1798/DBR/2013

भारत सरकार

जल संसाधन मंत्रालय

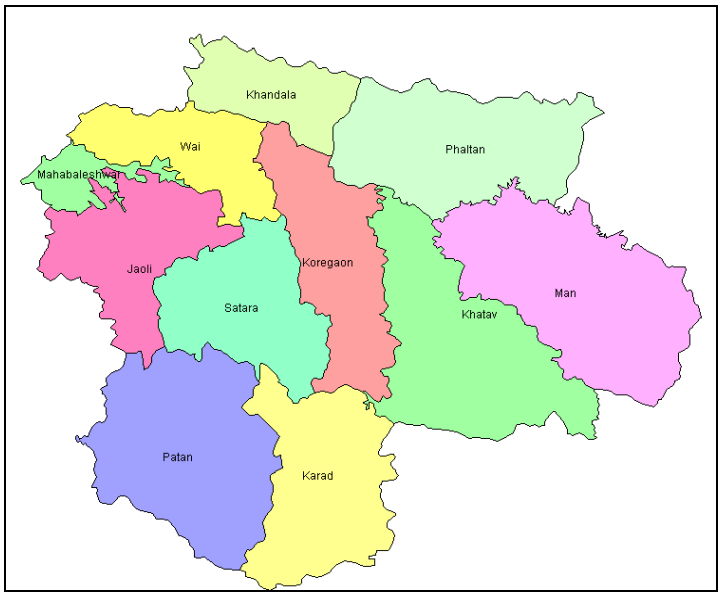
केंद्रीय भूजल बोर्ड

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र राज्य के अंतर्गत सातारा जिले की

भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
SATARA DISTRICT
MAHARASHTRA



By

Abhay Nivasarkar
Scientist-B

द्वारा

अभय निवसरकर
वैज्ञानिक - ख

मध्य क्षेत्र, नागपुर
CENTRAL REGION, NAGPUR
2013

SATARA DISTRICT AT A GLANCE

1. LOCATION

North latitude	**:**	**17°05' to 18°11'**
East longitude	**:**	**73°33' to 74°54'**
Normal Rainfall	:	473 -6209 mm

2. GENERAL FEATURES

Geographical area	:	10480 sq.km.
Administrative division		: Talukas – 11 ; Satara , Mahabeleshwar
(As on 31.3.2013)		Wai, Khandala, Phaltan, Man,Jatav, Koregaon Jaoli, , Patan, Karad.
Towns	:	10
Villages	:	1721
Watersheds	:	52

3. POPULATION (2001, 2010 Census)	:	28.09,000., 3003922
Male	:	14.08,000, 1512524
Female	:	14.01,000, 1491398
Population growth (1991-2001)	:	14.59, 6.94 %
Population density	:	268 , 287 souls/sq.km.
Literacy	:	78.22 %
Sex ratio	:	995 (2010 Census)
Normal annual rainfall	:	473 mm 6209 mm (2001-2010)

4 GEOMORPHOLOGY

Major Geomorphic Unit	:	Western Ghat, Foothill zone , Central , Plateau and eastern plains
:		
Major Drainage	:	Krishna, Nira, Man

5 LAND USE (2010)

Forest area	:	1346 sq km
Net Sown area	:	6960 sq km
Cultivable area	:	7990 sq km

6 SOIL TYPE	**:**	2 Medium black, Deep black

7 PRINCIPAL CROPS

Jawar	:	2101 sq km
Bajara	:	899 sq km
Cereals	:	942 sq km
Oil seeds	:	886 sq km
Sugarcane	:	470 sq km

8 GROUND WATERMONITORING

Dugwell	:	**46**
Piezometer	**:**	**06**

9 GEOLOGY

Recent	:	Alluvium

Upper-Cretaceous to Eocene	:	Deccan Trap (Basalt)

10 HYDROGEOLOGY

Water Bearing Formation	:	Basalt- Weathered /Fractured / Jointed/ Vesicular/ massive/ under Phreatic and semi confined condition

11 WATER LEVEL

Premonsoon Depth to water level May 2011	0.09	to	16.2 mbgl
Post Monsoon Depth to water (Nov 2011)	0.02	to	13.65 mbgl

Water Level Trend

Pre -monsoon Water Level Trend (2001-2010)			
Rise	0.019	to	0.972 m/year
Fall	0.003	to	0.627 m/year
Post Monsoon Water level trend (2001-2010)			
Rise	0.006	to	0.887m/year
Fall	Neglible	to	0.323 m/year

Annual Trend (2001-2010)

Rise	0.009	to	0.790 m/year
Fall	0.031	to	0.245 m/year

12 GROUND WATER EXPLORATION AS ON 31.3.2013

Wells	EW 19, OW 09
Depth Range	67 to 301 m
Discharge	Trace to 15 lps

13 GROUND WATER QUALITY

Ground Water is Suitable for Drinking and irrigation purpose

14 DYNAMIC GROUND WATER RESOURCES : (As on 31/3/2009)

Net Annual Ground Water Availability	105584.1 HAM
Existing Gross Ground Water Draft for irrigation	68650.12 HAM
Existing Gross Ground Water Draft for domestic and industrial water supply	4743.316 HAM
Existing Gross Ground Water Draft for All uses (11+12)	73393.43 HAM
Provision for domestic and industrial requirement supply to 2025	9396.149 HAM
Net Ground Water Availability for future irrigation development (10-11-14)	27582.26 HAM
Stage of Ground Water Development	69.51%
Over Exploited taluka	: None
Critical taluka	: None
Semi-Critical taluka	: None

15 RURAL WATER SUPPLY (March 2005)

Total Villages	: 1721
Piped water supply schemes	: 3354

Dugwells	: 1336
Hand pumps/ Borewells	: 8969

Ground Water Information
Satara District
Contents

List of Figures

List of Tables

GROUND WATER INFORMATION

DISTRICT SATARA

1.0 Introduction

Satara district is one of the oldest districts and located in western part of Maharashtra State. In 1960 Northern Satara district was named as Satara and Southern Satara district named as Sangli district. It is bounded by Pune district in the north, Solapur district in the east, Sangli district in the south and Ratnagiri district in the west. Raigad district lies to its north-west. Satara district is located in the western part of Deccan plateau and lies between 17°05' and 18°11' north latitudes and 73°33' and 74°54' east longitudes. The entire area of the district falls in parts of Survey of India degree sheet No's 47-G, 47-K, 47-J and 47-F. The district has an area of 10480 sq.km, which constitutes about 3% of the total area of Maharashtra. Prior to 1971, district had 9 talukas but presently there are 11 talukas. These talukas consist of 1721 villages including 20 unhabited villages besides 10 towns.

The total population of Satara district as per 2001 census is 28.09,000, out of which rural population is 2398765 (85%). Schedule Caste and Schedule Tribe population is 233014 and 18342 respectively. The male population is 14.08,000, and female population is 14.01,000 whereas the population density is 268 souls/sq.km. The increase in population is 14.590% over the period of 10 years from 1991 to 2001

Satara is one of the famous districts for tourist destination. Mahabaleshwar and Panchghani are the two hill stations which have great tourism attraction and Pratapgarh have quite a historical importance. Shingarpur, Sajjangarh, Pusgaon, Godavale, Buchafal are the religious places of great importance. A figure showing taluka boundaries is shown in figure 1.

