Virajpet taluks and 0.15 – 0.25 in Somavarpet taluk (Fig. 10).

Fig. 7

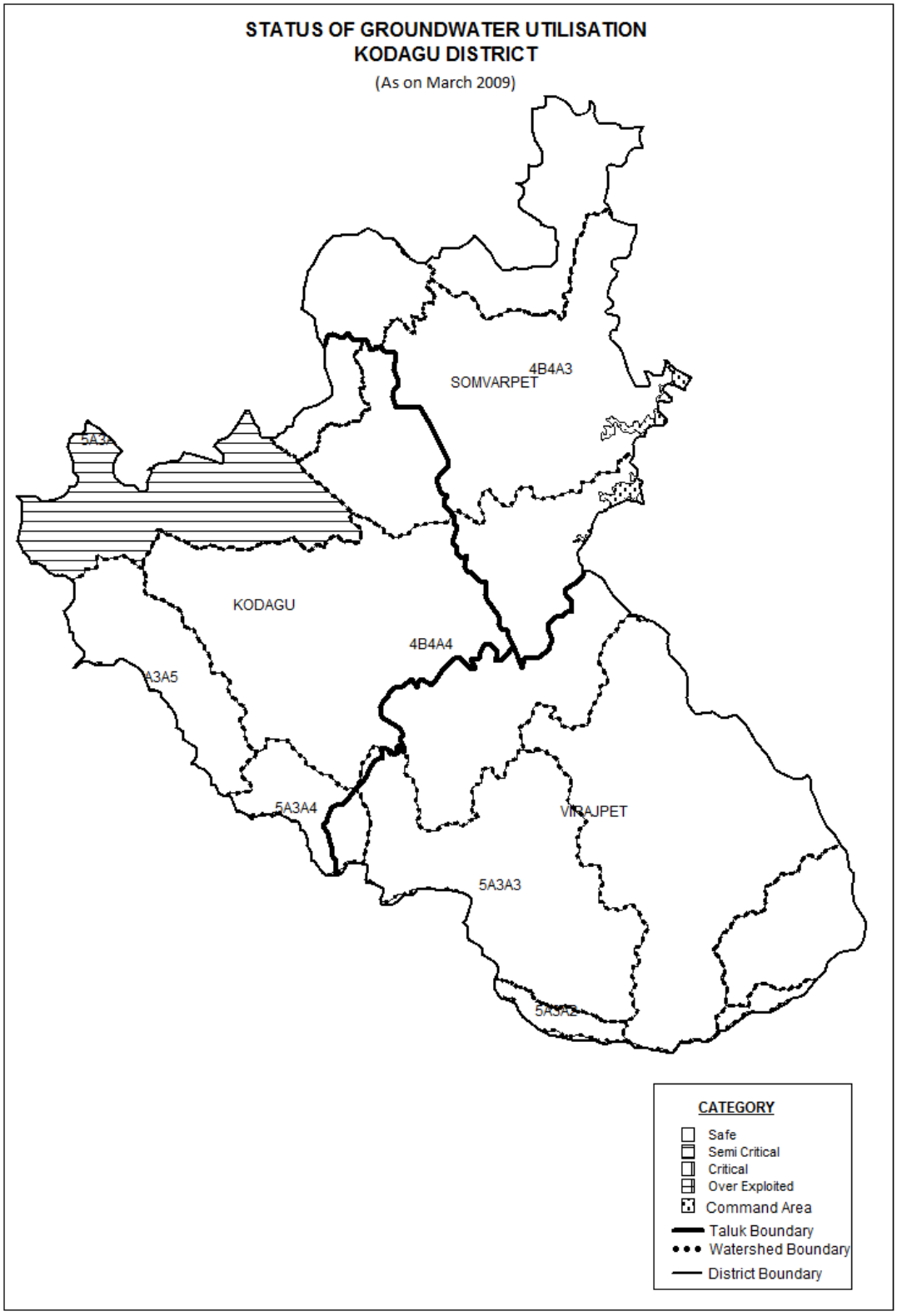

STATUS OF GROUNDWATER UTILISATION
KODAGU DISTRICT
(As on March 2009)
4B4A3
SOMVARPET
KODAGU
4B4A4
5A3A4
VIRAJPET
5A3A3
CATEGORY
Safe
Semi Critical
Critical
Over Exploited
Command Area
Taluk Boundary
Watershed Boundary
District Boundary

