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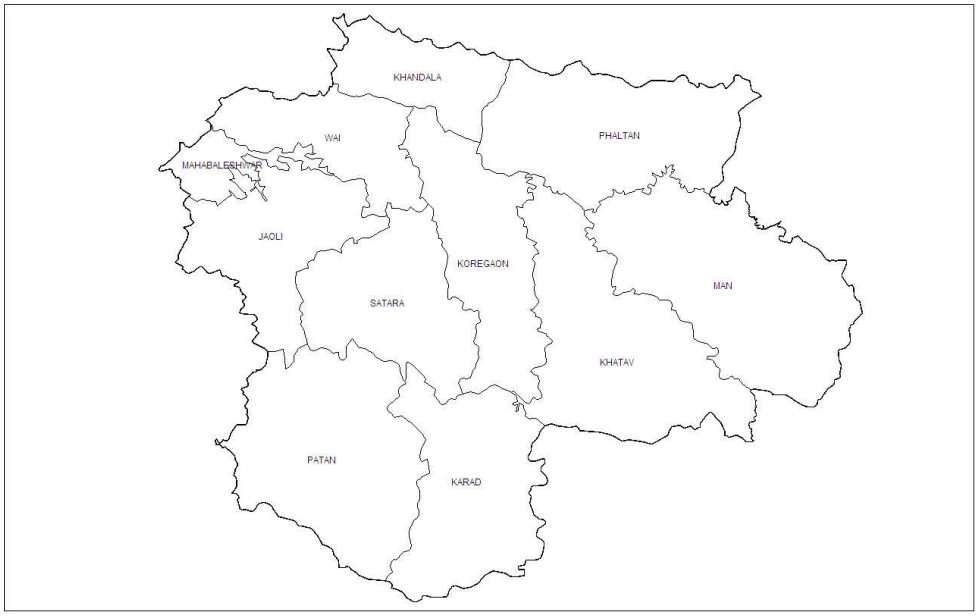
भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र राज्य का अंतर्गत सातारा जिला की
भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
SATARA DISTRICT
MAHARASHTRA



By

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Scientist-D

द्वारा

डा. प्रभात कुमार जैन

वैज्ञानिक- घ

मध्यवर्ती क्षेत्र

नागपुर

CENTRAL REGION

NAGPUR

2009

SATARA DISTRICT AT A GLANCE

1. GENERAL INFORMATION

Geographical Area	:	10480 sq. km.
Administrative Divisions (As on 31/03/2007)		Taluka – 11; Satara, Mahabaleshwar, Wai, Khandala Phaltan, Man, Jhatav, Koregaon, Jaoli, Patan and Karad.
Villages	:	1739
Population	:	28,09,000
Normal Annual Rainfall	:	473 mm to 6209 mm

2. GEOMORPHOLOGY

Major Physiographic unit	:	4; Western Ghats, Foothill zone, Central Plateau and Eastern Plains
Major Drainage	:	3; Krishna, Nira and Man

3. LAND USE (2000-01)

Forest Area	:	1375 sq. km.
Net Area Sown	:	5576 sq. km.
Cultivable Area	:	7992 sq. km.

4. SOIL TYPE : 2; Medium Black and Deep Black soils

5. PRINCIPAL CROPS (2000-01)

Jowar	:	2101 sq. km.
Bajra	:	899 sq. km.
Cereals		942 sq. km.
Oil Seeds	:	886 sq. km.
Sugar Cane	:	470 sq. km.

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

Dugwells	:	75482 / 181019
Borewells	:	2095 / 4581
Tanks	:	5532 / 13645
Other Surface Sources	:	9222 / 42186
Net Irrigated Area	:	119755 ha

7. GROUND WATER MONITORING WELLS (As on 31/05/2007)

Dugwells	:	46
Piezometers		6

8. GEOLOGY

Recent	:	Alluvium
Upper Cretaceous-Lower Eocene	:	Deccan Trap (Basalt)

9. HYDROGEOLOGY

Water Bearing Formation	:	Basalt – Weathered / fractured / jointed vesicular / massive, under phreatic and semi-confined to confined conditions
Premonsoon Depth to Water Level (May-2007)	:	1.00 to 28.90 m bgl
Postmonsoon Depth to Water Level (Nov.-2007)	:	0.01 to 13.65 m bgl
Premonsoon Water Level Trend (1998-2007)	:	Rise : Negligible to 0.56 m/year Fall : Negligible to 0.51 m/year
Postmonsoon Water Level Trend (1998-2007)	:	Rise : Negligible to 0.32 m/year Fall: Negligible to 0.28 m/year

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

Wells Drilled	:	EW-19, OW-09
Depth Range	:	67.50 to 301.00 m bgl
Discharge	:	Traces to 15.00 lps

11. GROUND WATER QUALITY

Good and suitable for drinking and irrigation purpose

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

Net Annual Ground Water Availability	:	1167.48 MCM
Annual Ground Water Draft (Irrigation + Domestic)	:	716.68 MCM
Allocation for Domestic and Industrial requirement up to next 25 years	:	93.48 MCM
Stage of Ground Water Development	:	61.39%

13. GROUND WATER CONTROL AND REGULATION

Over-Exploited Taluka	:	None
Critical Taluka	:	None
Semi-Critical Taluka	:	1 (Khatav)
Notified Taluka	:	None

14. MAJOR GROUND WATER PROBLEMS AND ISSUES

Drought area has been observed in major parts of the district in entire eastern, north eastern and south eastern parts comprising almost entire Khandala, Phaltan, Khatav, Mhaswad talukas and parts of Koregaon and Karad talukas. Deeper water levels more than 10 m bgl are also seen in northern part around, Mahabaleshwar, Khandala and Wai and in south eastern part of the district in parts of Man and Khatav talukas. Also Khatav taluka has been categorised as “Semi–Critical” taluka, where stage of ground water development has reached almost 90%. Apart from this 5474 ha of land has been demarcated as water logged area by Irrigation Department, Govt. of Maharashtra in Nira canal command area of district.

Ground Water Information
Satara District

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Satara District

1.0 Introduction

Satara district is one of the five district of Western Maharashtra area of the State. It is situated in the western part of the State and lies between north latitudes 17° 05" and 18° 11' and east longitude 73 ° 33' and 74° 54'. The total area of the district is 10480 sq. km. and falls in parts of Survey of India degree sheet No. 47-F, G, J and K. The district is bounded in the north by Pune district on the east by Solapur district, on the south by Sangli district and on the west by Ratnagiri district of Konkan region of state. Sahayadri hills of western ghat forms the western boundary, while Nira River forms the northern boundary of the district. The district headquarter is located at Satara town.

For administrative convenience, the district is divided in 11 talukas namely Jaoli, Karad, Khandala, Khatav, Koregaon, Man, Mahableshwar, Patan, Phaltan, Satara and Wai. It has total population of 28,09,000 as per 2001 census and population density is 268 persons/sq. km. The district has 15 towns, 1739 villages, 11 Panchayat Samitis, 1488 Gram Panchayats and 8 Nagar Parishads. As per land use details (2000-01), the district has an area of 10480 sq. km. out of which 1375 sq. km. is occupied by forests. The gross cultivable area is 7992 sq. km. whereas net area sown is 5576 sq. km.