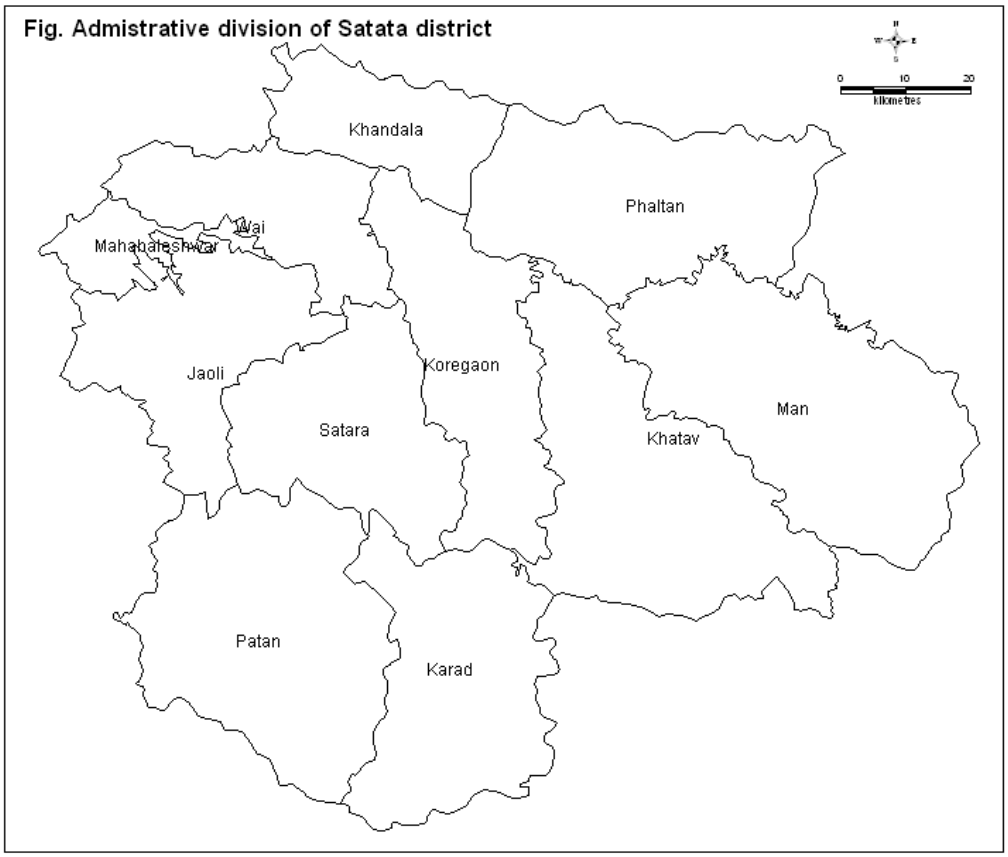


Figure 1: Administrative Set up of Satara District

The following studies have been taken up by Central Ground Water Board in the district. A list of studies conducted in the district is presented in the Table 1.

Table 1: Studies Carried out by CGWB in the District

Sl no	Officer	AAP	Type of Survey / Study
1	Shri J P Das	1975-76	Systematic Hydrogeological survey in parts of Satara District
2	Dr D K Chadha	1976-77	Systematic Hydrogeological survey in parts of Satara District
3	Shri A R Bhaisare	1977-78 1978-79 1979-80	Systematic Hydrogeological survey in parts of Satara District
4	Shri Das and Shri S Sudarshan	1979-1981	Systematic Hydrogeological survey in parts of Satara District
5	Shri S Sudarshan	1980-81	Systematic Hydrogeological survey in parts of Satara District
6	Shri P K Naik	1988-89	Systematic Hydrogeological survey in parts of Satara District
7	Shri R P Singh	1989-90	Systematic Hydrogeological survey in parts of

			Satara District
8	Shri D K Rai	1989-90	Systematic Hydrogeological survey in parts of Satara District
9	Shri A Sudarsha	1991-92	ReappraisaHydrogeological survey in parts of Satara District
10	Dr P K Naik	1991-92 1992-93	Reappraisal Hydrogeological survey in parts of Satara District
11	S/Shri K.P. Dongre and A. Nivasarkar	2011-12	Ground Water Management Studies in of Man Basin.

In addition to above studies a report on ground water resource 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 58 exploration wells (EW) and 25 observation wells (OW) and 3 Piezometers (PZ) have been drilled so far. The main objective of ground water Exploration is to decipher the sub surface geology of the district to identify various water bearing horizons, their depth range, yield and their extent, to compute their hydraulic characteristic and also to evacuate chemical quality of ground water to establish their suitability for various uses. The Taluka wise salient features of ground water exploration are giver in table-2.

Table 2: Ground water Exploration Data (2012)

S. No.	Taluka	Wells Drilled	Drilled Depth (m bgl)	Zones (m bgl)	Discharge (lps)	SWL (m bgl)
1.	Javali	Ew-3	200.00	16.00 to 181.00	0.14 to 2.16	5.00 to 12.00
2.	Karad	EW-5 OW-1	95.00 to 200.00	7.40 to 95.80	1.37 to 5.77	6.25 to 50.00
3.	Khandala	EW-6 OW-4 Pz-1	40.00 to 200.00	10.00 to 79.00	0.38 to 10.00	3.20 to 7.95
4.	Khatav	EW-7 OW-3	67.40 to 301.00	6.00 to 152.00	0.14 to 5.00	2.02 to 8.28
5.	Koregaon	EW-5 OW-3	122.25 to 200.00	4.25 to 134.55	0.14 to 12.18	1.40 to 17.50
6.	Man	EW-9 OW-5	135.50 to 201.60	16.20 to 150.00	0.71 to 10.00	1.00 to 64.50
7.	Patan	EW-5 OW-2	80.60 to 200.00	22.60 to 186.30	Traces to 3.00	1.47 to 74.50
8.	Phaltan	EW-7 OW-3	7.70 to 201.00	28.00 to 96.80	0.14 to 0.72	3.17 to 17.25

		Pz-1				
9.	Satara	EW-6 OW-2 Pz-1	177.10 to 201.5.50	35.00 to 36.00 152.00 to 153.00	2.16 to 5.15	1.40 to 18.20
10.	Wai	EW-5 OW-1 Pz-1	5.70 to 200.00	12.00 to 16.00	Traces to 3.00	1.60 to 17.29
11.	**Total**	**EW-58 OW-25 PZ-3**	**5.70 to 301.00**	**4.25 to 186.30**	**Traces to 10.00**	**1.00 to 64.50**

The perusal of Table-2 shows that the depth of 58 EW and 25 OW and 3 Pz drilled in hard rock area (Deccan trap basalt) of the district varies from 5.70 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 been drawn from deeper aquifer in case of scarcity for drinking water supply. The discharge of the wells drilled in the district varies between traces to10.00 liters per second (lps).

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 14.4^0 C and mean maximum temperature is 36.8 C at Satara town in the district.

The rainfall analysis for the period 1901-2005 revels that the normal annual rainfall over the district varies from 473 to about 6209 mm. In the eastern part of the district around Mhasawad (Man taluka) and Phaltan taluka it is minimum and increases toward the west and reaches maximum around Mahabaleshwar. However, probability of occurrence of normal rainfall is maximum (50 to 55%) in the south eastern part 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 north eastern

and south western part of district comprising almost entire khandala, phaltan, khatav, mhaswad talukas and part of Koregaon and Karad talukas which experienced drought for more than 20% of the years can be categorized as “drought area”. The average rainfall data for the period (1998-2010) are represented in table-3.

