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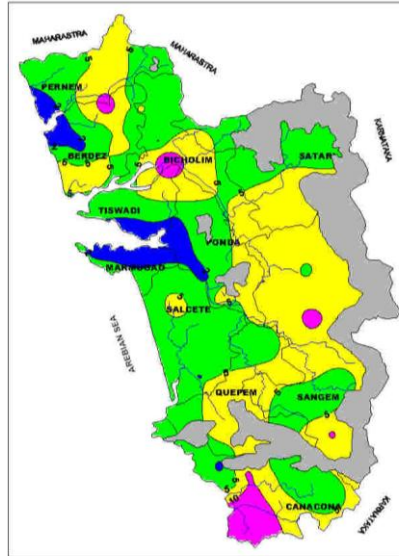
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

DEPT. OF WATER RESOURCES, RD & GR

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गोवा राज्य की भूजल वार्षिकी पुस्तिका

**GROUND WATER YEAR BOOK OF GOA STATE
(2018-2019)**



**SOUTH WESTERN REGION
BANGALURU**

DECEMBER 2019

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GROUND WATER YEAR BOOK OF GOA STATE (2018-2019)

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FOREWORD

Groundwater is a dynamic and replenishable precious natural resource. It requires to be monitored regularly and also to be appraised of the changes that are taking place in this regime. In this regard, Central Ground Water Board collects the groundwater level and quality data from the Groundwater Regime Monitoring Stations. The water levels are monitored four times a year during the months of May, August, November and January and ground water samples for the determination of the quality of Groundwater are collected once a year during the month of May. This report consists of the water level for the year 2018-19 and chemical quality data collected during May, 2018. Maps showing the depth to groundwater level in different parts of Goa and the changes observed in the water level in the last one year and the last one decade are included and discussed elaborately in the report. Groundwater stressed areas where water level are depleting as interpreted from the available data are also delineated. The report also contains the discussions on distribution and variation of rainfall in the state for normal period. Interpretation of Chemical quality of Groundwater on the basis of the samples collected during May, 2018 is also included in the report.

The data has been compiled and presented by Ms. D.Dhayamalar, Sc-D, Smt. Rakhi U R., Sc-B, Dr.Lubna Kouser, Asst. Hydrologist, Smt. V. Hemalatha, STA (HG). The groundwater samples were analyzed and interpreted by Dr.K.Ravichandran, Sc-D (Chem), Smt. Lalitha B.H, STA (Chem), Dr. Sailee Bhange, STA (Chem). A lot of labour has been put by various personnel of SWR, Bangalore and WKSU, Belgavi office for the timely and reliable collection of field data. The diligent effort put by Smt. S.Saritha, Sc-B and Smt Sangita P.Bhattacharjee, Sc- B of Report processing section in bringing out this report in a short span of time is praise worthy.

It is hoped that the information contained in this yearbook of 2018-19 will be useful for the stake holders, planners and other user agencies associated with the developement and management of water resources in the state of Goa.

December 2019



**(V. Kunhambu)
Regional Director**

EXECUTIVE SUMMARY

Central Ground Water Board, an apex Organization under Ministry of Jal Shakti, Government of India, is carrying out the monitoring of ground water levels all over the country for generating a sound database so that the changes in ground water regime could be scientifically studied, analysed and strategies for its optimal utilization can be planned.

The behaviour of ground water table during the ground water year 2018-2019 in Goa State has been studied by monitoring a set of dug wells and purpose-built piezometers during the months of May 2018, August 2018, November 2018 and January 2019. As of January 2019, Central Ground Water Board, South Western Region, monitors 93 dug wells and 47 piezometers to study the ground water scenario of Goa State.

The present compilation relates to the year 2018-2019. It provides information pertaining to water levels and also chemical quality of the phreatic aquifer. Thematic maps depicting the ground water scenario along with geochemical quality are furnished and discussed in this report. In addition, the fluctuations in water level and piezometric surface between different time frames have been analysed and presented. Various thematic maps presented reflect the effect of rainfall received during the period of study and the long-term behaviour of water level according to ground water recharge and draft conditions obtained in various agro-climatic zones. The data on seasonal rainfall are furnished to correlate the effect of the rainfall on water levels. In general, the water levels are deep in the month of May (Pre-monsoon period) and a rising trend of water levels during November (Post-monsoon period) was observed. Water level fluctuation takes place during August, November and January depending on the monsoon rainfall and level of groundwater development.

During the pre-monsoon period, the depth to water levels of 2 -5 m bgl and 5 - 10 mbgl are more prevalent in the State. Shallow water levels of less than 2 m bgl are noticed as isolated patches in Goa State. Depth to water level 10-20 m bgl is noticed in isolated pockets in some parts of the state.

During the post-monsoon period, the depth to water levels of 2 -5 m bgl and 5 - 10 mbgl are more prevalent in the State. Depth to water level of less than 2 mbgl is observed as patches in Bardez, Mormugao, Tiswadi and Pernem taluks. Depth to water level more than 10 is noticed as patches in some part of Goa State.

Results of chemical analysis of water samples collected during May 2018 are also discussed for understanding the spatial variation of EC, Chloride, Fluoride and Nitrate concentration in the phreatic aquifer system of Goa.

GROUNDWATER YEAR BOOK OF GOA STATE (2018-19)

1.0 GENERAL FEATURES

1.1 Introduction

Central Ground Water Board, South Western Region, Bangalore is monitoring water levels in the State of Goa from the established network of 140 monitoring stations, as a part of 'Ground Water Regime Monitoring'. This monitoring is done four times in a water year during May, August, November and January for water levels. Water samples from these stations are collected once in a year during the month of May to assess the ground water quality.

The State of Goa is located between 14°53'54" and 15°48'00" north latitudes and 73°40'33" and 74°20'13" east longitudes and is situated on the western coast of Peninsular India. It is bounded in the north by Maharashtra State, in the east and south by Karnataka State and in the west by the Arabian Sea. The State has a total geographical area of 3702 Sq. km., which is administratively divided into two districts namely North Goa and South Goa with 11 taluks. The taluk wise distribution of Ground water monitoring stations being monitored during the year by the Region is given in **Table 1**.

Table 1: District wise distribution of monitored Ground water monitoring stations

Sl.No.	Taluk	Geographical Area* (Sq. km)	No. of Ground water monitoring stations
District: North Goa			
1	Tiswadi	213.6	6
2	Bardez	264.0	13
3	Pernem	251.7	9
4	Bicholim	238.8	10
5	Satari	495.1	11
6	Ponda	292.8	6
District: South Goa			
7	Sanguem	873.7	18
8	Cancona	352.0	10
9	Quepem	318.3	5
10	Salcete	292.9	13
11	Mormugao	109.1	2

*Source: Statistical Pocket Book of Goa 1993-94, Directorate of Planning, Statistics and Evaluation, Government of Goa

1.2 Physiography

Goa State forms a part of coastal tract on the west coast of India. Physiographically, the Goa State is divided into four morphological units namely

1. Coastal plains with dominant marine land forms on the west followed successively towards the east
2. Vast etch plain
3. Low dissected denudation hills and table land
4. Deeply dissected high Western Ghats denudational hills occurring all along the eastern part of Goa rising to a maximum of 832 m above mean sea level. The alluvial landforms are limited in aerial extent.

1.3 Drainage

The State of Goa is drained by the west flowing rivers- Terekhol, Chapora, Mandovi and Zuari. The Sahyadri hill ranges in the east form the main watershed. The streams originating here flow in westerly and northwesterly direction to join the Arabian Sea. Major portion of the State is drained by the two rivers, viz. Mandovi and Zuari. The river Terekhol forms the northern boundary of Goa State and separates it from the Maharashtra State. The other smaller rivers draining the State are Chapora, Baga, Saleri, Sal, Talpona and Galgibaga (**Table 2**).

Table 2: Details of the Major/Minor river Basin area in Goa State

Drainage Basin / Sub Basin	Area		Taluks
	Sq. km	%	
Terekhol	71	1.93	Pernem
Chapora	255	6.88	Pernem, Bicholim and Bardez
Baga	50	1.35	Bardez
Mandovi	1580	42.68	Bicholim, Bardez, Satari, Sanguem, Tiswadi and Ponda
Zuari	973	26.28	Tiswadi, Ponda, Salcete, Quepem, Mormugao, Sanguem and Canacona
Sal	301	8.13	Mormugao, Salcete, Quepem and Canacona
Saleri	149	4.03	Quepem and Canacona
Talpona	233	6.29	Canacona and Sanguem
Galgibaga	90	2.43	Canacona
Total	3702	100	

Primarily the underlying rocks govern the drainage system in the area. The drainage pattern is generally of dendritic type. The major river Zuari follows the major NW synclinal axis. The river valleys are 'V' shaped in the western high hill ranges, but broadens in central midlands and become 'U' shaped in the low lands and coastal plains (**Plate I**).

1.4 GEOLOGICAL CONDITIONS

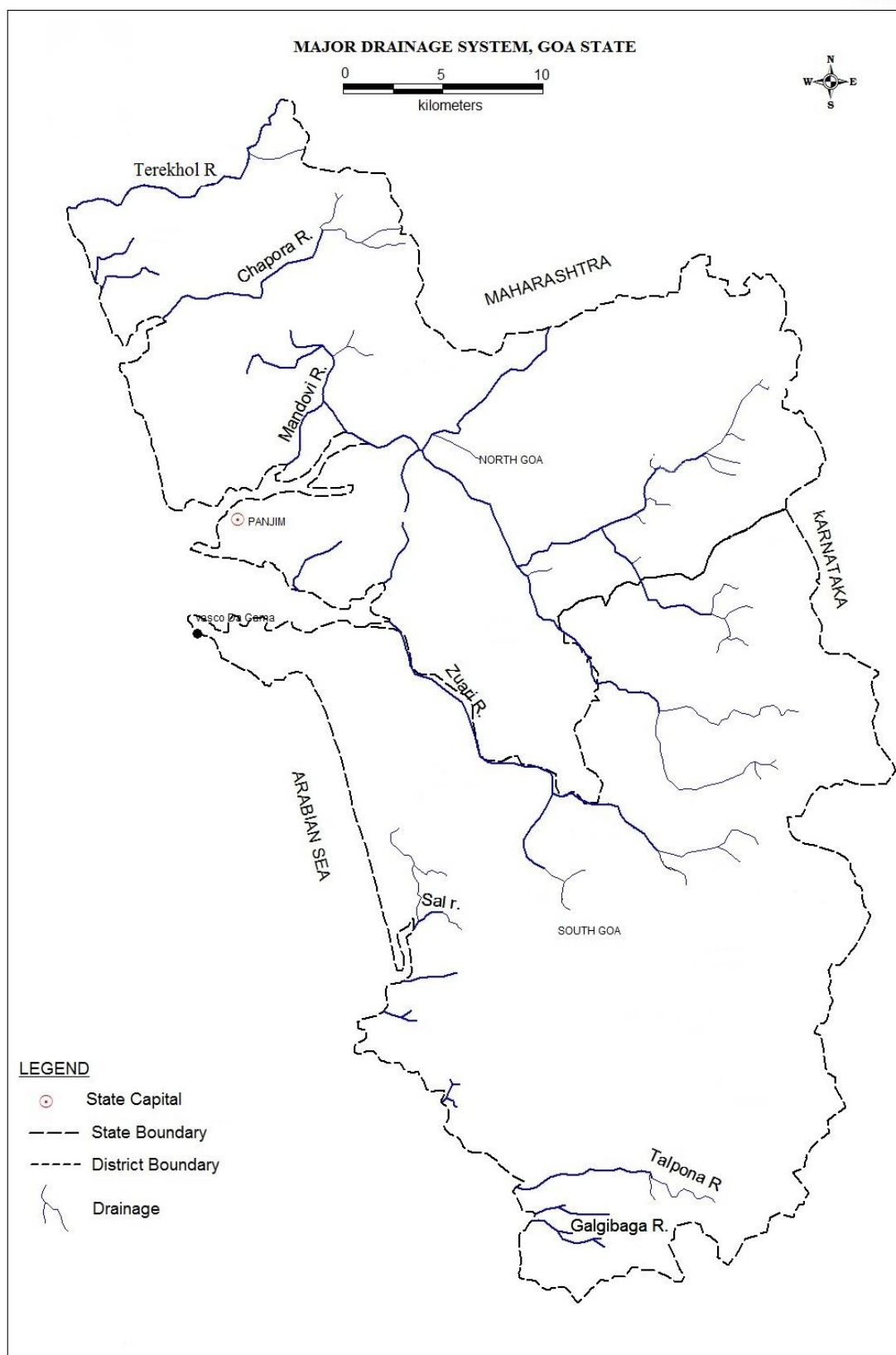
Major part of the Goa State is underlain by rocks of Precambrian age comprising of banded biotite gneisses, Meta volcanics, phyllites, biotite and chlorite schists, greywacke, conglomerate (tilloid), pink phyllites with associated banded ferruginous quartzite and chert breccia. These rocks are intruded by ultra basic, basic sills and dykes, followed by granites and pegmatites. Dolerite dykes and quartz veins form the youngest intrusives in the area (**Plate II**).

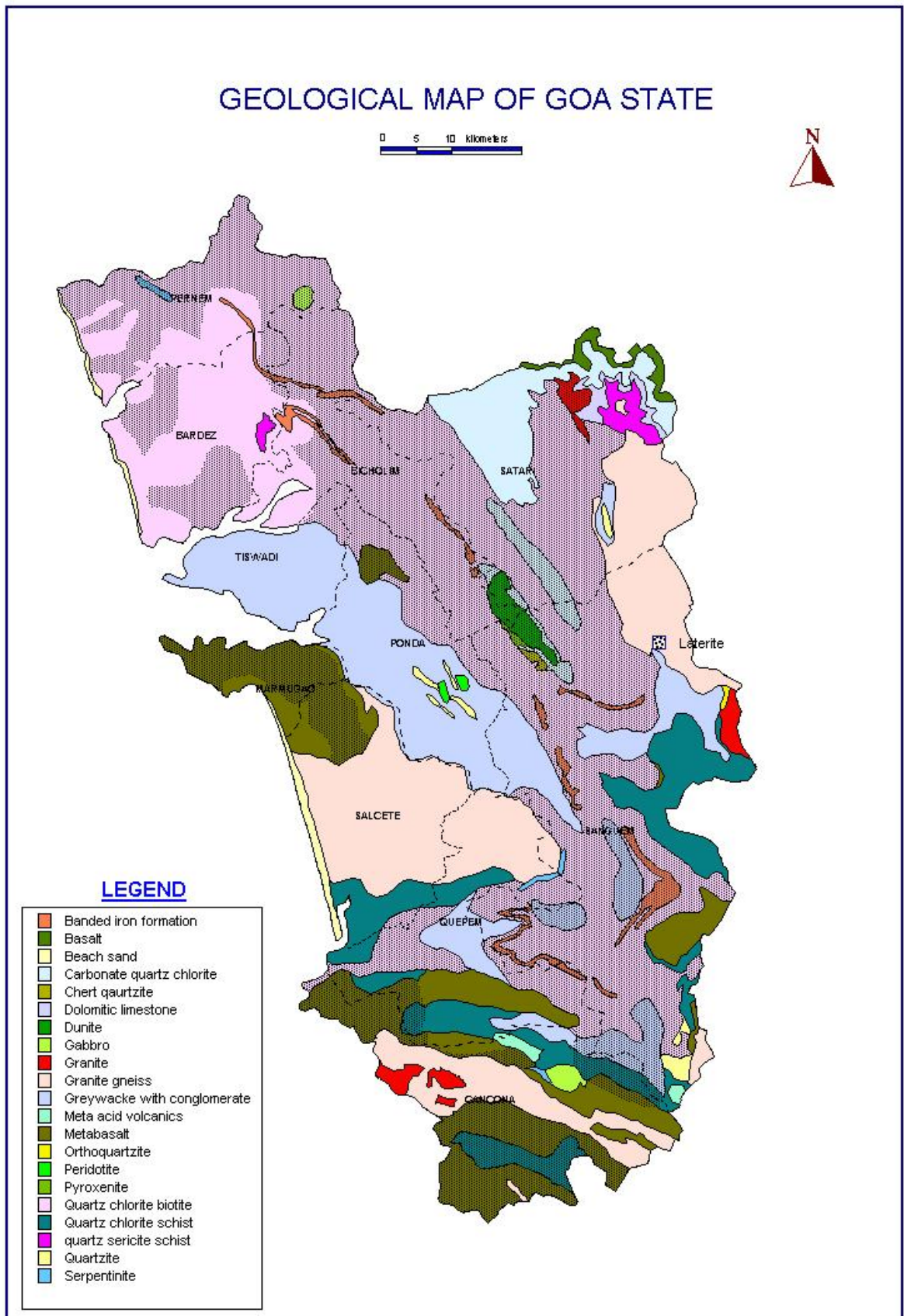
The Deccan Trap basalts of Late Cretaceous to Early Eocene age occupy a small portion in the north eastern part in the high altitudes.

Almost all formations in the state have undergone lateritisation to various degrees depending upon the climate and rock type. The lateritisation is more pronounced in the coastal areas than in the hilly regions Phyllites, Schists and Meta volcanics are more susceptible to lateritisation and the gneissic / granitic rocks are least susceptible. In general, the thickness of laterites varies from about 3 to 30 mts. Laterites are highly porous due to the process of leaching and weathering. Hence, they have very good capacity to hold and transmit groundwater. Groundwater in laterites occurs under phreatic conditions.

Major portion of the state is occupied mainly by crystalline rocks and consolidated and metamorphosed sedimentaries, which do not possess primary porosity. Secondary porosity introduced through weathering, fracturing and jointing, produces the void spaces to hold and transmit ground water. Groundwater in these rocks occurs under water table conditions in the weathered zone and under semi confined and confined conditions in the deeper fractured zone.

Beach sands along the coast and alluvium along major rivers have limited occurrence and the ground water occurs in the primary porosity under water table conditions.





2.0 CLIMATE AND RAINFALL

The State has a tropical-maritime monsoonal type climate with distinct aerographic influence. The climate is equable and humid throughout the year. Due to the maritime climate the diurnal variation in temperature is not much. The months of January and February are generally pleasant with dry and clear skies. May is the hottest month with temperature around 30°C and January the coolest month with temperature around 25°C.

2.1 Rainfall

Rain occurs during the monsoon period from June to September. Over 90 percent of annual rainfall occurs during monsoon period. The balance of 10 percent occurs during the pre monsoon period from March to May and post monsoon period from October to December. However the rainy period extends from May to November.

The analysis of Rainfall data for the period of 1970 to 2000 from 12 stations over the Goa state indicates that the monsoon rainfall is in the order of 3460 mm (more than 99 % of annual rainfall), 218.1 mm (6%) during post monsoon period of October to December and 102.5 (3%) are from January to May months. The overall annual rainfall over the Goa state is based on 30 years rainfall data which is 3483.3mm. The minimum rainfall of 2611.7 mm is recorded at Mormugao station in South Goa district and maximum of 5090 mm is in Sanguem station which is also from South Goa. The annual normal rainfall in North Goa ranges from 2766.9 at Panaji along the west coast and highest at Valpoi in the east Ghats section indicating rainfall increases from west to east. Average rainfall in North Goa is 3400.1mm. Similarly in South Goa it ranged 2611.7 mm at Mormugao in west coast and maximum at Sanguem in the eastern ghat section indicating that the rainfall increases from west to east. The overall annual normal rainfall in south Goa is 3733.13mm.

