



भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र राज्य के अंतर्गत गोंदिया जिले की
भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
GONDIA DISTRICT
MAHARASHTRA



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द्वारा
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मध्यवर्ती क्षेत्र
नागपुर
CENTRAL REGION
NAGPUR
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GONDIA DISTRICT AT A GLANCE

1.	GENERAL INFORMATION	
	Geographical Area	5858.95 sq. km.
	Administrative Divisions (As on 31/03/2007)	Taluka- 8, Gondia, Goregaon, Tiroda, Arjuni Moregaon, Deori, Amgaon, Salekasa, Sadak Arjuni
	Villages	954
	Population (2001)	1201000
	Normal Annual Rainfall	1300 to 1500 mm
2.	GEOMORPHOLOGY	
	Major Physiographic unit	Two: Structural units like hills and ridges, denudational units like pediments and fluvial units
	Major Drainage	One: Wainganga River and its tributaries like Bagh, Chulbandh, Panghodi Suz, Gadhavi, Chandan, Bavanthadi
3.	LAND USE (2000-01)	
	Forest Area	2150.00 sq.km
	Cultivable Area	3152.85 sq.km
	Net Area Sown	1739.59 sq.km
4.	SOIL TYPE	The main types of soils are Kali, Kankar, Morand, Khardi, Sihar and Bardi
5.	PRINCIPAL CROPS (2000-01) (Net area sown)	
	Rice	1834.28 sq.km
	Total Pulses	197.30 sq.km
	Total Oil Seeds	79.63 sq.km
	Wheat	37.80 sq.km
6.	IRRIGATION BY DIFFERENT SOURCES (2000-01) (Nos/ Potential Created in ha)	
	Dugwells	6931/10623
	Borewells	211/445
	Tanks & Ponds	573/49785
	Other Minor Surface Sources	238/4816
	Net Irrigated Area	6381
7.	GROUND WATER MONITORING WELLS (May 2007)	
	Dugwells	22
	Piezometers	4
8.	GEOLOGY	
	Recent	Alluvium and Laterite
	Proterozoic (Vindhyan, Dongargarh, Sausar and Sakoli Super Group)	Quartzite and Shale, Andesite, Sandstone, Granite, Rhyolite; Muscovite-biotite-schist, Granite, Tirodi Gneiss; Schist, Phyllites, Quartzite.
	Archeans (Amgaon Super Group)	Granite & Gneisses.

9.	HYDROGEOLOGY	
	Water Bearing Formation	Weathered Granite & Gneisses
	Premonsoon Depth to Water Level (May - 2007)	4.85 to 13.55 m bgl (May-2007)
	Postmonsoon Depth to Water Level (November - 2007)	1.30 to 7.25 m bgl (Nov-2007)
	Premonsoon Water Level Trend (1998-2007)	Rise: Negligible to 0.56 m/year Fall: 0.03 to 0.41 m/year
	Postmonsoon water level trend (1998-2007)	Rise: Negligible to 0.05 m/year Fall: 0.02 to 0.15 m/year
10.	GROUND WATER EXPLORATION March 2007)	
	Wells Drilled	EW- 14, OW-5, PZ-2
	Depth Range	24.50 to 201.50 m bgl
	Discharge	0.38 to 7.76 lps
	Transmissivity	3.42 to 56 m ² /day
	Storativity	2.1 0 x 10 ⁻⁵ to 1.7 x 10 ⁻⁵
11.	GROUND WATER QUALITY (May 2007)	
	EC (μS/cm)	90 - 1560
	TDS	57 -873
	Cl (ppm)	7 -390
	F (ppm)	0.06 - 2.38
	NO ₃ (ppm)	0.1 - 94
	Type of Water	Mainly Ca-HCO ₃
	General Water Quality	Suitable for both drinking and irrigation purposes.
12.	DYNAMIC GROUND WATER RESOURCES (March 2004)	
	Net Annual Ground Water Availability	592.20 MCM
	Annual Ground Water Draft (Irrigation+Domestic)	85.11 MCM
	Allocation for Domestic and Industrial requirement up to next 25 years	55.69
	Stage of Ground Water Development	18.05

Ground Water Information Gondia District

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Ground Water Information

Gondia District

1.0 Introduction

The district comes under Nagpur division (Vidarbha) in Maharashtra State. It is newly formed district and carved out by the division of Bhandara district in May 1999. Gondia district as well as its parent district is unique in Maharashtra and differs from the rest of the State in the following three ways:-

- i. The entire area of the district is occupied by crystalline rocks while rest of the State is covered by Deccan Basalt.
- ii. Paddy is the staple food crop of the district while wheat is the main agriculture produce in the rest of the State; and
- iii. It is endowed with the presence of Malguzari Tanks.

Gondia district is situated on north-eastern side of Maharashtra State and share the state borders with Madhya Pradesh on north and Chattisgarh in east. It covers an area of about 5859 sq.km and lies between 20°39' and 21°38' north latitudes and 79° 52' to 80°42' east longitudes. The adjoining districts to Gondia are on northern side Balaghat district of Madhya Pradesh State and on eastern side Rajnandgaon district of Chhatisgarh State. To the south and west are Chandrapur district and Bhandara district respectively of Maharashtra.

The total population of the district is about 12,00,151 and the population density is 247 per sq.km as per 2001 census. The literacy rate of district is about 68%. Basically district is divided into eight talukas namely Gondia, Goregaon, Tiroda, Arjuni Moregaon, Deori, Amgaon, Salekasa, Sadak Arjuni and eight Panchayat Samiti. Only two Municipalities exist at Gondia and Tiroda. The district falls under the Wainganga basin with rivers like Bagh, Chulbandh, Gadhavi and Bavanthadi are the tributaries of river Wainganga. A list of studies conducted in different parts of the district is presented in **Table-1**.

Table 1: Studies undertaken by CGWB (March 2007).

S. No.	Year	Surveyed area	Work done
1.	1986-87	Covering parts of Toposheet No's 55 O/16 & 55 P/13	Systematic Hydrogeological Survey
2.	1987-88	Site Selection for Rural Water Supply in parts of Gondia district.	Drought Relief Work in Maharashtra
3.	1991-92	Wainganga Basin, north western parts of Gondia district.	Reappraisal Hydrogeological Surveys
4.	1995-96	Wanganga Basin, northern part of Gondia district.	Reappraisal Hydrogeological Surveys

A report on 'Ground Water Resources and Development Potential of Gondia district' was compiled by Smt. Pushpa Jain, Scientist-B and Ms. Priya Alimchandani, Asstt. Hydrogeologist in the year 2004. A map of the district showing the taluka boundaries, taluka headquarters and location of monitoring wells is presented as **Figure-1**.