Fig-8

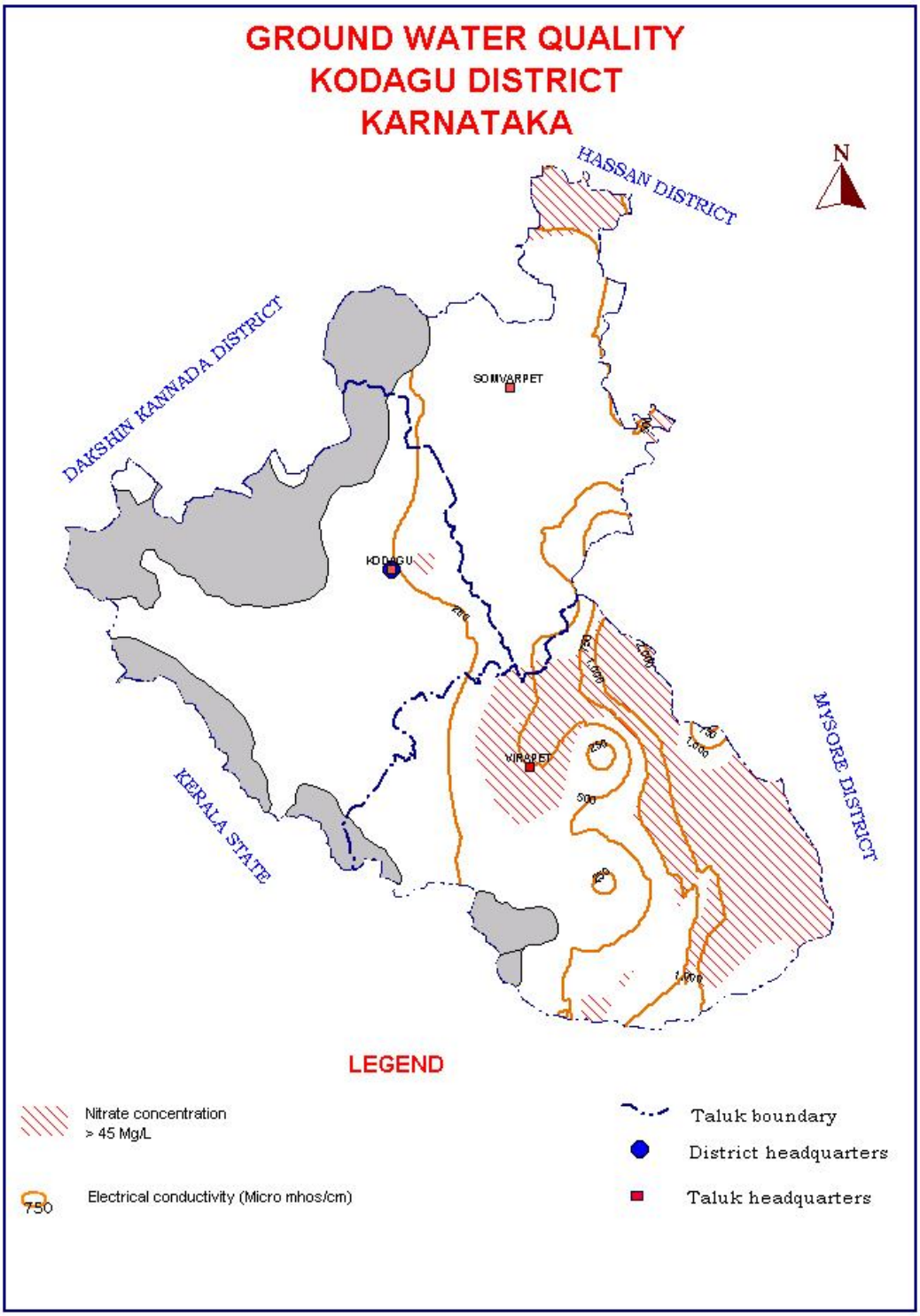

GROUND WATER QUALITY
KODAGU DISTRICT
KARNATAKA
N
HASSAN DISTRICT
DAKSHIN KANNADA DISTRICT
SOMWARPET
KODAGU
VIRAJPET
KERALA STATE
MYSORE DISTRICT
LEGEND
Nitrate concentration
> 45 Mg/L
Electrical conductivity (Micro mhos/cm)
750
Taluk boundary
District headquarters
Taluk headquarters