The months of June (840.7mm) and July (1246.9 mm) are the wettest months with around 2187.6 mm (63%) of annual normal rainfall rainfall in two months. Rainfall during the months of January and February is negligible. Valpoi in the north Goa and Sanguem in the south Goa, both in the interior hilly areas, are wettest places in the state. Isohyetal Map of Goa state for the period 1970 to 2000 has been presented in **Plate III**. Normal monthly rainfall in respect of 12 stations of Goa state is presented in **Table 3**.

**NORMAL MONSOON (JUNE - SEPTEMBER) RAINFALL
(1970-2000) GOA STATE**

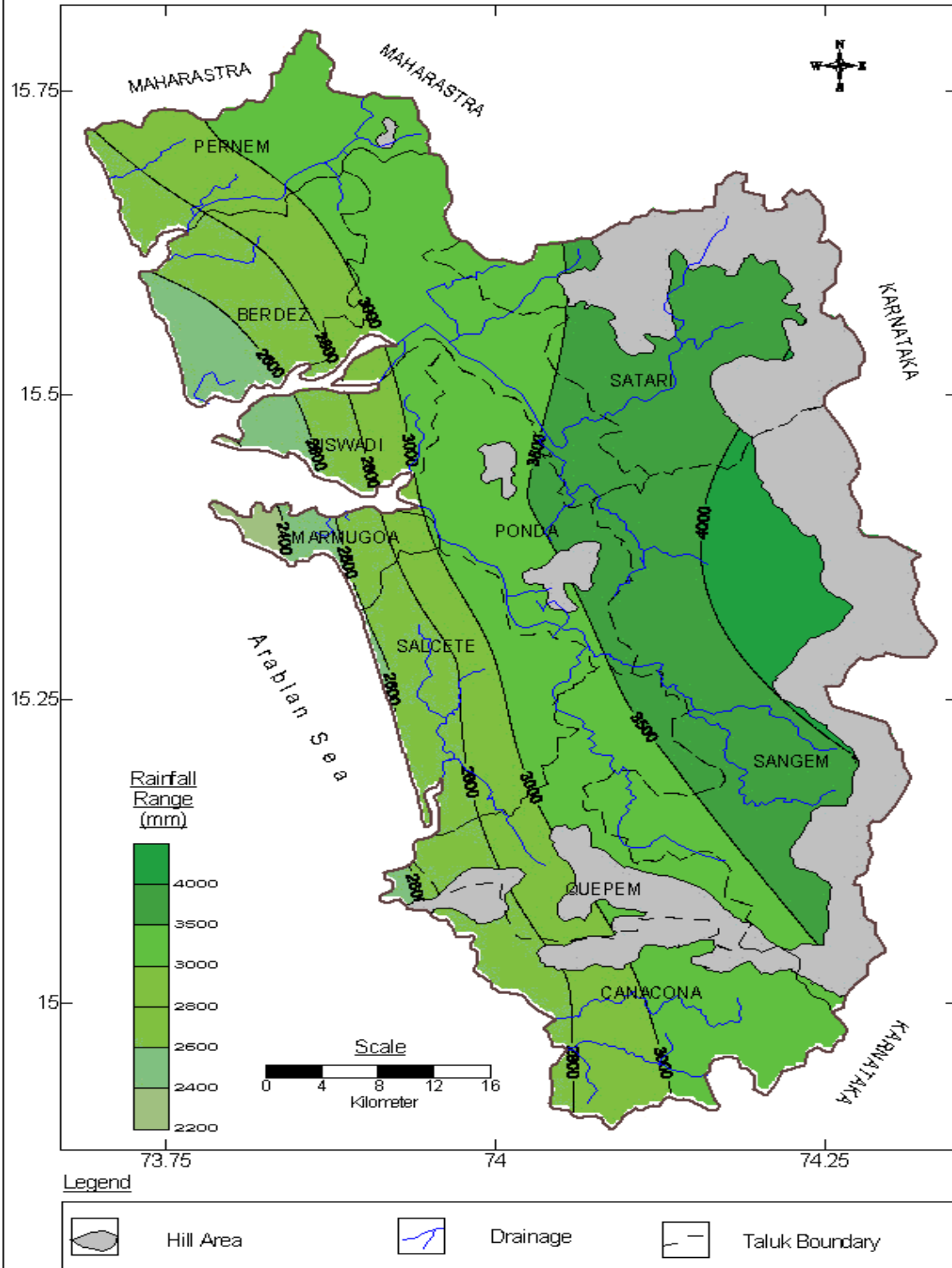


Table 3: Monthly Normal Rainfall of Goa State (in mm)

Station	JAN	FEB	Winter	MAR	APR	MAY	Pre Mon	JUN	JUL	AUG	SEP	SW Mon	OCT	NOV	DEC	NE Mon	ANNUAL
PERNEM	1.0	0.3	1.3	0.8	13.6	69.5	83.9	923.8	1220.8	623.3	277.7	3045.6	146.4	34.0	2.9	183.3	3314.1
MAPUSA	1.1	0.2	1.3	0.2	15.8	89.8	105.8	870.0	1009.3	538.9	276.0	2694.2	127.5	33.8	2.6	163.9	2965.3
BICHOLIM	1.0	0.2	1.2	0.1	10.0	64.4	74.5	957.5	1264.9	659.6	312.1	3194.1	196.7	50.0	3.6	250.3	3520.1
PONDA	1.2	0.1	1.3	0.3	21.0	91.0	112.3	1072.6	1358.0	691.2	323.3	3445.1	177.4	46.4	2.7	226.5	3785.2
VALPOI	1.4	0.1	1.5	0.9	13.7	92.3	106.9	955.5	1486.3	849.0	378.4	3669.2	216.6	51.2	4.1	271.9	4049.5
COLEM	1.4	0.3	1.7	1.7	19.8	111.5	133.0	1075.2	1800.1	1091.7	516.7	4483.7	266.3	60.8	5.3	332.4	4950.8
MARGAO	1.3	0.4	1.7	0.1	16.4	86.8	103.3	913.1	1054.4	505.8	257.2	2730.5	117.8	40.1	3.9	161.8	2997.3
QUEPEM	0.2	0.3	0.5	0.0	12.2	93.1	105.3	960.9	1378.2	712.7	320.2	3372.0	165.0	56.4	0.3	221.7	3699.5
SANGUEM	0.6	0.0	0.6	1.6	11.5	78.9	92.0	1010.5	1537.2	774.7	391.6	3714.0	215.0	64.5	3.9	283.4	5090.0
CANACONA	0.6	0.0	0.6	0.4	16.2	96.2	112.8	902.0	1025.0	537.4	293.2	2757.6	130.1	41.2	7.2	178.5	3049.5
PANAJI	1.7	0.1	1.8	0.7	18.4	86.6	105.7	869.4	923.4	456.2	252.7	2501.7	118.9	35.8	3.0	157.7	2766.9
MORMUGOA	1.8	0.0	1.8	0.4	20.3	81.3	102.0	777.8	905.1	412.9	225.9	2321.7	138.7	42.6	4.9	186.2	2611.7
MEAN	1.1	0.2	1.3	0.6	15.7	86.2	102.5	940.7	1246.9	954.3	318.7	3460.6	168.0	46.4	3.7	218.1	3483.3

3.0 DEPTH TO WATER LEVEL

May 2018

The statement showing the distribution of ground water monitoring wells along with depth to water level of phreatic aquifer in different depth ranges is presented in **Table 4** and **Plate-IV** which depicts the ground water scenario in May 2018. Salient features of the depth to water level scenario during May 2018 are given below:

1. A perusal of the water level data reveals that the depth to water level ranged from 0.86 m bgl (Satari taluk) to 14.95 m bgl (Bardez taluk).
2. The salient feature of the analysis is that the depth to water level over major part of the State lies within 10 m bgl in 86% of wells analysed, while 14% of wells show depth to water level more than 10 m bgl.
3. Depth to water level of less than 2 m bgl has been recorded in 8% of wells analysed and noted in Bardez, Pernem, Ponda, Quepem, Satari and Tiswadi taluks.
4. Depth to water level in the range of 2 to 5 m bgl has been recorded in 44% of wells analysed and noted in all the eleven taluks.
5. Depth to water level in the range of 5 to 10 m bgl has been recorded in 34% of wells analysed and noted in almost all taluks except Mormugao taluk
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 14% of wells analysed and noted as isolated patches in Bardez, Bicholim, Canacona, Salcete, Sanguem and Satari taluks.

S.No	Taluk	No of Wells analysed	Min	Max	No/Percentage of Wells showing Depth to water table (mbgl) in the range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Bardez	12	1.91	14.95	1	8.3	7	8.3	1	8.3	3	25	0	0	0	0
2	Bicholim	7	2.74	18.7	0	0	3	42.9	3	42.9	1	14.3	0	0	0	0
3	Canacona	8	3.9	14.63	0	0	4	50	2	25	2	25	0	0	0	0
4	Mormugao	1	2.81	2.81	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	1.93	7.33	1	11.1	6	66.7	2	22.2	0	0	0	0	0	0
6	Ponda	5	1.45	6.5	2	40	1	20	2	40	0	0	0	0	0	0
7	Quepem	3	1.43	6.10	1	33.3	1	33.3	1	33.3	0	0	0	0	0	0
8	Salcete	11	2.19	13.25	0	0	5	45.5	5	45.5	1	9.1	0	0	0	0
9	Sanguem	15	2.51	13.8	0	0	4	26.7	7	46.7	4	26.7	0	0	0	0
10	Satari	10	0.86	10.84	1	10	4	40	4	40	1	10	0	0	0	0
11	Tiswadi	4	1.68	8.30	1	25	1	25	2	50	0	0	0	0	0	0
	Total	87	0.85	14.95	7	8	37	44	29	34	12	14	0	0	0	0

Depth to Piezometric Surface:

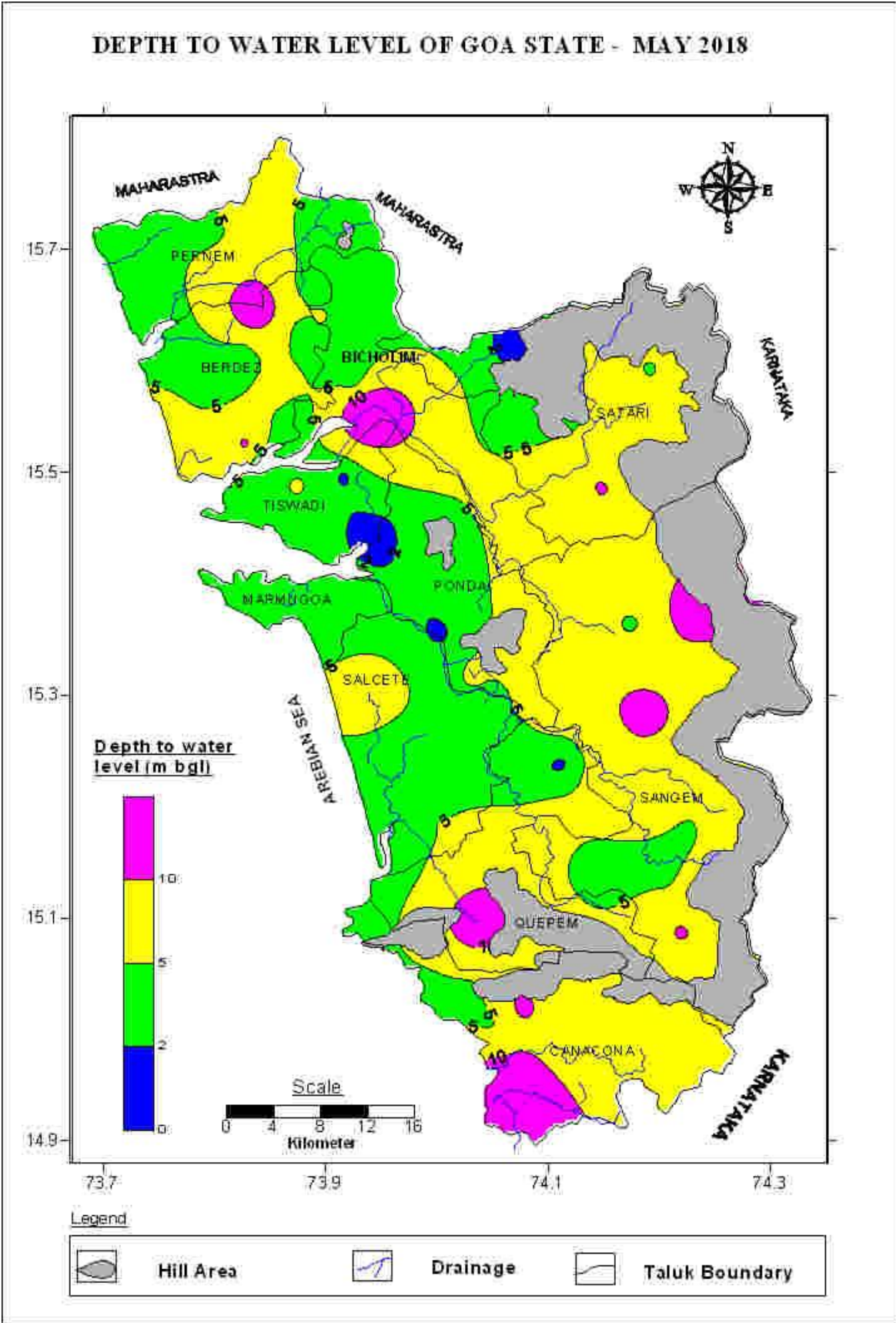
Depth to piezometric surface has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to piezometric surface is given in **Table 5**. Salient features of the depth to piezometric surface during May 2018 are given below:

1. The depth to piezometric surface ranged from 0.3 m bgl (Mormugao taluk) to 23.62 m bgl (Bicholim taluk) in Goa State.
2. 98% of wells have recorded depth to piezometric surface within 20 m bgl and 2% of wells show depth to piezometric surface more than 10 m bgl.
3. Depth to piezometric surface of less than 2 m bgl has been recorded in 12% of wells analysed and this has been noted in Mormugao, Salcete and Tiswadi taluks.
4. Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in 23% of wells analysed and noted in Bardez, Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
5. Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in 26 % of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Salcete, Sanguem, and Satari taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 37% of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Ponda, Quepem, Sanguem and Satari taluks.
7. Depth to piezometric surface in the range of 20 to 40 m bgl has been observed in 2% of wells analysed and noted only in Bicholim taluk.

Table 5: Depth to Piezometric Surface (May 2018)

S.No	Taluk	No. of Wells Analysed	Min	Max	No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Bardez	4	4.77	19.81	0	0	1	25	1	25	2	50	0	0	0	0
2	Bicholim	4	6	23.62	0	0	0	0	2	50	1	25	1	25	0	0
3	Canacona	5	7.25	12.77	0	0	0	0	2	40	3	60	0	0	0	0
4	Marmugoa	1	0.3	0.3	1	66.7	0	0	0	0	0	0	0	0	0	0
5	Pernem	8	2.8	18.05	0	0	2	25	2	25	4	50	0	0	0	0
6	Ponda	2	16.77	18	0	0	0	0	0	0	2	100	0	0	0	0
7	Quepem	1	15.8	15.8	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	8	1.71	6.6	2	25	2	50	2	25	0	0	0	0	0	0
9	Sanguem	3	4.7	10.96	0	0	1	33.3	1	33.3	1	33.3	0	0	0	0
10	Satari	4	4.62	18.8	0	0	1	25	1	25	2	50	0	0	0	0
11	Tiswadi	3	0.49	4.4	2	100	1	33.3	0	0	0	0	0	0	0	0
	Total	43	0.3	23.62	5	12	10	23	11	26	16	37	1	2	0	0

DEPTH TO WATER LEVEL OF GOA STATE - MAY 2018



August 2018

The statement showing the distribution of ground water monitoring wells along with depth to water level of phreatic aquifer in different depth ranges is presented in **Table 6 and Plate V** which depicts the ground water scenario in August 2018. Salient features of the depth to water level scenario during August 2018 are given below.

1. A perusal of the water level data reveals that the depth to water level ranged from 0.30 m bgl (Canacona taluk) to 14.50 m bgl (Canacona taluk).
2. The salient feature of the analysis is that the depth to water level over major part of the State lies within 10 m bgl in 98% of wells analysed, while 2% of wells show depth to water level more than 10 m bgl.
3. Depth to water level of less than 2 m bgl has been recorded in 40% of wells analysed and noted in all taluks except Mormugao taluk.
4. Depth to water level in the range of 2 to 5 m bgl has been recorded in 42% of wells analysed and noted in all the taluks.
5. Depth to water level in the range of 5 to 10 m bgl has been recorded in 16% of wells analysed and noted Bardez, Canacona, Pernem, Salcete and Sanguem taluks.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 2% of wells analysed and noted as isolated patch in Bardez and Canacona taluks.