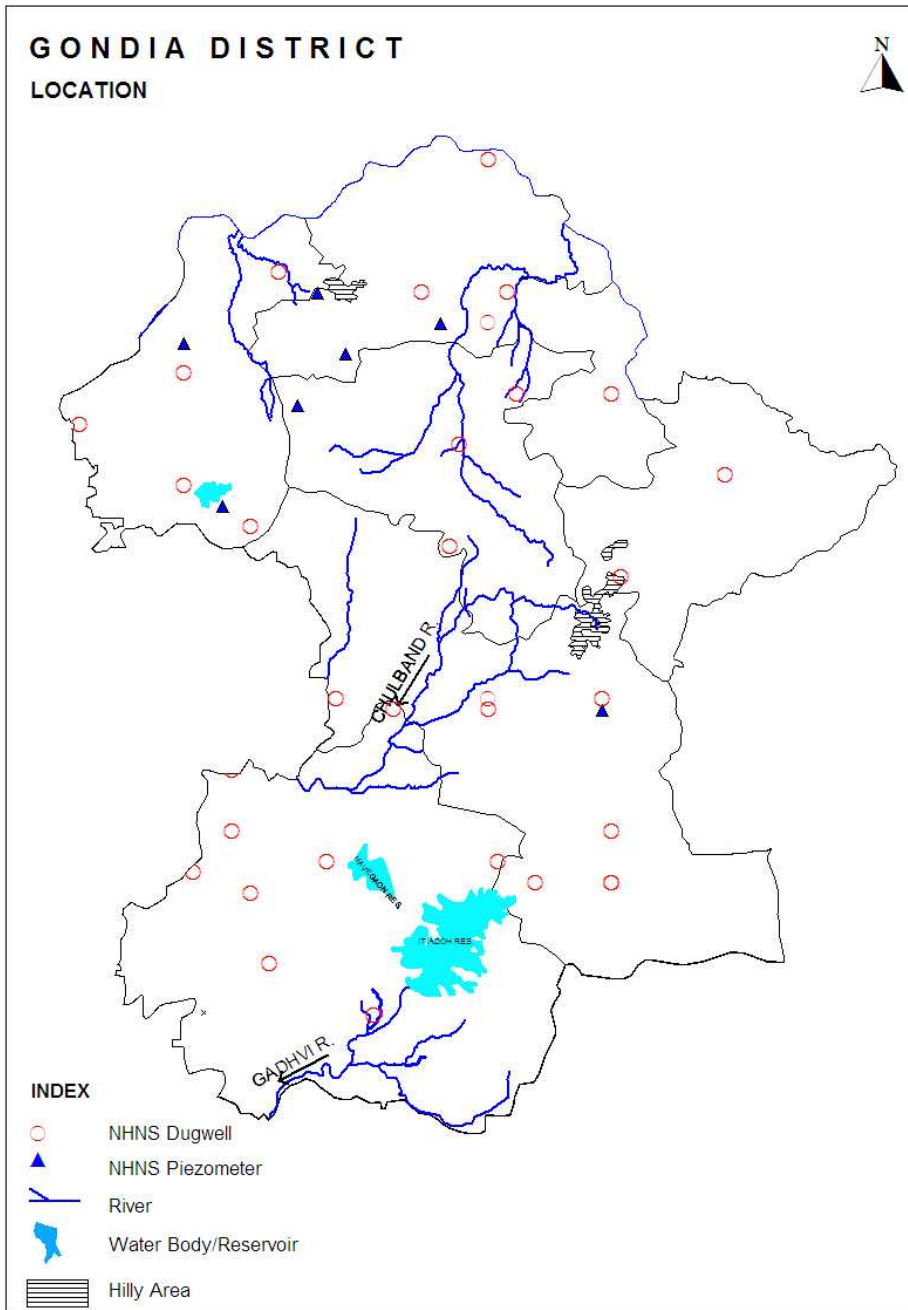


Figure-1: Location

Apart from above studies, the CGWB has also taken up 'Ground Water Exploration Programme' in the district. The exploratory drilling programme in Gondia district was started in the year 1992-93 and a total of 14 exploratory wells, 5 observation wells and 2 Piezometers have been drilled in the district tapping weathered granites and gneisses. The drilling was carried out by a DTH Rig. The drilling was carried out down to depths of 24.50 to 201.50 m bgl. Two to three water-bearing zones were taped totalling to a thickness varying from 3 to 30 m. The shallowest zone was struck at 10.30 m bgl while the deepest zone at 129.30 m bgl. The static water level ranged from 2.24-17.20 m bgl. Preliminary yield tests have shown yields ranging from 0.38 to 7.76 lps with six wells having yields of more than 3 lps. The transmissivity of these wells ranged from 3.42 to

56.00 m²/day while the Storativity ranges from 2.1 x 10⁻³ to 1.7 x 10⁻⁵. The specific capacities of these tubewells ranged from 0.19 to 0.80 lpm/m of drawdown. The salient features of ground water exploration are given in **Table-2**.

Table 2: Salient Features of Ground Water Exploration (March 2007).

S. No.	Salient Features	Details
1	No. of exploratory wells drilled	EW-14, OW-5, Pz-2
2	Depth range (m bgl)	24.50 to 201.50
3	Number of zones encountered	2 to 3
4	Thickness of individual zone (m)	3 to 30
5	Formation	Weathered granites and gneisses
6	Depth range of zones encountered (m bgl)	10.30 to 129.30
7	SWL range (m bgl)	2.24 to 17.2
8	Yield range (lps)	0.36 to 7.76
9	No./ % of boreholes with yield more than 3 lps	6/50 %
10	Transmissivity (m ² /day)	3.42 to 56.00
11	Storativity	2.1 x 10 ⁻³ to 1.7 x 10 ⁻⁵

2.0 Climate and Rainfall

The Climate of the district is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The mean minimum temperature is 6°C and mean maximum temperature is 45°C.

The normal annual rainfall over the district ranges from 1300 mm to 1500 mm. It is the minimum in the north-west south-east direction and increases in the north-east direction. Tiroda receives the minimum rainfall of 1357.8 mm while the maximum rainfall of 1415.8 mm is received at Deori. The average annual rainfall of the period 1998-2007 in the district varies from 1212 mm (Goregaon) to 1481 mm (Deori) and the same is presented in **Table-3**.