The perusal of table-3 indicated that the average annual rainfall during the period ranges between 550.5 mm (Man) to 5830.3 mm (Mahabaleshwar).

Table 3: Annual Rainfall Data for 2001-2010 **(in mm)**

Station	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
Javali	1092.5	1320.1	1191.9	1103.6	3679.2	2760.0	1679.1	1505.5	1438.9	1529.8	1730.1
Karad	654.9	467.2	419.4	777.9	1230.8	1070.3	1025.1	807.5	730.0	875.1	805.8
Khandala	349.7	NA	NA	760.4	735.6	685.9	685.9	426.6	560.3	638.5	605.4
Khatan	518.6	398.8	NA	951.5	684.2	602	593.3	390.4	854.7	839.6	648.1
Koregaon	519.8	586.2	393.6	987.6	1435.5	1345.8	895.2	537.6	846.8	912.4	846.1
Mahabaleshwar	4500.8	5094.3	4441	6506.9	8824.3	8669.2	6265	5584.01	4193.8	4223.3	5830.3
Man	357.6	353.0	NA	534.2	572.8	558.6	595.2	416.5	797	769.5	550.5
Patan	1203.4	1244.7	987.7	1612.8	3250.9	2851.6	2221	1200	1154.7	1522.8	1724.9
Phaltan	478.4	344.3	NA	764.5	471.8	698.2	725	332.7	864.4	1034.4	634.9
Satara	1031.6	341.6	586.7	1092.7	1849.8	1676.1	1232	723.1	936.5	1013.7	1048.4
Wai	678.0	561.6	541.2	1129.7	1574.30	1510.8	1033	795.0	895.6	1032.2	975.2

3.0 Geomorphology and Soil type

The district forms part of Deccan plateau of Sahayadri hill range. The residual hill ranges and the intermediate valley, all well developed on the table land surface form the main geomorphic element of landscape in the district. In the west, the district has the Sahaydrian scarp with its major peaks usually flat topped and intervening saddles. The Mahadeo range, which is next major well developed range in he district, beings as an off-shoot of the Sahayadri in the north western part. Eastward it runs as a main range and sets several minor ranges south-eastward and southwards. However, physiographically the district can be broadly divided in four major units viz., (i) hills and ghats, (ii) foothills zones, (iii) plateaus and (iv) plains.

The entire satara district falls in he drainage of thee major rivers, Nira, river in the entire northern part, Man river in the south-east and the Kishna river in the south. Krishna river which is one of the major rivers of Southern Peninsula rises on the eastern

brow of the Mahabelshwar plateau in the district and flows for about 176 km. in the district. Kudal, Vena, Urmodi, Tarli, Koyna, Vasna and Verla rivers are the main tributaries of Krishna river. The entire river system has parallel to semi-dendritic drainage pattern and the drainage density is quite high in the district. Based on the geomorphic setting and drainage pattern, the district is divided into 50 watersheds

4.0 Ground water Scenario

4.1 Hydrogeology

The entire district is underlying by Deccan trap basaltic lava flow 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. Hydrogeology of the district is shown in Figure 2.

4.1.1 Hard rock (Deccan Trap Basalt)

Deccan trap occupies about 95% of the area of the district. It occurs as basaltic lava flows which are normally horizontal and deposited over wide stretch and give rise to tabular 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 bole bed. Thickness of weathering varies widely in the district from 5 m to 20 m bgl. The weathered and fractured flows 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 depth of 20 m bgl form phreatic aquifer. The water bearing zones occurring between the depth of 20 m and 40 m are weathered interflow of shear zones and have water under semi-confined condition. Deep confined aquifers occur below the depth of 40m. The vesicular thickness of different lava flows varies from 8 to 10 m and forms the potential aquifer zones. However, the nature and density of vesicles their distribution, interconnection, depth of weathering and topography of the area are decisive factor for occurrence and

movement of ground water in vesicular unit. The massive portion of basaltic lava flows are devoid of water but when it is weathered , fractured ,jointed or contain weaker zones, ground water occur in it.

In winter season the yield of dug wells varies between 10 to 190 m^3/ day where as in summer it varies between 5 to 20 m^3/ day The discharge of aquifer tapping shallow and deeper aquifer ranges from traces to 15 lps as observed from exploration studies.

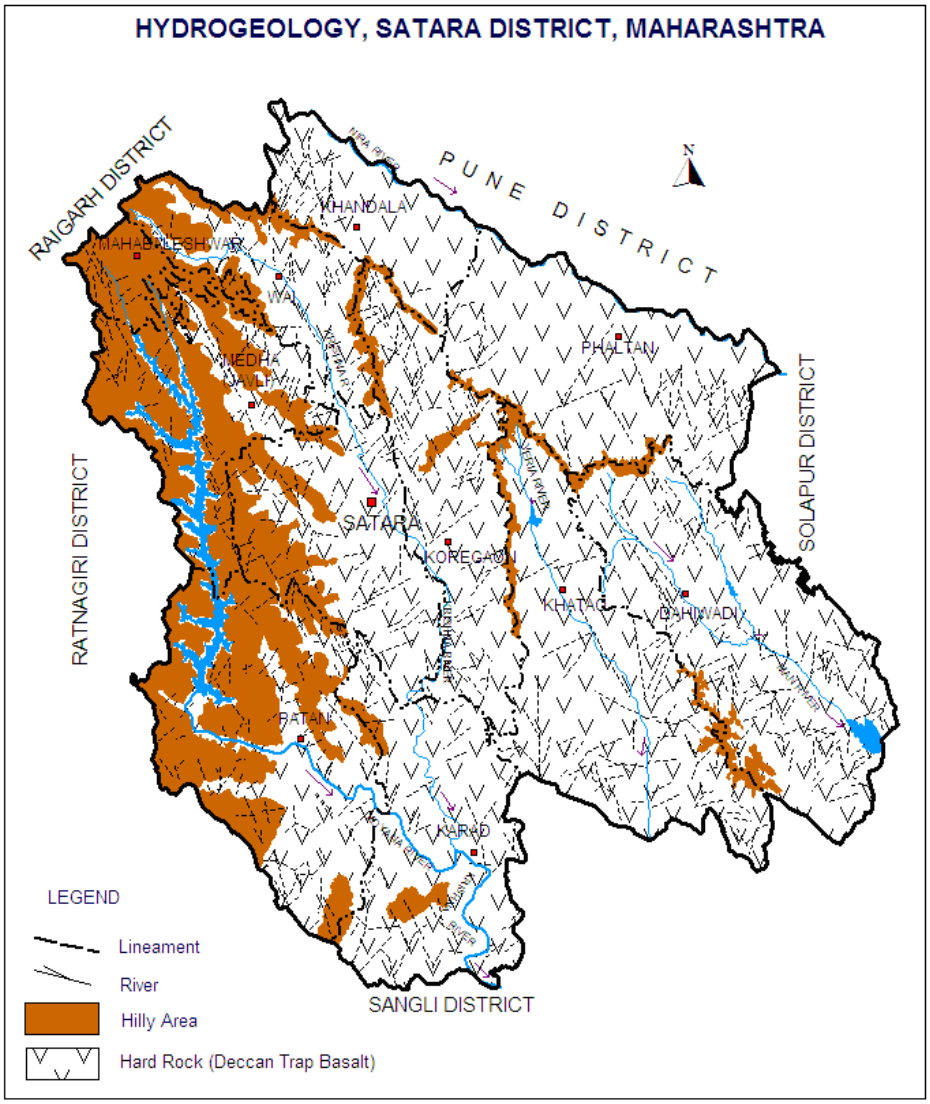


Figure 2: Hydrogeology

4.1.2 Soft Rock (Alluvium)

Alluvium occurs as narrow starches along banks and flood plains of major rivers like Nera, Man, Krishna, Yerla and their tributaries. In the alluvium, the coarse grained

detrital material like sand and gravel usually occurring as lenses form good aquifer, However they have limited aquifer extent. The ground water occurs in phreatic condition in flood plain alluvium deposit near the river banks.