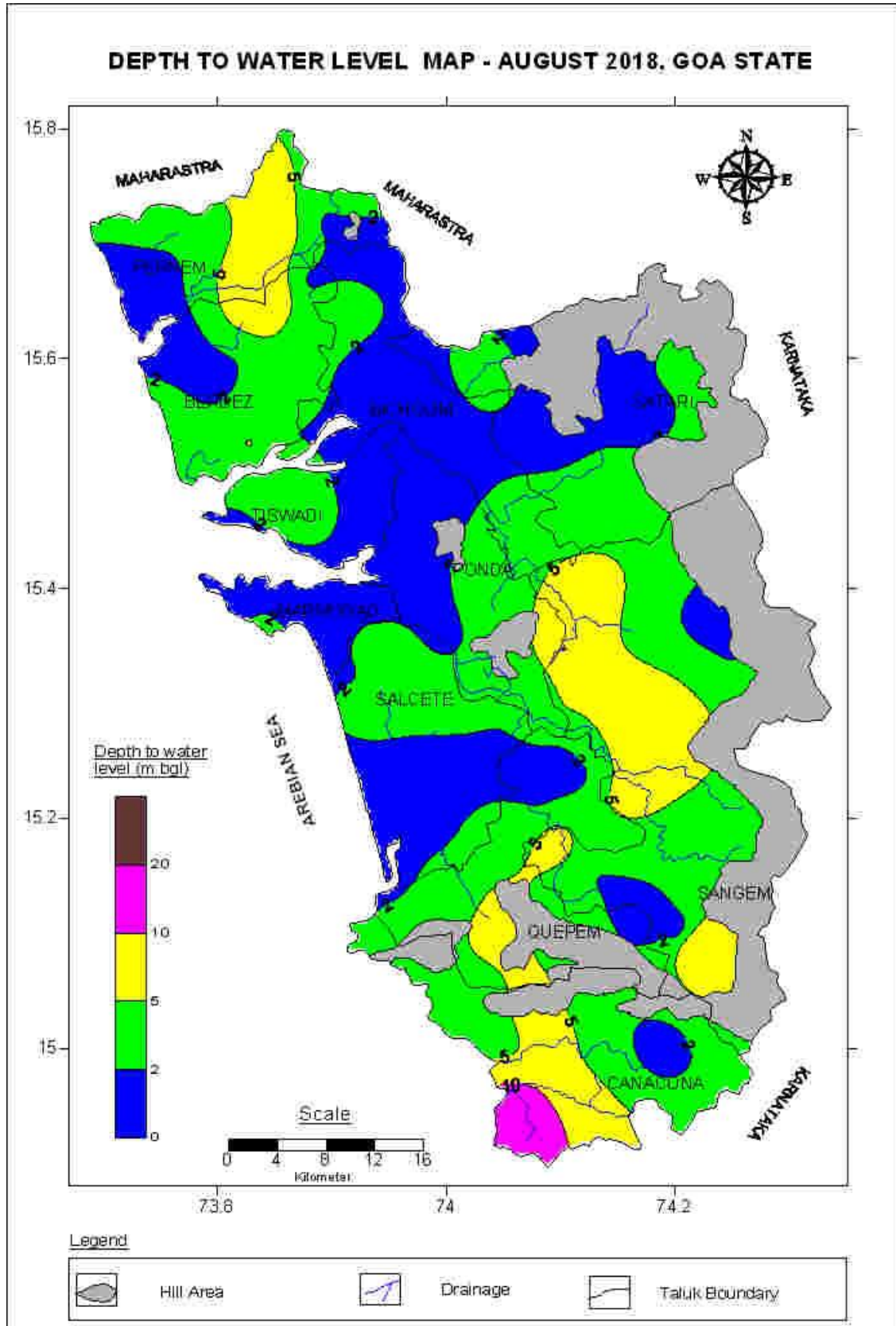
Table 6: Depth to Water Level (August 2018)																
S. No	Taluk	No of Wells analysed	Min	Max	No/Percentage of Wells showing Depth to water table (mbgl) in the range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	> 40	%
1	Bardez	12	0.65	10.55	4	33.3	5	41.7	2	16.7	1	8.3	0	0	0	0
2	Bicholim	6	0.9	4.53	3	50	3	50	0	0	0	0	0	0	0	0
3	Canacona	7	0.3	14.50	2	28.6	2	28.6	2	28.6	1	14.3	0	0	0	0
4	Mormugao	1	2.4	2.4	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	0.63	7.33	3	33.3	4	44.4	2	22.2	0	0	0	0	0	0
6	Ponda	5	1.2	5	2	40	3	60	0	0	0	0	0	0	0	0
7	Quepem	3	0.71	2.76	2	66.7	1	33.3	0	0	0	0	0	0	0	0
8	Salcete	11	0.58	5.7	6	54.5	4	36.4	1	9.1	0	0	0	0	0	0
9	Sanguem	15	0.42	9.18	3	20	6	40	6	40	0	0	0	0	0	0
10	Satari	10	0.5	3.18	6	60	4	40	0	0	0	0	0	0	0	0
11	Tiswadi	4	0.52	4.45	2	50	2	50	0	0	0	0	0	0	0	0
	Total	87	0.3	10.55	33	40	35	42	13	16	2	2	0	0	0	0

Depth to Piezometric Surface:

Depth to piezometric surface has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to piezometric surface is given in **Table 7**. Salient features of the depth to piezometric surface during August 2018 are given below:

1. The depth to piezometric surface ranged from 0.04 m bgl (Mormugao taluk) to 17.5 m bgl (Bicholim taluk) in Goa State.
2. All the wells have recorded depth to piezometric surface within 20 m bgl.
3. Depth to piezometric surface of less than 2 m bgl has been recorded in 29% of wells analysed and this has been noted in Canacona, Mormugao, Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
4. Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in 32% of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
5. Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in 20 % of wells analysed and noted in Bardez, Bicholim, Canacona, Ponda and Satari taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 20% of wells analysed and noted in Bicholim, Pernem, Ponda, Quepem, and Satari taluks.

S. No	Taluk	No. of Wells Analysed	Min	Max	No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Bardez	3	3.72	8.9	0	0	1	33.3	2	66.7	0	0	0	0	0	0
2	Bicholim	4	4.05	17.5	0	0	1	25	1	25	2	50	0	0	0	0
3	Canacona	5	1.84	7.88	1	20	1	20	3	60	0	0	0	0	0	0
4	Mormugoa	1	0.04	0.04	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	7	1.69	17.05	2	28.6	2	28.6	0	0	3	42.9	0	0	0	0
6	Ponda	2	7.2	13.53	0	0	0	0	1	50	1	50	0	0	0	0
7	Quepem	1	10.73	10.73	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	8	0.04	3.97	4	50	4	50	0	0	0	0	0	0	0	0
9	Sanguem	4	0.67	3.81	2	50	2	50	0	0	0	0	0	0	0	0
10	Satari	4	0.67	16.58	1	25	1	25	1	25	1	25	0	0	0	0
11	Tiswadi	2	0.5	2.63	1	50	1	50	0	0	0	0	0	0	0	0
	Total	41	0.04	17.5	12	29	13	32	8	20	8	20	0	0	0	0



November 2018

The statement showing the distribution of ground water monitoring wells along with depth to water level of phreatic aquifer in different depth ranges is presented in **Table 8** and **Plate VI** which depicts the ground water scenario in November 2018. Salient features of the depth to water level scenario during November 2018 are given below.

1. A perusal of the water level data reveals that the depth to water level ranged from 0.78 m bgl (Salcete taluk) to 15.39 m bgl (Canacona taluk).
2. The salient feature of the analysis is that the depth to water level over major part of the State lies within 10 m bgl in 91% of wells analysed, while 9% of wells show depth to water level more than 10 m bgl.
3. Depth to water level of less than 2 m bgl has been recorded in 14% of wells analysed and noted in Bardez, Canacona, Pernem, Ponda, Quepem, Salcete and Tiswadi taluks.
4. Depth to water level in the range of 2 to 5 m bgl has been recorded in 47% of wells analysed and noted in all the taluks.
5. Depth to water level in the range of 5 to 10 m bgl has been recorded in 30% of wells analysed and noted in all the taluks except Mormugao and Quepem taluks.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 9% of wells analysed and noted as isolated Bardez, Bicholim, Cancona and Sanguem taluks.

Table 8: Depth to Water Level (November 2018)

S.No	Taluk	No of Wells analysed	Min	Max	No/Percentage of Wells showing Depth to water table (mbgl) in the range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	> 40	%
1	Bardez	13	1.38	13.51	3	23	6	46	2	15	2	15	0	0	0	0
2	Bicholim	7	2.01	14.79	0	0	3	43	3	43	1	14	0	0	0	0
3	Canacona	9	1.49	15.39	2	22	3	33	1	11	3	33	0	0	0	0
4	Mormugao	1	2.95	2.95	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	0.91	7.85	1	11	6	67	2	22	0	0	0	0	0	0
6	Ponda	5	1.4	6.7	2	40	1	20	2	40	0	0	0	0	0	0
7	Quepem	3	1.97	4.52	1	33	2	67	0	0	0	0	0	0	0	0
8	Salcete	11	0.78	6.45	2	18	6	55	3	27	0	0	0	0	0	0
9	Sanguem	15	2.87	11.01	0	0	4	27	9	60	2	13	0	0	0	0
10	Satari	10	2.11	7.64	0	0	7	70	3	30	0	0	0	0	0	0
11	Tiswadi	4	0.99	8.4	1	25	2	50	1	25	0	0	0	0	0	0
	Total	87	0.78	15.39	12	14	41	47	26	30	8	9	0	0	0	0

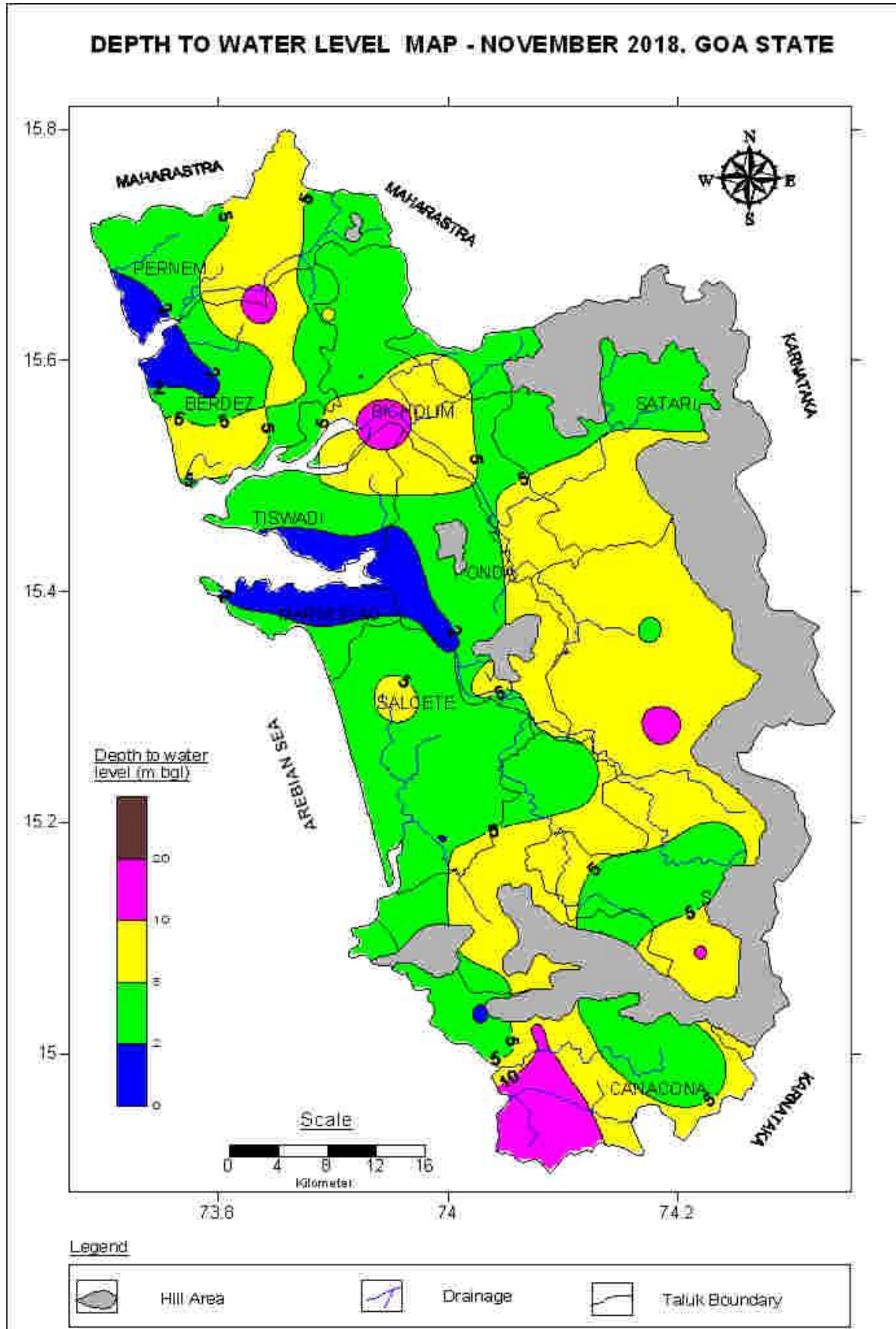
DEPTH TO PIEZOMETRIC SURFACE

Depth to piezometric surface has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to piezometric surface is given in **Table 9**. Salient features of the depth to piezometric surface during November 2018 are given below:

1. The depth to piezometric surface ranged from 0.1 m bgl (Bardez taluk) to 24.17 m bgl (Bicholim taluk) in Goa State.
2. 70% of wells have recorded depth to piezometric surface within 10 m bgl and 30% of wells show depth to piezometric surface more than 10 m bgl.
3. Depth to piezometric surface of less than 2 m bgl has been recorded in 20% of wells analysed and this has been noted in Bardez, Mormugao, Pernem, Salcete and Tiswadi taluks.
4. Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in 27% of wells analysed and noted in Bardez, Cancona, Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
5. Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in 23 % of wells analysed and noted in Bardez, Bicholim, Canacona, Sanguem and Satari taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 23% of wells analysed and noted in Bardez, Bicholim, Pernem, Ponda, Quepem, Sanguem and Satari taluks.
7. Depth to piezometric surface in the range of 20 to 40 m bgl has been noted in 7 % of wells analysed and noticed in Bicholim and Satari taluks.

Table 9: Depth to Piezometric Surface (November 2018)

S.No	Taluku	No. of Wells Analysed	Min	Max	No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	>40	%
1	Bardez	5	0.1	15.03	1	20	1	20	2	40	1	20	0	0	0	0
2	Bicholim	4	9.43	24.17	0	0	0	0	1	25	1	25	2	50	0	0
3	Canacona	5	3.84	9.54	0	0	1	20	4	80	0	0	0	0	0	0
4	Mormugao	1	0.32	0.32	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	7	1.83	18.05	1	14.3	3	42.9	0	0	3	42.9	0	0	0	0
6	Ponda	2	15.51	18.14	0	0	0	0	0	0	1	100	0	0	0	0
7	Quepem	1	13.86	13.86	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	8	0.83	4.75	4	50	4	50	0	0	0	0	0	0	0	0
9	Sanguem	4	3.97	10.78	0	0	1	25	2	50	1	25	0	0	0	0
10	Satari	4	3.23	20.05	0	0	1	25	1	25	1	25	1	25	0	0
11	Tiswadi	3	0.53	4.11	2	66.7	1	33.3	0	0	0	0	0	0	0	0
	Total	44	0.1	24.17	9	20	12	27	10	23	10	23	3	7	0	0



January 2019

The statement showing the distribution of ground water monitoring wells along with depth to water level of phreatic aquifer in different depth ranges is presented in **Table 10** and **Plate VII** which depicts the ground water scenario in January 2019. Salient features of the depth to water level scenario during January 2019 are given below.

1. A perusal of the water level data reveals that the depth to water level ranged from 1.43 m bgl (Pernem taluk) to 15.06 m bgl (Bicholim taluk).
2. The salient feature of the analysis is that the depth to water level over major part of the State lies within 10 m bgl in 89% of wells analysed, while 11% of wells show depth to water level more than 10 m bgl.
3. Depth to water level of less than 2 m bgl has been recorded in 7% of wells analysed and noted in Bardez, Pernem, Ponda, Sattari and Tiswadi taluks.
4. Depth to water level in the range of 2 to 5 m bgl has been recorded in 49% of wells analysed and noted in all the taluks.
5. Depth to water level in the range of 5 to 10 m bgl has been recorded in 33% of wells analysed and noted in all the taluks except Mormugao and Quepem taluks.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 11% of wells analysed and noted as isolated patch in Bardez, Bicholim, Canacona, Salcete and Sanguem taluks.

Table 10: Depth to Water Level (January 2019)

S.No	Taluks	No of Wells analysed	Min	Max	No/Percentage of Wells showing Depth to water table (mbgl) in the range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	> 40	%
1	Bardez	12	1.8	14.05	2	16.7	6	50	1	8.3	3	25	0	0	0	0
2	Bicholim	7	2.56	15.06	0	0	3	42.9	3	42.9	1	14.3	0	0	0	0
3	Canacona	8	3.57	14.67	0	0	5	62.5	1	12.5	2	25	0	0	0	0
4	Mormugoa	1	2.85	2.85	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	1.43	7.5	1	11	6	66.7	2	22.2	0	0	0	0	0	0
6	Ponda	5	1.65	6.51	1	20	1	20	3	60	0	0	0	0	0	0
7	Quepem	3	2.05	4.48	0	0	3	100	0	0	0	0	0	0	0	0
8	Salcete	11	2.08	10.76	0	0	8	73	2	18.2	1	9.1	0	0	0	0
9	Sanguem	15	2.49	11.2	0	0	3	20	10	66.7	2	13.3	0	0	0	0
10	Sattari	10	1.89	7.86	1	10	5	50	4	40	0	0	0	0	0	0
11	Tiswadi	4	1.83	8.45	1	25	1	25	2	50	0	0	0	0	0	0
	Total	85	1.43	15.06	6	7	42	49	28	33	9	11	0	0	0	0

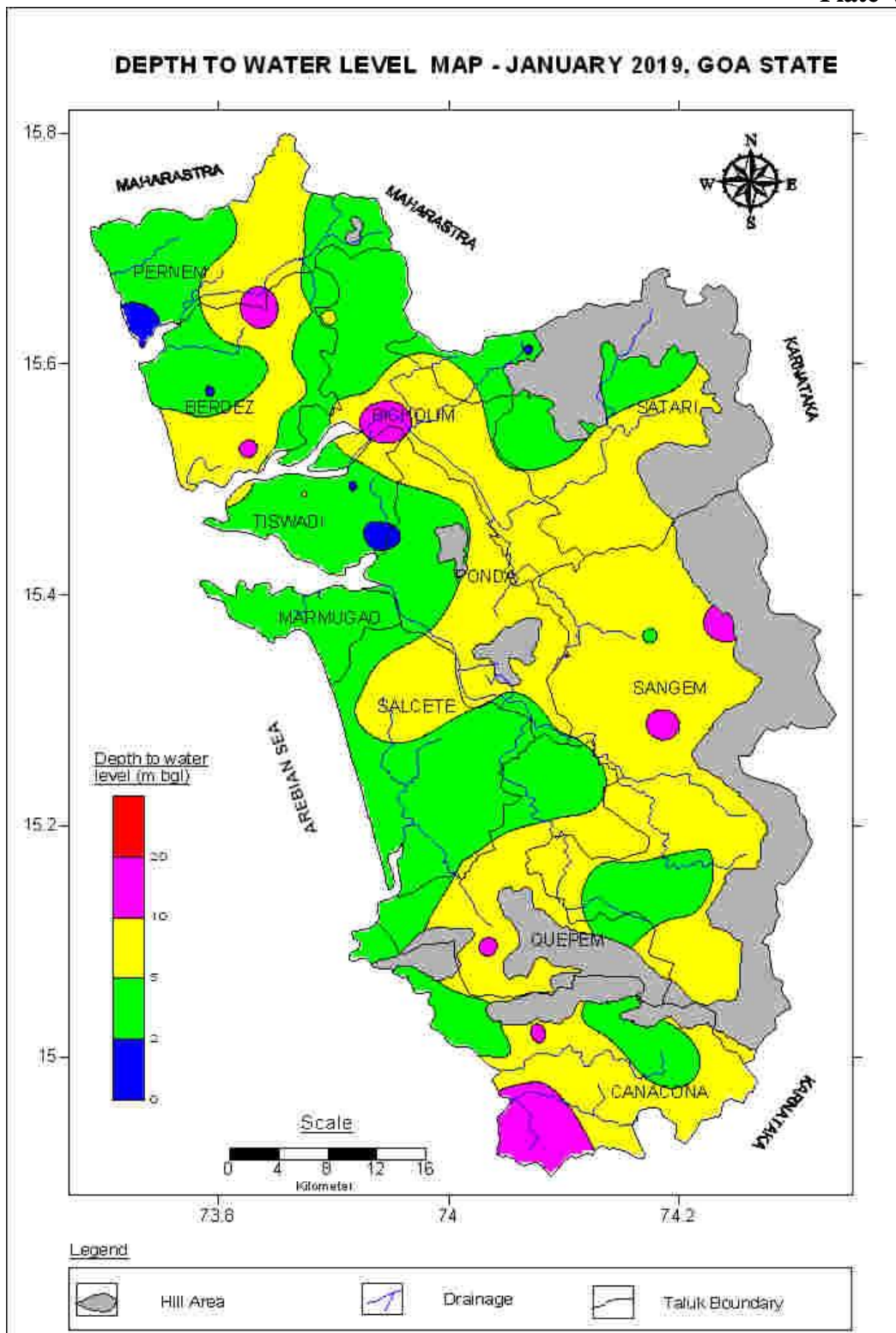
DEPTH TO PIEZOMETRIC SURFACE

Depth to piezometric surface has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to piezometric surface is given in **Table 11**. Salient features of the depth to piezometric surface during January 2019 are given below:

1. The depth to piezometric surface ranged from 0.3 m bgl (Mormugao taluk) to 20.93 m bgl (Bardez taluk) in Goa State.
2. 67% of wells have recorded depth to piezometric surface within 10 m bgl and 33% of wells show depth to piezometric surface more than 10 m bgl.
3. Depth to piezometric surface of less than 2 m bgl has been recorded in 16% of wells analysed and this has been noted in Bardez, Mormugao, Salcete and Tiswadi taluks.
4. Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in 18% of wells analysed and noted in Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
5. Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in 33 % of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Salcete, Sanguem and Satari taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 27% of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Ponda, Quepem, Sanguem and Satari taluks.
7. Depth to piezometric surface in the range of 20 to 40 m bgl has been noted in 7 % of wells analysed and noticed in Bardez, Bicholim and Ponda taluks.