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.	Officer	AAP	Type of Survey / Study
1	Shri. J. P. Dias	1975 – 76	Systematic Hydrogeological Survey in parts at Satara district
2	Dr. D. K. Chadha	1976 – 77	Systematic Hydrogeological Survey in parts at Satara district
3	Shri. A. R. Bhaisare	1977 – 78 1978 – 79 1979 – 80	Systematic Hydrogeological Survey in parts at Satara district
4	Shri. Das and Shri. S. Sudarshan	1979 – 81	Systematic Hydrogeological Survey in parts at Satara district
5	Shri. S. Sudarshan	1980 – 81	Systematic Hydrogeological Survey in parts at Satara district
6	Dr. P. K. Naik	1988 – 89	Systematic Hydrogeological Survey in parts at Satara district
7	Shri. R. P. Singh	1989 – 90	Systematic Hydrogeological Survey in parts at Satara district
8	Shri. D. K. Rai	1989 – 90	Systematic Hydrogeological Survey in parts at Satara district
9	Shri. A. Suresha	1991 – 92	Reappraisal Hydrogeological Study in parts of Satara district
10	Dr. P. K. Naik	1991 – 92 1992 – 93	Reappraisal Hydrogeological Study in parts of Satara district

In addition to above studies a report on Ground Water Resources and Development Potential of Satara district, Maharashtra was compiled during year 2005-06 by Shri. Sourabh Gupta, Scientist-D.

Ground water exploration in the district has been taken up since 1979 and total 19 Exploration Wells (EW) and 9 Observation Wells (OW) have been drilled so far. The main objective of Ground Water Exploration is to decipher the sub surface geology of the district, to identity various water bearing horizons, their depth range, yield and their article extent, to compute their hydraulic characteristics and also to evaluate chemical quality of ground water to establish their suitability for various uses. The taluka wise salient features of ground water exploration are given in **Table-2**.

Table 2: Salient Features of Ground Water Exploration.

S. No.	Taluka	Wells drilled	Drilled Depth (m bgl)	Zones (m bgl)	Discharge (lps)	SWL (m bgl)
1	Satara	EW – 4 OW – 2	177.10 to 201.50	35.00 to 36.00 152.00 to 153.00	0.78 to 5.94	1.40 to 18.20
2	Man	EW – 5 OW – 2	79.60 to 201.60	16.20 to 29.30 145.00 to 150.00	Dry to 10.98	1.00 to 10.24
3	Khatav	EW – 5 OW – 2	67.40 to 301.00	6.00 to 152.00	Dry to 15.00	3.10 to 8.28
4	Koregaon	EW – 1 OW – 1	122.25 to 134.55	4.25 to 134.55	1.73 to 3.77	2.45 to 2.55
5	Patan	EW – 3 OW – 2	80.60 to 201.50	22.60 to 23.60 185.30 to 186.30	Traces to 3.00	1.47 to 74.50
6	Phaltan	EW – 1 OW – Nil	201.00	-	0.58	17.25
7	Total	EW- 19 OW- 9	67.40 to 301.40	4.25 to 186.30	Traces to 15.00	1.00 to 74.50

The perusal of Table–2 shows that the depth of 19 EW and 9 OW drilled in hard rock area (Deccan Trap Basalt) of the district varies from 67.40 to 301.00 meters below ground level (m bgl). The water bearing zones were encountered in the depth range of 4.25 to 186.30 m bgl, which shows that the deeper zones below 50 m depth have also been encountered at many places in the district indicating that the water can also be drawn from deeper aquifer in case of scarcity for drinking water supply. The discharge of the wells drilled in the district varies between traces to 15.00 liters per second (lps).

A map of the district showing the taluka boundaries, taluka headquarters, physical features and location of exploratory and monitoring wells is presented as **Figure-1**.

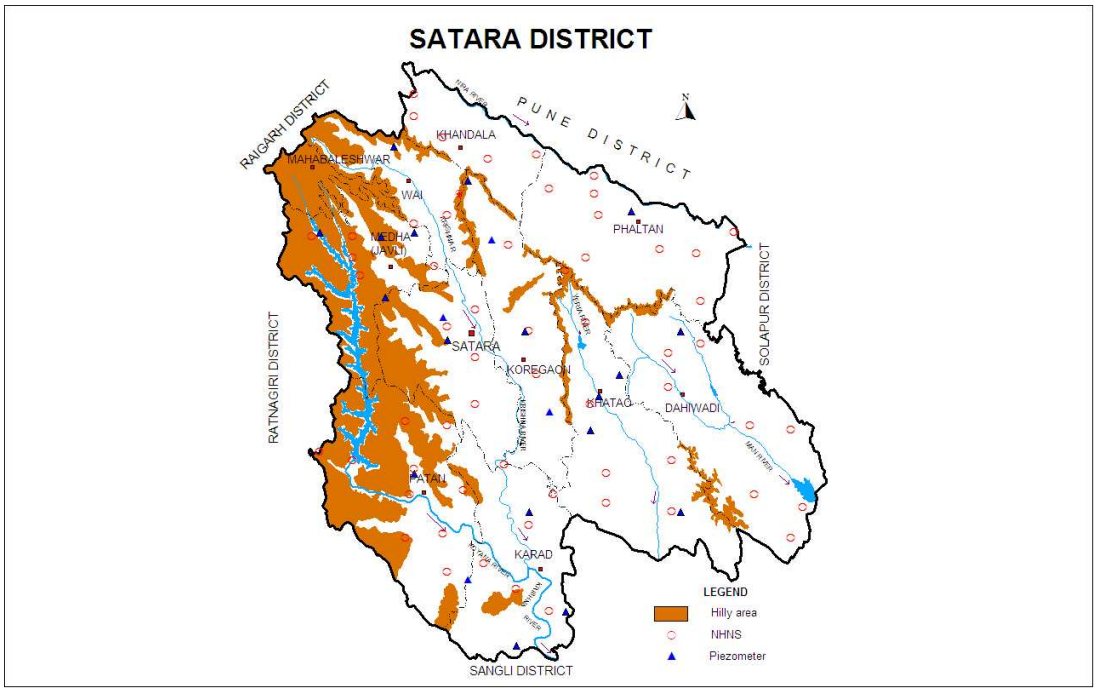

Figure-1: Location

2.0 Climate and Rainfall

The climate of the district is on the whole is agreeable. The winter season is from December to about the middle of February followed by summer season which last up to May. June to September is the south-west monsoon season, whereas October and November constitute the post-monsoon season. The mean minimum temperature is 14.4° C and mean maximum tem perature is 36.8° C at Satara town in the district.

The rainfall analysis for the period 1901-2005 reveals that the normal annual rainfall over the district varies from 473 to about 6209 mm. In the eastern part of the district around Mhaswad (Man taluka) and Phaltan taluka it is minimum and increases towards the west and reaches maximum around Mahabaleshwar. However, the probability of occurrence of normal rainfall is maximum (50 to 55%) in the south eastern parts around Mhaswad (Man), Vaduj, Pusewadi and Karad. While the probability of receiving excess rainfall (i.e., 25% or more) varies from 9% to 30%. It is minimum around Mhaswad (9%) and maximum around Pusewadi (30%). The study also reveals that entire eastern, north eastern and south eastern parts of the district comprising almost entire Khandala, Phaltan, Khatav, Mhaswad talukas and parts of Koregaon and Karad talukas in the plains which experienced droughts for more than 20% of the years can be categorized as “drought area”. The average rainfall data for the period (1998–2007) are presented in Table–3.