Fig. 9

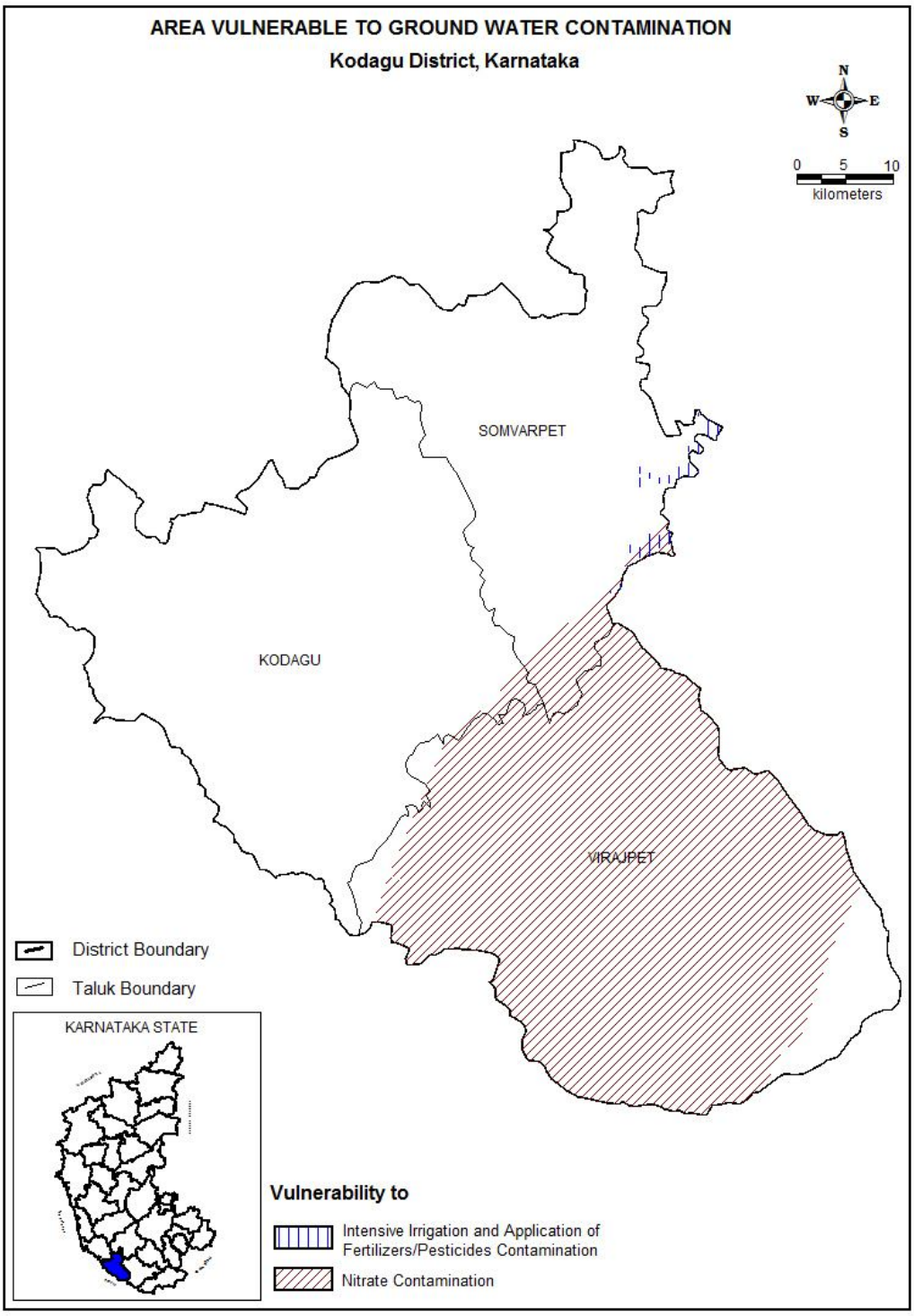