Table 11: Depth to Piezometric Surface (January 2019)

S.No	Taluks	No. of Wells Analysed	Min	Max	No. / Percentage of Wells Showing Depth to Water Table (mbgl) in the Range of											
					0-2	%	2-5	%	5-10	%	10-20	%	20-40	%	> 40	%
1	Bardez	5	2	20.93	1	20	0	0	2	40	1	20	1	20	0	0
2	Bicholim	4	6.2	26	0	0	0	0	2	50	1	25	1	25	0	0
3	Canacona	5	5.75	10.92	0	0	0	0	4	80	1	20	0	0	0	0
4	Mormugoa	1	0.3	0.3	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	8	2.15	19.3	0	0	3	37.5	1	12.5	4	50	0	0	0	0
6	Ponda	2	16.46	20.9	0	0	0	0	0	0	1	50	1	50	0	0
7	Quepem	1	14.78	14.78	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	8	1.5	5.88	3	37.5	2	25	3	37.5	0	0	0	0	0	0
9	Sanguem	4	4.01	11.38	0	0	1	25	2	50	1	25	0	0	0	0
10	Satari	4	3.98	18.88	0	0	1	25	1	25	2	50	0	0	0	0
11	Tiswadi	3	0.8	4.4	2	66.7	1	33	0	0	0	0	0	0	0	0
	Total	45	0.3	20.93	7	16	8	18	15	33	12	27	3	7	0	0



4. FLUCTUATION OF WATER LEVEL

MAY 2018 & NOVEMBER 2018

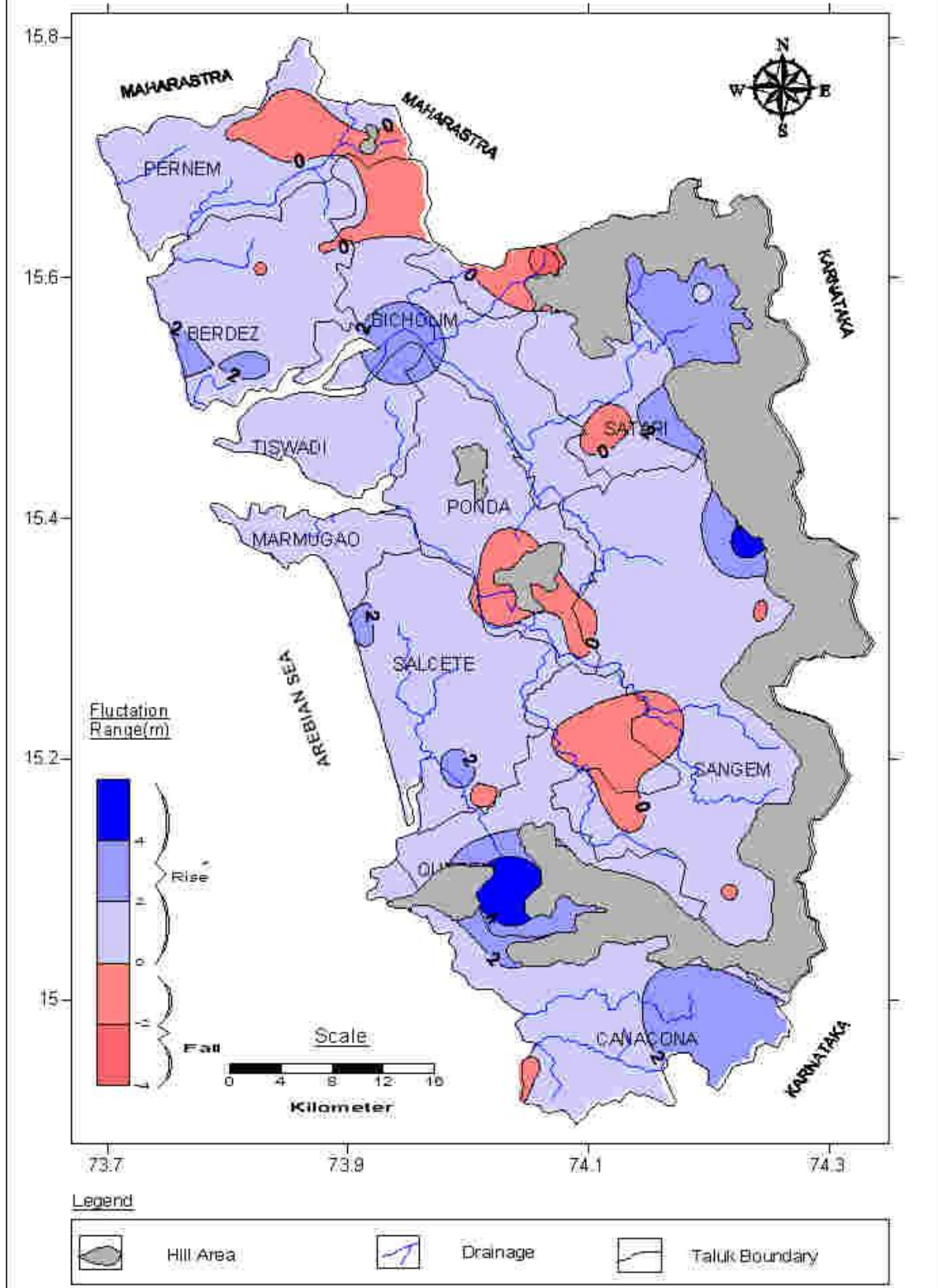
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 12** and **Plate VIII**. A comparison of water level shows that a fall in the water level is recorded in 28% of wells analysed, while 72% recorded rise.

1. Rise in the water level in the range of 0-2 m has been observed in 54% of wells analysed and noticed in all taluks except Mormugao taluk.
2. Rise in the water level in the range of 2-4 m has been observed in 16% of wells analysed and noted in Bardez, Bicholim, Canacona, Salcete, Sanguem and Satari taluks.
3. Rise in water level more than 4 m has been observed in 2% of wells analysed and noted in Salcete and Sanguem taluks.
4. The fall in water level in the range of 0-2 m has been observed in 27% of wells analysed and noticed in almost all the taluks.
5. The fall in water level in the range of 2-4 m has been observed in 1% of wells analysed and noted in parts Satari taluk.

Table 12: District wise categorisation of water level fluctuation (May 2018-Nov 2018)

S.No	Taluk	No of wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	12	6	50	2	16.7	0	0	4	33.3	0	0	0	0	8	4
2	Bicholim	7	4	57.5	1	14.3	0	0	2	28.6	0	0	0	0	5	2
3	Canacona	8	5	62.5	2	25	0	0	1	12.5	0	0	0	0	7	1
4	Marmugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Pernem	9	6	66.7	0	0	0	0	3	33.3	0	0	0	0	6	3
6	Ponda	5	3	60	0	0	0	0	2	40	0	0	0	0	3	2
7	Quepem	3	1	33.3	0	0	0	0	2	66.7	0	0	0	0	1	2
8	Salcete	11	6	54.5	3	27.3	1	9.1	1	9.1	0	0	0	0	10	1
9	Sanguem	15	10	66.7	1	6.7	1	6.7	3	20	0	0	0	0	12	3
10	Satari	10	2	20	4	40	0	0	3	30	1	10	0	0	6	4
11	Tiswadi	3	2	66.7	0	0	0	0	1	33.3	0	0	0	0	2	1
	Total	84	45	54	13	16	2	2	23	27	1	1	0	0	60	24

WATER LEVEL FLUCTUATION MAY 2018 - NOVEMBER 2018, GOA STATE

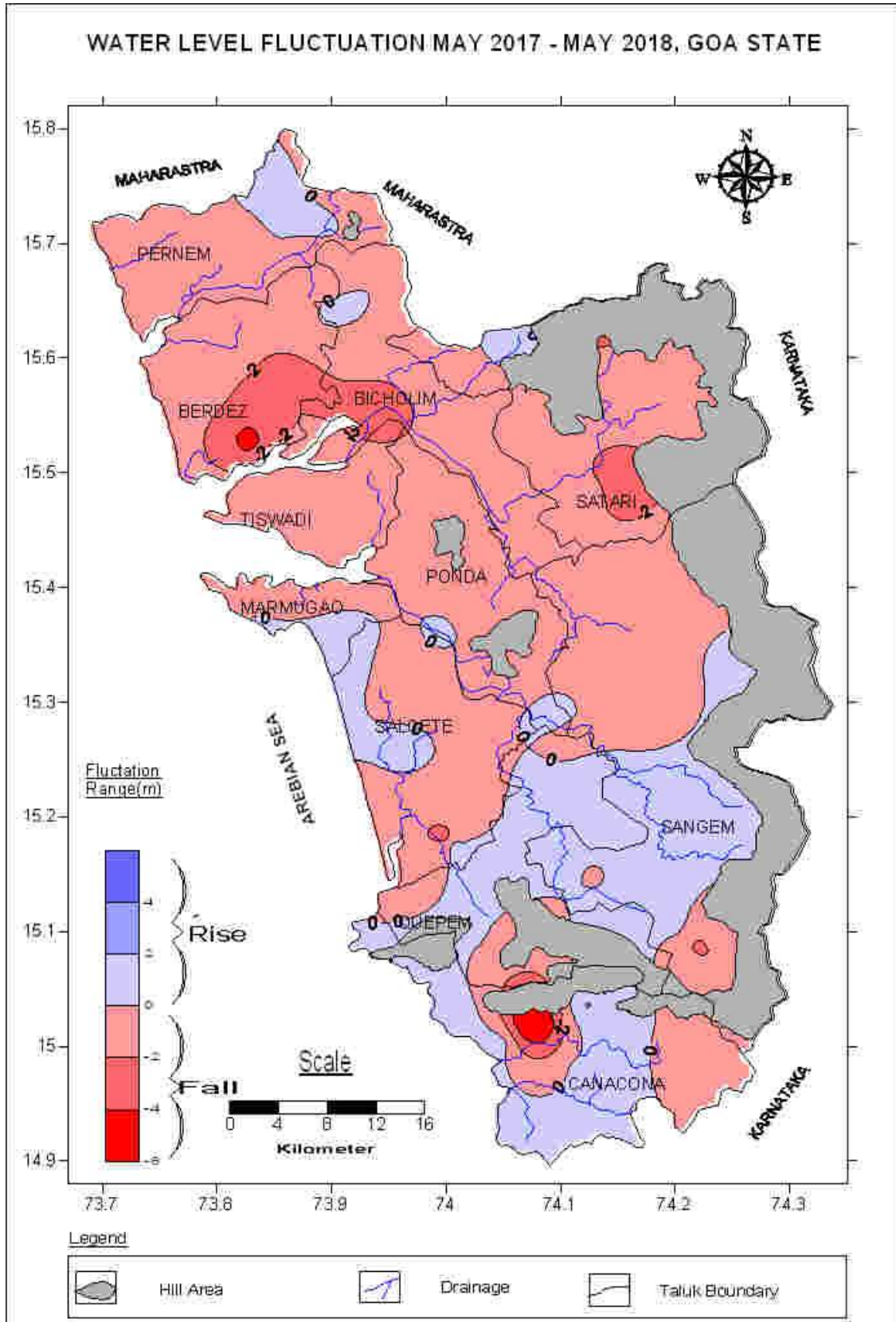


May 2017 & May 2018

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 13**. A comparison of water level shows that a fall in the water level is recorded in 36% of wells analysed, while 64% recorded rise. The fluctuation in water level has been plotted in **Plate IX**. A perusal of the plate shows that a general fall in the range of 0 – 2 m is noticed in major part of the area, followed by a rise of 0 – 2 m.

1. Rise in the water level in the range of 0-2 m has been observed in 35% of wells analysed and observed in all taluks except Bardez taluk.
2. Rise in water level in the range of 2-4 m has been observed in 1% of wells analysed and noted in Canacona taluk.
3. Fall in water level in the range of 0-2 m has been observed in 49% of wells analysed and noted in almost all taluks except Marmugoa.
4. Fall in water level in the range of 2-4 m has been observed in 10% of wells analysed and noted in Bardez, Bicholim, Ponda, Salcete, Sanguem and Satari taluks.
5. Fall in water level more than 4 m has been observed in 4% of wells analysed and noted in Bardez, Bicholim and Canacona taluks.

S.No	Taluk	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	11	0	0	0	0	0	0	9	82	1	9.1	1	9.1	0	11
2	Bicholim	7	1	14.3	0	0	0	0	3	43	2	29	1	14.3	1	6
3	Canacona	8	4	50	1	12.5	0	0	2	25	0	0	1	12.5	5	3
4	Marmugoa	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
5	Pernem	9	3	33.3	0	0	0	0	6	67	0	0	0	0	3	6
6	Ponda	4	2	50	0	0	0	0	1	25	1	25	0	0	2	2
7	Quepem	3	2	66.7	0	0	0	0	1	33	0	0	0	0	2	1
8	Salcete	10	6	60	0	0	0	0	3	30	1	10	0	0	6	4
9	Sanguem	10	6	60	0	0	0	0	3	30	1	10	0	0	6	4
10	Satari	10	1	10	0	0	0	0	7	70	2	20	0	0	1	9
11	Tiswadi	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
	Total	77	27	35	1	1	0	0	38	49	8	10	3	4	28	49



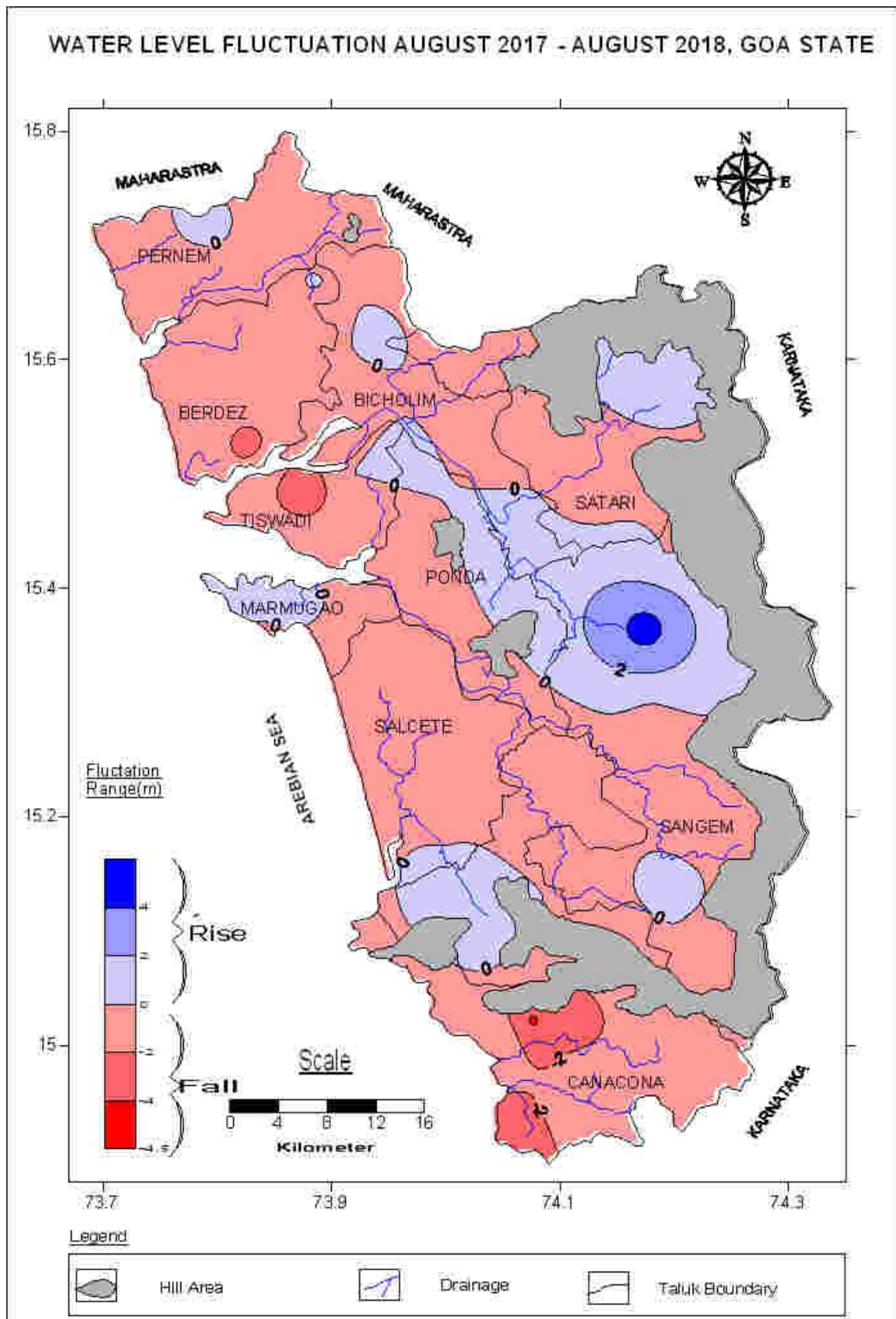
August 2017 & August 2018

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 14**. A comparison of water level shows that a fall in the water level is recorded in 79% of wells analysed, while 21% recorded rise. The fluctuation in water level has been plotted in **Plate X**. A perusal of the plate shows that a general fall in the range of 0 – 2 m is noticed in major part of the area, followed by a rise of 0 – 2 m.

1. Rise in the water level in the range of 0-2 m has been observed in 18% of wells analysed and observed in Bardez, Bicholim, Cancona, Pernem, Salcete, Sanguem, Satari and Tiswadi taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 1% of wells analysed and observed in Salcete taluk.
3. Rise in the water level in the range of more than 4 m has been observed in 1% of wells analysed and observed in Sanguem taluk.
4. Fall in water level in the range of 0-2 m has been observed in 71% of wells analysed and noted in all the taluks.
5. The fall in water level in the range of 2-4 m has been observed in 7% of wells analysed and noted in Bardez, Canacona, Sanguem and Tiswadi taluks.
6. The fall in water level more than 4 m has been observed in 1% of wells analysed and noted in Canacona taluk.