Table 3: Annual Rainfall Data (1998-2007)

Taluka	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Amgaon	1133.7	1355.3	1753.4	1429.4	1133.1	1375.2	998.8	1963.5	1860.7	1449.5	1445.26
Deori	1378.0	1698.6	1199.3	1664.9	776.7	1357.5	757.8	2420.8	2068.7	1491.7	1481.40
Gondiya	1487.4	1521.2	1489.4	1689.3	1196.6	1328.9	831.4	1603.1	1383.9	1100.1	1363.13
Goregaon	1097.0	903.2	1113.0	1210.7	1212.8	1304.3	964.4	1486.0	1670.7	1159.4	1212.15
Arjuni Morgaon	1648.2	1531.1	1627.3	1645.4	1003.2	1519.2	915.6	1743.8	1408.0	1572.3	1461.41
Sadak- Arjuni	1581.1	1897.9	1569.5	1914.0	1183.9	1210.5	1081.2	1477.0	1345.9	1120.0	1438.10
Salekasa	968.9	1408.7	816.9	976.5	890.9	1564.2	967.9	1989.7	1536.7	1390.2	1251.06
Tirora	1066.2	1510.5	1543.5	1667.6	886.1	1896.7	1072.1	1638.4	1156.1	953.7	1339.09

3.0 Geomorphology and Soil Types

The district forms part of Wainganga sub-basin and has an undulating terrain with elevations ranging from 263 to 315 m amsl. Physiographically, the district can be broadly divided into two physiographic units viz., the one controlled

by structural features i.e., the Structural Origin and the one controlled by differential weathering i.e., the Denudation Origin. The structural hills and ridges are more common in the eastern and south eastern parts of the district, while the denudational features like pediments/pediains are seen in north-central, west central and south-west portions.

The soils of the district are highly varied and are derived from weathering of crystalline metamorphic and igneous rocks. The main types of soils are Kali, Kankar, Morand, Khardi, Sihar and Bardi. Out of these, Sihar soils are used for growing the Rice, which is the main crop in the district.

4.0 Ground Water Scenario

4.1 Hydrogeology

Gondia district is unique in Maharashtra in the sense that the entire area of the district is occupied by metamorphic and igneous rocks. Major part of the district is occupied by the crystalline rocks of Pre-Cambrian formations viz; Archaean, Dharwars. A map depicting the hydrogeological features is shown in **Figure-2**.

4.1.1 Hard Rock Areas

4.1.1.1 Archeans

The Archeans are represented by Amgaon Group consisting of Augen gneisses, amphibolites, migmatites and these formations are confined to the N & NW corner of the district around Amgaon and Bahela.

4.1.1.2 Dharwars

The Amgaon group is followed by Dharwars (Lower Precambrian) are represented by Sakoli Group and Dongargarh Group of rocks, the latter forms the major stratigraphic unit in the district. The Sakoli Group consists of quartzites, schists, phyllites, metavolcanics and BIF and are confined to the N and NW part of Nagjhira. The areas surrounding Salekasa, Wadegaon, Murdoli, Deori and Chinchgarh rocks consisting of Rhyolites, Andesites, basic volcanics are present which respectively represents Bijli, Pitepani and Sitagota formations of the Dongargarh Group.

4.1.2 Ground Water Occurrence

The Pre-Cambrian crystalline rocks are the major water bearing formations in the district. The weathered portions of crystalline rocks together with joints and fracture zones act as good aquifers. Ground water occurs under water table conditions in the weathered mantle and then the fractured, well-jointed and sheared zones. Dug wells, dug cum bore wells and bore wells are the common ground water abstraction structures. Ground water occurs under water table conditions and semi-confined conditions in these formations. Water table conditions prevail in the weathered mantle and the fractures, jointed and sheared zones. At places where the argillaceous litho-units like phyllites and mica schists act as a confining medium, the ground water is found to occur under semi-confined conditions.

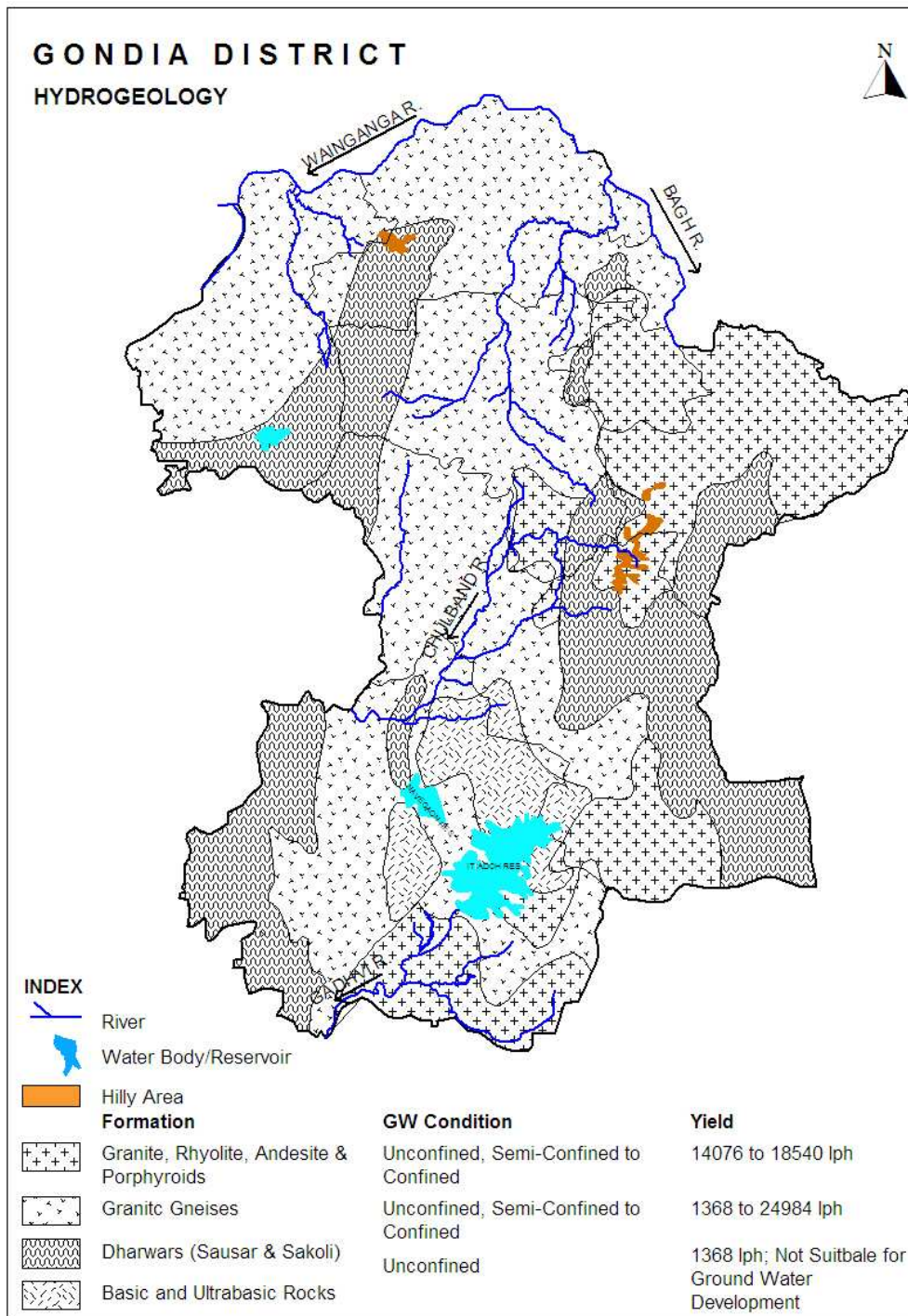


Figure-2: Hydrogeology

4.1.3 Water Level Scenario

Central Ground Water Board periodically monitors 26 Ground Water Monitoring Stations (GWMS) stations in the Gondia district four times a year i.e. during January, May (Pre-monsoon), August and November (Postmonsoon).