The perusal of Table–3 indicates that the average annual rainfall during the period ranges between 513.80 mm (Man) to 5896.48 mm (Mahabaleshwar).

Table–3: Annual Rainfall data (1998 – 2007)

S. No.	Station	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Ave-rage
1	Javali	1664.90	1608.40	942.50	1092.40	1320.10	1191.90	1103.60	3679.20	2760.00	1679.10	1704.21
2	Karad	705.70	790.20	535.90	654.90	467.20	419.40	777.90	1230.80	1070.30	1025.10	767.74
3	Khandala	699.80	481.80	442.80	349.70	NA	NA	760.40	735.60	786.60	685.90	617.83
4	Khatav	839.90	461.10	406.00	518.60	398.80	NA	951.50	684.20	602.00	593.30	606.16
5	Koregaon	841.70	887.40	621.80	519.80	586.20	393.60	987.60	1435.50	1345.80	895.20	851.46
6	Mahabale-shwar	4997.90	5506.60	4158.40	4500.80	5094.30	4441.40	6506.90	8824.30	8669.20	6265.00	5896.48
7	Man	764.00	577.90	311.00	357.60	353.00	NA	534.20	572.80	558.60	595.20	513.81
8	Patan	1560.10	1691.80	1165.00	1203.40	1244.70	987.70	1612.80	3250.90	2851.60	2220.60	1778.86
9	Phaltan	864.30	532.80	385.30	478.40	344.30	NA	764.50	471.80	689.20	725.00	583.96
10	Satara	911.90	1059.70	959.60	1031.60	341.60	583.70	1092.70	1849.80	1676.10	1231.70	1073.84
11	Wai	1123.40	1101.00	662.00	678.00	561.60	541.20	1129.70	1574.30	1510.80	1033.40	991.54

(Source: www.agri.mah.nic.in)

3.0 Geomorphology and Soil Types

The district forms part of Deccan Plateau of Sahayadri hill ranges. The residual hill ranges and the intermediate valleys, all well developed on a table land surface forms the main geomorphic element of landscape in the district. In the west, the district has the Sahayadrian scarp with its major peaks, usually flat topped and intervening saddles. The Mahadeo Range, which is the next major well developed range in the district, begins as an off-shoot of the Sahayadri in the north-western part. Eastward it runs as a main range and sets of several minor ranges south-eastwards and southwards. However, physiographically the district can be broadly divided in major four units viz., (i) Hills and Ghats, (ii) Foothills zones, (iii) Plateaus and (iv) Plains.

The entire Satara district falls in the drainage of three major rivers, Nira, River in the entire northern part, Man River in the south-east and Krishna River in the south. Krishna River which is one of the major River of southern peninsula, rises on the eastern brow of the Mahableshwar plateau in the district and flows for about 176 km. in the district. Kudal, Vena, Urmodi, Tarli, Koyna, Vasna and Yerla rivers are the main tributaries of Krishna River. All the rivers have parallel to semi-dendritic drainage pattern and the drainage density is quite high in the district. Based on geomorphologic setting and drainages pattern, the district is divided into 50 watersheds.

4.0 Ground Water Scenario

4.1 Hydrogeology

The entire district is underlain by Deccan Trap basaltic lava flows of Upper Cretaceous to Lower Eocene age. The shallow alluvial formation of Recent age also occurs as narrow stretch along the major rivers flowing in the district however, they have limited areal extension. A map depicting the hydrogeological features is shown in **Figure-2**.

4.1.1 Hard Rock (Deccan Trap Basalt)

Deccan Trap occupies about 95% area of the district and it occurs as basaltic lava flows, which are normally horizontally disposed over a wide stretch and give rise to tableland type of topography also known as plateau. These flows

occur in layered sequence ranging in thickness from 4 to 66 m. Flows are represented by massive portion at bottom and vesicular portion at top and are separated from each other by marker bed known as bole bed. The thickness of weathering varies widely in the district form 5 to 20 m bgl. The weathered and fractured trap occurring in topographic lows form the main aquifer in the district.

The ground water occurs under phreatic, semi-confined and confined conditions. Generally the shallower zones down to the depth of 20 m bgl form phreatic aquifer. The water bearing zones occurring between the depths of 20 and 40 m are weathered interflow or shear zones and yield water under semi-confined conditions. Deep confined aquifers occur below the depth of 40 m. The vesicular portion of different lava flows varies in thickness from 8 to 10 m and forms the potential aquifer zones. However the nature and density of vesicles, their distribution, inter-connection, depth of weathering and topography of the area are the decisive factors for occurrence and movement of ground water in vesicular units. The massive portion of basaltic flows are devoid of water, but when it is weathered, fractured, jointed or contain weaker zones ground water occurs in it.

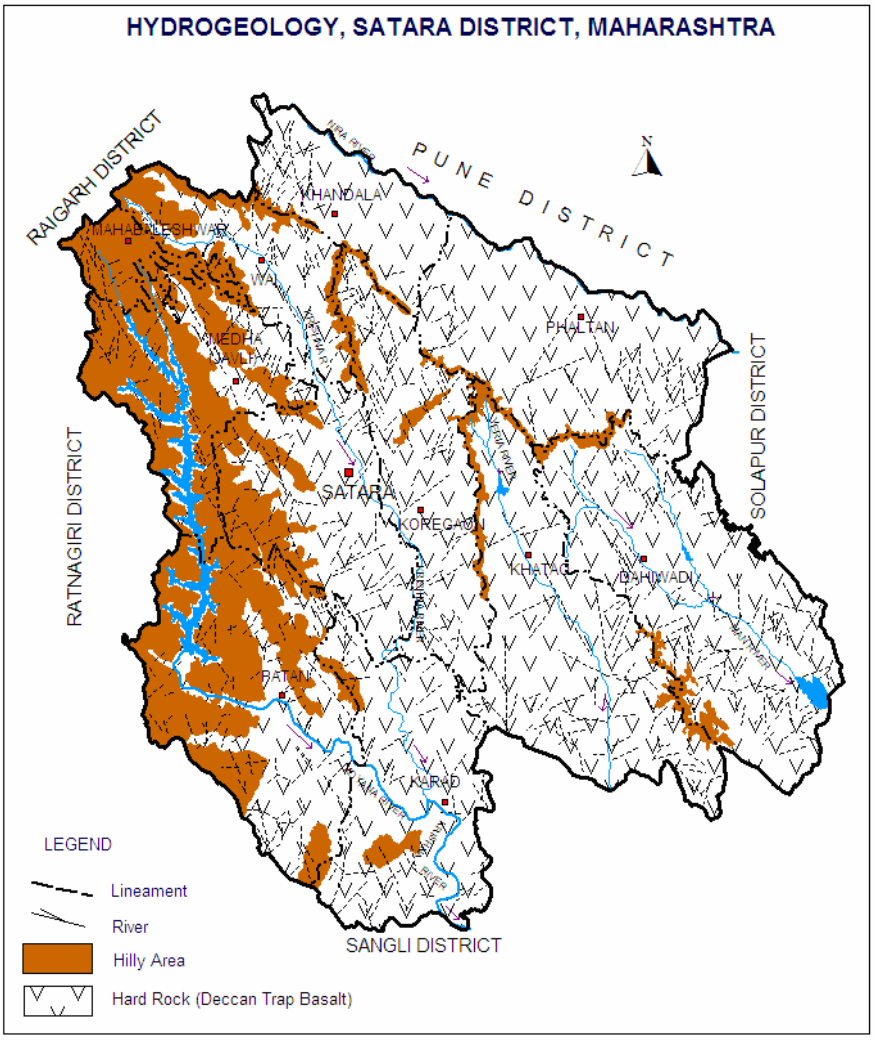

Figure-2: Hydrogeology

In winter season the yield of the dugwells varies between 10 to 190 m^3/day whereas in summer it varies between 5 to 20 m^3/day depending on the type of aquifer encountered. The discharge of borewells tapping both shallow and deeper aquifers range between trace and 15.00 lps as observed from exploration studies.

