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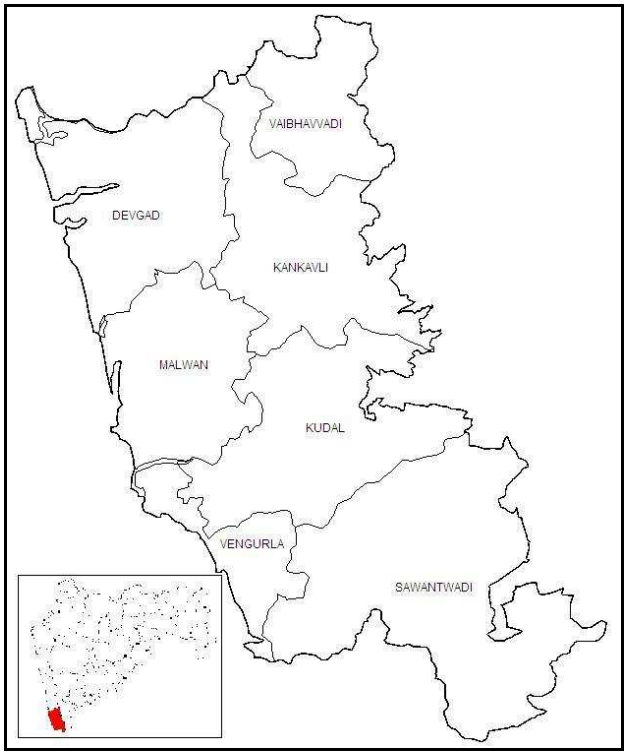
भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र राज्य के अंर्तगत सिंधुदुर्ग जिले की भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
SINDHUDURG DISTRICT
MAHARASHTRA



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मध्यवर्ती क्षेत्र
नागपुर
CENTRAL REGION
NAGPUR
2009

SINDHUDURG DISTRICT AT A GLANCE

1. GENERAL INFORMATION

Geographical Area	:	5087 sq. km.
Administrative Divisions (As on 31/03/2007)	:	Taluka- 8; Sawantwadi, Vengurla, Kudal, Kankavli, Malvan, Deogad, Dodamarg and Vaibhavwadi
Villages	:	743
Population	:	8,69,000
Normal Annual Rainfall	:	2300 mm to 3200 mm

2. GEOMORPHOLOGY

Major Physiographic unit	:	5; Coastline, Estuarine plains, Lateritic plateaus, Residual hills, Scrap faces of Sahayadri.
Major Drainage	:	6; Gad, Karli, Terekhol, Tillari, Wagothan and Deogad

3. LAND USE (2000-01)

Forest Area	:	390 sq. km.
Net Area Sown	:	1354 sq. km.
Cultivable Area	:	2495 sq. km.

4. SOIL TYPE

Four types viz., Rice soil, Garden soil, Varkas soil and Alluvial soil.

5. PRINCIPAL CROPS (2000-01)

Rice	:	798.65 sq. km.
Nachani	:	32.11 sq. km.
Cashewnut	:	233.00sq. km.
Mango	:	153.57 sq. km.

6. IRRIGATION BY DIFFERENT SOURCES (2000-01) **- Nos./Potential Created (ha)**

Dugwells	:	4868
Borewells	:	20
Tanks/Ponds	:	351
Other Minor Surface Sources	:	2874
Net Irrigated Area	:	105 sq. km.

7. GROUND WATER MONITORING WELLS (As on 31/03/2007)

Dugwells	:	
Piezometers	:	

8. GEOLOGY

Recent to sub-Recent	:	Alluvium, beach sand
Pleistocene	:	Laterite and lateritic spread
Miocene		Shale with peat and pyrite nodules
Cretaceous to Eocene		Deccan Trap Basalt lava flows
Upper Pre-Cambrian		Kaladgi Series: quartzite, sandstone, shale and associated limestone
Dharwar Super Group		Phyllite, conglomerate, quartzite

9. HYDROGEOLOGY

Water Bearing Formation	:	Basalt- weathered/fractured/ jointed vesicular/massive, under phreatic and semi-confined to confined conditions Laterite: GW occurs under phreatic

		conditions Alluvium- Sand/gravel under phreatic conditions
Premonsoon Depth to Water Level (May-2007)	:	1.94 to 17.40 m bgl
Postmonsoon Depth to Water Level (Nov.-2007)	:	0.01 to 14.85 m bgl
Premonsoon Water Level Trend (1998-2007)	:	Rise: 0.02 to 0.53 m/year Fall: 0.03 to 0.20 m/year
Postmonsoon Water Level Trend (1998-2007)	:	Rise: Negligible to 0.32 m/year Fall: 0.01 to 0.14 m/year

10. GROUND WATER EXPLORATION (As on 31/03/07)

Wells Drilled	:	PZ-5
Depth Range	:	
Discharge	:	

10. GROUND WATER QUALITY

Good and suitable for drinking and irrigation purpose.

Type of Water	:	Ca-HCO_3 type in majority of samples

11. DYNAMIC GROUND WATER RESOURCES- (As on 31/03/2004)

Net Annual Ground Water Availability	:	100.30 MCM
Annual Ground Water Draft (Irrigation + Domestic)	:	70.74 MCM
Allocation for Domestic and Industrial requirement up to next 25 years	:	29.88 MCM
Stage of Ground Water Development	:	70.51 %

12. GROUND WATER CONTROL AND REGULATION

Over-Exploited Taluka	:	None
Critical Taluka	:	None
Notified Taluka	:	None

16. MAJOR GROUND WATER PROBLEMS AND ISSUES

Even though the district receives high rainfall in the range of 2300 to 3200 mm/year, water scarcity in the non-monsoon seasons is the major issue of concern and many villages face water scarcity in the summer.

The district has a coastline of 121 km and has 14 creeks, about 76900 ha of agricultural land is reported to be saline due to sea water ingress along the coast and creeks.

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Sindhudurg District

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1.0 Introduction

Sindhudurg district is located in the Konkan region of Maharashtra State and covers a geographical area of 5087 sq.km. The district lies in the Survey of India degree sheets 47H, 48 E and 48 I. The district is located between north latitude 15°37' and 16° 40' and east longitude 73° 19' and 74° 13'. The district is bounded in the north by Sindhudurg district, west by Arabian Sea and in the east by Kolhapur district and in the south by Goa State and Belgaum district of Karnataka State. National Highway 17 passes through the district. The district has 7 railway stations with a 103 km. stretch of Konkan Railway line. It has good road and rail links with Goa and Mumbai. The district has a geographical area of 5087 sq. km. out of which about 390 sq.km. is covered by forest, whereas cultivable area is 2495 sq. km. and net sown area is 1354 sq. km.

The district headquarters is located at Oras (Kudal). The district comprises of two revenue sub-divisions viz: Sawantwadi and Kankavli. The eight taluka of the district are Sawantwadi, Vengurla, Kudal, Kankavli, Malvan, Deogad, Dodamarg and Vaibhavwadi. The population of the district as per 2001 census is 8,69,000. The district comprises of 5 towns and 743 villages.

Central Ground Water Board has taken up several studies in the district. A list of studies conducted in the district is presented in Table-1.

Table 1: Studies undertaken by CGWB.