Table 14: District wise categorisation of water level fluctuation (August 2017-August 2018)

S.No	District Name	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	11	1	9.1	0	0	0	0	8	72.7	2	18.2	0	0	1	10
2	Bicholim	5	1	20	0	0	0	0	4	80	0	0	0	0	1	4
3	Canacona	6	1	16.7	0	0	0	0	3	50	1	16.7	1	16.7	1	5
4	Marmugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Pernem	9	2	22.2	0	0	0	0	7	77.8	0	0	0	0	2	7
6	Ponda	5	0	0	0	0	0	0	5	100	0	0	0	0	0	5
7	Quepem	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
8	Salcete	9	1	11.1	1	11.1	0	0	7	77.8	0	0	0	0	2	7
9	Sanguem	13	3	23.1	0	0	1	7.7	8	61.5	1	7.7	0	0	4	9
10	Sattari	10	3	30	0	0	0	0	7	70	0	0	0	0	3	7
11	Tiswadi	4	2	50	0	0	0	0	1	25	1	25	0	0	2	2
	Total	76	14	18	1	1	1	1	54	71	5	7	1	1	16	60



November 2017 & November 2018

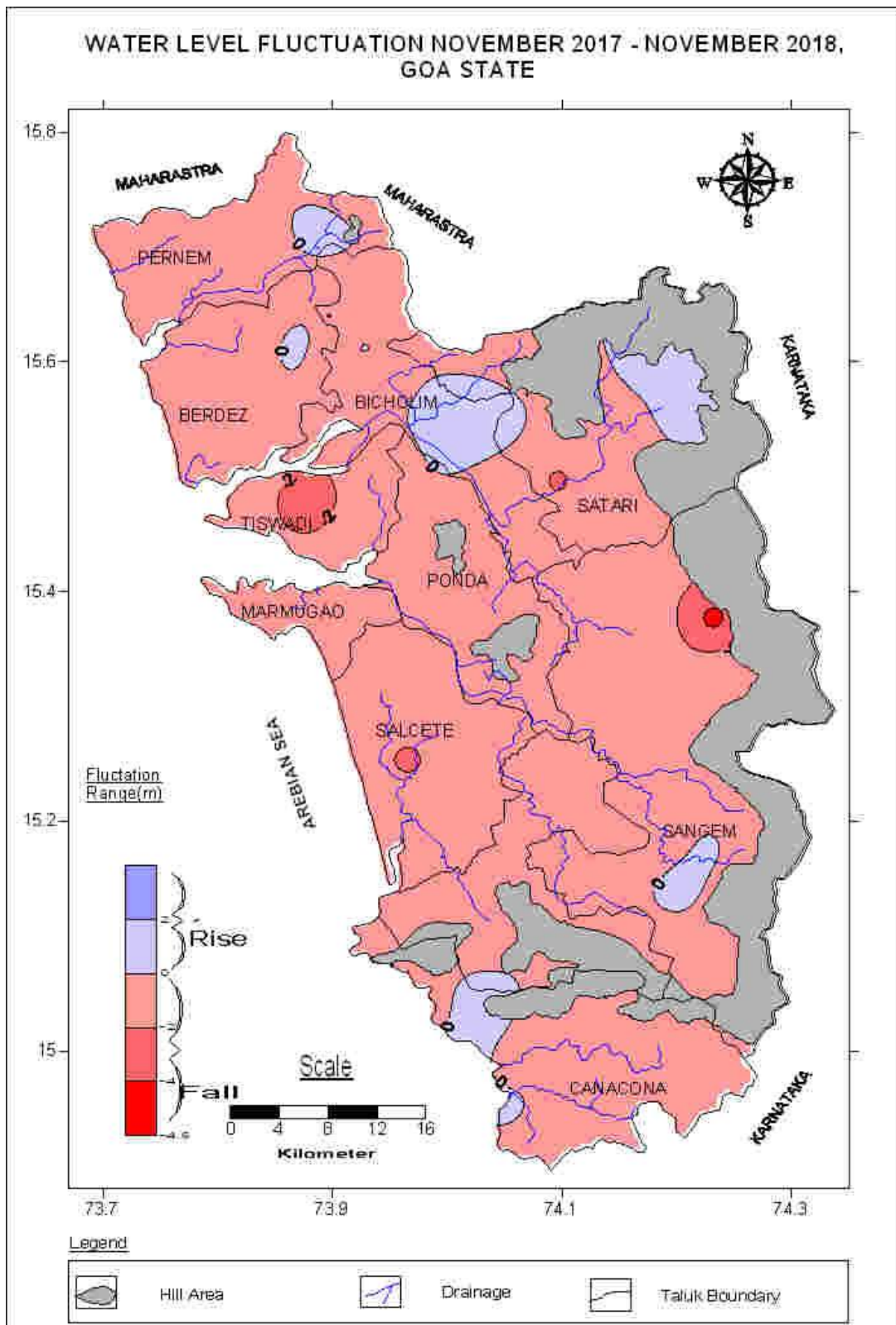
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 15**. A comparison of water level shows that a fall in the water level is recorded in 87% of wells analysed, while 13% recorded rise. The fluctuation in water level has been plotted in **Plate XI**. A perusal of the plate shows that a general fall in the range of 0 – 2 m is noticed in major part of the area, followed by a rise of 0 – 2 m.

1. Rise in the water level in the range of 0-2 m has been observed in 13% of wells analysed and observed in Bardez, Bicholim, Canacona, Pernem, Salcete, Sanguem and Satari taluks.
2. The fall in water level in the range of 0-2 m has been observed in 80% of wells analysed and noted in all the taluks.
3. The fall in water level in the range of 2-4 m has been observed in 6% of wells analysed and noted in Bardez, Bicholim, Salcete and Tiswadi taluks.
4. The fall in water level more than 4 m has been observed in 1% of wells analysed and noted only in Sanguem.

Table 15: District wise categorisation of water level fluctuation (Nov 2017-Nov 2018)

S.No	Taluk	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Ri se	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	12	1	8.3	0	0	0	0	10	83.3	1	8.3	0	0	1	11
2	Bicholim	6	1	16.7	0	0	0	0	3	50	2	33.3	0	0	1	5
3	Canacona	9	2	22	0	0	0	0	7	77.8	0	0	0	0	2	7
4	Mormugao	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Pernem	9	1	11.1	0	0	0	0	8	88.9	0	0	0	0	1	8
6	Ponda	5	0	0	0	0	0	0	5	100	0	0	0	0	0	5
7	Quepem	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
8	Salcete	9	1	11.1	0	0	0	0	7	77.8	1	11.1	0	0	1	8
9	Sanguem	13	2	15.4	0	0	0	0	10	76.9	0	0	1	7.7	2	11
10	Satari	10	2	20	0	0	0	0	8	80	0	0	0	0	2	8
11	Tiswadi	3	0	0	0	0	0	0	2	66.7	1	33.3	0	0	0	3
	Total	80	10	13	0	0	0	0	64	80	5	6	1	1	10	70

Plate XI



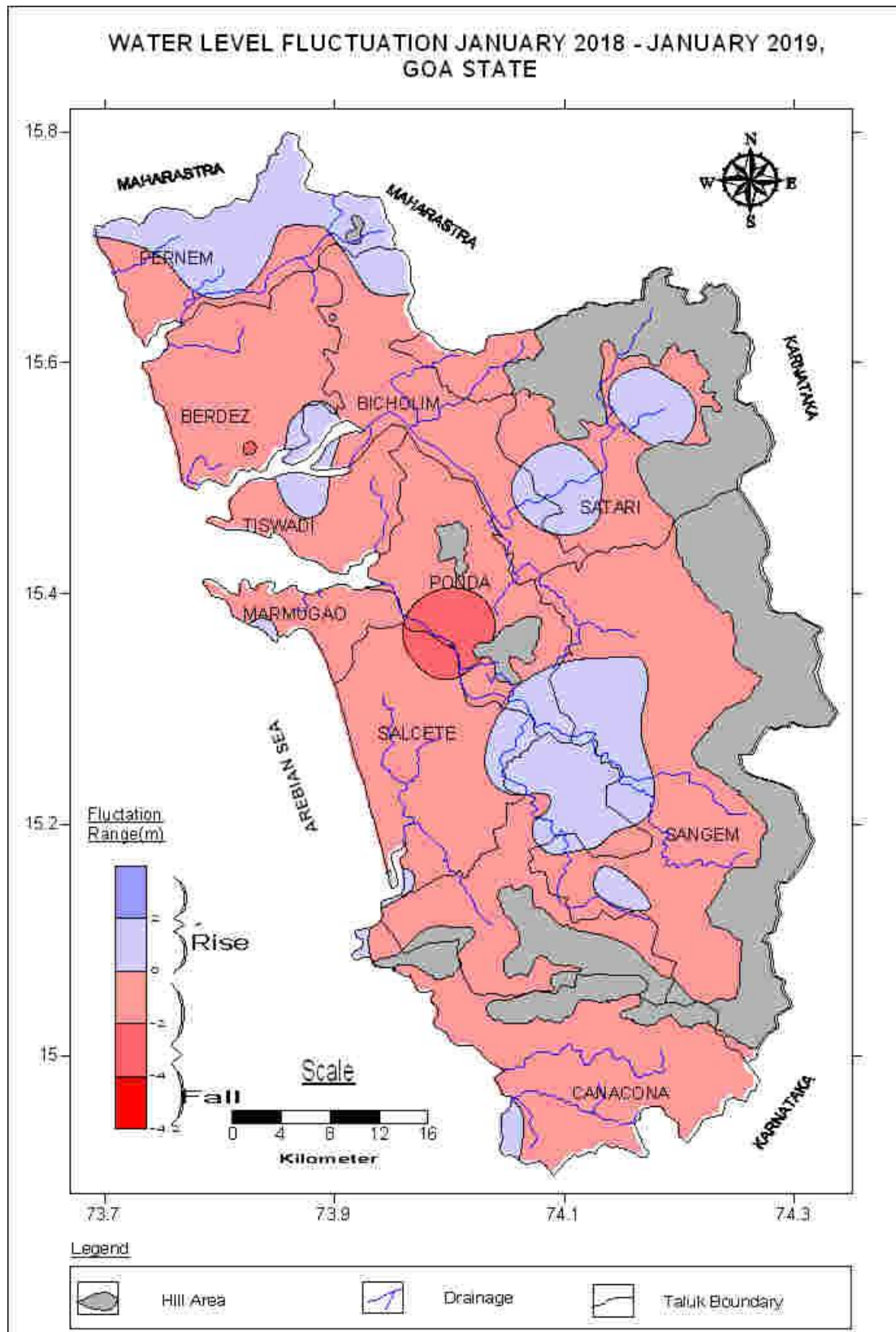
January 2018 & January 2019

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 16**. A comparison of water level shows that a fall in the water level is recorded in 74% of wells analysed, while 26% recorded rise. The fluctuation in water level has been plotted in **Plate XII**. A perusal of the plate shows that a general fall in the range of 0 – 2 m is noticed in major part of the area, followed by a rise of 0 – 2 m.

1. Rise in the water level in the range of 0-2 m has been observed in 26% of wells analysed and observed in almost all taluks.
2. The fall in water level in the range of 0-2 m has been observed in 70% of wells analysed and noted in all the taluks.
3. The fall in water level in the range of 2-4 m has been observed in 2% of wells analysed and noted in Bardez, Bicholim and Tiswadi taluks.
4. The fall in water level more than 4 m has been observed in 1% of wells analysed and noted only in Ponda taluk.

Table 16: District wise categorisation of water level fluctuation (Jan 2018-Jan 2019)

S.No	Taluk	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	12	3	15	0	0	0	0	7	58.3	2	16.7	0	0	3	9
2	Bicholim	7	3	42.9	0	0	0	0	4	57.1	2	0	0	0	3	6
3	Canacona	8	1	12.5	0	0	0	0	7	87.5	0	0	0	0	1	7
4	Marmugoa	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
5	Pernem	9	5	56.6	0	0	0	0	4	44.4	0	0	0	0	5	4
6	Ponda	5	1	20	0	0	0	0	3	60	0	0	1	20	1	4
7	Quepem	3	2	66.7	0	0	0	0	1	33.3	0	0	0	0	2	1
8	Salcete	10	1	10	0	0	0	0	9	90	0	0	0	0	1	9
9	Sanguem	15	3	20	0	0	0	0	12	80	0	0	0	0	3	12
10	Sattari	10	1	10	0	0	0	0	9	90	0	0	0	0	1	9
11	Tiswadi	4	1	25	0	0	0	0	3	75	1	0	0	0	1	4
	Total	84	22	26	0	0	0	0	59	70	2	2	1	1	22	62



FLUCTUATION BETWEEN DECADAL MEAN WATER LEVEL & WATER LEVEL

The fluctuations of water level recorded during the particular period with respect to decadal mean indicate the impact of ground water development and ground water recharge during the decade. Positive fluctuation indicates improved recharge over and above ground water development and negative fluctuations indicate increased ground water development over and above the recharge.

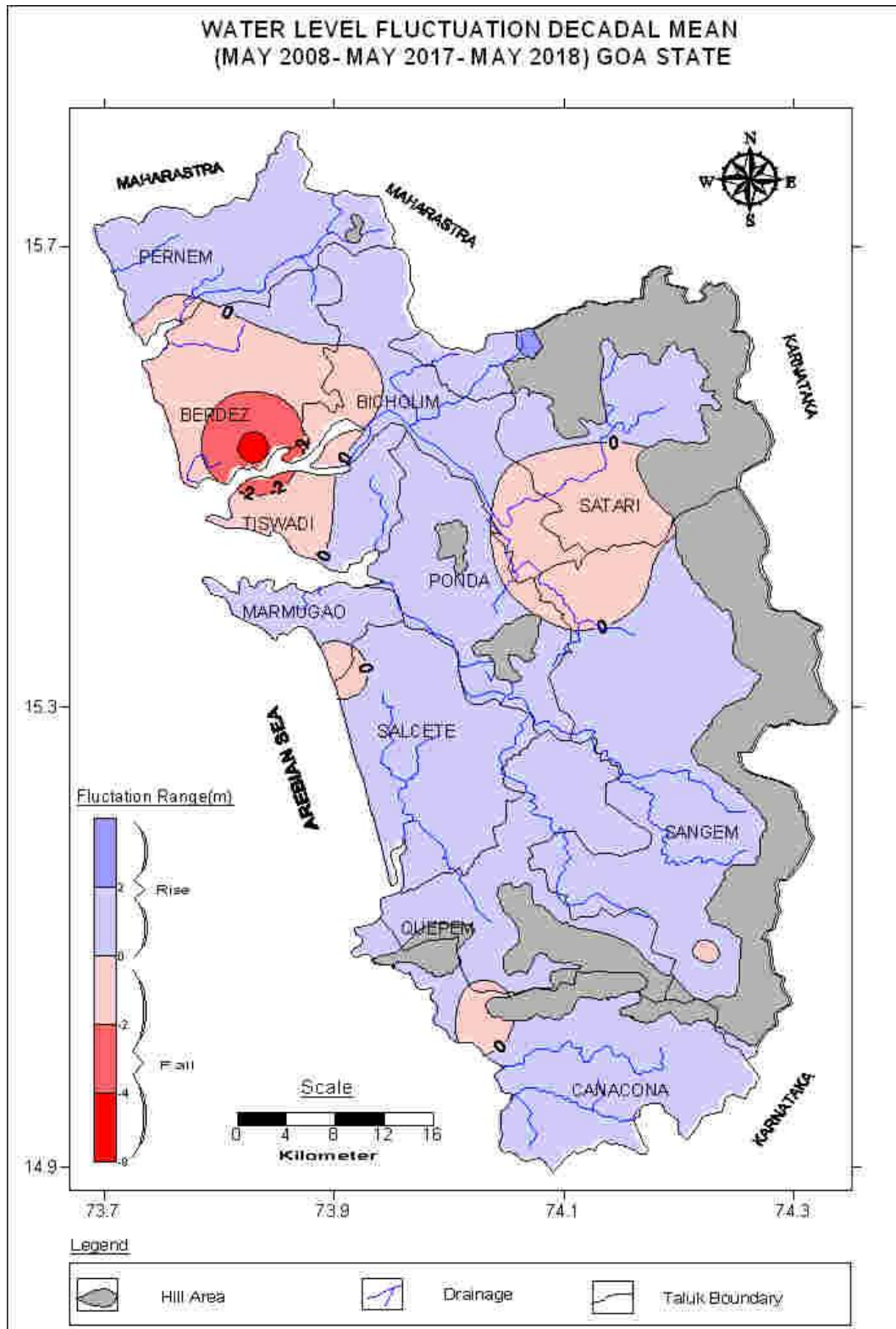
Mean Water Levels For The Period May 2008-2017& May 2018:

The water level data for May 2018 were compared with mean water level for the period May 2008-2017. The district-wise distribution of Ground water monitoring wells falling in different ranges of water level fluctuation is presented in **Table 17** and **Plate XIII**. A comparison of water level shows a rise in 75% and a fall in 25% of the wells.

1. Rise in the water level in the range of 0-2m has been observed in 72% of wells analysed, spread all over the State.
2. Rise in the water level in the range of 2-4 m has been observed in 3% of wells analysed and noted only in Satari taluk.
3. The fall in water level in the range of 0-2m has been observed in 22% of wells analysed and noted in Bardez, Canacona, Pernem, Salcete, Sanguem and Satari taluks.
4. Fall in water level of more than 4 m is recorded in 3% of wells analysed and noted in Bardez taluk.

Table 17: District wise categorisation of water level fluctuation (Decadal mean 2008-2017 & May 2018)

S.No	Taluk	No of wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	4	1	25	0	0	0	0	2	50	0	0	1	25	1	3
2	Bicholim	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
3	Canacona	6	5	83.3	0	0	0	0	1	17	0	0	0	0	5	1
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	3	60	0	0	0	0	2	40	0	0	0	0	3	2
6	Ponda	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
7	Quepem	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
8	Salcete	3	2	66.7	0	0	0	0	1	33	0	0	0	0	2	1
9	Sanguem	4	3	75	0	0	0	0	1	25	0	0	0	0	3	1
10	Satari	5	3	60	1	20	0	0	1	20	0	0	0	0	4	1
11	Tiswadi	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
	Total	36	26	72	1	3	0	0	8	22	0	0	1	3	27	9

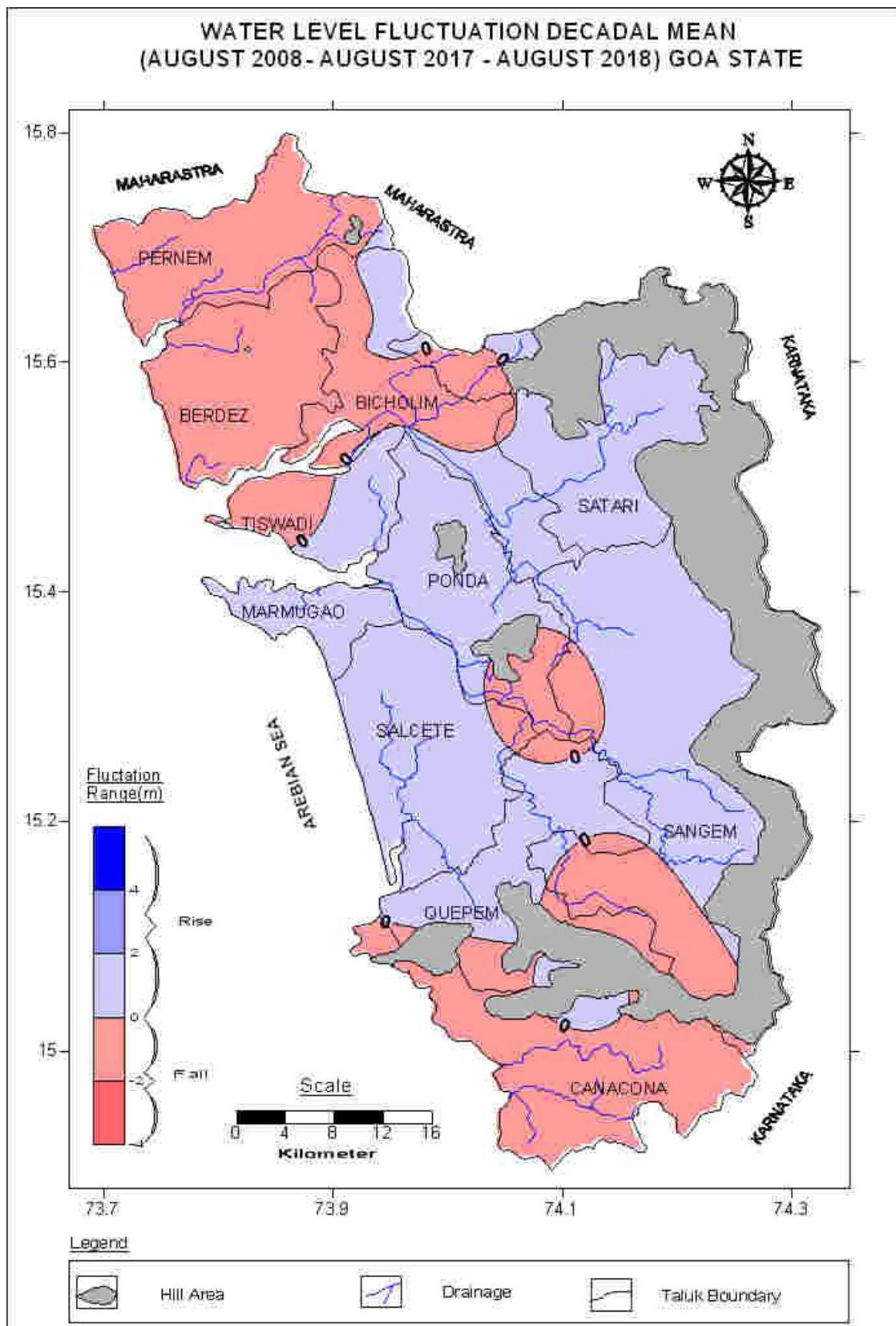


Mean Water Levels For The Period August 2008-2017 & August 2018:

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 18** and **Plate XIV**. A comparison of water level shows that a rise in the water level is recorded in 51% of the wells analysed, while 49% recorded fall. Salient features of the comparison of water levels are given below:

1. Rise in the water level in the range of 0-2m has been observed in 51% of wells analysed and noted almost in all taluks.
2. Fall in water level in the range of 0-2m has been observed in 49% of wells analysed and noted in Bardez, Canacona, Pernem, Ponda, Sanguem and Satari taluks.