4.1.3.1 Premonsoon Depth to Water Level (May-2007)

The depth to water level in the district during May 2007 ranges between

4.85 (Sarrah) and 13.18 m bgl (Dongargaon2). Depth to water level during premonsoon has been depicted in **Figure-3**. Shallow water levels in the range of 5 to 10 m bgl are seen in major part of the district, i.e., in major parts of Tiroda, Amgaon, Gondia and Salekasa talukas. Deep water levels in the range of 10 to 20 mbgl are observed in the eastern parts of the district covering parts of Deori and Arjuni Morgaon talukas.

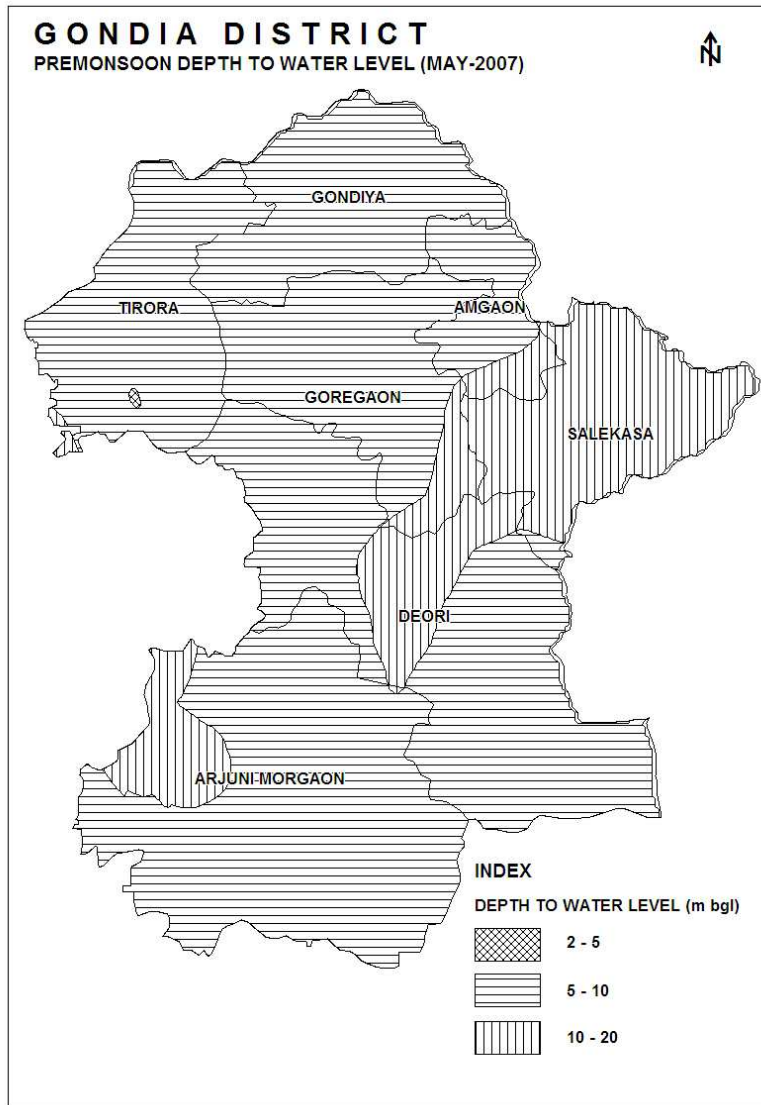


Figure-3: Premonsoon Depth to Water Level (May 2007)

4.1.3.2 Postmonsoon Depth to Water Level (Nov.-2007)

The depth to water level during postmonsoon (Nov. 2007) ranges between 1.3 m bgl (Sarrah) and 6.45 m bgl (Dongargaon2). Spatial variation in post monsoon depth to water level is shown in **Figure-4**. Shallow water levels within 5 m bgl occupy almost entire district. Water levels between 5 and 10 m bgl are observed in central and southern part of the district, occupying parts of Deori and Arjuni Morgaon talukas.

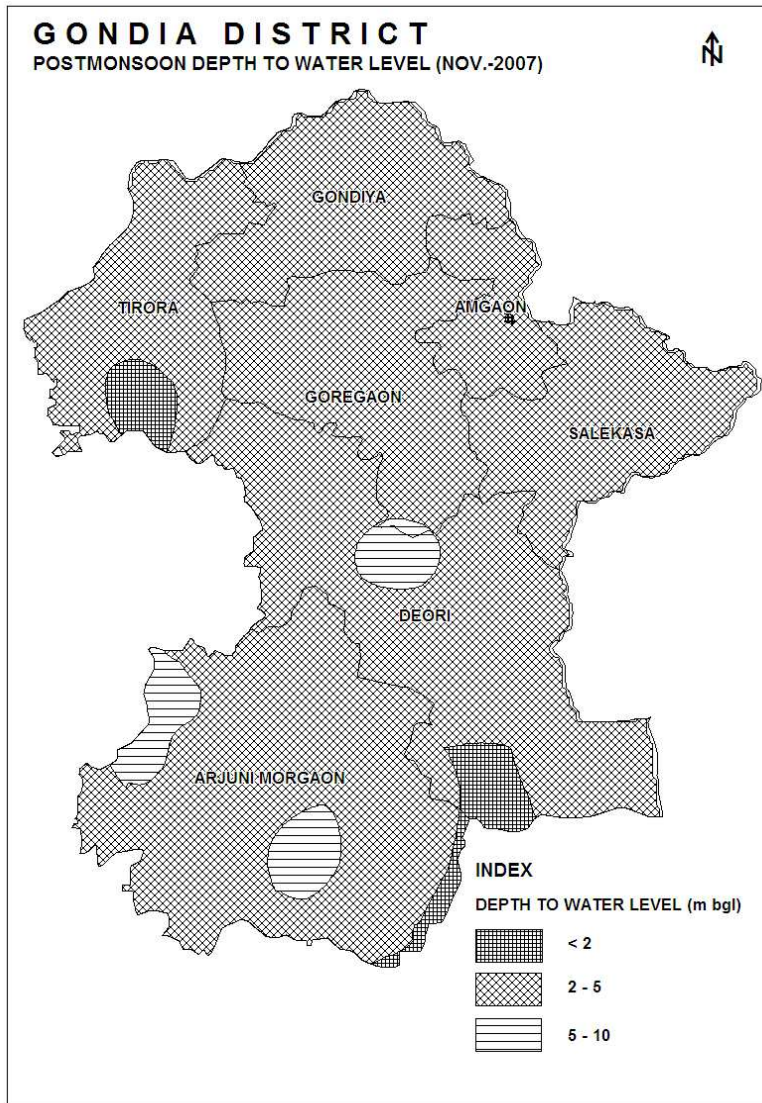


Figure-4: Postmonsoon Depth to Water Level (Nov. 2007)