S. No.	Year	Officer(s)	Toposheets	Type of Survey/Study
1	1983-84,	D. B. Shetye	47- H/7, 47- H/10, 47- H/11 and 47- H/15	SHS
2	1984-85	D. B. Shetye	48- E/9, 48- E/13, 48- E/14, 47- H/8 and 47- H/12	SHS
3	1990-91	D. B. Shetye	47- H/10, 47- H/14 and 47- H/15	SHS
4	1999-2000	L.J. Balachandra	Entire District	RHS

(Here, SHS- Systematic Hydrogeological Survey, RHS- Reappraisal Hydrogeological Studies)

Shri L.J. Balachandra, Scientist-B in 1999-2000 has compiled the report entitled "Ground Water Resources and Development Potential of Sindhudurg District, M.S." Central Ground Water Board has so far not carried out ground water exploration work in the district. However, 5 Peizometers (Pz) to monitor ground water levels have been drilled in the district. A map of the district showing the taluka boundaries, taluka headquarters, physical features and location of Peizometers and monitoring wells is presented as **Figure-1**.

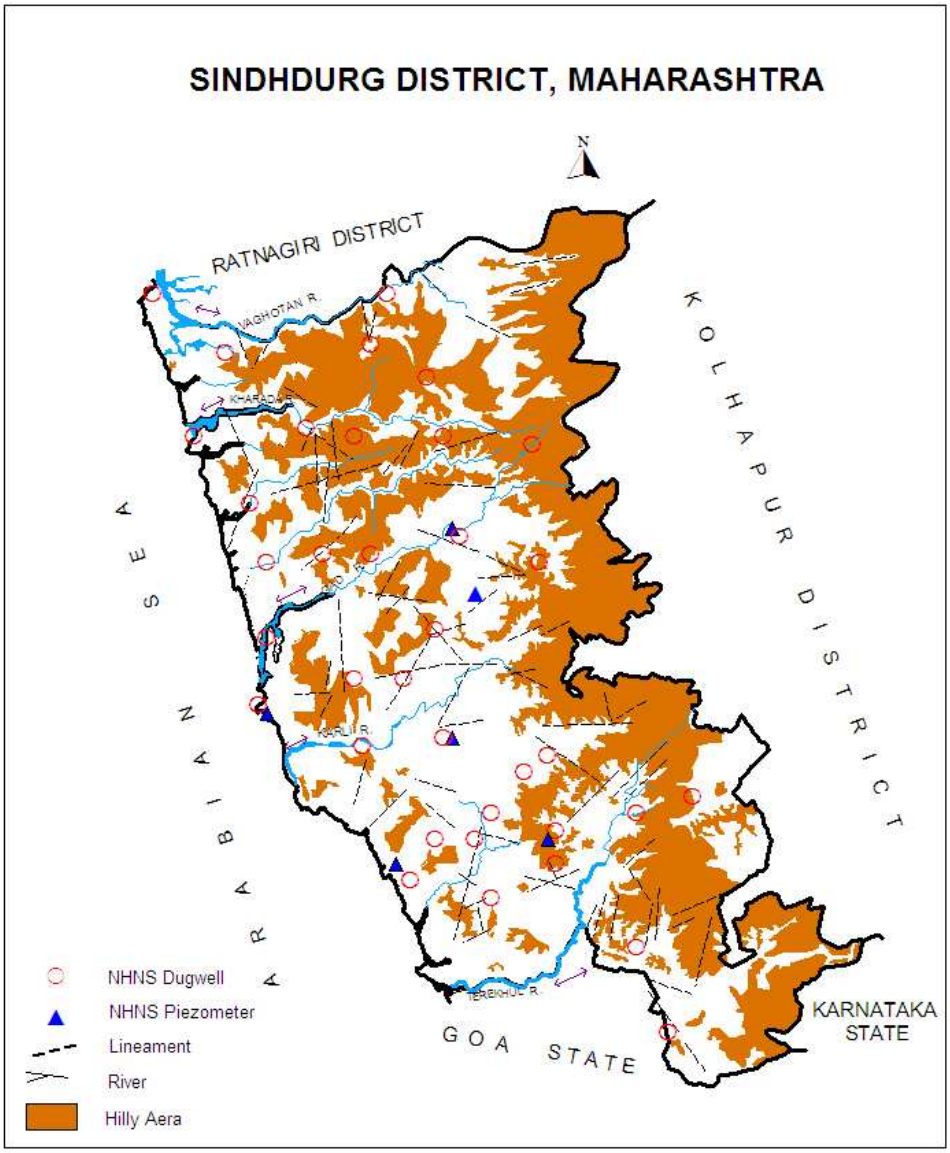

Figure-1: Location

2.0 Climate and Rainfall

Climatic conditions in the district are strongly influenced by its geographical conditions. The district falls under the 'Assured and High Rainfall zone'. The climate is generally humid. The cold season is from December to February followed by summer from March to May. June to September is the southwest monsoon, while, October and November constitute the post-monsoon season. Being a coastal district, variation in the temperature during the day and throughout the season is not large. December is the coldest month with mean daily maximum temperature at 32.7℃ and the mean da ily minimum temperature at 18.7℃. April is the hottest month. The relative humidity during the southwest monsoon is very high (86 to 90%). The relative humidity during winter and summer months is also above 57%.

The normal annual rainfall over the district varies from 2300 mm (Malvan) to about 3205 mm (Kudal). It is minimum in the western part of the district along

the coast and gradually increases towards east and reaches maximum along Western Ghats. The average annual rainfall for the period 1998-2007 ranges from 2541.70 mm (Devgadh) to 3937.80 mm (Savantwadi). The annual rainfall data of all talukas is given in Table 2.

Table 2: Annual Rainfall Data. (mm)

Taluka	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Avg.
Devgad	3179.1	2264.0	3015.0	1619.5	2033.9	2132.0	2091.0	2535.4	3231.0	3316.2	2541.7
Dodamarg	5214.1	NA	814.5	2853.4	2784.0	3053.0	2751.0	3600.0	4063.6	4160.1	2929.4
Kankawali	4155.4	3163.5	2939.0	2168.6	2116.0	2066.8	2404.0	2692.0	3508.0	3331.0	2854.4
Kudal	3107.4	3202.6	2989.2	2143.3	1977.8	2540.0	2712.0	3059.0	2829.0	3342.0	2790.2
Malwan	3425.5	2728.0	3520.2	2554.1	2048.9	2415.0	2535.0	2484.0	2529.2	2836.0	2707.6
Sawantwadi	5214.1	4174.8	4095.0	2860.4	2962.0	3570.0	3503.5	3938.9	4955.4	4103.9	3937.8
Vaibhavwadi	4155.2	3510.2	3195.5	2963.9	2799.9	3152.0	3339.6	4421.0	5357.4	4692.2	3758.7
Vengurla	3084.4	3159.7	3705.9	2198.8	2166.3	2578.1	2525.6	3055.8	3214.7	3479.3	2916.9