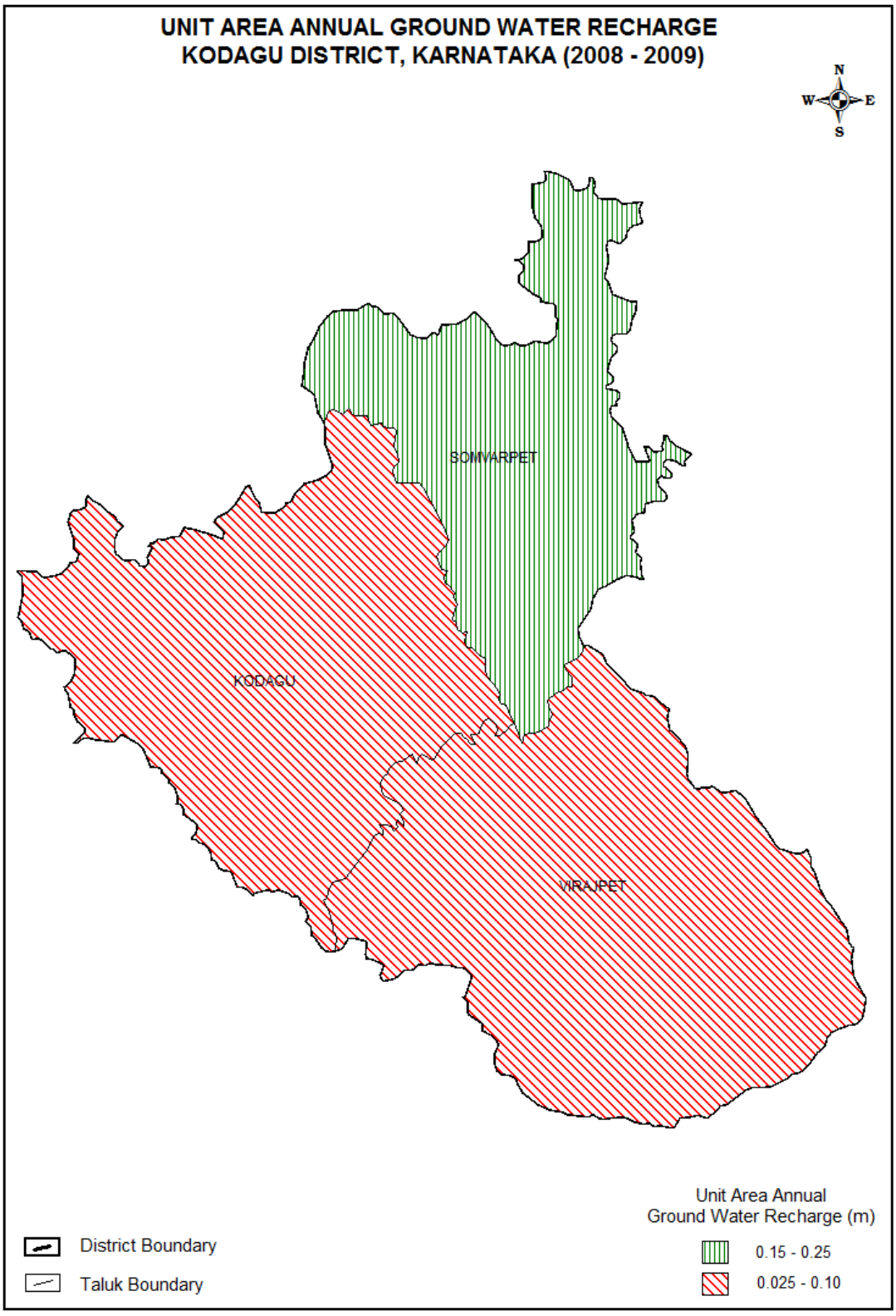