4.1.3.3 Seasonal Water Level Fluctuation (May-Nov. 2007)

The pre and post-monsoon fluctuation varies from 1.2 to 7.23 m. In entire district rise in water levels in the range of 1.20 (Karandli) to 9.55 m (Dongargaon) is observed with fluctuation of more than 4 m being the most dominant range observed in entire southern, central and north eastern areas. The fluctuation of 2 to 4 m is observed in about 3 patches occupying parts of Tirora, Deori and Arjuni Morgaon talukas.

4.1.4 Water Level Trend (1998-2007)

Trend of water levels for premonsoon and postmonsoon period for last ten years (1998-2007) have been computed for 21 GWMS. Analysis of trend indicates that during premonsoon period, rise in water level has been recorded at 9 stations and it ranges between negligible (Ghonari) and 0.56 m/year (Sondad). Fall in water level has been observed at 12 stations and it ranges between 0.02 at Goregaon and 0.42 m/year at Amgaon. During post-monsoon period, rise in water levels has been recorded at 3 stations and it ranges from negligible m/year

(Karandli) to 0.54 m/year (Sindkheda), whereas at 18 stations, fall in water level ranging between 0.02 m/year (Kohmera) and 0.16 m/year (Sejgaon) is observed. Thus in major part of the district, both during pre and postmonsoon periods declining trends of water levels have been observed. The premonsoon trend map was also prepared and the same is presented in **Figure-5**.

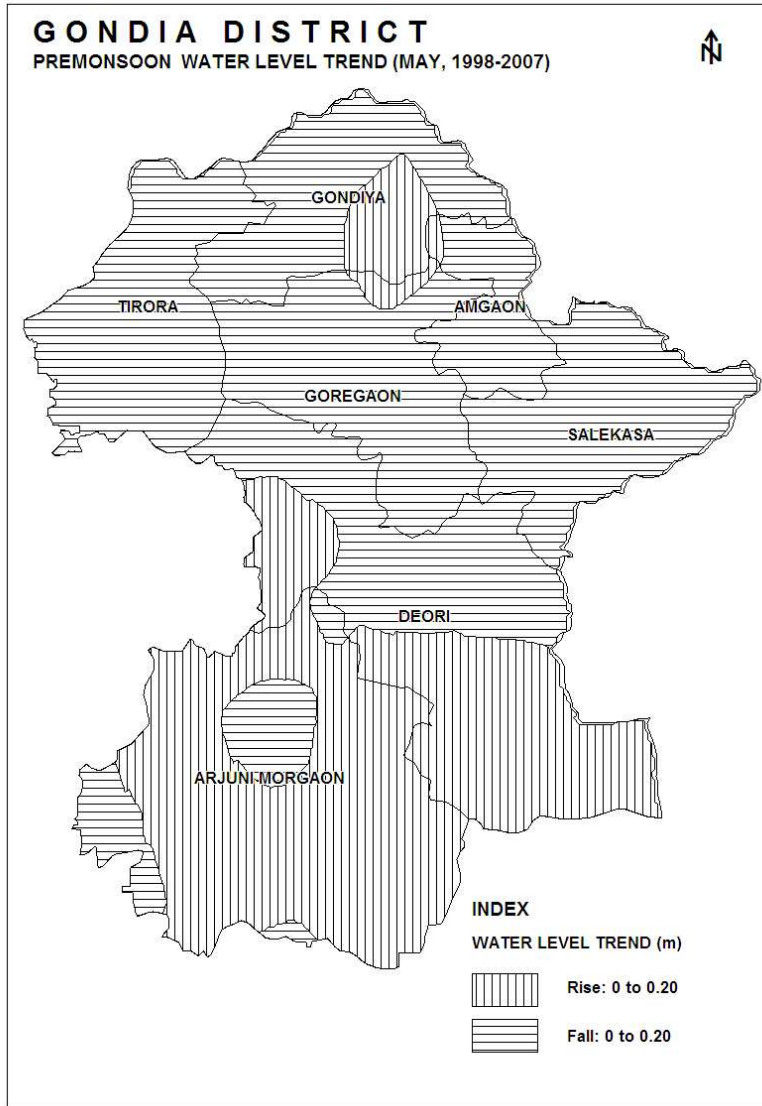


Figure 5: Premonsoon Water Level Trend (May 1998-2007)

It shows that in northern half of district fall in water level trend of up to 20 cm/year is observed whereas in southern parts rise of up to 20 cm/year is observed. The fall in water level is observed in almost entire Gondia, Tiroda, Amgaon, Goregaon, Salekasa talukas and northern parts of Deori taluka. Thus, the future water conservation and artificial recharge structures needs to be prioritised in these areas. The rise is observed in almost entire Arjuni Morgaon taluka and southern parts of Deori taluka.

4.2 Yield of Wells

The CGWB has drilled 13 exploratory wells in Gondia district to evaluate

the potential and aquifer parameters. The yield of these borewells ranged between 2808 and 25200 lph. Out of 13 exploratory wells, seven are high yielding with the yield range from 11412 lph to 25200 lph. It has been observed that the borewells drilled in granitic gneisses are more productive than drilled in Schist's/ Quartzite's. The yield of GSDA borewells generally range between 2000 to 5000 lph.

4.3 Aquifer Parameters

Based on pumping tests, it was observed that in Fractured Gneisses the transmissivity ranges from 7.25 to 56.00 m²/day, the storativity ranges from 2.00 x 10⁻⁴ to 1.70 x 10⁻⁵ and special capacity ranges from 0.19 to 0.80 lps/m of drawdown. The transmissivity in Fractured Schist's ranges from 3.42 to 17.00 m²/day, the storativity was estimated as 2.1 x 10⁻³ and the specific capacity ranges from 0.38 to 0.40 lps/m of drawdown.

4.4 Ground Water Resources

Based on GEC-97 methodology, the Central Ground Water Board and Ground Water Survey and Development Agency (GSDA) have jointly estimated the dynamic ground water resources of Gondia district based on GEC-97 methodology. The same is presented in **Table-4**, whereas the graphical representations of the resources on the map are shown in **Figure-6**.