3.0 Geomorphology and Soil Types

The outstanding feature in the relief of the district is its highly uneven nature and very narrow riverine plains that fringe the coastline. About 40 to 50% of the area in the district is hilly. The district has three major physiographic divisions from east to west. (i) The eastern part close to the Western Ghats, is highly dissected with deep valleys. (ii) The middle part of the district is occupied by flat-topped hills with undulating plateau with elevations up to 300 meter above mean sea level (m amsl) covered by Laterite. (iii) The coastal plain in the western part with elevations of 100 to 150 m amsl. The physiograhic features have given rise to five characteristic landforms viz. (i) The coast line (ii) The estuarine alluvial plains (iii) The Lateritic plateau (iv) Highly eroded remnant hills (v) Scarp faces of Sahayadri hill ranges. The drainage system of the major rivers in the district is mostly of sub-parallel type and the tributaries drainage pattern tends to be sub-rectangular type. Major joints in the Basalt control the drainage pattern. The river systems are young with a small drainage area and westerly seasonal regime. During monsoon the rivers carry heavy load of water having tremendous headward eroding capacity and ultimately drain in the Arabian Sea. All the major rivers originate in the Sahayadri Hill ranges. The five major rivers in the district are Gad (Length- 84km.), Karli (92km.), Terekhol (69km.), Tillari (53 km.), Deogad (48km.) and Wagothan (24km.). All these rivers form part of the westerly flowing river system originating from Sahayadri hill ranges and debouching in Arabian Sea.

The soil formation in the district in the district is controlled mainly by climate. Most of the soils are derived from Lateritic rocks. The soils are classified based on physical characteristics into four types viz., Rice soil, Garden soil, Varkas soil and Alluvial soil. The Rice soils are termed as ‘Mali soils’ when situated in higher levels, ‘Kuryat soils’ in lower levels and ‘Panthar or Vaigam’ when situated near water courses. Varkas soils are reddish brown to yellowish red in colour and are situated on hill slopes. These soils are poor in fertility, shallow in depth and coarse in texture. Garden soils are of mixed origin, yellow red to brown in color and are located in the valley portions. These soils are light, well drained and fairly fertile. Coastal Alluvial soils are recent deposits found along the coastal tracts and constitute deep loam. Due to inundation of sea, part

of the coastal soils has become salty. In the Deogad, Malwan and Vengurla talukas practically entire strip is salty.

4.0 Ground Water Scenario

4.1 Hydrogeology

Dharwarian metasediments (Archean), Kaladgi formation (Precambrian), Deccan Trap lava flows (Upper Cretaceous to Lower Eocene age), , Laterite (Pleistocene) and Alluvial deposits (Recent to Sub-Recent) are the water bearing formations observed in Sindhudurg district. However Kaladgi formation occurs in very limited patches and does not form potential aquifer in the district. The Alluviums also has limited areal extent found mainly along the coast. A map depicting the hydrogeological features is shown in **Figure-2**.

4.1.1 Hard Rock Areas

4.1.1.1 Dharwarian Metasediments

The Dharwarian metasediments and intrusions are devoid of primary porosity and permeability. The major aquifer formations are Granitic Gneisses and Granites, which are banded or jointed, locally sheared and weathered that facilitates movement and storage of water. The secondary porosity and permeability thus developed gives rise to moderately yielding aquifers. Granulites are dense and compact and hence not suitable for storage or transmission of ground water. The unconfined aquifer is developed down to depth of 15 metres below ground level (m bgl) and the yield of the wells tapping such aquifer varies form 2 to 3 m^3/day. Borewells generally tap deeper aquifer down to the depth of 70 m bgl and their yield varies between 500 and 7770 litres/hr.

4.1.1.2 Kaladgi

The Kaladgi rocks are mainly represented by orthoquartzite, sandstone and shales. They are jointed in diverse directions and this along with weathered portion controls the water bearing properties. The unconfined aquifer is developed down to depth of 10-12 m bgl and the yield of the wells tapping such aquifer varies form 2 to 5 m^3/day. Borewells generally tap deeper aquifer down to the depth of 60 m bgl and their yield varies between 500 and 9315 litres/hr.

4.1.1.3 Deccan Trap Basalt

The primary porosity is negligent in the Deccan trap basalts. The secondary porosity imparted due to jointing, fracturing plays an important role in ground water circulation. In the basaltic terrain ground water occurs under unconfined conditions in the phreatic zone up to a depth of 15 meters in the weathered zone, fractures and joints in the massive unit and weathered/fractured vesicular units. The basalts occupying higher elevations do not form good aquifers however the basalts occupying lower elevations give rise to good aquifers. The unconfined aquifer is developed due to the weathering and jointing of upper flow in Basalt down to depth of 15-20 m bgl and the yield of the wells tapping such aquifer varies form 0.50 to 4.00 m^3/day. Borewells are not common in the district and they tap deeper aquifer in generally down to the depth of 90 m bgl their yield varies between 500 and 770 litres/hr.