4.2 Water Level Scenario

The Central Ground Water board (CGWB) monitors water level data of 52 National hydrograph Stations (NNHS) in the district. Map showing location of monitoring station is shown in figure 3. The NNHS are monitored four times in a year ie January, May (Premonsoon) August and November (Post monsoon). The Water Level data for 2011 has been given in Table 4.

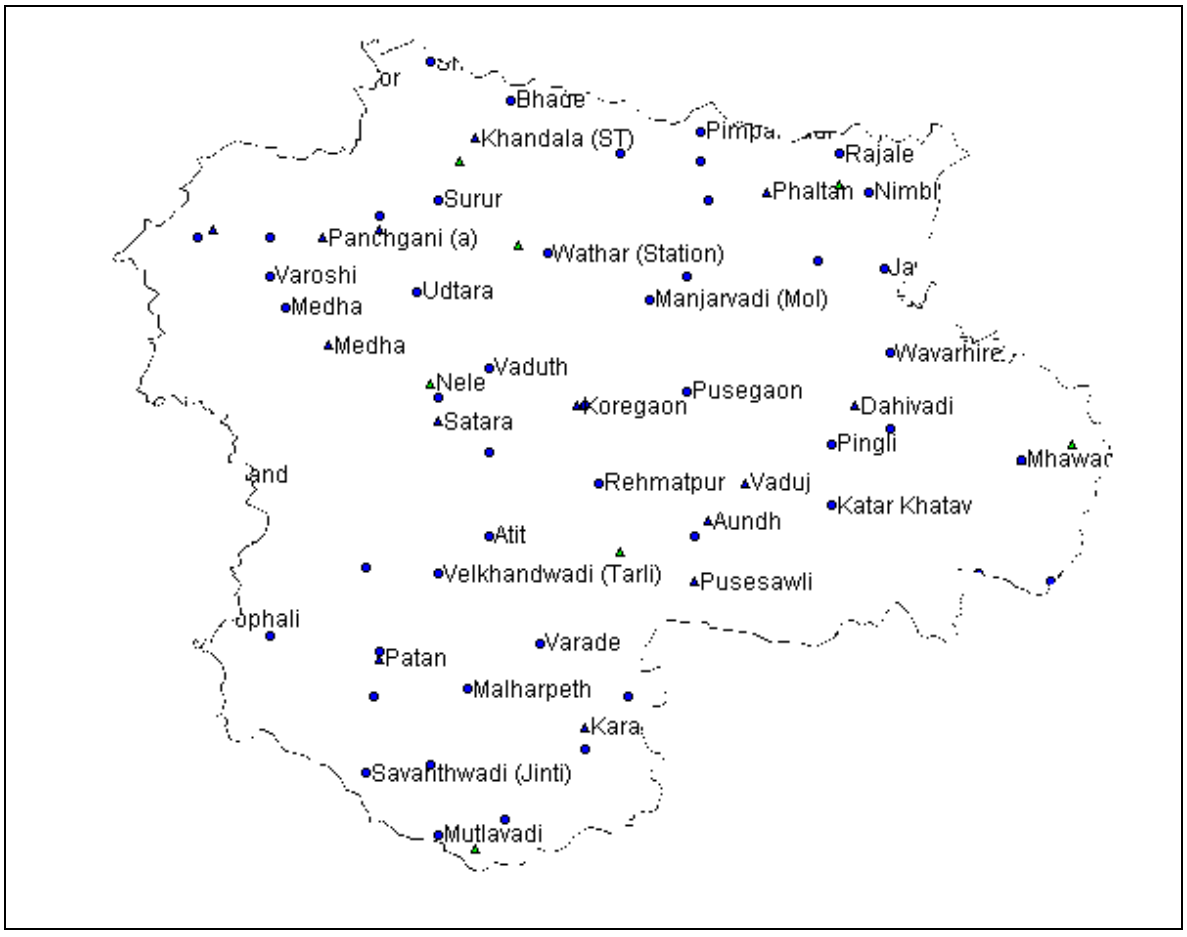


Figure 3: Location of Water Level Monitoring Stations

4.2.1 Depth to Water Level – Pre-monsoon 2011

Depth to water level in Satara district during may 2011 ranges from 0.09 m bgl (Shendri) to 16.2 (Mahabaleshwar) Depth to water level during premonsoon (May 2011) has been

depicted in the figure 4 . The perusal figure 3 indicate that most prominent range of water level is 5-10 m bgl which is seen almost entire district.

The dominant range of water level is followed by shallow water level range within 5 m bgl which occupies south western and south central Part of the district .Apart from this, small in a isolated patch in the north eastern part of the district , near Mamabeleshwar Panchgani, Shirur, Pimpode and Wather and one in eastern part of the district Manand Khatav talukas , where deeper water level more then 10 m m bgl is observed..