Ground water resources assessment was done for 4120.47 sq.km area of which 1450.20 sq.km is under command and 2670.27 sq.km is non-command. As per this estimation, the total annual ground water recharge is 626.79 MCM with the natural discharge of 34.61 MCM, thus the net annual ground water availability comes to be 592.20 MCM. The gross draft for all uses is estimated at 85.11 MCM with irrigation sector being the major consumer having a draft of 57.30 MCM. The allocation for domestic and industrial water requirement supply up to the next 25 years are worked out at 55.69 MCM. The net ground water availability for future irrigation is estimated at 458.94 MCM. The stage of ground water development varies from 7.03 % (Arjuni Morgaon) to 24.85 % (Gondia). The overall stage of ground water development for the district is 18.05 % and falls in 'Safe' category.

4.5 Ground Water Quality

Central Ground Water Board is monitoring the ground water quality of Gondia district through its National Hydrograph Network Stations (NHNS), which mainly consist of the dugwells representing shallow aquifer. The objective behind the monitoring is to develop an overall picture of the ground water quality in the district. During the year 2007, the board carried out the ground water quality monitoring of 24 Network Stations. The sampling of ground water was carried out in the month of May (Pre-monsoon period). The samples after collection were immediately subjected for the chemical analysis in the Regional Chemical Laboratory of the Board at Nagpur.

Table-4: Ground Water Resources (March 2004).

S. No.	Taluka	Area type	Net annual ground water availability (ham/yr.)	Annual ground water draft (ham/yr.)			Allocation for domestic & industrial requirement supply up to next 25 years (ham/yr.)	Ground water availability for future irrigation (ham/yr.)	Stage of ground water development (%)	Category
				Irrigation	Domestic & industrial uses	Total				
1	Gondia	C	5199.84	858.32	226.18	1084.50	523.93	2720.02	20.86	Safe
		NC	2771.90	558.87	337.86	896.73	606.95	2330.89	32.35	
		Total	7971.74	1417.19	564.04	1981.23	1130.88	5050.91	24.85	
2	Tirora	C	6117.00	945.06	347.02	1292.08	619.72	3228.42	21.12	Safe
		NC	1593.50	308.17	109.38	417.55	265.20	1791.64	26.20	
		Total	7710.49	1253.23	456.40	1709.63	884.93	5020.06	22.17	
3	Amgaon	C	3851.20	222.00	189.72	411.72	401.45	2403.82	10.69	Safe
		NC	692.78	53.11	72.71	125.82	130.94	751.31	18.16	
		Total	4543.98	275.12	262.43	537.54	532.39	3155.12	11.83	
4	Goregaon	C	353.92	25.31	36.11	61.42	96.01	126.84	17.35	Safe
		NC	3517.83	271.50	379.27	650.77	762.48	2299.44	18.50	
		Total	3871.75	296.81	415.38	712.19	858.49	2426.28	18.39	
5	Salekasa	C	3444.39	282.01	74.86	356.86	158.13	2109.42	10.36	Safe
		NC	3060.01	162.64	144.42	307.06	286.90	3417.83	10.03	
		Total	6504.40	444.65	219.28	663.93	445.03	5527.25	10.21	
6	Deori	C	452.80	191.77	38.28	230.05	44.65	324.00	50.81	Safe
		NC	6444.32	369.12	264.07	633.19	557.12	5133.06	9.83	
		Total	6897.12	560.90	302.35	863.24	601.77	5457.06	12.52	
7	Arjuni Moregaon	C	7409.49	237.86	158.39	396.25	230.84	4155.23	5.35	Safe
		NC	7150.33	446.57	181.41	627.98	465.12	9634.59	8.78	
		Total	14559.82	684.43	339.80	1024.24	695.96	13789.82	7.03	
8	Sadak Arjuni	C	2750.08	308.85	80.57	389.42	98.56	1421.93	14.16	Safe
		NC	4408.13	488.47	141.06	629.53	321.06	4045.24	14.28	
		Total	7158.20	797.32	221.63	1018.95	419.62	5467.18	14.23	
9	District Total	C	29578.73	3071.17	1151.13	4222.30	2173.30	16489.68	18.84	
		NC	29638.77	2658.47	1630.17	4288.64	3395.75	29404.00	17.27	
		Total	59217.50	5729.64	2781.30	8510.95	5569.06	45893.69	18.05	

Here, C- Command, NC- Non-Command.

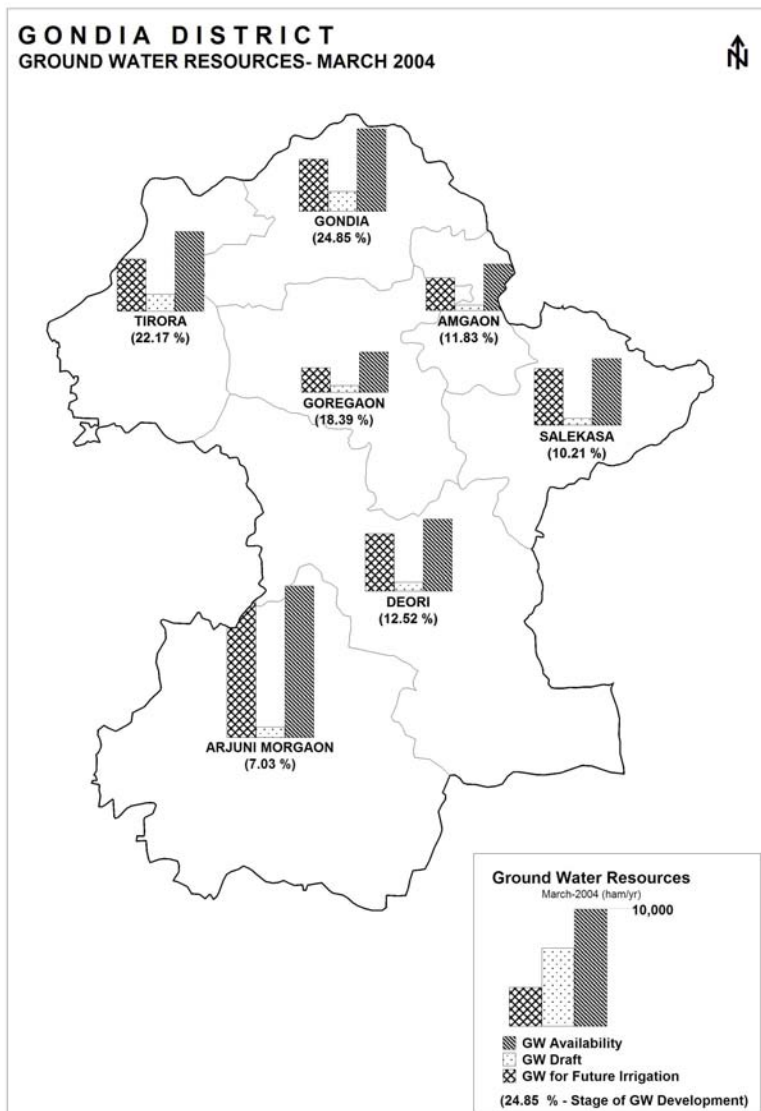


Figure 6: Ground Water Resources

The parameters analyzed include hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), carbonate (CO₃), bicarbonate (HCO₃), chloride (Cl), sulphate (SO₄), nitrate (NO₃) and fluoride (F). The outcome of the results of analysis is discussed below.