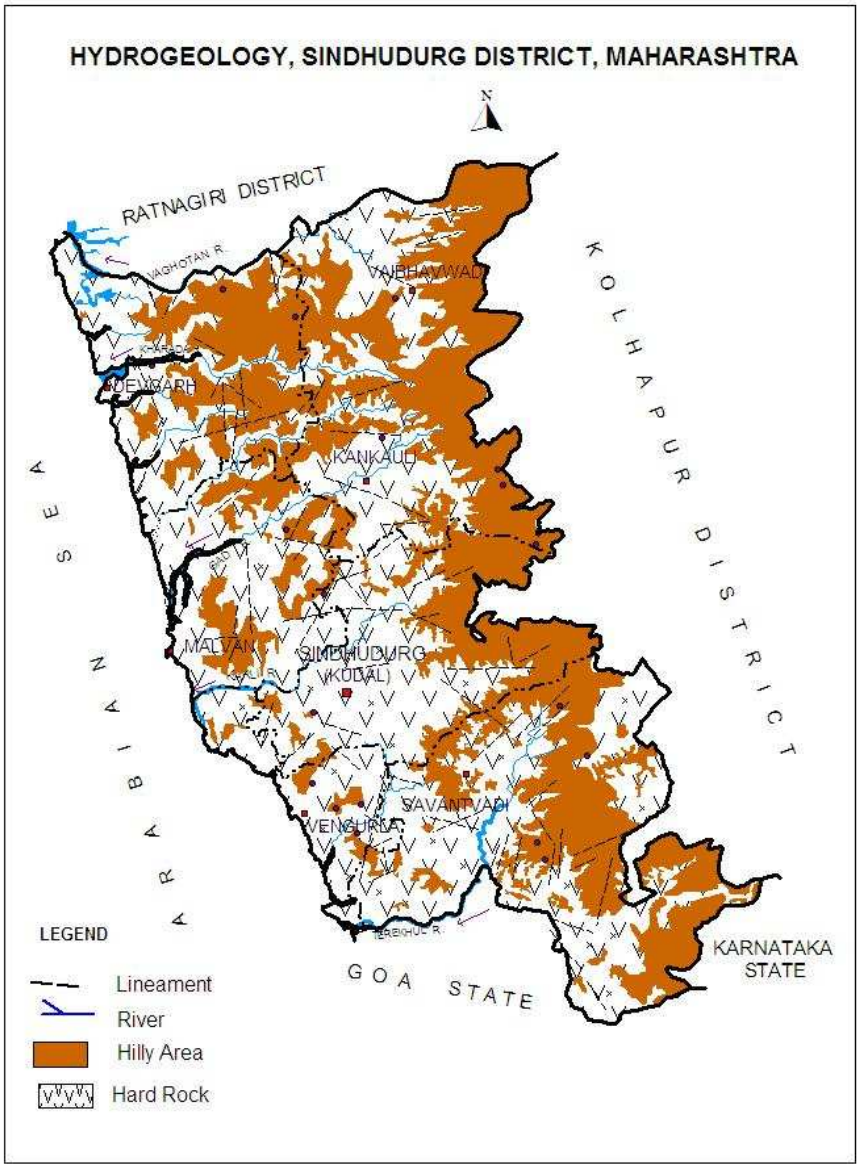

Figure-2: Hydrogeology

4.1.1.4 Laterite

Laterite has better porosity due to intricate network of sinuous conduits making it porous formation. The ground water circulates through a network of voids and conduits, joints and fractures. The local water table aquifer develops in the topmost layer down to the depth of 20 m bgl under unconfined conditions. The wells in these areas show rapid decline in water levels during post monsoon season and go dry in peak summer due to lateral movement at lithomarge/laterite contact and through spring discharge. Only dugwells are found in this formation.

4.1.2 Soft Rock Areas

4.1.2.1 Beach Sand/Alluvium

The Alluvial deposits are found along the coastal areas in few isolated patches having limited areal extent and limited thickness as Beach Sand. The ground water occurs in inter-granular pore spaces of sands, gravels and silts.

The ground water occurs under phreatic/unconfined aquifer at relatively shallow depths of 2-10 m bgl and their yield ranges from about 2 to 5 m^3/day.

4.2 Water Level Scenario

Central Ground Water Board periodically monitors 34 National Hydrograph Network Stations (NHNS) stations in Sindhudurg district, four times a year i.e., in January, May (Premonsoon), August and November (Postmonsoon).

4.2.1 Depth to Water Level – Premonsoon (May-2007)

The depth to water levels in the district during May 2007 ranges between 1.94 (Amboli) and 17.40 m bgl (Achra). Depth to water levels during premonsoon (May 2007) has been depicted in **Figure-3**.

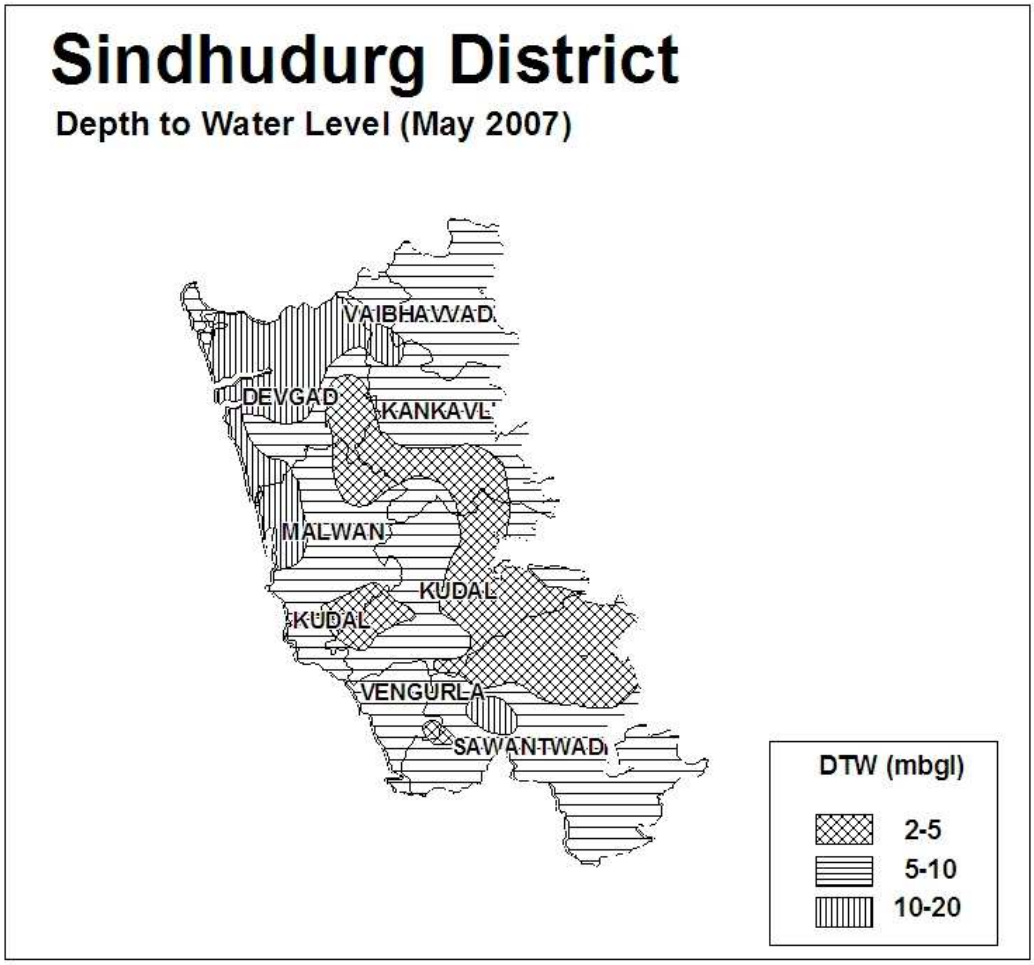

Figure-3: Depth to Water Level (Premonsoon- May 2007)

The shallow water levels within 10 m bgl are seen in almost entire district. The deeper water levels in the range of 10-20 m bgl are observed in north western part of the district in parts of Devgad and Malvani talukas.

4.2.2 Depth to Water Level – Postmonsoon (Nov.-2007)

The depth to water levels during Nov. 2007 ranges between 0.01 m bgl at few NHNS (Amboli and Vados) and 14.85 m bgl (Vagothan). Spatial variation in postmonsoon depth to water levels is shown in **Figure-4**. In the entire district the

water levels are shallow within 5 m bgl. The water levels of 2 to 5 m bgl are the most dominant range. The water levels in the range of 5 to 10 m bgl are observed in patches in northern and western coastal areas i.e., in parts of Vaibhavwadi, Devgad and Kankavli talukas.