4.1.2 Soft Rock (Alluvium)

Alluvium occurs as narrow stretches along banks and flood plains of major rivers like Nira, Man, Krishna and Yerla and their tributaries. In the Alluvium the coarse-grained detrital material like sand and gravel usually occurring as lenses forms good aquifer, however they have limited areal extension. The ground water occurs in phreatic aquifer under water table conditions in flood plain Alluvium deposits near the river banks.

4.2 Water Level Scenario

Central Ground Water Board (CGWB) monitors water level data of 52 National Hydrograph Network Stations (NHNS) in the district. The NHNS are measured four times in a year i.e., January, May (Premonsoon), August and November (Postmonsoon).

4.2.1 Depth to Water Level – Premonsoon (May 2007)

The depth to water level in Satara district during May 2007 ranges from 1.00 m bgl (Morgir(Shivpur Peth)) to 28.90 m bgl (Khandala). Depth to water levels during premonsoon (May 2007) has been depicted in **Figure-3**. The perusal of **Figure-3** indicates that the most predominant water level range during premonsoon period in the district is 5 to 10 m bgl, which is seen in almost entire district.

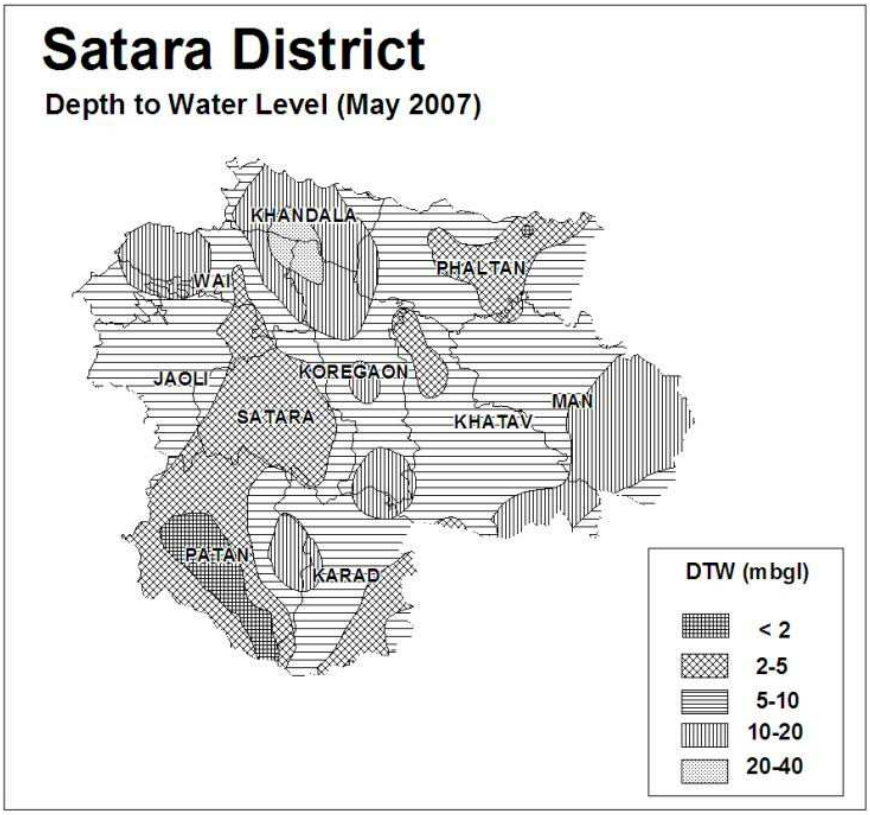

Figure-3: Depth to Water Level (Premonsoon- May 2007)

This dominant range of water level is followed by shallow water level range within 5 m bgl, which occupies south western and west central parts of the district. Apart from this a small isolated patch in north eastern part of Phaltan taluka is also observed. The deeper water levels (10 to 20 m bgl) are mainly observed in two elongated patches, one in north western part of the district near Mahabaleshwar, Pachgani, Shirur, Pimpode and Wathar and one in eastern part of the district in parts of Man and Khatav talukas, whereas deeper water level of more than 20 m bgl is observed only at one place i.e., Khandala.

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

The depth to water levels in the district during November 2007 ranges between 0.01 (Manjarwadi) and 13.65 m bgl (Mahabaleshwar). Depth to water levels during postmonsoon (May 2007) has been depicted in **Figure-4**. The perusal of **Figure-4** indicates that the major part of the district has shallow water levels i.e., within 5 m bgl during postmonsoon season. While the shallowest water level i.e., less than 2 m bgl is seen in 3 to 4 patches among which largest patch covering parts of Satara and Jaoli talukas is seen is western part of the district. The water levels in the range of 5-10 m bgl are seen in the 2 to 3 isolated patches in south eastern, north central and southern parts of the district. The water levels in 10-20 m bgl range are seen in single isolated patch in hilly areas around Mahabaleshwar in north western part of the district.

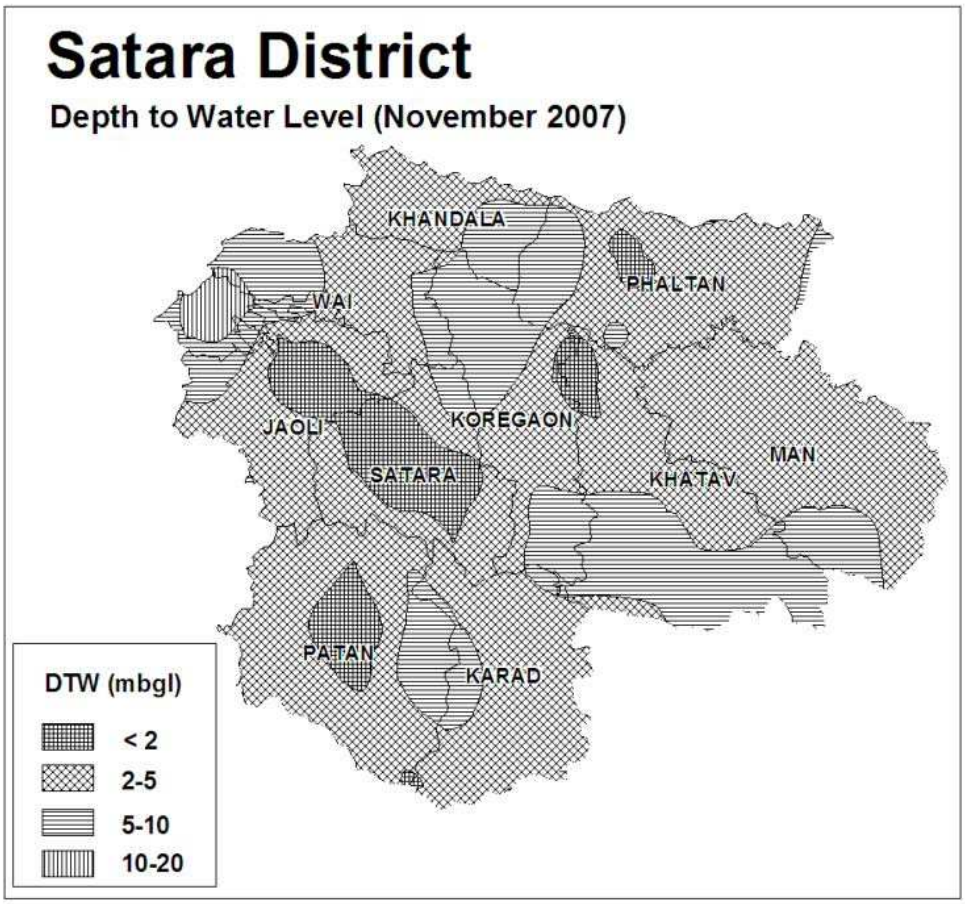

Figure-4: Depth to Water Level (Postmonsoon- Nov. 2007)