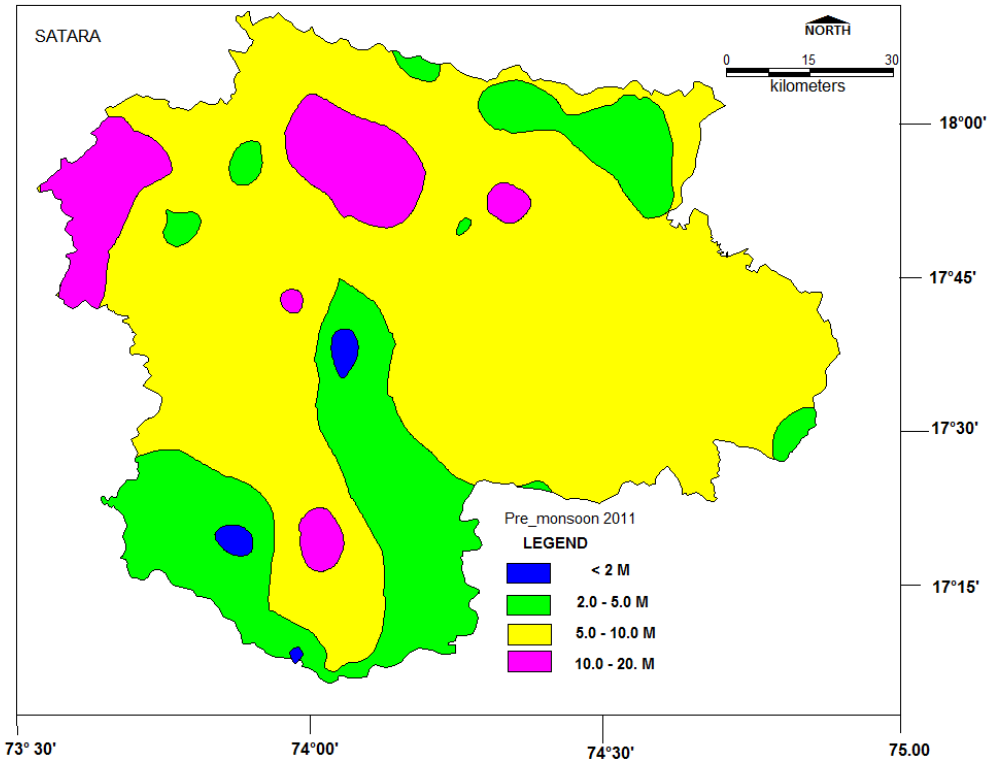


Figure 4: Pre monsoon Depth to water Level

4.2.2 Depth to Water Level – Post-monsoon 2011

Depth to water level in the district during November 2011 ranges between 0.02 (Medha) and 13.65 m mbgl (Mahabeleshwar). The depth to water level in post monsoon 2011 depicted in figure 5 indicate that major part of the district has water level in the range of 5-10m bgl in post monsoon season. While shallowest water level ie less then 2 m seen in 4 or three patches

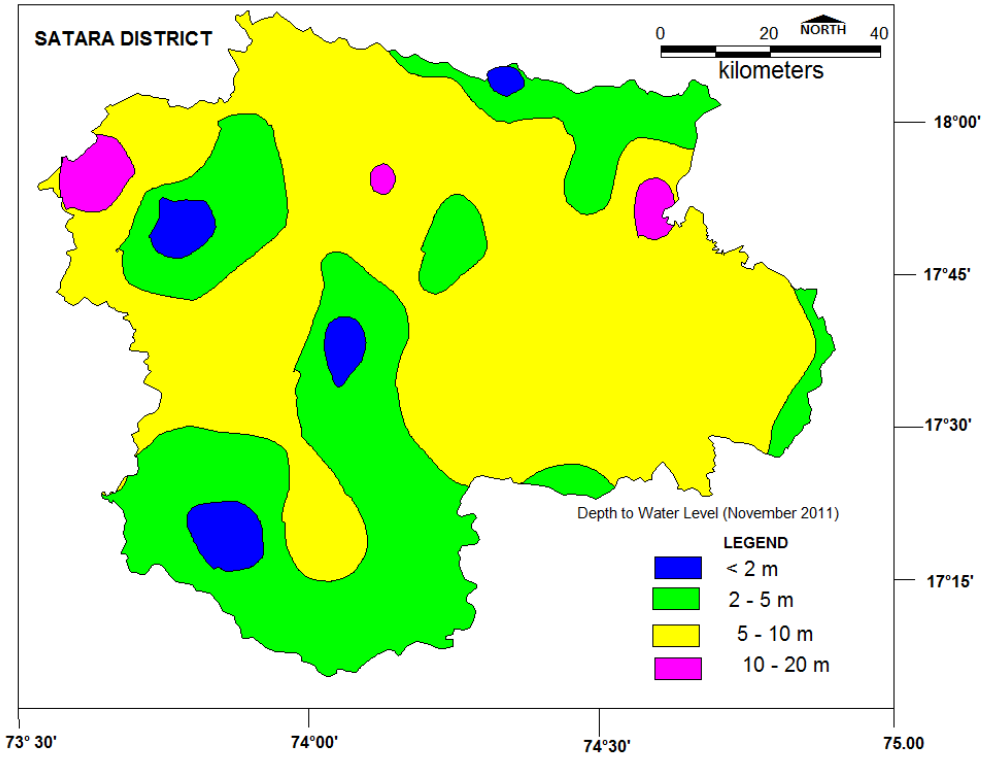


Figure 5: Post monsoon Depth to Water Level

4.2.3 Seasonal Water Level Fluctuation

The Seasonal water level fluctuation ranges between -7.5 (Javali) to 7.05m at Udtara. Well wise data are give in table 4.

Table 4 -Depth to Watet Level in Different Season (Pre and Post –monsoon 2011)

Sl no	HS LOCATION	DTWL (mbgl) May	DTWL (mbgl) Nov	Fluctuation (m)	DISTRICT
1	Atit	2.4	2.35	0.05	Satara
2	Aundh	9.86	9.2	0.66	Satara
3	Bhade	8	7.17	0.83	Satara
4	Dhebevadi	8.19	3.85	4.34	Satara
5	Javali	4.4	11.9	-7.5	Satara
6	Katar Khatav	7.8	5.02	2.78	Satara
7	Kondve	10.51	8	2.51	Satara
8	Koregaon	6.4	5.2	1.2	Satara
9	Mahabaleswar	16.2	13.6	2.6	Satara
10	Malharpeth	12.4	8.84	3.56	Satara
11	Malkapur	3.25	2.7	0.55	Satara
12	Manainagar	3.49	2.4	1.09	Satara
13	Manjarvadi (Mol)	4.55	2.7	1.85	Satara
14	Medha	4.45	0.2	4.25	Satara

15	Mhaswad	6.6	6.25	0.35	Satara
16	Mirgaon	5.7	7.5	-1.8	Satara
17	Mogarle	5.43	3.63	1.8	Satara
18	Morgir (Shivpurpeth)	1.37	0.73	0.64	Satara
19	Nimblak	3.6	4.84	-1.24	Satara
20	Nimblak2	3.85	4.26	-0.41	Satara
21	Nimbore	2.43	3.3	-0.87	Satara
22	Panchagani	10.55	7.7	2.85	Satara
23	Patan	0	0	0	Satara
24	Pingli	9.25	8.5	0.75	Satara
25	Rehmatpur	7.25	6.2	1.05	Satara
26	Shendri	0.9	0.3	0.6	Satara
27	Shenwadi	3.95	4	-0.05	Satara
28	Shirwal	9.45	7.1	2.35	Satara
29	Surur	11.62	6.4	5.22	Satara
30	Taradgaon	6.7	7	-0.3	Satara
31	Tathvade	12	8.1	3.9	Satara
32	Udtara	7.05		7.05	Satara
33	Undale	7.03	2.3	4.73	Satara
34	Vaduth	5	4.07	0.93	Satara
35	Varade	2.15	3.4	-1.25	Satara
36	Varoshi	5.15	1.45	3.7	Satara
37	Velkhandwadi (Tarli)	7.86	5.2	2.66	Satara
38	Wai	3.9	3.1	0.8	Satara
39	Wathar (Station)	13.29	10.55	2.74	Satara
40	Yelegaon	5.25	2.3	2.95	Satara

4.2.4 Pre monsoon Water Level Trend (2001-2010)

Trend analysis of Water Level data for Decade (2001-2010) has been done for pre post monsoon periods and presented in table 5. Trend analysis of pre monsoon and postmonsoon and annual have been described below.

Both rising and falling decadal trends are observed in various parts of the district. It is observed from the figure that rise of water level in the range of 0-2 m/decade has been recorded in major part of the district. Rise in the range of 2-4m/decade is recorded in NW and southern part of the district. >4m/year rise is recorded in isolated patches. 0-

2m/decade falling trend is observed in SE and NE parts.2-4m/decade and more than 4m/decade fall is recorded in northern and NE parts of the district.