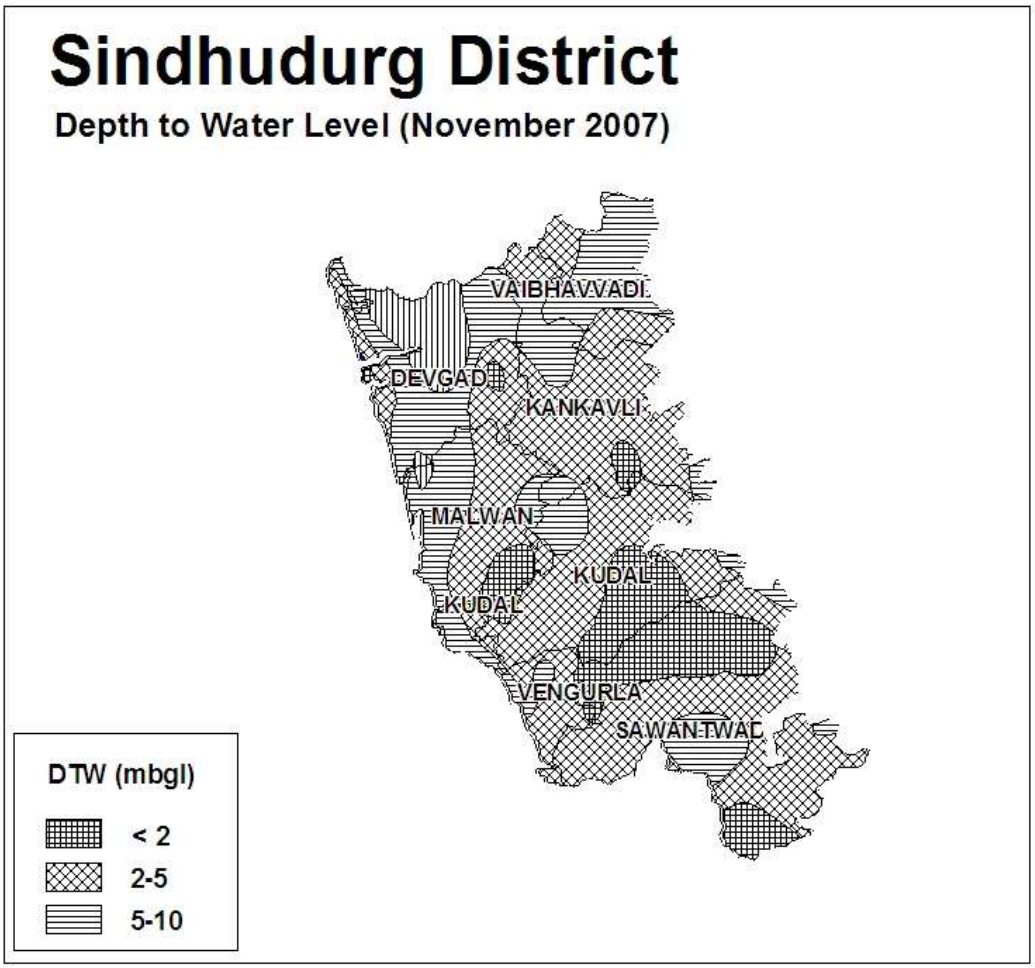

Figure-4: Depth to Water Level (Postmonsoon- Nov.2007)

4.2.3 Seasonal Water Level Fluctuation– (May to Nov. 2007)

The rise in water levels in the range of 0.75 m (Vijayadurga) to 10.60 m (Insuli) has been observed. Major part of the district show rise of water level up to 4 m. Rise above 4 m was observed in few patches in north western coastal part and in southern part of Savantwadi taluka.

4.2.4 Water Level Trend (1998-2007)

Trend of water levels for premonsoon and postmonsoon period for last ten years (1998-2007) have been computed for 37 NHNS. Analysis of long term water level trend indicates that during premonsoon period, rise in water levels has been recorded at 28 stations and it ranges between 0.02 m/year (Vengurla) and 0.53 m/year (Kasal). Fall in water levels has been observed at 9 stations in the range of 0.03 m/year at 3 NHNS (Matond, Vados and Savarwad) to 0.20 m/year (Devgarh). During postmonsoon period, rise in water levels has been recorded at 27 stations and it ranges from negligible (Ramgarh) to 0.32 m/year (Kunkaule), whereas at 10 stations, fall in water levels ranging between 0.01

(Shirgaon (Shirgar)) and 0.14 m/year (Dodamarga) is observed. In majority of NHNS the rise/fall during both the periods is up to 0.20 m/year and in major part of the district, both during pre and postmonsoon periods rising trend of water levels has been observed.

The premonsoon and postmonsoon trend map was also prepared and the same is presented in **Figure-5**. It shows that during premonsoon the rise in water level trend of up to 20 cm/year is observed in almost entire district, except in 2-3 isolated patches observed southern and western coastal parts occupying parts of Savantwadi, Kudal and Devgarh talukas where fall in water level trend of up to 20 cm/year is observed. During postmonsoon also rise is observed in major parts of the district, whereas area under fall has increased slightly in Kudal in central part of the district and in Devgarh in north western part of the district. Thus the situation is favourable for further ground water development in almost entire district.

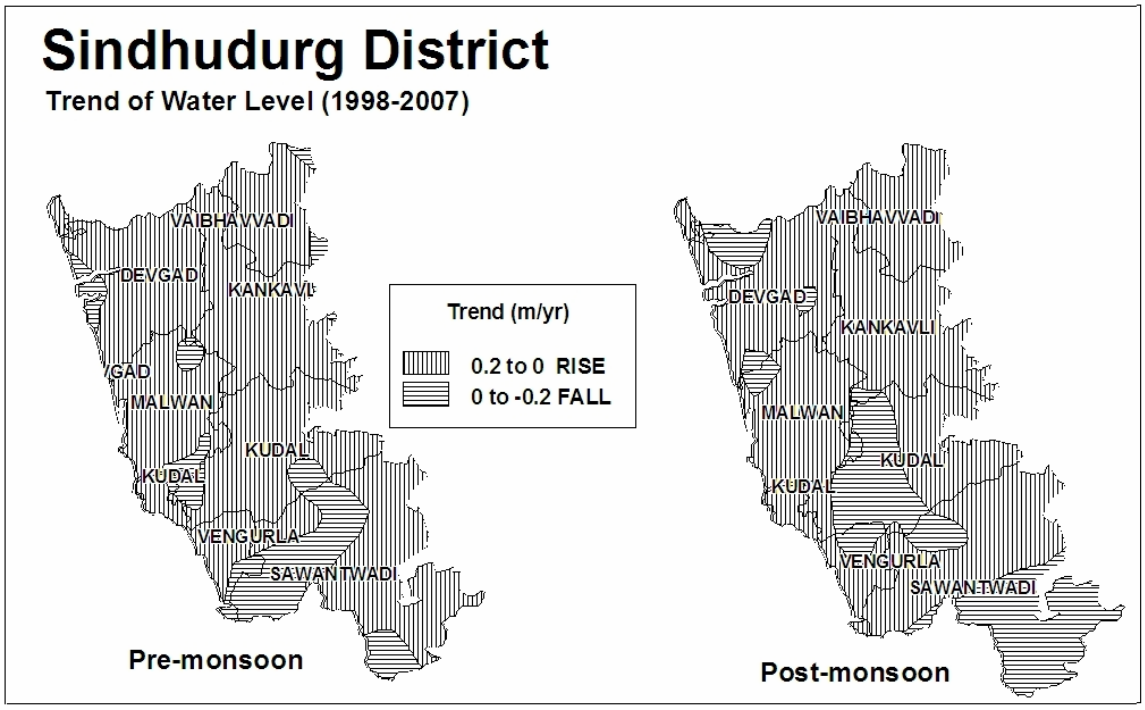

Figure-5: Water Level Trend (Premonsoon and Postmonsoon- 1998-2007)

4.3 Aquifer Parameters

As mentioned earlier, CGWB has not carried out any deep exploratory drilling in Sindhudurg district and as such no data is available on aquifer parameters of deeper aquifer. The aquifer parameters are available from dugwell pumping tests conducted during previous studies by CGWB. The summarised results of pumping test are given in Table-3. The specific capacity ranges from 3.38 to 424.57 lpm/m of drawdown, transmissivity ranges form 5.58 to 375.22 m^2/day, whereas permeability varies from 4.28 to 425.22 m/day.