S.No	Taluk	No of wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
2	Bicholim	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
3	Canacona	5	1	20	0	0	0	0	4	80	0	0	0	0	1	4
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	1	20	0	0	0	0	4	80	0	0	0	0	1	4
6	Ponda	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
7	Quepem	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
8	Salcete	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
9	Sanguem	4	2	50	0	0	0	0	2	50	0	0	0	0	2	2
10	Satari	5	3	60	0	0	0	0	2	40	0	0	0	0	3	2
11	Tiswadi	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
	Total	35	18	51	0	0	0	0	17	49	0	0	0	0	18	17



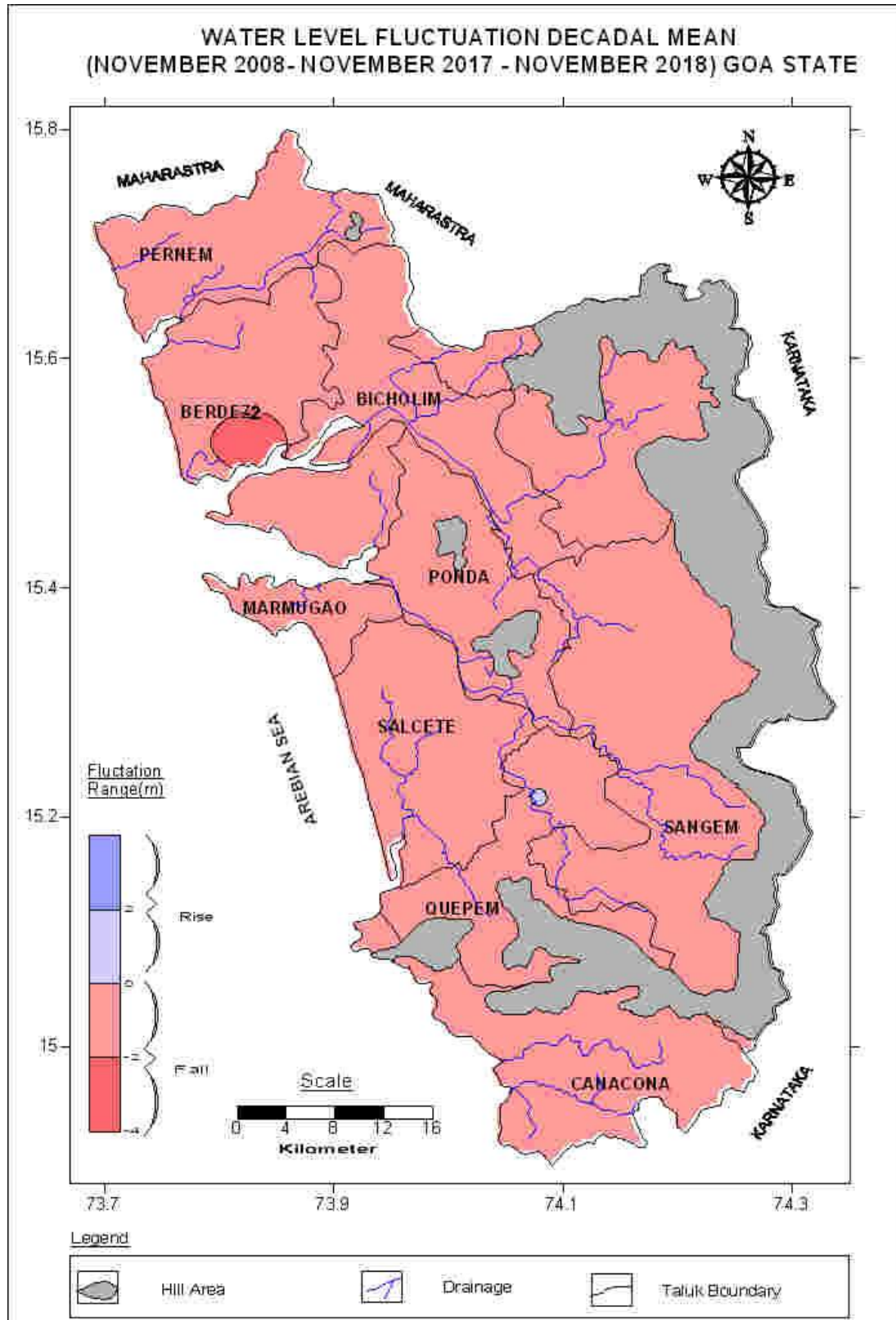
Mean Water Levels For The Period November 2008-2017 & November 2018:

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 19**. The fluctuation in water level has been plotted in **Plate XV**. A comparison of water level shows that a fall in the water level is recorded in 97% of wells analysed, while 3% recorded rise. Salient features of the comparison of water levels are given below:

1. Rise in the water level in the range of 0-2 m has been observed in 3% of wells analysed and noted in Quepem taluk.
2. The fall in water level in the range of 0-2 m has been observed in 94% of wells analysed and noted in almost all taluks.
3. The fall in water level in the range of 2-4 m has been observed in 3% of wells analysed and noted only in Bardez taluk.

Table 19: District wise categorisation of water level fluctuation (Decadal mean 2008-2017 & Nov 2018)

S.No	Taluk	No of wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	5	0	0	0	0	0	0	4	80	1	20	0	0	0	5
2	Bicholim	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
3	Canacona	6	0	0	0	0	0	0	6	100	0	0	0	0	0	6
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	0	0	0	0	0	0	5	100	0	0	0	0	0	5
6	Ponda	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
7	Quepem	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
8	Salcete	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
9	Sanguem	4	0	0	0	0	0	0	4	100	0	0	0	0	0	4
10	Satari	5	0	0	0	0	0	0	5	100	0	0	0	0	0	5
11	Tiswadi	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
	Total	36	1	3	0	0	0	0	34	94	1	3	0	0	1	35



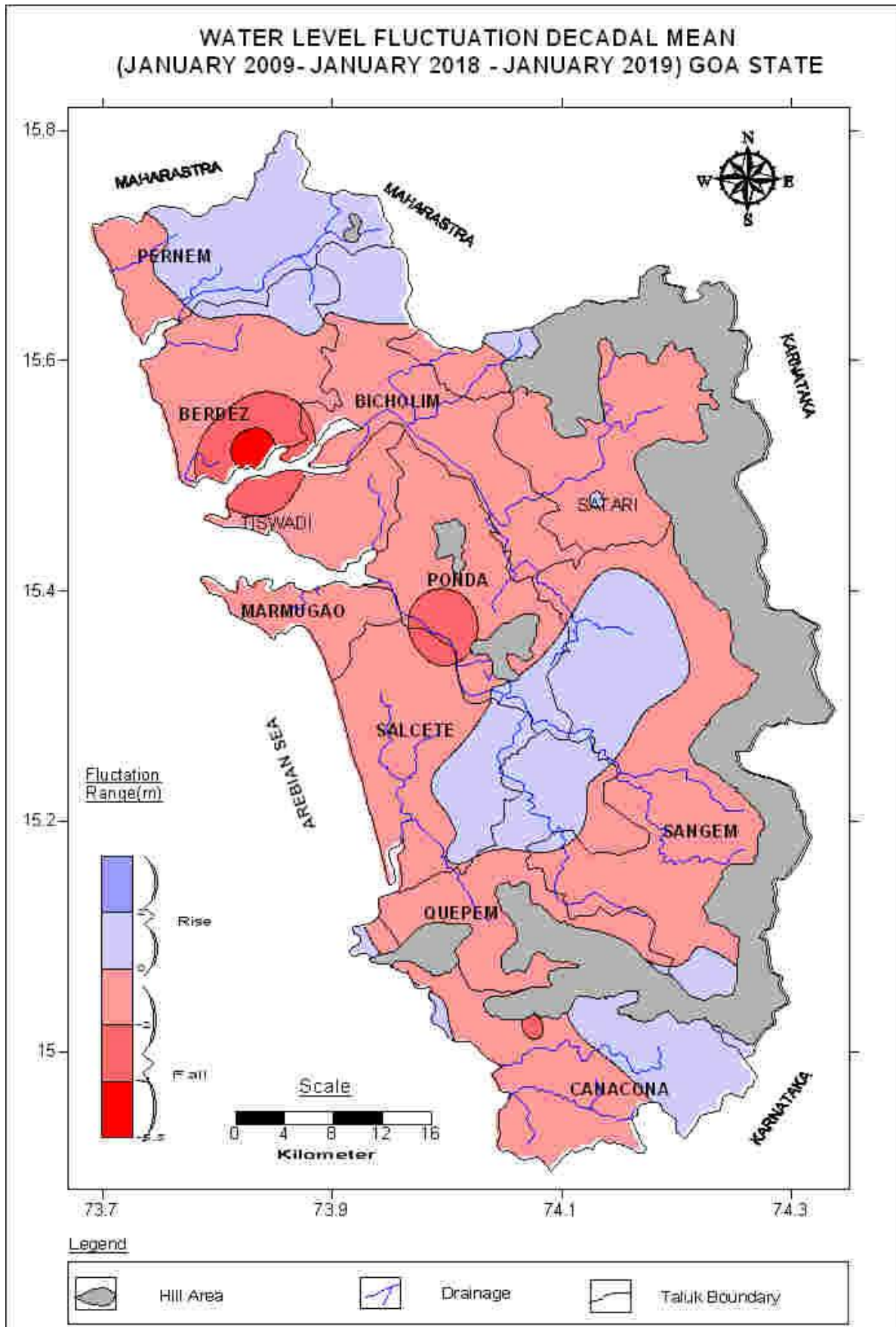
Mean Water Levels For The Period January 2009-2018 & January 2019:

The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 20**. The fluctuation in water level has been plotted in **Plate XVI**. A comparison of water level shows that a fall in the water level is recorded in 73% of wells analysed, while 27% recorded rise. Salient features of the comparison of water levels are given below:

1. Rise in the water level in the range of 0-2 m has been observed in 27% of wells analysed, noted in all taluks except Mormugao and Tiswadi taluk.
2. The fall in water level in the range of 0-2 m has been observed in 68% of wells analysed and noted in almost all taluks except Marmugoa.
3. The fall in water level in the range of 2-4 m has been observed in 3% of wells analysed and noted in Canacona and Ponda taluks.
4. The fall in water level in the range of >4 m has been observed in 2% of wells analysed and noted only in Bardez taluk.

Table 20: District wise categorisation of water level fluctuation (Decadal mean 2009-2018 & Jan 2019)

S. No	Taluk	No of wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	Bardez	7	1	14.3	0	0	0	0	5	71.4	0	20	1	14.3	1	6
2	Bicholim	3	1	33.3	0	0	0	0	2	66.7	0	0	0	0	1	2
3	Canacona	7	2	28.6	0	0	0	0	4	57.1	1	14.3	0	0	2	5
4	Marmugoa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	6	3	50	0	0	0	0	3	50	0	0	0	0	3	3
6	Ponda	4	2	50	0	0	0	0	1	25	1	25	0	0	2	2
7	Quepem	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
8	Salcete	7	1	14.3	0	0	0	0	6	85.7	0	0	0	0	1	6
9	Sanguem	12	3	25	0	0	0	0	9	75	0	0	0	0	3	9
10	Satari	10	2	20	0	0	0	0	8	80	0	0	0	0	2	8
11	Tiswadi	4	0	0	0	0	0	0	4	100	0	0	0	0	0	4
	Total	62	17	27	0	0	0	0	42	68	2	3	1	2	17	45



5. HYDROCHEMISTRY

The quality of shallow groundwater in Goa state has been evaluated by sampling and analysis of water sample collected from Groundwater Monitoring wells. About 78 Groundwater Monitoring wells were monitored for water quality during May 2018 representing pre-monsoon water quality. The district-wise chemical analysis data of the samples are given in the Annexure – II. The summarized results of groundwater quality ranges are given in **Table 21**

Table 21: Summarized results of groundwater quality ranges (May 2018)

S.No.	Parameters	Type (as per BIS)	Range	No. of sample	Percentage
1	Electrical Conductivity $\mu\text{s}/\text{cm}$ at 25°C	Fresh	< 750	77	98.7
		Moderate	751- 2250	01	1.3
		Slightly mineralized	2251- 3000	NIL	0.0
		Highly mineralized	> 3000	Nil	0.0
2	Chloride mg/L	Desirable limit	< 250	78	100.00
		Permissible limit	251-1000	NIL	0.00
		Beyond permissible limit	> 1000	NIL	0.00
3	Fluoride mg/L	Desirable limit	< 1.0	78	100
		Permissible limit	1.1- 1.5	NIL	0.00
		Beyond permissible limit	>1.5	NIL	0.00
4	Nitrate mg/L	Permissible limit	< 45	75	96.00
		Beyond permissible limit	> 45	03	4.00

5.1 pH

pH is the measure of hydrogen or hydroxyl ion concentration in water. The pH scale is used to predict whether the water is acidic or basic in nature. The pH scale ranges from 0 to 14, the mid point 7 is taken as neutral and waters having $\text{pH} < 7$ is called acidic, and having $\text{pH} > 7$ is called basic. pH is an important parameter in water chemistry, because geochemical reactions such as oxidation-reduction, dissolution-precipitation are pH dependent. For example, mineral solubility is enhanced under acidic pH, whereas high pH leads to precipitation of minerals such as calcite. Consequently, water having acidic pH would be more corrosive and alkaline pH would lead to the deposition of minerals resulting in encrustation.

In the shallow groundwater of the state, the pH ranged between 7.48 and 9.60. Analysis of the data shows that a major part of state has pH ranging from 7 to 8.3. Based on the NHS 2018 data, in about 30% of the area the groundwater pH is between 8.3 and 9.60. The occurrence of $\text{pH} < 7$

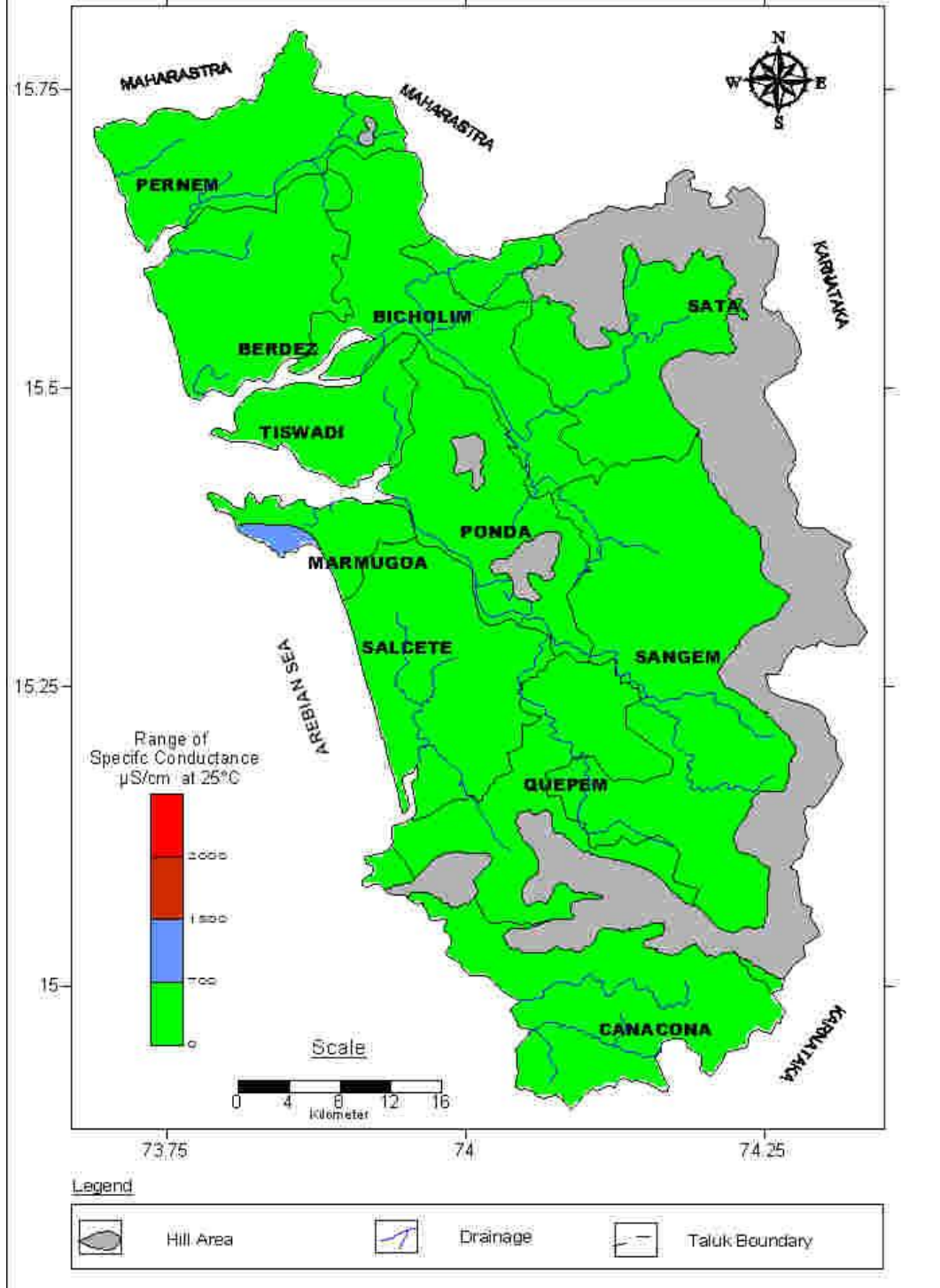
are sporadic and is insignificant. No pattern of spatial variation is observed with respect to the distribution of pH. In recharge areas, where fresh rainwater gets recharged, groundwater without much dissolution is characterized by low EC values. It increases along groundwater flow path, because of the utilization of H⁺ ions for mineral dissolution leading to the formation of bicarbonate ions with increase of alkalinity.