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

Seasonal water level fluctuation between premonsoon and postmonsoon for the year 2007 have been computed. The seasonal rise in water level in the district ranges from 0.85 (Manure) to 25.68 m (Khandala). However fall in water level is also seen at 9 locations ranging between 0.02 (Aundh) to 4.05 m (Mahabaleshwar). The rise in water level within 4 m is observed in major part of the district in south eastern, north eastern, central, western and southern parts of the district covering almost entire Khatav, Phaltan and Satara talukas and parts of Man, Karad, Patan and Jaoli talukas, whereas rise of more than 4 m is observed in northern (parts of Khandala, Wai and Koregaon talukas), eastern (almost entire Man taluka) and south central parts (northern part of Karad and southern part of Koregaon taluka). The fall in water levels between 0 to 2 m is also observed in two isolated patches in southern parts of Patan taluka and western parts of Mahabaleshwar taluka.

4.2.4 Water Level Trend (1998–2007)

Long term water level trend for premonsoon and postmonsoon periods for last 10 years (1998–2007) have been computed and analysed. The analysis indicates that during premonsoon period rise in water levels ranging between negligible at few NHNS and 0.56 m/year (Tathvade) have been recorded at 26 NHNS, while fall in water levels ranging between negligible at few NHNS and 0.51 m/year (Malkapur) have been recorded at 20 NHNS. During postmonsoon period rise in water levels have been recorded at 28 NHNS and it ranges from negligible at few NHNS to 0.32 m/year (Mirgaon), whereas at 16 NHNS fall in water levels ranging between negligible at few NHNS and 0.28 m/year (Pingli) have been recorded. The premonsoon trend map was also prepared and the same is presented in **Figure-5**.

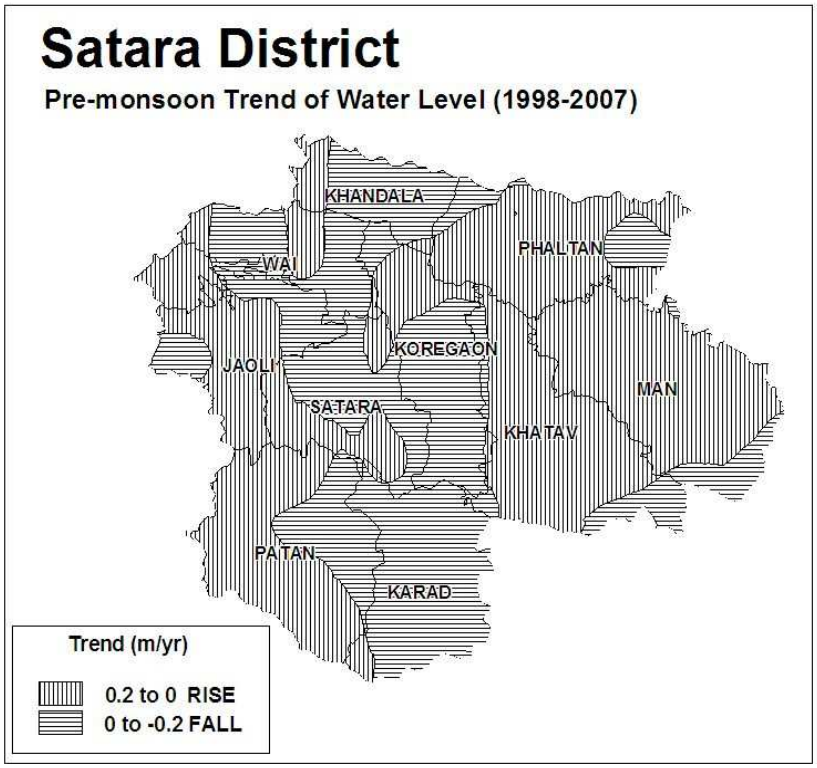

Figure-5: Water Level Trend (Premonsoon- 1998-2007)

The perusal of Fugure-5 shows that the rise in water level trend of up to 0.20 m/year is observed in almost entire eastern and western parts of the district covering entire Phaltan, Man and Khatav talukas and parts of Koregaon, Patan and Jaoli talukas. The fall in water level trend of up to 0.20 m/year is observed in an elongated patch extending from north to south in central part of the district covering parts of Khandala, Wai, Satara, Koregaon, Patan and talukas and almost entire Karad taluka. Thus the future ground water conservation and recharge structures need to be prioritized in these areas.

4.3 Aquifer Parameters

The aquifer parameters of water table/phreatic aquifer are available from systematic hydrogeological surveys conducted by CGWB. In Deccan Trap Basalt, the specific capacity of the dugwells ranges from 58 to 373 lpm / m of drawdown, specific yield ranges from 1.5 to 2% and transmissivity ranges between 30 and 450 m^2 / day. In addition to these the yields of borewells drilled by CGWB and tapping deeper aquifers ranges between 0.58 to 15 lps for a drawdown of 4 to 29 m. The hydraulic and well characteristics of basaltic aquifer are presented in Table–4.

Table-4: Aquifer Parameters in Deccan Trap Basalt.

S. No.	Aquifer	Specific Capacity (lpm/m of drawdown)	Transmmisivity (m^2/day)	Specific Yield (%)	
				Range	Average
1	Vesicular Basalt	96–169	30 – 300	0.8–2.8	2.70
2	Vesicular and Weathered Basalt	58–140	40 – 335	0.4–2.7	2.00
3	Highly Weathered and decomposed Basalt	75–379	40 – 415	0.3–1.9	1.50
4	Fractured and Jointed Massive Basalt	113–250	30 – 450	0.1–2.9	2.70

4.4 Yield of Dugwells and Borewells

The yields of the wells are function of the permeability and transmissivity of aquifer encountered and it varies with location, diameter and depth of wells etc. There are mainly two types of ground water abstraction structures in the district i.e., dugwells and borewells, however the yield of wells also vary according to nature of formation tapped and its saturated thickness. Therefore, the dugwells located in the topographic lows, morphological depressions and on or near the lineaments yield comparatively more water than the located elsewhere, which is particularly true in basaltic terrain. The yield of dugwell also varies depending on the season. The summer and winter yields of dugwells for different formations encountered in Deccan Trap Basalt are presented in Table-5.

Table–5: Yield of Dugwells in Deccan Trap Basalt.