Table-3: Aquifer Parameters.

S. No.	Aquifer	Specific Capacity (lpm/m of dd)	Transmissivity (m^2/day)	Permeability (m/day)
1	Laterite	79.10 to 424.57	46.59 to 375.22	7.40 to 425.22

2	Fractured Basalt	3.38 to 51.44	5.58 to 28.95	4.28 to 24.85

4.4 Yield of Wells

The yields of the wells are the functions of the permeability and transmissivity of aquifer encountered and vary with thickness of the aquifer zone encountered, location, diameter and depth etc. Ground water in the area is being developed by two type of abstraction structures i.e., borewells and dugwells. However dugwells are the main ground water abstraction structures in the district. Majority of dugwells in the district are basically used for domestic purpose. Some of the dugwells with good yield are fitted with centrifugal pumps which are used for irrigation purpose and some with submersible pumps for piped water supply schemes. Generally dugwells with rope and pulley as well as Persian wheel are used for domestic purpose.

The yield of dugwells in Coastal Alluvium ranges from 2 to 5 m^3/day, in Deccan Trap it varies from 0.50 to 4.00 m^3/day, in Kaladgis it varies between 2 and 5 m^3/day, whereas in Metamorphics it ranges between 2 and 3 m^3/day. The depth of the dugwells in all the formations is shallow up to 13 m bgl. The wells located in topographic lows have better yield than located elsewhere. However, the yield of the dugwells is more during post-monsoon period and declines with the approach of summer.

The borewells are mainly constructed for rural water supply. The successful borewells are fitted with hand pumps and those with high yield are fitted with power pumps. The yield of the borewells drilled by Groundwater Survey and Development Agency (GSDA) ranges between 500 to 9315 lph, whereas the depths of the borewells range between 45 and 70 m bgl. The formation-wise depth and yield of dugwells and borewells are given in Table-4.

Table-4: Yield of Dugwells and Borewells.

S. No.	Formation	Dugwells		Borewells	
		Depth (m bgl)	Yield (m^3/day)	Depth (m bgl)	Yield (lph)
1	Coastal Alluvium	2.00 to 11.80	2 to 5	---	--
2	Deccan Trap	8.00 to 13.50	0.5 to 4	45 to 65	500 - 770
3	Kaladgis	3.80 to 10.00	2 to 5	50 to 60	500 - 9315
4	Metamorphics	3.00 to 11.50	2 to 3	50 to 70	500 – 7770

4.5 Ground Water Resources

Central Ground Water Board and Groundwater Survey and Development Agency (GSDA) have jointly estimated the ground water resources of Sindhudurg district based on GEC-97 methodology. The same is presented in Table-5. Out of total area of 5087 sq. km., ground water resources estimation was carried out for 2793.05 sq.km., out of which 2770.44 sq.km. area falls under non-command category and 22.60 sq.km. area comes under the command category. Taluka wise ground water resources are shown in **Figure-5.**

As per the estimation the total annual ground water recharge is 105.68 MCM with the natural discharge of 5.40 MCM, thus the net annual ground water availability comes to be 100.30 MCM. The total annual draft for all uses is estimated at 70.74 MCM with irrigation sector being the major consumer having a

draft of 52.92 MCM. The net annual ground water availability for future irrigation is 17.48 MCM, whereas the allocation for domestic and industrial requirements is 29.88 MCM. The stage of ground water development varies from 38.35% (Savantwadi) to 88.80% (Malvan). The overall stage of ground water development for the district is 70.53%. All the 8 talukas and 11 watersheds have been categorised as “Safe”.

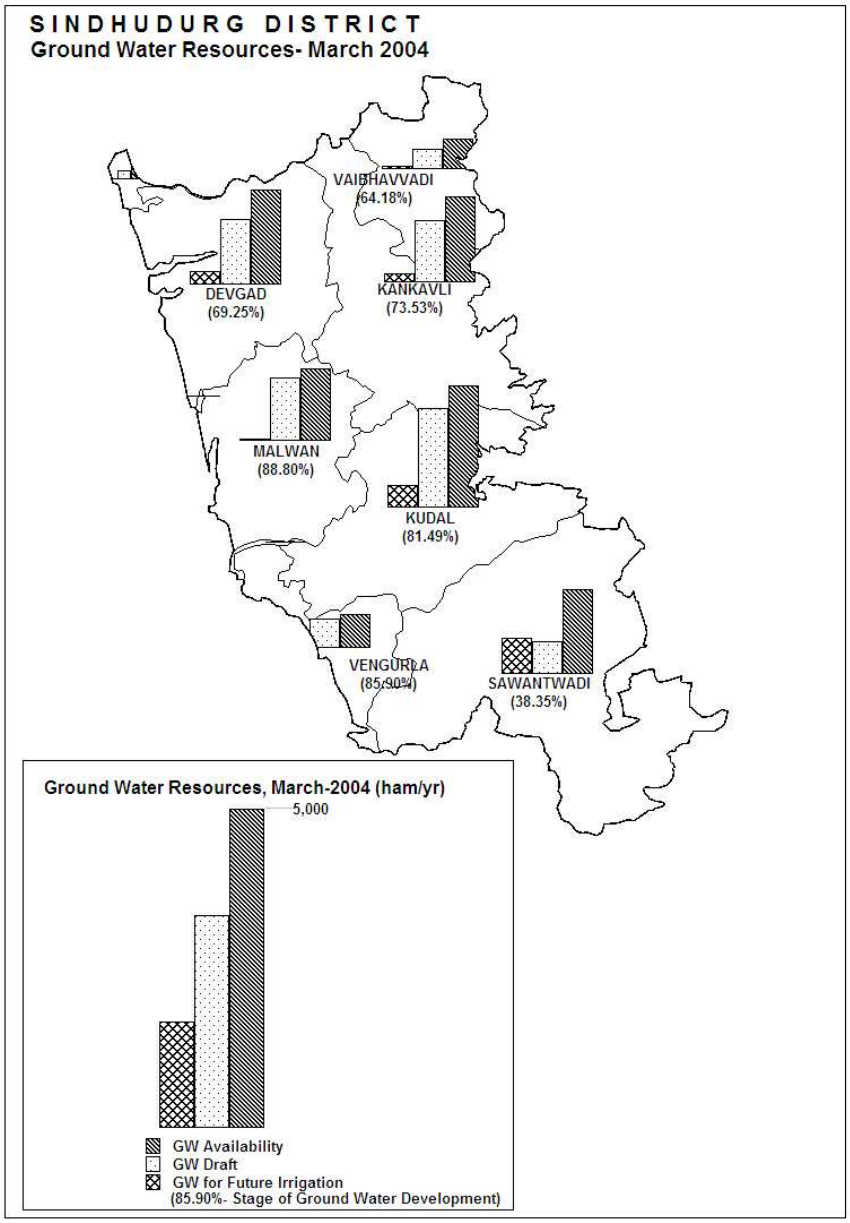

Figure-5: Ground Water Resources (March 2004)

Table-5: Ground Water Resources (March 2004).