5.2 Electrical Conductivity

Electrical conductivity (EC) is the indicator of the total mineral content of water and hence it indicates the total dissolved solids (TDS) present in water. TDS of water determines its usefulness to various uses of water. Generally water having TDS <500 mg/l is good for drinking and other domestic uses. However, in the absence of alternative sources TDS up to 2000 mg/l may be used for drinking purposes, however with TDS > 2000 mg/l, palatability decreases. The distribution of EC in the shallow groundwater of Goa state is shown in **Plate XVII**.

The groundwater quality in the state is fresh in about 99 % of the Groundwater Monitoring wells as indicated by the EC value less than 750 $\mu\text{s}/\text{cm}$ at 25°C. In about 1 % of the Groundwater Monitoring wells, the EC is between (751-2250) $\mu\text{s}/\text{cm}$ at 25°C indicating that the ground water is moderately mineralized. The highest value of 1510 $\mu\text{s}/\text{cm}$ at 25°C is recorded at Baga.

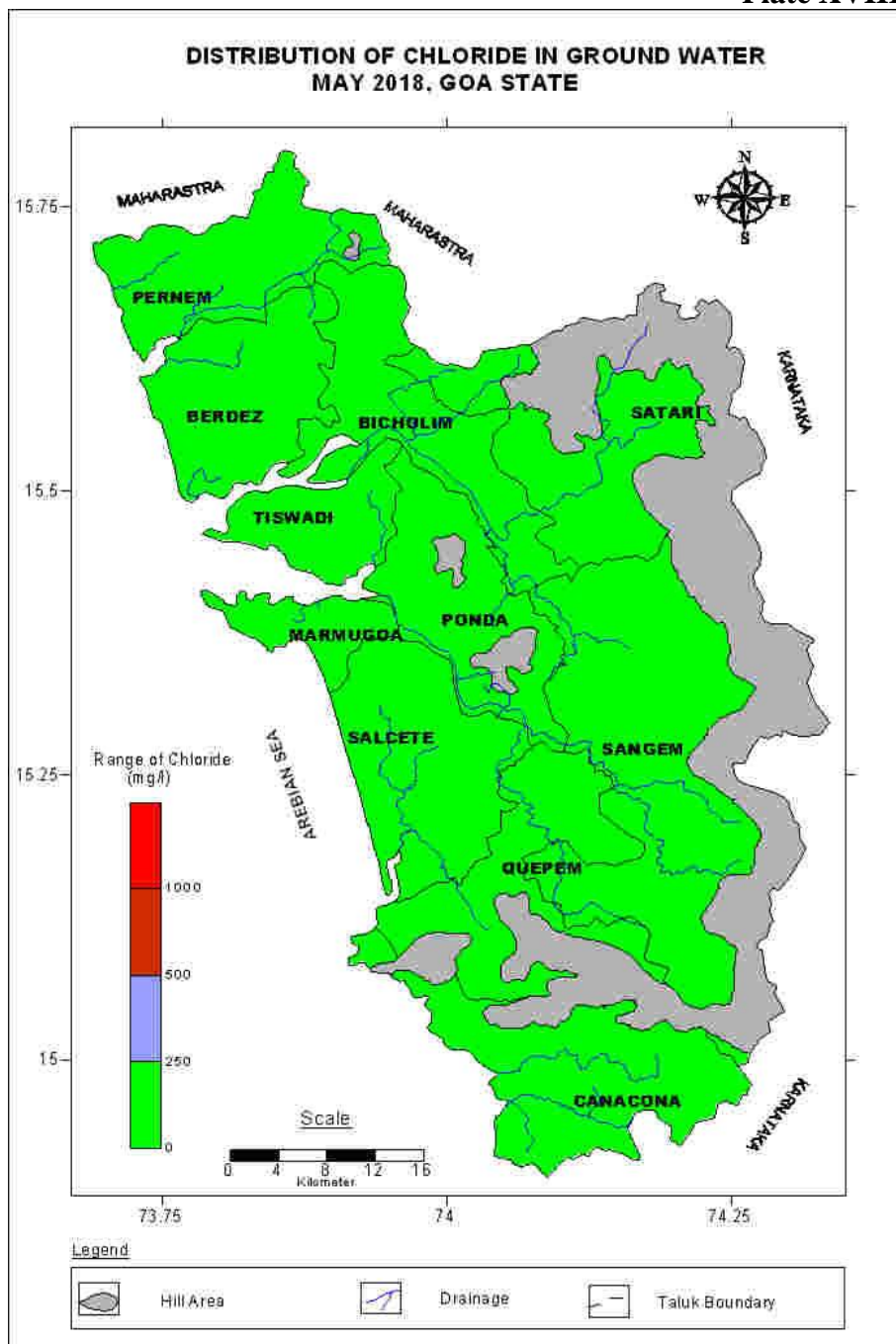
**DISTRIBUTION OF SPECIFIC CONDUCTANCE IN GROUND WATER
MAY 2018, GOA STATE**



5.3 Chloride

Chloride is one of the major anion in groundwater. The high mobility of the ion and the high solubility of chloride salts make the chloride ions present in waters. Moreover, chloride ions do not take part in any of the geochemical (or) biochemical reactions; hence it can be used as a good indicator of groundwater pollution. Over 500 mg/l it imparts saline taste to drinking water. BIS specified 250 mg/l as the desirable and 1000 mg/l as the permissible limit in the absence of alternate sources for drinking water. The chloride content is less than 250 mg/l in the entire sample analyzed. The spatial distribution of chloride concentration in groundwater of Goa state is shown in **Plate XVIII**.

Plate XVIII



5.4 Nitrate (NO₃)

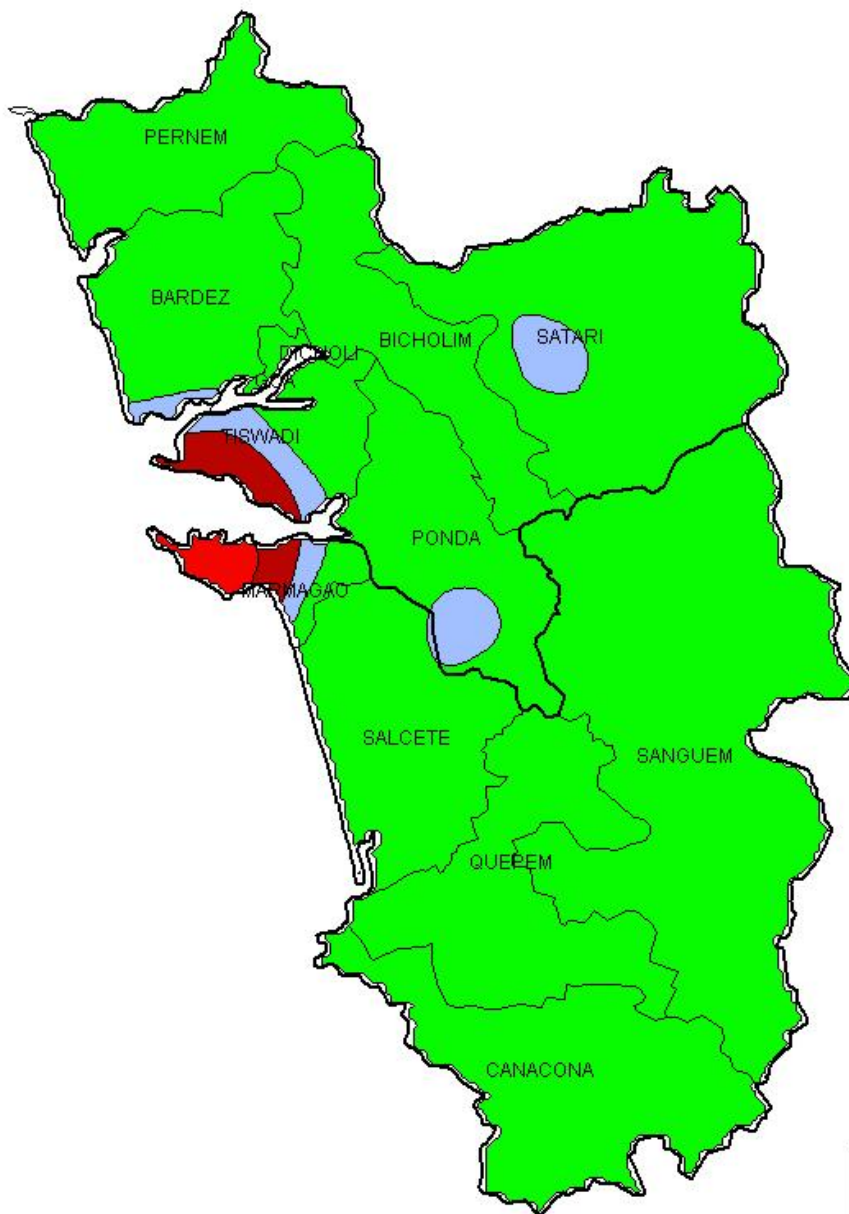
Nitrate is one of the major indicators of anthropogenic sources of pollution. The negative charge and high mobility favors its persistence in nature and transport along the groundwater flow path. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in groundwater can be fairly attributed to infiltration of water through soils containing animal waste and fertilizer. A large proportion of this nitrogen gets converted into nitrate which, being soluble in water and not retained by soils, gets leached into water bodies. As the lithogenic sources of nitrogen are very rare, its presence in groundwater is almost due to anthropogenic activity.

NO₃ is an oxidizing agent and is readily oxidizes haemoglobin (Hb) into methaemoglobin (MeHb) a blue coloured pigment and gets reduced to NO₂. The oxidized Hb impairs seriously the oxygen carrying capacity of the blood and thus causes hypoxia, which may have fatal consequences in anaemic individuals and infants under 8 weeks of age. The MeHb formed in the infant blood gives a characteristic bluish colour to the skin and mucous membrane, thus giving the name “Blue Baby Syndrome”. This condition is particularly important in the case of infants because the infant and the foetal – Hb, which is $\alpha_2\gamma_2$ type has greater affinity for oxygen (O₂) than adult Hb which is $\alpha_2\beta_2$ type. Thus the Me-Hb formed in the foetal blood severely impairs the oxygen carrying capacity of the blood in infants, causing the blue baby disease.

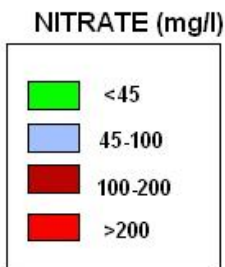
In addition to methemoglobinemia, excess nitrate may cause oral cancer, cancer of the colon, rectum and other gastrointestinal cancers, Alzheimer’s disease, vascular dementia, absorptive, secretive functional disorders of the intestinal mucosa, changes in the maturation, differentiation and apoptosis in intestinal crypts, multiple sclerosis, reduced casein digestion, development of tolerance (lowering of response) to nitrate drugs and recurrent stomatitis in human beings. Nitrate may get reduced to Nitrite (NO₂) in the intestinal tracts, which may further react with amino acids to form nitrosoamines which are potential carcinogens. Consumption of high nitrate containing water may cause adverse effect on the cardiovascular system and central nervous system. BIS specified 45 mg/L as the desirable limit and as the permissible limit in the absence of alternate sources for drinking water.

The Nitrate content is less than 45mg/l in about 98 % of the sample analyzed and 2 % of sample shows more than 45 mg/l which are from North Goa district. Places like Baga, Calungute and Colwala have shown nitrate content above permissible limit. The distribution of nitrate in shallow groundwater is shown as contour map in **Plate XIX**.

DISTRIBUTION OF NITRATE IN GROUND WATER MAY 2018, GOA STATE



0 5 10
kilometers



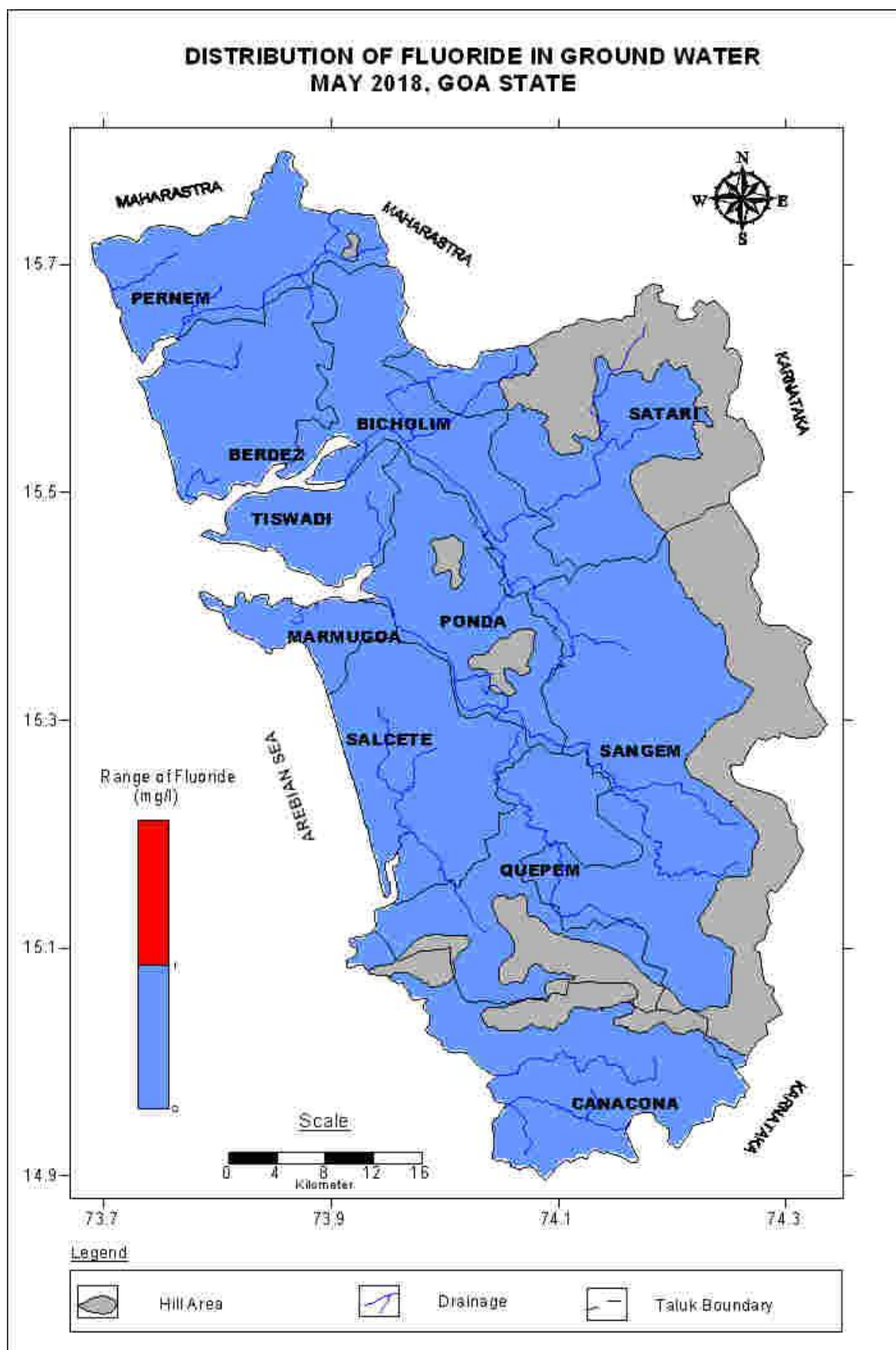
5.5 Fluoride

Fluorine is the most electronegative element and highly reactive, thus combining with all other elements to form covalent fluorides. Fluoride exists naturally in all waters derived from the dissolution of fluoride containing minerals. Surface water generally has low fluoride while groundwater may have high concentrations of fluoride as has been found in many parts of the world.

The formation of high fluoride groundwaters is principally governed by climate, composition of bedrock and hydrogeology. Areas with semi arid climate, crystalline, igneous bedrock and alkaline soils are the most affected. The common fluoride bearing minerals are Fluorspar (CaF_2), Cryolite (Na_3AlF_6), Fluorapatite ($\text{Ca}_{10}\text{F}_2(\text{PO}_4)_6$), and Amphiboles such as hornblende.

Fluoride is an impurity commonly found in phosphatic fertilizers used in the agriculture. Accumulation of fluoride in the soils eventually results in leaching by percolation into the groundwater aquifer and thereby increases the concentration of fluoride level.

It is generally accepted that minor amounts of fluoride is beneficial for teeth and bones. Around 1.0 mg/l greatly reduces the incidence of dental carries. At a levels over 1.5 mg/L, fluoride can cause a mottled discolouring and malformation of teeth. Very high concentration of fluoride can produce skeletal change. Hence, BIS specified 1.0 mg/l as the desirable limit and 1.5mg/l as the permissible limit in the absence of alternate sources for drinking water. The Fluoride content is less than 1.5 mg/l in all the 78 samples collected from National Hydrograph stations. Distribution of fluoride is shown in **Plate XX**.



6. CONCLUSIONS

The behaviour of ground water table during May 2018 to January 2019 in Goa State has been studied by monitoring the dug wells tapping phreatic aquifers. The data on water levels was analysed in detail and salient features are as follows:

1. 86% of wells have recorded depth to water level within 10 m bgl during premonsoon period (May 2018), whereas during post-monsoon period (November 2018), about 91% of wells recorded water level less than 10 m bgl.
2. 98% of wells have recorded depth to water level within 10m bgl during August 2018 and 89% during January 2019.
3. 71% of wells have recorded rise in water levels and 29% of wells have recorded fall in water levels during Nov 2018 (post monsoon) in comparison to May 2018 (pre-monsoon).
4. 75% of wells have recorded rise in water levels and 25% of wells recorded fall in water levels during May 2018 in comparison to decadal mean.
5. 3% of wells have recorded rise in water levels and 97 % of wells have recorded fall in water level during November 2018 with respect to respective decadal mean.
6. In general the groundwater quality in the state is fresh in about 99 % of the Groundwater Monitoring wells as indicated by the EC value less than 750 $\mu\text{s}/\text{cm}$ at 25°C. In about 1 % of the Groundwater Monitoring wells, the EC is between (751-2250) $\mu\text{s}/\text{cm}$ at 25°C indicating that the groundwater is moderately mineralized.
7. The chloride content is less than 250 mg/l in the entire sample analyzed.
8. The Fluoride content is less than 1.5 mg/l in all the 78 samples collected from Ground Water Level Monitoring stations.
9. The Nitrate content is less than 45mg/l in about 98 % of the sample analyzed and 2 % of sample shows more than 45 mg/l. Places from North Goa district like Baga, Calungute and Colwala have shown nitrate content above permissible limit.