4.5.1 Chemical Characteristics of Ground Water:

The overall range of the parameters analysed in groundwater samples from the district along with average value is summarized in Table-5. All the parameters analysed are expressed in mg/L except pH and EC. The electrical conductivity is expressed in $\mu\text{S}/\text{cm}$ at 250C. The results indicate that the ground water in the district is alkaline in nature. The average EC and TDS values of ground water indicate that the ground water in the district is fresh (TDS < 1000 mg/L). However, some of the samples which were collected from the well located at Tiroda have high EC value (1560 $\mu\text{S}/\text{cm}$). The ions such as Ca, Mg, Na, HCO₃, Cl, NO₃ and SO₄ are present as major ions in ground water and the

average concentration of Ca ion is highest among the cations while the concentration of HCO₃ is highest among the anions.

Table- 5: Range of Parameters in Ground Water (May 2007).

Parameter	Range	Parameter	Range
pH	7.4 - 8.0	K (mg/L)	0.2 - 27
EC (µS/cm)	90 - 1560	CO ₃ (mg/L)	Nil
TDS (mg/L)	57 - 873	HCO ₃ (mg/L)	31 - 329
TH (mg/L)	30 - 625	Cl (mg/L)	7 - 390
Ca (mg/L)	8 - 186	SO ₄ (mg/L)	0.1 - 78
Mg (mg/L)	2.4 - 41	NO ₃ (mg/L)	0.1 - 94
Na (mg/L)	2.8 - 110	F (mg/L)	0.06 - 2.38

4.5.2 Geochemical Classification of Ground Water:

The water rock interaction adds several ions to ground water. The concentration of these ions in water gives us idea about the type of water in particular formation under natural condition. The variation in concentration of these ions due to man-made surface and subsurface activities reflects the changes in type of water. In Gondia district, majority of area is occupied by Archean formation while Alluvium occurs along the course of main rivers in certain parts. The epm percentage of alkaline earths (Ca+Mg), alkali metals (Na+K), weak acids (CO₃+HCO₃) and strong acids (Cl+SO₄+NO₃) ions in the ground water samples were calculated and samples were broadly classified into four classes as given in **Table-6**.

Table-6: Geochemical Classification of Ground Water Samples (May 2007).

Sr. No.	Classification	Type	No. of Samples	% of Samples
1	Alkaline earths (Ca+Mg > 50%) exceeds alkali metals and weak acids (CO ₃ +HCO ₃ > 50%) exceeds strong acids	Ca-HCO ₃	15	62
2	Alkali metal (Na+K > 50%) exceeds alkaline earths and weak acids (CO ₃ +HCO ₃ > 50%) exceeds strong acids.	Na-HCO ₃	3	13
3	Alkaline earths (Ca+Mg > 50%) exceeds alkali metals and strong acids (Cl+SO ₄ +NO ₃ > 50%) exceeds weak acids	Ca-Cl	6	25
4	Total	-	24	100

It is clear from the table that the 62% and 25% of ground water samples in the district are of Ca-HCO₃ and Ca-Cl type respectively while 13% of samples are of Na-HCO₃ type. The Ca-Cl type of water may be due to the percolation of waste and wastewater containing high concentration of strong acids ions (Cl+SO₄+NO₃) to ground water.

4.5.3 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 of the district. The overall classification of ground water samples falling below desirable limit (<DL), in the range of desirable and maximum permissible limit (DL-MPL) and above maximum permissible limit (>MPL) for drinking water purpose is shown below in **Table-7**.

Table-7: Classification of Ground Water Samples as per BIS Drinking Water Standards (IS-10500-91, Revised 2003), (May 2007).

Parameter s	DL	MPL	Samples < DL		Samples DL - MPL		Samples > MPL	
			No.	%	No.	%	No.	%
TDS (mg/L)	500	2000	20	83	4	17	0	0
TH (mg/L)	300	600	20	83	3	13	1	4
Ca (mg/L)	75	200	21	87	3	13	0	0
Mg (mg/L)	30	100	20	83	4	17	0	0
Cl (mg/L)	250	1000	23	96	1	4	0	0
SO ₄ (mg/L)	200	400	24	100	0	0	0	0
NO ₃ (mg/L)	45	No relaxation	22	92	No relaxation		2	8
F (mg/L)	1.0	1.5	21	88	2	8	1	4

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

The table explains that the ground water is suitable for drinking purposes as the concentration of detected parameters are below the MPL of drinking water standards barring few pockets. The potability of ground water in few samples have also been affected due to high concentration of TH and NO₃ ions.

4.5.4 Suitability of Ground Water for Irrigation Purpose

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

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

$$SAR = \frac{Na^+}{\sqrt{(Ca^{++} + Mg^{++})/2}}$$

SAR value is used to calculate the degree to which irrigation water tends to

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

Residual Sodium Carbonate (RSC): Residual Sodium Carbonate (RSC) is considered to be superior to SAR as a measure of sodicity particularly at low salinity levels. Calcium reacts with bi-carbonate and precipitate as CaCO₃. Magnesium salt is more soluble and so there is less tendency for it to precipitate. As calcium and magnesium are lost from the water, the proportion of sodium is increased with the increase in sodium hazard. This hazard is evaluated in terms of RSC.

$$\text{RSC} = (\text{CO}_3 + \text{HCO}_3) - (\text{Ca} + \text{Mg})$$

The classification of ground water samples based on SAR and RSC values for its suitability for irrigation purpose is shown below in **Table-8**.

Table-8: Classification of Ground water for Irrigation based on SAR and RSC (May 2007).

SAR	<10		10-18		18-26	>26	
Quality	Good		Good to Permissible		Doubtful	Unsuitable	
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	No. of Samples	%
24	24	100	0	0	0	0	0
RSC	<1.25		1.25-2.50		>2.50		
Quality	Good		Doubtful		Unsuitable		
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	%	
24	23	96	1	4	0	0	

The table explains that SAR and RSC values of majority of ground water samples are less than 10 and 1.25 respectively indicating ground water is suitable for irrigation purposes.