AREA VULNERABLE TO GROUND WATER CONTAMINATION
Kodagu District, Karnataka
N
W
E
S
0 5 10
kilometers
SOMVARPET
KODAGU
VIRAJPET
District Boundary
Taluk Boundary
KARNATAKA STATE
Vulnerability to
Intensive Irrigation and Application of Fertilizers/Pesticides Contamination
Nitrate Contamination

Fig. 10


UNIT AREA ANNUAL GROUND WATER RECHARGE
KODAGU DISTRICT, KARNATAKA (2008 - 2009)
N
W
E
S
SOMVARPET
KODAGU
VIRAJPET
Unit Area Annual
Ground Water Recharge (m)
0.15 - 0.25
0.025 - 0.10
District Boundary
Taluk Boundary

4.4 STATUS OF GROUND WATER DEVELOPMENT

4.4.1 MADIKERI TALUK

Recharge to groundwater mainly takes place through infiltration of rainwater and to a lesser extent from surface water sources and applied surface water irrigation. Groundwater is the main source of drinking water in Madikeri taluk, except for a small contribution from surface water for domestic water supply of Madikeri town. Total irrigated area in the taluk constitutes about 0.12% of the net sown area and groundwater contribution to irrigated agriculture is meager. Ground water development is 16% and falls under 'Safe' category. As the pre-monsoon depth to water level is between 2 and 10 m bgl in almost entire taluk, shallow zone ground water can be developed for irrigation through dug wells in topographic low areas and dug-cum-bore wells in valley slope areas having comparatively deeper water levels. Optimum depth of dug well is 7-15 m having a diameter of 6-7 m and the optimum depth of dug-cum bore well is15-30 m having a diameter of 6-7 m in dug part and 100 mm in lower bore well part. The four exploratory bore wells drilled by the Central Ground Water Board have yielded 1.3 to 8.5 litre per second (lps) for drilled depth of 94 to 200 m bgl. The moderate yield up to 5 lps is quite common in the district, and in the northeastern parts of the taluk, wells of higher yields (up to 15 lps) are possible if site selection is done based on sound scientific investigations.

4.4.2 SOMVARPET TALUK

Groundwater is the main source of drinking water in the entire Somawarpet taluk. Total irrigated area in the taluk constitutes about 6.6% of the net sown area and groundwater accounts for less than 1% of the net irrigated area. Ground water development is 29% and falls under 'Safe' category. As the pre-monsoon depth to water level is between 5 and 10 m bgl in most parts of the taluk, shallow zone ground water can be developed for irrigation through dug wells in topographic low areas and dug-cum-bore wells in valley slope areas having comparatively deeper water levels. Optimum depth of dug well is 8 -15 m having a diameter of 6-7 m and the optimum depth of dug-cum bore well is 15-35 m having a diameter of 6-7 m in dug part and 100 mm in lower bore well part. The four exploratory bore wells drilled by the Central Ground Water Board have yielded 1.0 to 14.0 litre per second (lps) for drilled depth of 94 to 134 m. Good yield up to 15 lps is possible if site selection is done based on sound scientific investigations, except northern parts of the taluk, where wells have lower yields (up to 5 lps).