Post Monsoon Trend:

Rising as well as falling trends of water levels have been observed during post monsoon period. Rising trend of water level is observed in the range of 0.006 to 0.887 m/year where as falling trend is recorded in the range of negligible to 0.23m/year.

Annual Trend (2001-2010)

Rising as well as falling annual trends of water levels have been observed during 2001-2010 period. Rising trend of water level is observed in the range of 0.009 to 0.790 m/year where as falling trend is recorded in the range of 0.031to 0.245 m/year.

Table 5: Decadal Water Level Trend Data for Period 2001-2010

S. No.	Location	Premonsoon		Postmonsoon		Annual	
		Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year
1	Manure		0.1225	0.0063			0.0309
2	Bhade	0.0952			0.0501		0.0358
3	Medha		0.1163	0.0165			0.0375
4	Varade		0.6269		0.0012		0.0426
5	Savanthwadi (Jinti)	0.283			0.3232		0.0432
6	Kondve		0.1227		0.2628		0.1105
7	Velkhandwadi (Tarli)		0.38		0.2637		0.2448
8	Wai		0.0387		0.0879	0.0099	
9	Manainagar		0.0034	0.0251		0.0318	
10	Shirwal		0.3583	0.2501		0.0329	
11	Atit	0.0399		0.0097		0.034	
12	Mahabaleswar	0.0822			0.1447	0.0376	
13	Shendri	0.0209		0.0817		0.0446	
14	Nimblak2	0.0451		0.1659		0.0564	
15	Morgir (Shivpurpeth)	0.2516			0.0006	0.0923	
16	Manjarvadi (Mol)	0.1655			0.0326	0.1151	
17	Yelegaon	0.2078			0.0687	0.1223	
18	Malharpeth	0.0189		0.1017		0.1596	
19	Vaduth	0.2073		0.0894		0.1597	
20	Patan	0.1606		0.1096		0.185	
21	Nimblak	0.1176		0.3291		0.1868	
22	Dhebevadi	0.2907		0.1414		0.22	
23	Wavarhire			0.3725		0.2259	

S. No.	Location	Premonsoon		Postmonsoon		Annual	
		Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year
24	Javali		0.0402	0.1469		0.2656	
25	Udtara	0.071		0.315		0.2737	
26	Koregaon	0.0822		0.3153		0.2863	
27	Rehmatpur	0.293		0.7146		0.2902	
28	Pusegaon	0.3717		0.1705		0.2998	
29	Mutlavadi	0.9726		0.2783		0.3016	
30	Panchagani	0.1407		0.1919		0.3053	
31	Pimpalwadi	0.2167		0.1952		0.3312	
32	Undale	0.2303		0.3878		0.3432	
33	Shenwadi	0.1463		0.1854		0.3469	
34	Mogarle	0.3576		0.0408		0.3479	
35	Aundh	0.3372		0.463		0.3484	
36	Tathvade	0.3585		0.2166		0.3509	
37	Pingli	0.1908		0.2752		0.4139	
38	Katar Khatav	0.4934		0.2265		0.4142	
39	Nimbore	0.3219		0.4281		0.4468	
40	Surur	0.2773		0.3814		0.4887	
41	Rajale	0.1606		0.4019		0.499	
42	Taradgaon	0.2945		0.3463		0.5902	
43	Mhaswad	0.4508		0.1532		0.5908	
44	Malkapur	0.4097		0.5055		0.5971	
45	Wathar (Station)		0.0866	0.8871		0.7351	
46	Mirgaon	0.714		0.485		0.7906	
47	Oglewadi		0.0862				

4.3 Aquifer Parameter

The aquifer parameters of water table/ phreatic aquifer are available from report of systematic hydrogeological surveys conducted by CGWB. In the 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 450m^2/day. In the addition to these, the yield of borewells drilled by CGWD tapping deeper aquifer ranges from 0.56 to 15.0 lps for drawdown of 4 to 29 m. The hydraulic and well characteristics of basaltic aquifer are presented in table 6.

Table 6: Aquifer Parameters

Sl no	Aquifer	Specific Capacity (lpm/m of drawdown)	Transmissivity (m^2/day)	Specific Yield Range (%)	Average Specific yield (%)
1	Vesicular Basalt	96-169	30-300	0.8-2.8	2.70
2	Vesicular Basalt, Weatheredr Basalt	58-140	40-335	0.4-2.7	1.55
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 Bore wells

The yield of the wells is function of the permeability and transmissivity of aquifer encountered and it varies with location, diameter and depth of the wells etc. There are mainly two types of ground water abstract structures in the district i.e., dugwells, however the yield of wells also varies according to the nature of formation tapped and its saturated thickness. Therefore, the dugwells locate in the topographic lows, morphological depression and on or near the liniments, yield comparatively more than the those located elsewhere, which is particularly true in the basaltic terrain. The yield of dugwells also varies depending on the season. The summer and winter yield of dugwells for different formations encountered in Deccan trap basalt is presented in table-7

Table 7:-: Yield of Dugwells in Deccan Trap Basalt.

Sl.No.	Aquifer	Yield of dugwell (m^3/day)	
		Winter	Summer
1	Vesicular basalt	10-75	5-10
2	Vesicular and weathered basalt	10-110	5-25
3	Highly weathered and decomposed basalt	10-120	5-20
4	Fracture and jointed massive basalt	15-190	8-10

The yield of borewells shows wide variation 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 liters 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 (As on 2009)

CGWB and GSDA, Govt of Maharashtra have estimated ground water resources of Maharashtra state for the year 2008-09 based on GEC-97 Methodology. The details of estimated resources for Satara District are given in Table 6. As per the estimation, Net ground water availability in the district as on 2009 is 105584.1 ham, Draft for irrigation and Drinking purposes are 68650.12 and 4743.316ham respectively. Net Ground water availability for future irrigation is 27582.26. Provision of industrial and domestic water requirement for the 2025 is 9396.149 ham an all talukas are categorised as Safe.