S. No.	Aquifer	Yield of dugwells m^3 / day	
		Winter	Summer
1	Vesicular Basalt	10–75	5-10
2	Vesicular and Weathered	10–110	5 – 25

	Basalt		
3	Highly Weathered and decomposed Basalt	10–120	5 – 20
4	Fractured and Jointed Massive Basalt	15–190	8-10

The yield of borewells shows wide variations and it varies from traces to 15 lps as seen from CGWB exploration data. The borewells drilled by State ground water department/agency also indicate wide variation in yield from 500 liter per hour (lph) to more than 15000 lph. However the success rate of borewells in the district is around 70% only.

4.5 Ground Water Resources

Central Ground Water Board and Ground Water Survey and Development Agency (GSDA) have jointly estimated the ground water resources of Satara district based on GEC–97 methodology and the same are presented in Table–6. Ground water resources estimation was carried out for 8744.66 sq. km. area out of which 736.32 sq. km. area is under command and 8008.33 sq. km. area is under non–command. Taluka wise ground water resources are shown in **Figure-6.**

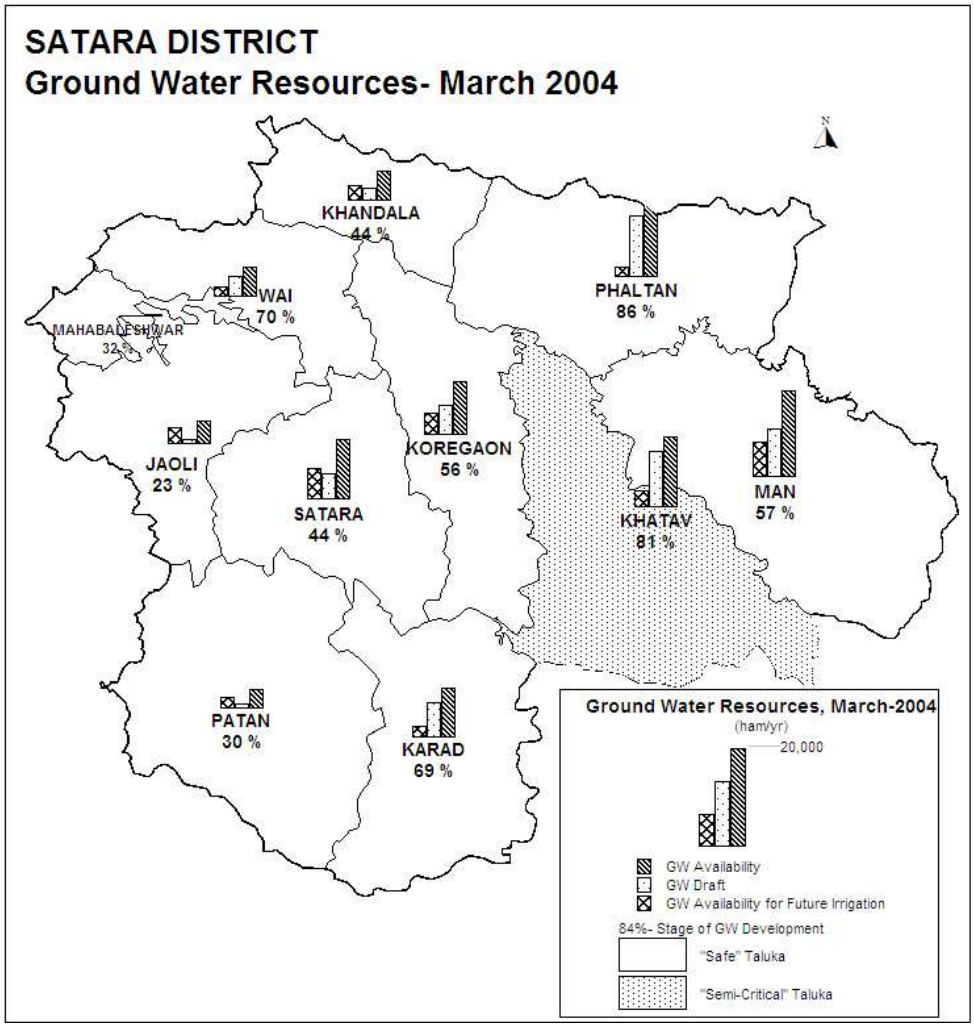

Figure-6: Ground Water Resources (March 2004)

Table-6: 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.)	Groundwater availability for future irrigation (ham/yr.)	Stage of groundwater development (%)	Category
			Irrigation	Domestic & industrial uses	Total				
Koregaon	C	4286.53	2929.58	202.41	3132.00	297.20	1059.75	73.07	Safe
	NC	8313.00	3708.08	251.09	3959.17	502.17	4102.74	47.63	
	Total	12599.52	6637.67	453.50	7091.17	799.37	5162.49	56.28	
Karad	C	1582.55	1093.36	71.21	1164.57	142.42	346.76	73.59	Safe
	NC	10236.01	6393.65	658.15	7051.80	1284.99	2628.37	68.89	
	Total	11818.56	7487.01	729.36	8216.37	1427.41	2975.13	69.52	
Patan	NC	4636.25	994.38	379.61	1373.98	758.95	2882.93	29.64	Safe
Satara	C	6025.50	2862.88	481.46	3344.34	962.92	2199.71	55.50	Safe
	NC	8249.89	2553.22	336.27	2889.49	669.20	5027.48	35.02	
	Total	14275.40	5416.09	817.73	6233.83	1632.12	7227.19	43.67	
Jaoli	C	151.27	82.38	15.92	98.30	31.84	37.04	64.99	Safe
	NC	5265.37	926.62	241.88	1168.50	329.33	4009.42	22.19	
	Total	5416.64	1009.00	257.80	1266.80	361.17	4046.46	23.39	
Phaltan	C	7015.53	6470.79	309.83	6780.61	417.20	800.23	96.65	Safe
	NC	9923.07	7404.52	367.00	7771.52	598.38	1920.16	78.32	
	Total	16938.60	13875.31	676.82	14552.13	1015.58	2720.39	85.91	
Man	C	243.44	260.81	23.24	284.04	0.00	0.00	116.68	Safe
	NC	19897.87	10858.13	401.52	11259.64	801.54	8238.20	56.59	
	Total	20141.31	11118.93	424.75	11543.68	801.54	8238.20	57.31	
Khatav	C	1051.84	2090.81	137.90	2228.71	0.00	0.00	211.89	Semi-Critical
	NC	15472.95	10534.86	557.07	11091.94	1108.30	3829.79	71.69	
	Total	16524.79	12625.68	694.97	13320.65	1108.30	3829.79	80.61	

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.)	Groundwater availability for future irrigation (ham/yr.)	Stage of groundwater development (%)	Category
			Irrigation	Domestic & industrial uses	Total				
Khandala	C	903.60	189.33	17.44	206.77	34.88	679.39	22.88	Safe
	NC	6005.55	2613.49	193.20	2806.69	386.40	3005.65	46.74	
	Total	6909.14	2802.82	210.64	3013.46	421.28	3685.04	43.62	
Mahabalesh-war	NC	427.58	109.12	25.80	134.92	51.60	266.86	31.55	Safe
Wai	C	2934.28	2912.17	221.09	3133.27	223.55	208.71	106.78	Safe
	NC	4126.03	1577.67	210.47	1788.14	420.95	2127.42	43.34	
	Total	7060.32	4489.84	431.57	4921.41	644.50	2336.13	69.71	
District Total	**C**	**24194.54**	**18892.11**	**1480.50**	**20372.61**	**2110.01**	**5331.59**	**84.20**	
	NC	**92553.57**	**47673.73**	**3622.06**	**51295.79**	**6911.81**	**38039.02**	**55.42**	
	Total	**116748.11**	**66565.84**	**5102.56**	**71668.40**	**9021.82**	**43370.61**	**61.39**	