4.4.3 VIRAJPET TALUK

Groundwater is the main source of drinking water in the entire Virajpet taluk. Total irrigated area in the taluk constitutes about 64,469 ha and almost the entire is rain-fed. Ground water development, which is mainly utilised for domestic needs, is only 21% and falls under 'Safe' category. As the pre-monsoon depth to water level is between 5 and 10 m bgl in almost 25% area in the northern parts of

the taluk, shallow zone ground water can be developed for irrigation through dug wells in topographic low areas and through dug-cum-bore wells in valley slope areas having comparatively deeper water levels. Optimum depth of dug well is 10 -15 m having a diameter of 6-7 m and the optimum depth of dug-cum bore well is 20- 40 m having a diameter of 6-7 m in dug part and 150 mm in lower bore well part. The five exploratory bore wells drilled by the Central Ground Water Board have yielded less than 1 to 16.0 litre per second (lps) for drilled depth of 160 to 201 m bgl. As depicted in **Figure 4**, more than half of the taluk area falling on southern and western parts is not having good ground water potential and the bore wells drilled in this area have given quite low yield of less than 1 lps. In other parts of the taluk, the bore wells have given moderate yield ranging up to 5 lps, except a small area located in the northern parts of the taluk, where bore wells give exceptionally better yields ranging up to 15 lps under favourable conditions.

5.0 GROUND WATER MANAGEMENT STRATEGY

Kodagu district located in the south western part of Karnataka state falls in the high precipitation zone with undulating rugged topography occupying the eastern and western slopes of the Western Ghats. Almost 35% of the district's geographical area is covered by forest. As per the data available (Kodagu District at a Glance 2004-05), the net sown area comprises 36% of the total geographical area. Paddy is grown in favourable areas. Coffee, Tea, Plantain and Areca nut are the main horticulture crops. About 2% of the net sown area is irrigated and of this a mere 10% is irrigated by ground water. Although the contribution of groundwater is very low in agriculture sector, it is playing a vital role as being the main source of drinking water, almost in the entire district. Hence, its optimum use and sustainable management is more important. At present ground water is not utilised in agriculture sector to its true worth and hence it is recommended to opt for its increased utilisation. As majority of the crops are basically horticultural, it may be prudent to go for sprinkler and drip irrigation methods. Efforts should be oriented towards judicious utilization, conservation and augmentation of groundwater. In the areas of deeper ground water level and the plains, artificial recharge measures like percolation tanks and check dams are to be implemented to augment the groundwater resource. In the hilly areas, which predominates the district, watershed treatment techniques can help in augmenting the groundwater resources. Point recharge structures would help in recharging deeper depleted fractures and fissures in days to come so as to have a sustainable yield from bore wells tapping deep aquifers. Scientific management of groundwater should be kept in mind while extending institutional finance to farmers and awareness should be created in different user communities.

5.1 GROUND WATER DEVELOPMENT

Groundwater development has reached 22.10% for the district as a whole and the district falls in the 'safe' category. There is a lot of scope to further development of this useful resource. In general, as groundwater level is not

declining, revitalizing by cleaning and deepening the dug wells will help in augmenting the yield. The shallow zone ground water can further be developed for irrigation through dug wells in topographic low areas and dug-cum-bore wells in valley slope areas having comparatively deeper water levels. Optimum depth of dug well is 8 -12 m having a diameter of 4-6 m, the optimum depth of dug-cum bore well is 15-30 m having a diameter of 4-6 m in dug part and 150 mm in lower bore well part. Bore wells are possible in all topographic conditions. The pinpointing of site, depth, yield prospects, etc., should be done based on sound scientific investigations.