4.6 Status of Ground Water Development

Ground water development depends on many factors viz., availability, crop water requirement, socio-economic fabric and on the yield of the aquifers existing in that area.

The entire area is occupied by crystalline rocks of Archean age and as per 2001 census the district had 893 villages and two major towns. The drinking water to these villages is mainly from dugwells, borewells and tubewells in the area. As per the Minor Irrigation Census (2000-2001), the district has 7142 irrigation dugwells and the borewells which create on ground water potential of 110.66 sq.km., out of which 77.67 sq.km., potential is utilized. Apart from these irrigation wells, a number of small diameter domestic wells are located in the house holds which are used mainly for domestic purposes.

The GSDA under Rural Water Supply Scheme has drilled about 7017 successful borewells in the district till March 2007, out of which 6884 are fitted

with hand pumps and 133 are fitted with electric pumps.

5.0 Geophysical Studies

In Gondia district, VES was carried out at 7 sites and the results reveals the three layered geo-electrical sections. The first layer resistivity ranges from 6.60 to 200.00 ohm-m with thickness ranging from 0.50 to 3.00 m which may be attributed as top soil. The second layer resistivity ranges from 16 to 80 ohm meters and thickness of 13 to 44 m this layer can be inferred as weathered fractured formation. The third layer resistivity is very high which may be attributed to the hard compact granite. Thus the middle layer having resistivity in the range of 16 to 80 ohm meters and thickness of 13 to 44 m has good ground water potential. The drilling at some of these sites have yielded up to 2820 lph of discharge.

6.0 Ground Water Management Strategy

Ground water has special significance for agricultural development in the district. Although the ground water development in the district is on lower side major parts are experiencing declining of ground water levels over a period of time. Thus there is a need to adopt an integrated approach of development of ground water resources dovetailed with ground water augmentation to provide sustainability to ground water development.

6.1 Ground Water Development

A major part of the Gondia district is underlain by crystalline rocks comprising of granitic gneisses, schist's, volcanics etc. These formations act as good aquifers only where the thickness of the weathered mantle is high and they are affected by sets of open joints and fractures. Ground water development in the area is on moderate scale. There are three type of ground water structures i.e. dugwells, borewells and tubewells in the area. Dugwells one normally able to sustain 3 to 6 hours of pumping per day and the duration of recuperation vary from 3 to 9 hours. A large number of dug-cum-borewells are present in this district, the depth of the bores ranging from 15 to 30 meters from the bottom of the well. Topographic lows and the areas where the thickness of weathered mantle is high are usually the favourable zones for such wells. The study of litholog of exploratory wells indicates the presence of weathered formations down to 30 m bgl followed by jointed/fractured formations extending up to another 30 to 40 m bgl. Due to this fact, the depth of dugwells should not exceed more than 25 m and depth of borewells by more than 70 m.

Table-9: Nature and Yield Potential of Aquifers

S. No.	Taluka	Main Formation	Yield Potential	Feasible Structures
1	Gondia	Granite Gneisses	Low to High	DW, DCB, BW
2	Tiroda	Granite Gneisses, Schist's/Quartzite	High	DW, DCB, BW
3	Amgaon	Granite, Rhyolite	Low to High	DW, DCB, BW
4	Goregaon	Granite Gneisses	Medium to High	DW, DCB, BW

5	Salekasa	Granite, Rhyolite	Medium to High	DW, DCB, BW
6	Arjuni Moregaon	Granite Gneisses, Schist's/Quartzite, Granite, Rhyolite	Low	DW
7	Sadak Arjuni	Granite Gneisses	Mostly low to high	DW
8	Deori	Schist's, Quartzite etc.	Medium to High	DW, DCB, BW

Here, DW- Dugwell, BW- Borewell and DCB- Dug-cum-Borewell.

The overall stage of ground water development for the district is on lower side, i.e., 18.05% thus there is a plenty of scope for further development of ground water resources throughout the district. However the development should be done in planned and scientific manner as northern parts of the district are showing falling water level trends.

6.2 Water Conservation and Artificial Recharge

Percolation Tanks and Cement Bandharas are the feasible artificial recharge structures in the district. The existing dugwells can also be used for artificial recharge; however, the source water should be properly filtered before being put in the wells. As the post-monsoon water levels are shallow in major part of the district, extreme care should be taken while selecting the sites for artificial recharge structures. The sites need to be located where the hydrogeological conditions are favourable, i.e., where sufficient thickness of de-saturated/unsaturated aquifer exists and water levels are more than 5 m deep in postmonsoon season. Such areas are restricted and occur in central and southern part of the district, occupying parts of Deori and Arjuni Morgaon talukas. However roof top rainwater harvesting by storing the water in storage tanks during rainy season for use during non-monsoon season should be encouraged in scarcity affected areas as well as in urban area.

7.0 Areas Notified by CGWA/SGWA

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

8.0 Recommendations

1. The major part of the district is underlain by crystalline rocks comprising of granitic gneisses, schist's, volcanics, etc. These formations act as good aquifers only where the thickness of the weathered mantle is high and they are affected by sets of open joints and fractures. Therefore, the topographic lows and the areas where the thickness of weathered mantle is high are usually the favourable zones for dugwells and dug-cum-borewells.
2. The study of litholog of borewells indicates the presence of weathered formations up to 30 m bgl followed by jointed/fractured formations extending up to another 30 to 40 m bgl. Due to this fact, the depth of dugwells should not exceed more than 25 m and that of borewells by more

than 70 m.

3. Major part of the district is underlain by hard rock, where only dugwells are most feasible structures for ground water development. The sites for borewells need to be selected only after proper scientific investigation.
4. 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.
5. The geophysical surveys in Gondia district reveals the three layered geo-electrical sections and the middle layer having resistivity in the range of 16 to 80 ohm meters and thickness of 13 to 44 m has good ground water potential.
6. The overall stage of ground water development for the district is on lower side, i.e., 18.05% thus there is a plenty of scope for further development of ground water resources throughout the district. However the development should be done in planned and scientific manner as northern parts of the district are showing falling water level trends.
7. As the post-monsoon water levels are shallow in major part of the district, extreme care should be taken while selecting the sites for artificial recharge structures. The sites need to be located where the hydrogeological conditions are favourable, i.e., where sufficient thickness of de-saturated/unsaturated aquifer exists and water levels are more than 5 m deep. Such areas are restricted and occur in central and southern part of the district, occupying parts of Deori and Arjuni Morgaon talukas
8. Roof top rainwater harvesting by storing the water in storage tanks during rainy season for use during non-monsoon season should be encouraged in scarcity affected areas as well as in urban area.
9. Abandoned Malguzari tanks should be revived and proper care should be taken of the existing tanks by regularly de-silting them and reclamation of tanks should be stopped.