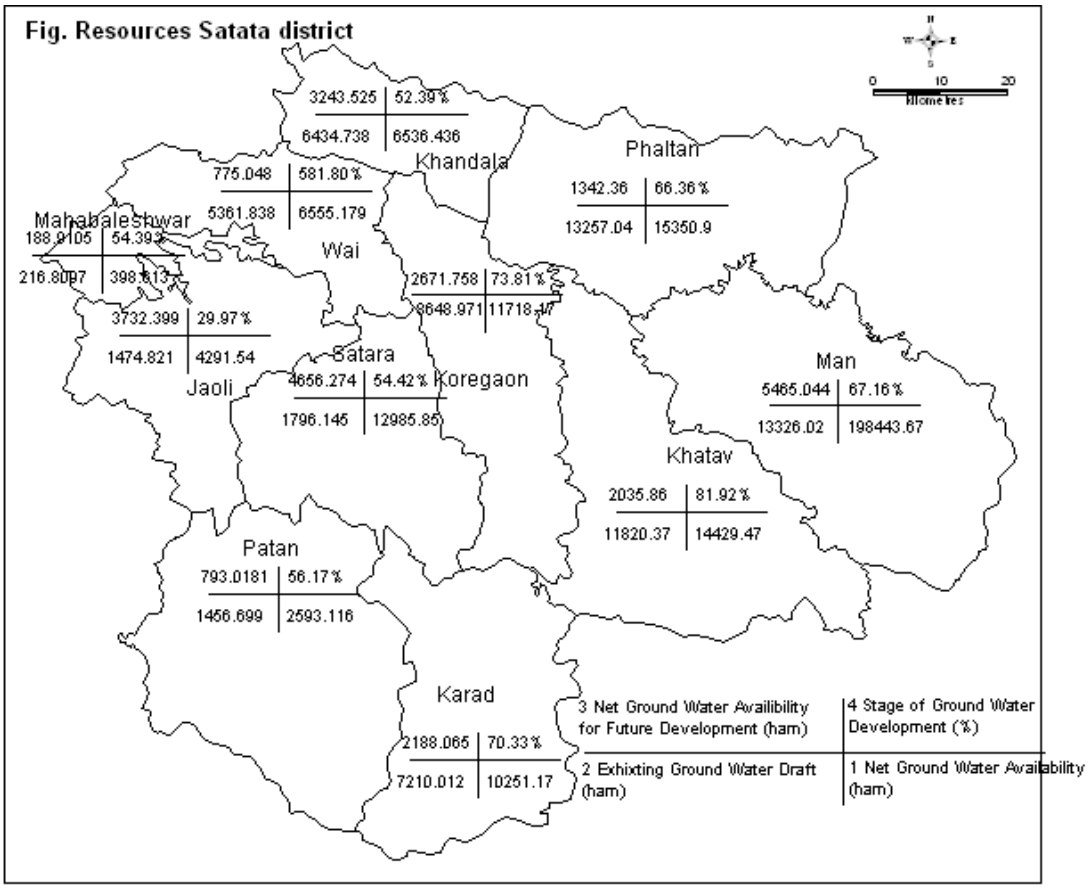


Figure 6: Ground water Resources (2009)

Table 8 : Ground water Resources of Satara District as on 2009

Figures in HAM

Sr No.	District	Administrative Unit	Command / Non-Command / Total	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	Provision for Domestic and Industrial Requirement Supply to 2025	Net Ground Water Availability for Future Irrigation Development	Stage of Ground Water Development %	Category
1	Satara	Jaoli	Command	133.5391	58.73529	6.358854	65.09414				
2	Satara	Jaoli	Non Command	4788.001	1149.678	260.0492	1409.727				
3	Satara	Jaoli	Total	4921.54	1208.413	266.4081	1474.821	573.6766	3732.399	29.96666	Safe
4	Satara	Karad	Command	1631.273	1610.51	185.055	1795.565				
5	Satara	Karad	Non Command	8619.899	4746.407	668.0399	5414.447				
6	Satara	Karad	Total	10251.17	6356.917	853.0949	7210.012	1706.19	2188.065	70.33354	Safe
7	Satara	Khandala	Command	637.9277	111.1568	6.905882	118.0626				
8	Satara	Khandala	Non Command	5898.528	3144.271	162.4037	3306.675				
9	Satara	Khandala	Total	6536.456	3255.428	169.3096	3424.738	350.358	3243.525	52.39441	Safe
10	Satara	Khatav	Command	531.5782	300.76	87.6775	388.4375				
11	Satara	Khatav	Non Command	13897.85	10946.41	485.5227	11431.93				
12	Satara	Khatav	Total	14429.43	11247.17	573.2002	11820.37	1146.4	2035.86	81.91849	Safe
13	Satara	Koregaon	Command	3657.027	2326.881	226.0991	2552.98				
14	Satara	Koregaon	Non Command	8061.148	5862.5	233.4905	6095.991				
15	Satara	Koregaon	Total	11718.17	8189.381	459.5896	8648.971	944.1542	2671.758	73.80817	Safe
16	Satara	Mahabaleshwar	Non Command	398.613	198.8196	17.99007	216.8097				
17	Satara	Mahabaleshwar	Total	398.613	198.8196	17.99007	216.8097	33.98806	188.9105	54.39102	Safe
18	Satara	Man	Command	183.9871	161.28	18.104	179.384				
19	Satara	Man	Non Command	19659.68	12625.11	521.5275	13146.64				
20	Satara	Man	Total	19843.67	12786.39	539.6315	13326.02	1094.772	5955.044	67.15502	Safe
21	Satara	Patan	Non Command	2593.116	1113.24	343.429	1456.669				
22	Satara	Patan	Total	2593.116	1113.24	343.429	1456.669	686.858	793.0181	56.17446	Safe
23	Satara	Phaltan	Command	5642.687	4772.058	205.2679	4977.326				
24	Satara	Phaltan	Non Command	9708.214	8011.62	268.0923	8279.712				
25	Satara	Phaltan	Total	15350.9	12783.68	473.3602	13257.04	919.4723	1342.36	86.36	Safe
26	Satara	Satara	Command	5558.943	2866.191	309.5867	3175.778				
27	Satara	Satara	Non Command	7426.911	3657.006	363.3603	4020.367				
28	Satara	Satara	Total	12985.85	6523.198	672.947	7196.145	1227.286	4656.274	55.41526	Safe
29	Satara	Wai	Command	2603.709	2121.849	141.8631	2263.712				
30	Satara	Wai	Non Command	3951.47	2865.633	232.493	3098.126				
31	Satara	Wai	Total	6555.179	4987.482	374.3561	5361.838	712.994	775.048	81.79544	
			Grand Total	**105584.1**	**68650.12**	**4743.316**	**73393.43**	**9396.149**	**27582.26**	**69.5**	

4.6 Ground Water Quality

CGWB is monitoring the ground water quality of the Satara district since the last four decades through its established monitoring wells. The objectives behind the monitoring are to develop an overall picture of the ground water quality of the district. During the year 2011, the Board has carried out the ground water quality monitoring of 31 monitoring wells. These wells mainly consist of the dug wells representing the shallow aquifer. The sampling of ground water from these wells was carried out in the month of May 2011 (pre-monsoon period). The water samples were subjected to chemical analysis of various parameters in the Regional Chemical Laboratory of the Board at Nagpur. The parameters analyzed, include pH, Electrical Conductivity (EC), Total Hardness (TH), Nitrate (NO_3) and Fluoride (F). The sample collection, preservation, storage, transportation and analysis were carried out as per the standard methods given in the manual of American Public Health Association for the Examination of Water and Wastewater (APHA, 1998). The ground water quality data thus generated was first checked for completeness and then the validation of data was carried out using standard checks. Subsequently, the interpretation of data was carried out to develop the overall picture of ground water quality in the district in the year 2011.

During year 2011, CGWB has carried out the ground water quality monitoring of 31 samples and the pH of these water samples varies from 7.68 to 8.42, whereas electrical conductivity varies from 92 to 4240 µS/cm. The total hardness varies from 35 to 995 mg/l; NO_3 varies from 13 to 126 mg/l, F from 0.01 to 0.76 mg/l.

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., TH, NO_3 and F prescribed in the standards and is given in **Table-9**.

Table-9: 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
TH (mg/L)	300	600	22	8	1
NO_3 (mg/L)	45	No relaxation	19	-	12
F (mg/L)	1.0	1.5	31	-	-

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

The perusal of **Table-9** shows that the concentrations of all the parameters except nitrate in most of the samples are within the maximum permissible limit of the within BIS standards. It is also seen from the **Table-9** that the potability of ground water in the wells is mainly affected due to the Nitrate (NO_3) as its concentration exceeds more than MPL in 39% of samples. Overall, it can be concluded that the ground water quality in the wells monitored in the district is affected because of high NO_3 concentrations. The high concentration of Nitrate may be due to domestic waste, waste water and sewage in the urban and rural part of district.