5.2 WATER CONSERVATION AND ARTIFICIAL RECHARGE

Kodagu is predominantly a hilly district comprising of undulating and rugged terrain. Although the rainfall is quite high, the topographical conditions lead to high runoff. Under these conditions it is advisable to opt for watershed treatment techniques, which can help in augmenting the groundwater resources. In some parts of the district, especially in Virajpet taluk, where water levels are deep, point recharge structures will help in recharging the deeper depleted aquifers so as to have a sustainable yield from bore wells tapping the deep aquifers. Fast, unchecked and indiscriminate withdrawal of groundwater through different abstraction structures results in the decline of ground water level. Further, deforestation and conversion of grass-covered land for other activities reduces the natural groundwater recharge area. Hence, major quantity of the rainfall leaves the area as run-off causing floods and heavy soil erosion. The moderate to high sloping, undulating terrain in parts of the district covering areas are suitable for artificial recharge structures like gully plugs, gabion structures, cement plugs, nalla bunds, contour bunds and contour trenches. Even in the shallow water level areas, there are deep water levels occurring as patches, where suitable artificial structures can be constructed. By constructing suitable structures the contact time of this flowing water with the land can be increased substantially leading to recharge of the aquifer system. The selection of a suitable artificial recharge structure is site specific. So scientific studies should be conducted while selecting the site for a specific type of structure.

6.0 GROUND WATER RELATED ISSUES & PROBLEMS

Thirty-eight suicide cases among farmers were reported in Kodagu district during the last few years of which 17 cases were due to crop failures and the remaining were due to various other reasons. Maximum farmers suicide cases of 11 have occurred in Somawarpet taluk followed by 5 in Virajpet taluk and 1 Madikeri taluk. As the ground water development in the district is still very low (mere 30%), optimum and judicious development of ground water can help in addressing this distress situation being faced by the farmers during the drought periods.

7.0 AWARENESS & TRAINING ACTIVITY

Central Ground Water Board has planned to organise Water Management Training Programmes (WMTP) and one Mass Awareness Programmes (MAP) in the district during Annual Action Programme (2007 – 08). These Mass

Awareness and Water Management Training Programme (WMTP) are to be organised as a nation wide programme for generals public and officers of different departments attached to Zilla Panchayat, NGOs', Representatives from Farmers and Education Institutions etc., Wide spectrum of topics are covered during these programme including rain water harvesting, artificial recharge techniques, water management, ground water conservation, water quality and its effects on human health, role of women in water management etc.

8.0 AREAS NOTIFIED BY CGWA / SGWA

As all the three taluks fall under 'Safe' category, none of the taluk has been notified under CGWA / SGWA.

9.0 RECOMMENDATIONS

As already discussed in the above topics, Kodagu district located on the Western Ghats predominantly comprises of hilly areas consisting of undulating and rugged terrain. Although the average annual rainfall is quite high (1593 - 4398 mm), the topographical conditions lead to high runoff. Under these conditions, in general, adopting watershed treatment is a good option. It includes the construction of Vegetative Checks, Nallah bunds, Contour bunding, check dams and gabion structures, etc. It will help in augmenting the natural recharge. The rejuvenation of the existing tanks by de-silting and construction of additional percolation tanks will help in recharging the phreatic zone. Further, the existing dugwells may be revitalized to yield better by cleaning and deepening. It is observed that majority of the farming in the area is rain-fed. Whatever the hardship on farmers is reported, it seems to be the result of failure of monsoon as almost the entire district has received less than normal rainfall during 2001, 2002 and 2003 respectively. Hence, it is necessary to opt for a scientific management of the available ground resources. In Virajpet taluk, where the water levels are comparatively deeper, artificial recharge to ground water though percolation tank structures are the apt solution to mitigate the water scarcity. The district has good number of small tanks. Rejuvenation of these tanks for storage of water and accelerated ground water recharge along with construction of additional storage structures that will directly recharge the ground water is the most practical solution to prolong the onset of drought. Inter-basin transfer of surface water from west flowing rivers can be used for irrigation and artificial recharge to ground water using percolation tanks to enable ground water recharge during lean periods. As the entire district falls under 'safe' category the available resource can be utilized judiciously by going for construction of optimum number of new abstraction structures.