Taluka	Area type	Net annual ground water availability (ham/yr.)	Annual ground water draft (ham/yr.)			Allocation for domestic & industrial requirement supply up to next 25 years (ham/yr.)	Ground water availability for future irrigation (ham/yr.)	Stage of ground water develop-ment (%)	Category
			Irrigation	Domestic & industrial uses	Total				
Kankavali	Command	51.97	0.00	6.98	6.98	13.95	38.02	13.42	Safe
	Non command	1515.57	865.47	280.21	1145.68	523.23	126.87	75.59	
	Total	1567.55	865.47	287.18	1152.66	537.18	164.89	73.53	
Vaibhavwadi	Non command	572.16	229.38	137.84	367.22	275.67	67.11	64.18	Safe
Devgarh	Non command	1723.91	892.44	301.34	1193.78	581.48	250.00	69.25	Safe
Malwan	Command	34.01	1.99	1.20	3.19	2.39	29.62	9.38	Safe
	Non command	1287.71	932.14	238.37	1170.51	351.74	3.83	90.90	
	Total	1321.72	934.14	239.56	1173.70	354.13	33.45	88.80	
Sawantwadi	Command	271.33	14.33	11.26	25.59	22.52	234.47	9.43	Safe
	Non command	1289.69	286.77	286.26	573.03	562.34	440.57	44.43	
	Total	1561.01	301.10	297.52	598.63	584.86	675.04	38.35	
Kudal	Command	466.96	27.38	16.44	43.82	32.88	406.70	9.38	Safe
	Non command	1771.08	1472.34	307.65	1779.99	298.74	0.00	100.50	
	Total	2238.04	1499.72	324.09	1823.82	331.62	406.70	81.49	
Vengurla	Non command	611.66	391.38	134.02	525.40	203.99	16.29	85.90	Safe
Doudamarg	Non command	433.97	179.15	59.89	239.04	119.77	135.05	55.08	Safe
District total	**Command**	**824.28**	**43.71**	**35.87**	**79.58**	**71.74**	**708.81**	**9.65**	
	Non command	**9205.75**	**5249.08**	**1745.58**	**6994.66**	**2916.96**	**1039.72**	**75.98**	
	Total	**10030.03**	**5292.79**	**1781.45**	**7074.24**	**2988.70**	**1748.53**	**70.53**	

4.6 Ground Water Quality

Central Ground Water Board monitors the ground water quality of the district through analysis of water samples collected from its National Hydrograph Network Stations (NHNS) which represent the shallow aquifer of the district only. The objective behind quality monitoring is to understand an overall picture of ground water quality of the district. During year 2007, CGWB has carried out the ground water quality monitoring at 34 NHNS.

The results of chemical analysis show that the ground water in the district is alkaline in nature. The type of ground water observed is mostly of Ca-HCO_3, whereas in few samples it is of Na-Cl type. The concentration of major ions indicates that among the cations, the concentration of magnesium ion is highest followed by sodium and calcium, while among the anions the concentration of chloride ion is highest, followed by bicarbonate, sulphate and nitrate ions.

4.6.1 Suitability of Ground Water for Drinking Purpose

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. Though many ions are very essential for the growth of human, but when present in excess, have an adverse effect on human body. The standards proposed by the Bureau of Indian Standards (BIS) for drinking water (IS-10500-91, Revised 2003) were used to decide the suitability of ground water. The classification of ground water samples was carried out based on the desirable and maximum permissible limits for the parameters viz., TDS, TH, Ca, Mg, Cl, SO_4 and NO_3 prescribed in the standards and is given in Table-6.

It is observed that out of the 34 ground water samples, TDS and TH are above desired limits but below permissible limits in samples collected from NHNS well located at Malvan and Mangaon Bazar respectively, whereas Mg is above desired limits but below permissible limits in samples collected from NHNS well located at Zarap and Mangaon Bazar. In all other samples all the parameters are within the desired limits, thus ground water is suitable for drinking purpose.

Table 6: Classification of Ground Water Samples for Drinking based on BIS Drinking Water Standards (IS-10500-91, Revised 2003).

Parameters	DL	MPL	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TDS (mg/L)	500	2000	33	1	0
TH (mg/L)	300	600	33	1	0
Ca (mg/L)	75	200	34	0	0
Mg (mg/L)	30	100	32	2	0
Cl (mg/L)	250	1000	24	0	0
SO_4 (mg/L)	200	400	24	0	0
NO_3 (mg/L)	45	No relaxation	34	0	0
F (mg/L)	1.0	1.5	34	0	0

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit.)

4.6.2 Suitability of Ground Water for Irrigation Purpose

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends

primarily on the presence of dissolved salts and their concentrations. Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation.

4.6.2.1 Sodium Absorption Ratio (SAR)

Sodium Absorption Ratio (SAR) is an expression pertaining to cation make up of water and soil solution and is used for characterizing the sodium hazard of irrigation water.

SAR value is used to calculate the degree to which irrigation water tends to enter into cation exchange section in the soil. The main problem with high sodium concentration is its effect on soil permeability. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. The higher value of SAR indicates soil structure damage.

4.6.2.2 Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) is considered to be superior to SAR as a measure of sodicity particularly at low salinity levels. The classification of ground water samples based on SAR and RSC values for its suitability for irrigation purpose is shown below in Table-7.

The perusal of Table-8 shows that the ground water samples from all the wells have SAR values less than 10 and RSC values less than 1.25. Thus the ground water quality in the wells monitored is good for irrigation purpose and there is a less possibility of developing sodium hazard.

Table 7: Classification of Ground Water for Irrigation based on SAR and RSC.

SAR	**<10**		**10-18**		**18-26**		**>26**	
Category	**Good**		**Good to Permissible**		**Doubtful**		**Unsuitable**	
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	%	No. of Samples	%
34	34	100	Nil	Nil	Nil	Nil	Nil	Nil
RSC	**<1.25**		**1.25-2.50**		**>2.50**			
Category	**Good**		**Doubtful**		**Unsuitable**			
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	%		
34	34	100	Nil	Nil	Nil	Nil		

4.7 Status of Ground Water Development

Ground water development depends on many factors viz., availability, crop water requirement, socio-economic fabric and on the yield of the aquifers existing in that area. Ground water is predominantly used for irrigation, as it is the major ground water utilising sector. As per the Minor Irrigation Census data available for year 2000-01, area irrigated by ground water is about 61.59 sq.km., whereas surface water accounts for 43.20 sq.km. and the net irrigated area is 105 sq.km. The net irrigated area is negligible i.e., about 8% when compared with the net area sown. The district had 4868 irrigation dugwells, which create an irrigation potential of 71.12 sq.km., out of which 46.35 sq.km., of irrigation potential is utilised. There are very few irrigation borewells in the district and the area irrigated by them is negligible.

State Government agencies have drilled number of borewells fitted with hand pumps and electric motors for rural drinking water purposes in the district. In all till March 2007, GSDA, Government of Maharashtra was successfully operating 2653 borewells for rural water supply under various schemes in the district, out of which 297 are fitted with electric pumps and 2356 are fitted with hand pumps.