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. Electrical Conductivity (EC) is one of the most important quality criteria, which influence the water quality and its suitability for irrigation.

Electrical Conductivity (EC)

The amount of dissolved ions in the water is best represented by the parameter electrical conductivity. The classification of water for irrigation based on the EC values is as follows.

Low Salinity Water (EC: 100-250 µS/cm): This water can be used for irrigation with most crops on most soils with little likelihood that salinity will develop.

Medium Salinity Water (EC: 250 – 750 µS/cm): This water can be used if moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High Salinity Water (EC: 750 – 2250 µS/cm): This water cannot be used on soils

with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High Salinity Water (EC: >2250 µS/cm): This water is not suitable for irrigation under ordinary condition. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops should be selected.

The classification of ground water samples collected from monitoring wells was carried out for irrigation purpose and given below in **Table-10**.

It is clear from the **Table-10** that maximum number of samples (58%) falls under the category of medium salinity water while nearly 4% of samples fall in very high salinity water category. This shows that the ground water in the pre-monsoon season from shallow aquifer in the district should be used for irrigation with proper soil and crop management practices.

Table-10: Classification of Ground Water for Irrigation based on EC.

Type	EC (µS/cm)	No. of Samples	% of Samples
Low Salinity Water	<250	2	6
Medium Salinity Water	250-750	18	58
High Salinity Water	750-2250	10	32
Very High Salinity Water	>2250	1	4
Total		**31**	**100.0**

4.7 Status of Ground Water Development

Ground water in the district is predominantly used for irrigation, as it is major source for irrigation. The minor irrigation census data (2010-11) indicate that irrigated area by ground water in the district is 750.80 sq km where as district surface water source accounts for only 446.75 sq km area and net irrigated area is 1197.77 sq km in the district. There are 75482 irrigation dugwell in the district creating irrigation potential of 1810.19 sq km out which 1537.77 sq m irrigational potential is utilised, whereas 2095 bore wells created an irrigation potential of 45.81 sqkm out of which 32.96 sq kms is irrigation potential is utilised.

5.0 Ground water Management Strategy

5.1 Groundwater Development

Almost entire district is underlying 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 part of Madha, Patan , Wai and Man taluka. 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, Khatan, Phaltan, Satara and Karad talukas, ground water development potential is high in the hard rock area, where ground water development can be done through dugwells, dug-cam-borewells(DCB) and borewells. However the dugwells are the most feasible structure for ground water development. The site selection for construction of borewells needs proper scientific investigation. 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 aquifer occurring in the district is presented in table-11. 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, DCB and borewell. It also show that 2 talukas i.e., Phaltan and Khatav are having high potential, however in Khatav taluka , which has been categorized as “sem-critical”, future ground water development is not recommend.

Table-11: Nature and Yield Potential of Aquifer.

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

5.2 Water Conservation and Artificial Recharge Structure

The over all stage of ground water development in the district is 69.5% hence it is necessary to adopt water conservation and artificial recharge techniques to increase sustenance of this precious resource. A large number of water conversation structures in 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 harvest 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 plugs (2728 m^3), 1 farm pond, 34 earthen nala bunds, 4 cement nala bunds, 20 roof top rain water harvesting structures and 106798 r mt. Farm bunding and 417223r mt. of CCT. The Social Forestry department has also done of aforestation in 65 ha and constructed150 other farm bunds.

In basaltic terrain, structure feasible are check dams, gully plugs, percolation tanks, nalla bunds etc. The structure like gully plugs, contour bunds are most favourable in hilly areas, particularly in almost entire Musli, Vehle, Bhor and parts of Ked and Junar 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 structures suitable for alluvial areas restricted along the banks of major rivers and their tributaries, are shallow recharge wells on the river beds. Percolation tanks are also suitable, where source water availability is there.

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

6.0 Ground Water Related Issues and Problem

Drought areas has been observed in major parts of the district in the entire eastern, north eastern and south eastern parts comprising almost entire Khandala, Phanltan, Khatav, Mhaswad talukas and parts of Koregaon and Karad talukas. Deeper water levels of 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 the parts of Man and Khatav talukas. These are the areas where the ground water scarcity is quite common when the rainfall is deficient. The stage of ground water development in 5 talukas (Karad, Khatav, Koregaon, Phaltan and Wai) has already crossed 70%. Most of these talukas fall in rain shadow zone of Western Ghats, where rainfall is low. Hence special attention is required in above mentioned areas and immediate steps like ground water augmentation by artificial recharge practice and water conservation should be adopted before further ground water development is planned in these areas.

Apart from 5474 ha of land of Nira command area in the district has been characterised as water logged by Irrigation Department Govt. Maharashtra. 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 crop.

7.0 Mass Awareness and Training Activities

7.1 MAP and WMTP

No Mass awareness Programme and Water Management Training Programmes has been organised in the district till March 2013.

8.0 Area Notified by CGWA/SGWA

All talukas have been categorised as “Safe”. However, 7 water sheds viz. BM-101, BM-85, BM-86, KR-10, KR-22, KR-6 and KR-9 have been categorized as “Semi-Critical”, and 1 watershed i.e., KR-2 has been categorized as ”Over-Exploited”. But no area in the district has been notified by CGWA/SGWA so far.

9.0 Recommendations

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

1 The entire district is underlain by the Deccan trap basalt where only dugwells are most feasible structure 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. Beside, the borewells should only be used for drinking water supply and not for irrigation.

3 The stage of ground water development in 5 talukas (Karad, Khatav, Koregaon, Phaltan and Wai) has already crossed 70%. Most of these talukas fall in rain shadow zone of Western Ghats, where rainfall is low. Hence special attention is required in above mentioned areas and immediate steps like ground water augmentation by artificial recharge practice and water conservation should be adopted before further ground water development is planned in these areas.

4 It is also suggested that future groundwater development in "Semi-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 watershed there is sufficient scope for ground water development by constructing dugwells down to the depth of 20 m bgl so as to tap 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 hillock and undulating topography etc., which allows for the higher surface run off. Also, the underlying basalt formation has poor storage and transmission capability rendering the aquifer to limited potential. There aquifer gets 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 post monsoon water levels are less than 3.00 m bgl. Hence, small scheme of water conversation are quite useful for harvesting the surface run off and there by maintaining the supply during learn period. Storage tanks on the hill top, nala bund, check dams/ stop dam etc., should be constructed after studying the feasibility, UGB are also feasible to conserve the base flow.

6. Scope exists for the construction of suitable artificial recharge structure in central and eastern parts of the district. The percolation tanks, cement nala bunds. KT weirs, eastern 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 sustainability. However, the water used for recharge should be free from slit and other pollutants; hence provision of filter should be made near the recharging well.

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

8. To created public awareness among the masses, 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 or aquifer and declining trend of water level in the district. Similarly farmer should also be encouraged to adopt appropriate crop planning and irrigation practices.

9. Ground water quality is adversely affected by nitrate concentration in 39% of samples. Thus all the wells used for water supply should be analysed for nitrate contents and if it is found beyond permissible limit, the ground water may be used for other purposes than drinking. Adequate sanitary protection to the wells may be provided to control the nitrate contamination.

10. The overall stage of ground water development for the district is only about 69%. Therefore, there is scope for further development of ground water resources.