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Annexure I : Water level data of Goa State (May 2018 to Jan 2019)						
District	Site Type	Site Name	May-18	Aug-18	Nov-18	Jan-19
North Goa	Bore Well	Adavapal	4.77	3.72	4.45	6
North Goa	Bore Well	Ajosi	4.4	2.63	4.11	4.4
North Goa	Bore Well	Aldona	15.96	8.9	15.03	16.04
North Goa	Bore Well	Aropora	-	-	0	2
North Goa	Bore Well	Asapur	5.5	3.55	4.95	6.31
North Goa	Bore Well	Betki	16.77	13.53	15.51	16.46
North Goa	Bore Well	Colvale	-	-	13.51	13.42
North Goa	Bore Well	Kasar Pal	9.39	6.97	9.43	9.7
North Goa	Bore Well	Kirl Pirna	9.15	5.36	7.67	8.72
North Goa	Bore Well	Korgoan	10.91	10.15	10.63	11.32
North Goa	Bore Well	Krilwada	1.4	-	1.29	1.59
North Goa	Bore Well	Madakai	18	7.2	18.14	20.9
North Goa	Bore Well	Mayam	6	4.05	12	6.2
North Goa	Bore Well	Mola	0.49	0.5	0.53	0.8
North Goa	Bore Well	Morjum	2.8	1.69	1.83	2.15
North Goa	Bore Well	Narve	12.35	10.7	24.17	12.66
North Goa	Bore Well	Parsekarwada	18.05	17.05	18.05	19.3
North Goa	Bore Well	Sanqulim	23.62	17.5	24.17	26
North Goa	Bore Well	Sawantwada	5.13	1.9	4.57	4.9
North Goa	Bore Well	Silolieum	4.8	3.5	4.58	4.8
North Goa	Bore Well	Tivim	19.81	-	5.73	20.93
North Goa	Bore Well	Varkhand	14.65	11.5	14.03	15.01
North Goa	Dug Well	Adavapal	5.46	4.53	5.49	5.53
North Goa	Dug Well	Alto Betim Porvorim	10.69	5.25	8.03	11.9
North Goa	Dug Well	Amberem	7.1	6.45	7.05	7
North Goa	Dug Well	Anjuna Beach	11.44	8.88	11.49	12.33
North Goa	Dug Well	Baga	-	-	2.8	-
North Goa	Dug Well	Bayalwadikeri (Querim)	0.86	1.41	3.82	1.89
North Goa	Dug Well	Bhamber (Nanoda Cross)	4.82	2.42	3	4.63
North Goa	Dug Well	Bhujpal	4.16	1.03		3.38
North Goa	Dug Well	Bori	1.45	1.2	5.35	5.58
North Goa	Dug Well	Britona	1.91	1.61	1.4	1.96
North Goa	Dug Well	Calangute	8.68	4.6	1.95	6.8
North Goa	Dug Well	Charayode	6.02	0.69	1.99	3.8
North Goa	Dug Well	Colval	14.95	10.55	8.4	14.05
North Goa	Dug Well	Devulawada Narve	-	-	14.79	15.06
North Goa	Dug Well	Dhatwado Vante	6.95	2.2	6.6	5.95
North Goa	Dug Well	Gavalebhat	5.7	4.45	4.8	5.3
North Goa	Dug Well	Goa Velha	-	-	0.99	-
North Goa	Dug Well	Hasaravanni Vaipal	2.02	1.48	2.24	2.62
North Goa	Dug Well	Haspur	4.52	3.25	4.13	4.3
North Goa	Dug Well	Honda	3.55	1.86	2.65	4.06
North Goa	Dug Well	Jambhul Batt (Mayam Lake)	3.64	0.9	2.01	2.94

North Goa	Dug Well	Karanjhalen	3.05	1.45	2.6	3.95
North Goa	Dug Well	Khadki (Harijanwada)	10.84	3.18	7.64	7.86
North Goa	Dug Well	Khotodem	5.48	3.09	6.17	6.14
North Goa	Dug Well	Korgaon	4.65	3.35	3.85	3.92
North Goa	Dug Well	Kundel Dassolwada	1.6	1.2	1.56	1.65
North Goa	Dug Well	Mankem	4.18	2.24	3.74	3.65
North Goa	Dug Well	Mapuca	3.6	2.55	3.75	3.82
North Goa	Dug Well	Morji	1.93	0.63	0.91	1.43
North Goa	Dug Well	Morlem	3.3	2.93	3.23	3.86
North Goa	Dug Well	Mulgaon Shivalkherwad	3.1	1.97	2.83	3.55
North Goa	Dug Well	Nagargoan	6.88	0.5	4.18	5.14
North Goa	Dug Well	Nagjhar	7.33	7.33	7.85	7.5
North Goa	Dug Well	Olaulim	7.25	4.33	6.5	6.7
North Goa	Dug Well	Panchawadi (pz)	6.5	4.6	6.7	5.18
North Goa	Dug Well	Parra	2.15	0.65	1.38	1.8
North Goa	Dug Well	Pernem	3.69	3.47	3.72	2.22
North Goa	Dug Well	Pirna	3.55	1.31	2.35	3.17
North Goa	Dug Well	Pomburpa Palmar	3.25	2.98	3.24	3.28
North Goa	Dug Well	Sal	2.74	1.58	3.11	2.56
North Goa	Dug Well	Salwardhar Dumun	2.85	2.02	2.75	2.25
North Goa	Dug Well	Sawanthwada (Mandrem)	3.95	0.78	2.98	3.39
North Goa	Dug Well	Shiroda	6.05	5	6.4	6.51
North Goa	Dug Well	Shivoli (Brahmanwada)	3.22	0.69	1.83	2.45
North Goa	Dug Well	Sirsaim	3.75	2.4	3.8	3.45
North Goa	Dug Well	Uguem (Ugawe)	3.7	2.75	3.61	3.3
North Goa	Dug Well	Valpoi	5.27	1.8	5.3	5.94
North Goa	Dug Well	Velha Goa	1.68	0.52	-	1.83
South Goa	Bore Well	Aven	10.03	6.4	7.9	8.73
South Goa	Bore Well	Bogmola	0.3	0.04	2.11	0.3
South Goa	Bore Well	Canabonulim	5.63	3.33	6.32	4.3
South Goa	Bore Well	Carmona	6.6	3.9	2.94	5.88
South Goa	Bore Well	Cavelosim	1.71	0.47	4.67	1.55
South Goa	Bore Well	Chandavar	2.1	1.43	1.25	2.1
South Goa	Bore Well	Chinchinim	3.05	0.04	0.78	1.5
South Goa	Bore Well	Collem	5.7	1.38	0.83	6.23
South Goa	Bore Well	Dabel	12.77	7.17	9.54	10.92
South Goa	Bore Well	Dovorlim	4.51	3.97	4.75	5.38
South Goa	Bore Well	Kalay	4.7	2.13	3.97	4.01
South Goa	Bore Well	Manora Rai	4.55	3.37	4.67	5.57
South Goa	Bore Well	Meidawada	10.96	3.81	10.78	11.38
South Goa	Bore Well	Molem	-	0.67	5.3	7.85
South Goa	Bore Well	Morlem	4.62	0.67	4.15	3.98
South Goa	Bore Well	Nanoda	18.8	16.58	20.05	18.88
South Goa	Bore Well	Paddi Quiescend	15.8	10.73	13.86	14.78
South Goa	Bore Well	Patnem	7.25	1.84	3.84	5.75
South Goa	Bore Well	Ponquini	9.03	7.88	8.65	9.3
South Goa	Bore Well	Severdem	14.49	8.9	14.23	15.01

South Goa	Bore Well	Thane	9.24	3.85	7.15	8.31
South Goa	Bore Well	Verna	1.76	0.42	1.64	1.69
South Goa	Bore Well	Yedda	10.4	4.45	7.67	8.9
South Goa	Dug Well	Agonda Desaiwada	3.9	2.32	3.48	3.68
South Goa	Dug Well	Bagmola	2.81	2.4	2.95	2.85
South Goa	Dug Well	Ballynuvhen	6.4	4.66	6.15	6.38
South Goa	Dug Well	Barodi Velni (Betul)	2.19	1.43	2.17	2.08
South Goa	Dug Well	Betalbatti	6.22	2.47	4.11	5.09
South Goa	Dug Well	Bhati	4.66	2.58	3.42	5.02
South Goa	Dug Well	Bolkharnem	6.74	4.14	0.32	6.18
South Goa	Dug Well	Canacona	4.44	1.7	3.95	4.06
South Goa	Dug Well	Chikalim	2.78	0.58	2.13	2.23
South Goa	Dug Well	Collem (Kolamba)	8.3	2.2	5.77	8.45
South Goa	Dug Well	Cuncalim	5.13	0.93	1.98	2.25
South Goa	Dug Well	Cuncalim (pz)	5.03	4	6.13	4.5
South Goa	Dug Well	Daptamol Lolien	14.63	14.5	14.7	14.67
South Goa	Dug Well	Darbandahra (pz)	9.52	7.02	8.77	10
South Goa	Dug Well	Deulwada Kolamba	2.51	1.88	2.87	2.49
South Goa	Dug Well	Ghadiawada	1.43	0.71	1.97	2.05
South Goa	Dug Well	Guddemal	11.45	6.25	8.45	9.96
South Goa	Dug Well	Gulem Velipwada	-	-	1.49	3.57
South Goa	Dug Well	Hattipal Poinguinem	8.31	5.81	6.98	7.94
South Goa	Dug Well	Jambavli	9.03	5.95	8.9	8.55
South Goa	Dug Well	Kalay	11.45	8.7	11.01	10.95
South Goa	Dug Well	Kapsa	6.1	2.76	4.52	4.48
South Goa	Dug Well	Kaveslium	3.34	1.16	2.46	3
South Goa	Dug Well	Majorda Bpada Curilo	5.38	1.8	3.22	4.42
South Goa	Dug Well	Malkarnem	5.68	3.4	5.41	5.93
South Goa	Dug Well	Mashe	4.22	3.05	3.71	4.04
South Goa	Dug Well	Molem	13.8	0.42	8.66	11.2
South Goa	Dug Well	Navelim	4.07	1.14	4.07	4.47
South Goa	Dug Well	Netrolim	10.44	9.18	10.64	9.54
South Goa	Dug Well	Padi	13.25	5.7	6.45	10.76
South Goa	Dug Well	Ponquini	-	-	15.39	-
South Goa	Dug Well	Quepem	2.34	1.3	2.6	2.85
South Goa	Dug Well	Revona	8.09	4.92	8.02	7.79
South Goa	Dug Well	Shrishtal Gaondongar	5.98	3.57	4.3	4.43
South Goa	Dug Well	Sristal	11.23	8.55	10.98	4.43
South Goa	Dug Well	Suktali (Molem)	4.23	3.16	4.13	4.36
South Goa	Dug Well	Themchewada	8.93	6.53	9.4	7.01
South Goa	Dug Well	Vadam	4.68	3.08	3.48	3.93
South Goa	Dug Well	Vichundrem	7.3	0.5	6.97	7.14
South Goa	Dug Well	Yedda	5	0.3	2	3.6

ANNEXURE-II

HYDROCHEMICAL DATA OF GROUND WATER MONITORING STATIONS (GWMS) OF GOA, MAY-2018

Sl.No	Location	PH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F
			$\mu\text{S/cm}$		<.....mg/L.....>									
1	BAYAL WARDIKERI (DW)	7.65	60	25	6	2	5	1	0	18	11	1	6	0.13
2	MORLEM (DW)	8.32	50	25	4	4	4	1	0	24	11	1	0	0.11
3	HONDA (DW)	8.23	80	30	4	5	6	1	0	24	14	5	0	0.04
4	BHUIPAL (DW)	9.35	110	35	6	5	9	1	12	18	18	2	0	0.21
5	CHARAYOD (DW)	9.42	120	35	6	5	10	3	12	18	14	7	0	0.57
6	NAGARGAON (DW)	8.37	110	40	8	5	4	1	0	37	14	3	0	0.29
7	BAMBAR (DW)	7.83	70	35	10	2	3	0	0	31	11	2	0	0.34
8	KHADKI (DW)	8.02	50	20	2	4	3	1	0	12	11	1	2	0.05
9	KOTADEN (DW)	9.30	70	30	4	5	4	1	12	6	7	6	0	0.43
10	DHAT WADOO VANTE (DW)	8.35	60	25	8	1	5	1	0	12	18	3	0	0.11
11	PARRA (DW)	8.13	370	95	18	12	26	8	0	122	39	22	0	0.17
12	CALANGUTE (DW)	7.79	600	150	24	22	47	10	0	79	82	25	91	0.27
13	BAGA (DW)	9.60	1510	320	64	39	125	28	24	12	249	65	228	0.63
14	ANJUNA BEACH	7.97	220	55	16	4	19	2	0	37	43	3	12	0.43
15	SHIVOLI (DW)	8.31	240	60	20	2	15	7	0	92	21	5	0	0.37
16	MORJIM (DW)	8.04	160	50	6	9	11	2	0	55	21	6	0	0.20
17	SAWANTWADA (DW)	7.91	60	25	4	4	5	1	0	18	11	2	0	0.30
18	KORGAON (DW)	9.13	70	25	6	2	4	2	0	18	14	1	0	0.14
19	UGEM (DW)	8.95	80	25	2	5	6	3	6	6	16	6	2	0.20
20	AMBERAM (DW)	8.86	140	30	8	2	8	13	12	18	18	9	0	0.46
21	KUNDAI (DW)	8.80	60	20	4	2	7	0	0	18	11	8	0	0.28
22	SUTKALI (DW)	7.86	50	20	2	4	4	1	0	6	11	5	4	0.28
23	MOLEM (DW)	8.52	110	40	8	5	6	1	6	30	11	6	2	0.20
24	BOLKARNEM (DW)	8.14	70	35	8	4	3	2	0	31	11	6	0	0.00

25	COLLEM (DW)	8.22	50	20	6	1	4	1	0	18	11	2	0	0.01
26	KALAY (DW)	8.53	60	20	4	2	4	1	0	12	14	2	2	0.02
27	MALKARNEM (DW)	7.70	70	25	4	4	5	1	0	24	11	4	0	0.10
28	GHADIWADA (DW)	7.48	120	40	6	6	7	6	0	31	21	6	0	0.01
29	GUDDMOL (DW)	7.95	110	40	4	7	8	1	0	37	18	8	0	0.01
30	KAPSA (DW)	7.83	220	60	10	9	18	4	0	43	46	9	2	0.19
31	MANDEM (DW)	8.07	220	55	6	10	15	5	0	31	50	7	0	0.10
32	SHIRODI (DW)	7.96	130	40	6	6	8	3	0	31	18	5	4	0.09
33	BORIM	8.24	310	80	16	10	22	8	0	79	39	15	15	0.23
34	QUEPEM (DW)	8.02	110	40	6	6	4	2	0	31	11	8	0	0.02
35	JAMBAVALI (DW)	7.97	90	30	4	5	6	1	0	37	11	1	1	0.08
36	REVONA (DW)	8.32	130	50	8	7	8	4	6	31	18	7	0	0.11
37	DEVALWADA KOLAMBA (DW)	7.91	110	40	6	6	4	2	0	43	11	6	0	0.11
38	VICHURDEM (DW)	7.80	60	30	5	4	3	1	0	31	7	2	0	0.12
39	VADDEM (DW)	8.04	30	15	3	2	3	0	0	12	7	0	3	0.11
40	BHATI (DW)	8.34	30	15	4	1	3	0	0	12	7	1	0	0.14
41	NATROLIM (DW)	8.39	80	25	5	3	3	3	0	31	9	2	0	0.20
42	SHREESTHAL GAONKAR (DW)	7.93	90	35	5	5	6	1	0	43	9	3	0	0.16
43	YEDA (DW)	8.46	370	80	16	10	20	12	0	104	25	14	24	0.00
44	HATTIPAL (DW)	7.73	100	35	8	4	4	1	0	37	11	3	3	0.00
45	CANACONA (DW)	8.27	170	45	8	6	12	2	0	67	18	2	0	0.00
46	DAPTOMOL (DW)	7.71	40	10	2	1	5	0	0	12	5	1	1	0.17
47	MASHI (DW)	8.26	70	25	3	4	6	1	0	18	11	5	0	0.00
48	SHRISTHAL (DW)	8.45	50	20	4	2	4	1	0	24	7	2	1	0.00
49	NAVELIM (DW)	7.62	160	20	4	2	18	2	0	24	18	4	11	0.00
50	CUNCOLIM (DW)	7.87	190	40	10	4	17	2	0	61	14	9	0	0.00
51	PADI (DW)	7.97	90	30	6	4	6	0	0	43	7	2	0	0.00
52	GULEM (DW)	8.52	130	35	6	5	8	2	6	43	7	2	3	0.35

53	AGONDA (DW)	8.27	190	35	10	2	11	7	0	49	14	6	9	0.19
54	BARADI (DW)	8.79	120	35	8	4	10	2	12	31	11	2	3	0.00
55	CAVALUSIM (DW)	8.19	250	55	18	2	17	2	0	85	11	11	0	0.00
56	BETALBATIM (DW)	8.14	190	35	12	1	16	4	0	61	14	12	0	0.00
57	MAJORDA (DW)	8.63	320	50	12	5	27	18	12	67	21	20	6	0.00
58	BALLEY NUVEM (DW)	8.03	110	30	7	3	9	1	0	37	14	3	5	0.01
59	BOGMALO (DW)	7.99	170	35	11	2	14	2	0	37	16	4	14	0.00
60	CHICALIM (DW)	7.58	120	15	4	1	13	1	0	18	14	3	12	0.00
61	VELHA GOA (DW)	7.81	210	55	16	4	15	2	0	85	14	2	3	0.00
62	GAULEBHAT (DW)	8.29	100	20	4	2	9	2	0	18	11	1	9	0.00
63	KANRANJAHALEM (DW)	7.83	330	40	10	4	29	7	0	43	28	14	33	0.00
64	BRITONA (DW)	8.04	110	25	9	1	8	1	0	37	11	3	0	0.00
65	SALWADAR DW MUND (DW)	8.49	60	20	3	3	5	0	0	12	11	3	2	0.00
66	POMBURPA PALMAR (DW)	8.22	120	25	4	4	11	2	0	18	14	6	8	0.00
67	OLALIUM (DW)	8.02	70	20	2	4	7	1	0	18	11	2	0	0.00
68	MAPUSA (DW)	8.02	260	25	6	2	25	5	0	12	25	4	45	0.00
69	COLWALA (DW)	8.21	330	70	20	5	26	6	0	73	16	12	52	0.07
70	NAGJAR (DW)	8.67	90	25	4	4	6	3	0	18	12	1	10	0.00
71	HASARVANNE (DW)	7.85	100	10	4	0	11	1	0	24	11	3	0	0.01
72	HASAPUR (DW)	8.24	290	45	12	4	18	16	0	67	21	13	13	0.08
73	PIRNA (DW)	8.21	60	20	4	2	5	1	0	24	7	2	1	0.00
74	ADAVAPAL (DW)	7.95	60	20	2	4	4	1	0	15	7	2	3	0.00
75	SAL (DW)	7.84	140	35	6	5	6	12	0	40	11	8	7	0.00
76	MULGAON SHIVAL KHERWADA	8.13	70	15	4	1	5	1	0	18	9	1	0	0.00
77	NARVE (DW)	7.76	60	20	2	2	5	0	0	18	9	1	1	0.00
78	MAYEM (JAMBULBHAT) (DW)	8.41	100	30	4	5	6	3	0	37	7	3	0	0.00

जल बचाओ
और
जल संरक्षण करना

SAVE WATER
AND
CONSERVE WATER