(Here, C- Command, NC- Non-Command)

As per estimation total annual recharge is 1230.12 MCM and the natural discharge is 62.64 MCM, thus the net annual ground water availability comes to be 1167.48 MCM. The annual draft for all uses is estimated at 716.68 MCM with irrigation sector being the major consumer having a draft of 665.65 MCM while the draft for domestic and industrial uses was estimated at 51.02 MCM. The net annual ground water availability for future irrigation is 433.70 MCM, whereas the allocation for domestic and industrial requirements is 93.48 MCM. The stage of ground water development in the district varies from 23.39% (Jaoli taluka) to 80.61% (Khatav taluka). The overall stage of ground water development for the district is 61.39%. Out of 11 talukas, only one taluka viz., Khatav taluka have been categorized as “Semi-Critical”, whereas remaining 10 talukas are fall under “Safe” category.

The watershed wise ground water resource estimation was also done for all the 50 watersheds in the district. Out of 50 watersheds, 7 watersheds viz., BM-87, BM-101, KR–6, KR–11, KR–22, KR–23 and KR–42 have been categorized as “Semi-Critical, 3 watersheds viz., KR-10, KR–32 and BM–85 have been categorized as “Critical” and 1 watershed i.e., KR–2 has been categorized as “Over-Exploited”. In these 11 watersheds and Khatav taluka future ground water development is not recommended without adhering to the precautionary measures i.e., artificial recharge to augment the ground water resources and adoption of ground water management practices. The remaining 39 watersheds falling under “Safe” category are recommended for future ground water development.

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 29 NHNS.

The results of chemical analysis shows that the ground water in the district is alkaline in nature, while EC and TDS values shows that the ground water in the district is mineralized to medium extent. The concentration of major ions indicates that among the cations, the concentration of calcium ion is highest followed by magnesium and sodium, while among the anions the concentration of bicarbonate ion is highest, followed by chloride, sulphate and nitrate ions.

4.6.1 Suitability of Ground Water for Drinking Purpose.

The suitability of ground water for drinking purpose is to be determined keeping in view the effects of various constituents present in the 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 for drinking purpose in the district and same is presented in Table–7.

Table–7: Suitability of Ground Water Samples for Drinking based on BIS Standards (IS–10500–91, Revised 2003).

Parameters (mg/L)	Desirable Limit (mg/L)	Maximum Permissible Limit (mg/L)	No of samples falling in		
			Less than Desirable Limit	Desirable to Maximum Permissible Limit	More than Maximum Permissible Limit
TDS	500	2000	24	4	1
TH	300	600	23	5	1
Ca	75	200	24	5	Nil
Mg	30	100	18	10	1
Cl	250	1000	27	1	1
SO_4	200	400	28	Nil	1
NO_3	45	No relaxation	28	Nil	1
F	1.0	1.5	28	1	Nil

The perusal of Table-7 shows that concentration of 5 parameters has exceeded its maximum permissible limit at only one station i.e., Nimbore (Phaltan Taluka), whereas 1 parameter i.e., nitrate is found beyond permissible limit at Bhade. Overall the potability of ground water in the district is good except at above mentioned two places.

4.6.2 Suitability of Ground Water for irrigation purpose

The water used for irrigation is an important factor in productivity of crops, its yield and quality of irrigated crops. The quality of irrigation water primarily depends on the presence of dissolved salts and their concentrations. Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are one of the most important quality criteria for deciding the suitability of water for irrigation purpose.

4.6.2.1 Sodium Absorption Ratio (SAR)

Sodium Absorption Ratio (SAR) 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 in to cation exchange section in the soil. The high concentration of sodium reduces the soil permeability. Sodium also contributes directly to the total salinity of water and also toxic to the sensitive crops like fruits trees etc. The classification of ground water based on SAR is given in Table–8.

Table–8: Classification of Ground Water for Irrigation based on SAR.

SAR (%)	Category	No. of Samples
< 10	Good	29
10 – 18	Good to permissible	Nil
18 – 26	Doubtful	Nil
>26	Unsuitable	Nil

The perusal of Table–8 indicates that the ground water of the district is good for irrigation use and there is no salinity and sodium hazard to the crops grown in the district.

4.6.2.2 Residual Sodium Carbonate (RSC)

RSC is considered to be superior classification than SAR as a measure of sodicity particularly at low salinity levels. The classification of ground water based on RSC values to decide its suitability for irrigation purpose is given in Table–9.

Table–9: Classification of Ground Water for Irrigation based on RSC.

RSC	Category	No. of Samples
< 1.25	Good	28
1.25 to 2.50	Doubtful	Nil
> 2.50	Unsuitable	1

The perusal of Table – 9 indicates the ground water of the district is good for irrigation except at one place i.e., Bhade, where RSC value falls under unsuitable category. Hence care should be taken before using this water for irrigation to sensitive crops.

4.7 Status of Ground Water Development

The ground water in the district predominantly used for irrigation, as it is the major source for irrigation. The minor irrigation census data (2000–01) indicates that the area irrigated by ground water in the district is 750.80 sq. km. whereas surface water sources accounts for only 446.75 sq. km. area and net irrigated area is 1197.55 sq. km. in the district. There are 75482 irrigation dugwells in the district creating irrigation potential of 1810.19 sq. km. out of which 1537.77 sq. km. of irrigation potential is utilized, whereas 2095 borewells create an irrigation potential of 45.81 sq. km. out of which 32.96 sq. km. of irrigation potential is utilized.

In addition to these till March 2007, State Govt. agencies have drilled 8921 borewell for rural water supply out of which 675 are fitted with electric pump and rest are fitted with hand pumps.

5.0 Ground Water Development and Management Strategy

Ground water has special significance for agricultural development in the State of Maharashtra. The ground water development in some parts of the State has reached a critical stage resulting in decline of ground water levels. Thus, there is a need to adopt an integrated approach of ground water development coupled with ground water augmentation to provide sustainability to ground water resources.

5.1 Ground Water Development

Almost entire district is underlain by Deccan Trap Basalt. Also the isolated and small parts adjoining the hilly areas have low ground water development potential. Such areas occur in almost entire Mahabaleshwar taluka and parts of Madha, Patan, Wai and Man talukas. The major part of the district is occupied by areas with medium ground water development potential. Such areas are observed in northern and eastern part of the district comprising parts of Patan, Jaoli, Man and Khandala talukas. In central part of the district occupying parts of Wai, Khatav, Phaltan, Satara and Karad talukas ground water development potential is high. In the hard rock areas, the ground water development can be done through dugwells, dug-cum-borewells (DCB) and borewells. However the dugwells are the most feasible structures for ground water development. The borewells generally tap deeper aquifer therefore site selection for construction of borewells needs proper scientific investigations. The yield of dugwells in the district is expected from 10 to 190 m^3 / day depending upon local hydrogeological conditions.