5.0 Ground Water Management Strategy

Agricultural development in the district mainly depends on rainfall. The ground water development is on the higher side. The district also faces water scarcity during summer months in spite of heavy rainfall. There is thus a need to adopt an integrated approach of development of ground water resources dovetailed with ground water augmentation and rainwater conservation to provide sustainability to ground water development.

5.1 Ground Water Development

Major part of the district is covered by Basalt and Laterite. The Kaladgis and Dharwarian Metamorphics occupy comparatively less area, whereas Alluvium mainly occurs along the coast as beach sand at shallow depths. In all these formations dugwells are the most feasible structures for ground water development. The borewells sites need to be selected only after proper scientific investigation. The borewells generally tap deeper fractures, which may not be sustainable. Besides, the borewells should only be used for drinking water supply and not for irrigation. Apart from dugwells and borewells springs also serve as a dependable source for drinking and irrigation needs as observed from study around Nadhawade and Kolusra villages. The spring water could be harnessed for the problematic villages. If one spring does not give sufficient water, water of two or more springs should be harnessed and used for water supply or co-operative based irrigation purposes. As far as possible excess spring water should not be allowed to flow in long open channels/drains instead it should be arrested and conserved through check dams/bandharas etc., so as to bring more area under irrigation. The ground water quality of springs is also suitable for domestic and irrigation purposes.

Major parts of Sindhudurg district are covered by hilly areas. In these areas rocks are hard and compact, resistant to weathering with steep gradient causing rapid runoff and low infiltration and such areas are not feasible for ground water development. The overall stage of ground water development is on higher side i.e., about 70%, thus the scope of ground water development is limited in worthy areas. Further ground water development should be coupled with artificial recharge and water conservation measures, wherever feasible so as to augment the ground water resources and adoption of ground water management practices, so that the sustainable development is achieved.

5.2 Water Conservation and Artificial Recharge

A large number of water conservation structures in the form of check dams, percolation tanks and KT weirs have been constructed in the district. Till 2006, 698 Nala bunds, 221 cement bunds, 548 farm ponds and 1168 Vanrai Bandharas have been constructed in the district. The contour bunding has been carried out in 6996 hectares of land.

In hard rock area, the artificial recharge structures feasible are check dams,

gully plugs, percolation tanks, nalla bunds, etc. The structures like gully plugs, contour bunds are most favourable in the hilly areas. In the highland area and wide Lateritic plateau areas, contour trenching should be carried out to arrest the surface runoff and ensure recharge of rainfall runoff into the ground water reservoir. Existing dugwells can also be used for artificial recharge, however, the source water should be properly filtered before being put in the wells. These sites need to be located where the hydrogeological conditions are favourable, i.e., where sufficient thickness of unsaturated/de-saturated aquifer exists and water levels are deeper than 5 m. Occurrence of such areas are limited in the district as seen from postmonsoon water level map.

It is also observed that sufficient water is available in the rivers and streams in the post-monsoon period, hence lift irrigation schemes may be encouraged using small check dams.

6.0 Ground Water Related Issues and Problems

Even though the district receives high rainfall in the range of 2300 to 3200 mm/year, water scarcity in the non-monsoon seasons is the major issue of concern and many villages face water scarcity in the summer. In such areas in the basaltic terrain, attempts may be made to increase recharge and create additional storage spaces by employing unconventional methods like hydro-fracturing, bore blast technique, horizontal bores in dugwells along the plane of weakness etc., and artificial recharge structures. Small schemes of water conservations like storage tanks on hill tops/plateau needs to encouraged for mitigating the water scarcity situation.

There is a lack of efforts to harness and harvest the rain water in the region. Mass awareness programmes should be organized in large scale by district administration. Such programmes are necessary so as to educate the user regarding yielding capacity of aquifer, benefits of small water conservation schemes/efforts, appropriate crop planning and irrigation practices etc.

The district has a coastline of 121 km and has 14 creeks, about 76900 ha of agricultural land is reported to be saline due to sea water ingress along the coast and creeks. CGWB has carried out a study on sea water ingress in Mithibhao creek area of the district. About 15 ground water samples were collected from areas adjacent to the Mithibhao creek and it is observed that only 4 samples collected from 3 wadis viz., Jatewadi, Kondwadi and Yeshwantwadi which are located very close to the incomplete bund of Kharland Development Board show sea water contamination. To avoid ground water quality deterioration the existing damaged bunds/bandharas needs to be repaired in time and incomplete bunds needs to be completed by Kharland Development Board on priority basis.

7.0 Areas Notified by CGWA/SGWA

As per ground water resource estimation all the talukas fall under “Safe” category, hence till March 2007 the area has not been notified either by CGWA or SGWA.

8.0 Recommendations

1 The major part of the district is underlain by hard rocks i.e., Deccan Trap Basalt, Laterite, Dharwarian Metamorphics and Kaladgis where only

dugwells are most feasible structures for ground water development.

2 The sites for borewell need to be selected only after proper scientific investigation. The borewells generally tap deeper fractures, which may not be sustainable and are not recommended for irrigation purpose. However, to cater to the drinking water requirements the borewells can be used by installing the hand pumps.

3 The spring water should be harnessed for the problematic villages especially in hilly areas. If one spring does not give sufficient water, water of two or more springs should be harnessed and used for water supply or co-operative based irrigation purposes. As far as possible excess spring water should not be allowed to flow in long open channels/drains instead it should be arrested and conserved through check dams/bandharas etc., so as to bring more area under irrigation.

4 The overall stage of ground water development is about 70%, thus the scope of ground water development is limited in worthy areas. Further ground water development should be coupled with artificial recharge and water conservation measures, wherever feasible so as to augment the ground water resources and adoption of ground water management practices, so that the sustainable development is achieved.

5 In spite of heavy rainfall over the area, many villages face water scarcity in the summer. In such areas, attempts may be made to increase recharge and create additional storage spaces by employing unconventional methods like hydro-fracturing, bore blast technique, horizontal bores in dugwells along the plane of weakness etc., and artificial recharge structures. Small schemes of water conservations like storage tanks on hill tops/plateau needs to encouraged in mitigating the water scarcity situation.

6 The scope exists for construction of suitable artificial recharge structures in the district in limited areas. The structures recommended for the hilly areas are: contour bunds, gully plugs, nala bunds and check dams. For other hard rock areas, the nala bunds, check dams and KT weirs are suggested. The existing dugwells may also be used for artificial recharge of ground water provided source water is free of silt and dissolved impurities.

7 As sufficient water is available in the rivers and streams in the post-monsoon period for 2-3 months, lift irrigation schemes may be encouraged using small check dams.

8 The existing village ponds/tanks need to be rejuvenated to act both as water conservation and artificial recharge structures.

9 About 76900 ha of agricultural land is reported to be saline due to sea water ingress along the coast and creeks. To avoid ground water quality deterioration by sea water ingress the existing damaged bunds/bandharas constructed along the creeks needs to be repaired in time and incomplete bunds needs to be completed by Kharland Development Board on priority basis.

10 Mass awareness programmes should be organized in large scale by district administration. Such programmes are necessary to educate the user regarding yielding capacity of aquifer, benefits of small water conservation schemes/efforts, appropriate crop planning and irrigation practices etc.