The taluka wise nature and yield potential of the aquifer occurring in the district is presented in Table–10. A perusal of Table-10 shows that the 4 talukas i.e., Koregaon, Karad, Man and Wai talukas have medium to high yield potential

and the suitable abstraction structures are dugwell and DCB and borewells. It also shows that 2 talukas i.e., Phaltan and Khatav are having high potential, however in Khatav taluka, which has been categorised as “Semi-Critical”, future ground water development is not recommended without adhering the precautionary measures, i.e., artificial recharge to augment the ground water resources and adoption of ground water management practices, so that the sustainable development is achieved.

Table–10: Nature and Yield Potential of Aquifer.

S. No.	Taluka	Main Aquifer	Yield Potential	Type of wells suitable
1.	Koregaon	Basalt	Medium to High	Dugwells, DCB and borewells
2.	Karad	Basalt	Medium to High	Dugwells, DCB and borewells
3.	Patan	Basalt	Low	Dugwells and DCB
4.	Satara	Basalt	Low to Medium	Dugwells and DCB
5.	Jaoli	Basalt	Low to Medium	Dugwells, DCB and borewells
6.	Phaltan	Basalt	High	Dugwells, DCB and borewells
7.	Man	Basalt	Medium to High	Dugwells and borewells
8.	Khatav	Basalt	High	Dugwells, DCB and borewells
9.	Khandala	Basalt	Low to Medium	Dugwells and DCB
10.	Wai	Basalt	Medium to High	Dugwells, DCB and borewells
11.	Mahabaleshwar	Basalt	Low	Dugwells and DCB

5.2 Water Conservation and Artificial Recharge

The overall stage of ground water development in the district is 61.39% hence it is necessary to adopt water conservation and artificial recharge techniques to increase sustenance of this precious resources. A large numbers of water conservation structures in the form of percolation tanks, under ground bandharas (UGB), diversion dams, village tanks and KT weirs have been constructed in the district. Apart from these, Social Forestry and Agriculture departments, Govt. of Maharashtra have taken up many schemes with an aim to conserve monsoon runoff to conserve water and soil in the district. In this scheme the Govt of Maharashtra has constructed 1567 loose boulder structures, 345 stone check dams, gully plugging (2728 m^3), 1 farm pond, 34 earthen nala bunds, 4 cement nala bunds, 20 roof top rain water harvesting structures and 106798 rmt. farm bunding and 417223 rmt. of CCT. The Social Forestry department has also done of aforestation in 65 ha and constructed 150 other farms bunds.

In Basaltic 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 favorable in hilly areas, particularly in almost entire Mulsi, Velhe, Bhor and parts of Khed and Junnar talukas. Existing dugwells can also be used for artificial recharge, however, the source water should be properly filtered before being put in the wells. The most feasible artificial recharge structure suitable for Alluvial areas restricted along the banks of major rivers and their

tributaries, are shallow recharge wells on the river bed of the tributaries. Percolation tanks are also suitable, wherever source water availability is there.

The sites for artificial recharge structures need to be located where the hydrogeological conditions are favorable, i.e., where sufficient thickness of de-saturated/unsaturated aquifer exists and water levels are more than 5 m deep.

6.0 Ground Water Related Issues and Problems

Drought area has been observed in major parts of the district in entire eastern, north eastern and south eastern parts comprising almost entire Khandala, Phaltan, Khatav, Mhaswad talukas and parts of Koregaon and Karad talukas. Deeper water levels more than 10 m bgl are also seen in northern part around, Mahabaleshwar, Khandala and Wai and in south eastern part of the district in parts of Man and Khatav talukas. These are the areas where the ground water scarcity is quite common when rainfall is deficient. Also Khatav taluka has been categorised as “Semi–Critical” taluka, where stage of ground water development has reached almost 90%. Hence special attention is required in above mentioned areas and immediate steps like ground water augmentation by artificial recharge practices and water conservation should be adopted before further ground water development is planned in these areas.

Apart from this 5474 ha of land has been demarcated as water logged area by Irrigation Department, Govt. of Maharashtra in Nira canal command area of district. In this area, conjunctive use of surface and ground water is recommended to tackle the water logging and to avoid the soil salinity in the area for protection the crops.

7.0 Mass Awareness and Training Activities

7.1 M.A.P. and W.M.T.P.

Till March 2007, MAP and WMTP have not been organised in the district.

8.0 Areas Notified by CGWA/SGWA

As per water resources estimation only one taluka i.e., Khatav has been categorized under “Semi-Critical” category. In case of watersheds, 7 watersheds viz., BM-87, BM-101, KR–6, KR–11, KR–22, KR–23 and KR–42 have been categorized as “Semi-Critical, 3 watersheds viz., KR-10, KR–32 and BM–85 have been categorized as “Critical” and 1 watershed i.e., KR–2 has been categorized as “Over-Exploited”. But so far no watershed/taluka has been notified by either Central or State Ground Water Authority for ground water regulation in the district.

9.0 Recommendations

Based on the hydrogeological study following recommendations are given to achieve the development in planned and scientific manner.

1 The entire district is underlain by the Deccan Trap Basalt where only dugwells are most feasible structures for ground water development. In order to delineate and pinpoint favourable borewell site, micro level survey along with geophysical survey should be carried out. Wherever possible borewell site should be located in close vicinity of lineament.

2 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.

3 In Khatav taluka categorised as “Semi-Critical” future ground water development is not recommended without adhering the precautionary measures i.e., artificial recharge to augment the ground water resources and adoption of ground water management practices.

4 It is also suggested that future ground water development in "Semi-Critical" and "Critical" watersheds may be carried out after detailed ground water studies. In KR-2 watershed (“Over-Exploited”) future ground water development may be stopped for purposes other than drinking. In the remaining watersheds there is sufficient scope for ground water development by constructing dugwells down to the depth of 20 m bgl so as to tap the weathered, vesicular/fractured and jointed basalt with diameter of 3.0 to 6.0 m to allow the maximum water storage and larger seepage area.

5 The western part of the district has prominent hill ranges, isolated hillocks and undulations etc., which allows for the higher surface run off. Also, the underlying basalt formation has poor storage and transmission capabilities rendering these aquifers to be of the limited potential. These aquifers get fully recharged instantaneously and a situation of rejected recharge emerges. Also, the aquifer gets drained off quickly due to sloping and undulating topography. Feasibility of artificial recharge is limited in such areas as the postmonsoon water levels are less than 3.0 m bgl. Hence small schemes of water conservation are proved to be quite useful for harvesting the surface run off and thereby maintaining the supply during lean period. Storage tanks on hill tops, nala bunds, check dam/stop dam etc., should be constructed after studying the feasibility, UGB are also feasible to conserve the base flow.

6 Scope exists for construction of suitable artificial recharge structure in central and eastern parts of the district. The percolation tanks, cement nala bunds. KT weirs, earthen nala bunds etc., are suggested in basaltic area at suitable sites. Apart from this the dugwell recharge technique must be promoted in the district to enhance the sustainabity. However, the water used for recharging should be free from silt and other pollutants hence provision of filter should be made near the recharge well.

7 In the water logged areas occurring in the command area of Nira right bank canal large scale pumping should be adopted in dugwells to control rising of water levels in command area. Conjunctive use of surface and ground water is recommended to tackle the water logging and to avoid the soil salinity in the area for protection the crops. Also construction of ditches, drains along and across the ephemeral streams should be taken up and the drains should be de-silted, de-weeded and routinely maintained and checked so as to allow free flow of excessive irrigation water.

8 To enhance the ground water resources and for sustainable development, 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 and declining trend of water levels in the district. Similarly farmer should also be encouraged to adopt appropriate crop planning and irrigation practices.