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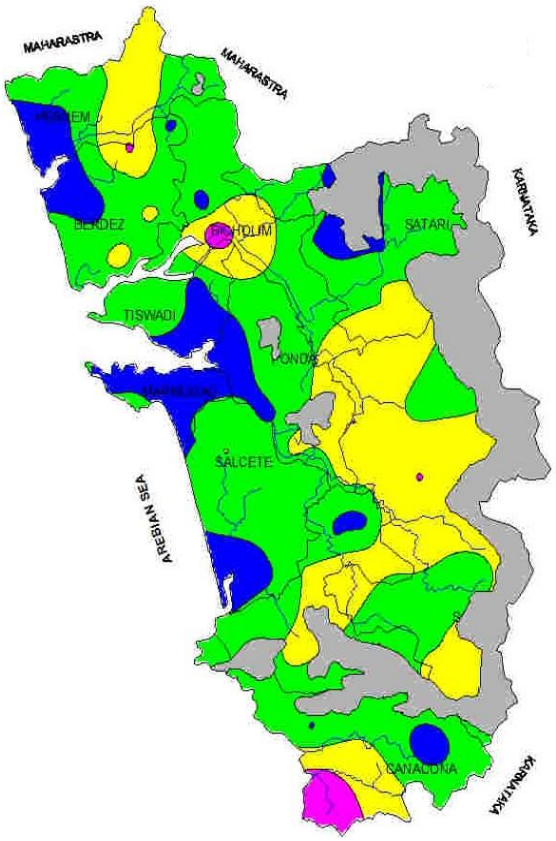
केन्द्रीय भूजल बोर्ड /Central Ground Water Board

गोवा राज्य की भूजल वर्ष पुस्तिका (2019-2020)
GROUND WATER YEAR BOOK OF GOA (2019-2020)



दक्षिण पश्चिम क्षेत्र /South Western Region
बेंगलुरु /Bangalore
August/2020

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GROUND WATER YEAR BOOK OF GOA STATE (2019-2020)

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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 ground 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 ground water level for the year 2019-20 and chemical quality data collected during May, 2019. Maps showing the depth to groundwater level in different parts of Goa and the changes observed in the ground 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, 2019 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 and Dr.K. Ravichandran, Sc-D (Chem). 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 efforts have been put by various personnel of SWR, Bangalore and by Dr.J. Davithuraj, Sc-B, WKSU, Belgavi office for the timely and reliable collection of field data. The diligent effort put by 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 year book of 2019-20 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.

August, 2020

(V. Kunhambu)
Regional Director

EXECUTIVE SUMMARY

Central Ground Water Board, an apex Organization under Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, 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, sustainable management and development can be planned.

The behaviour of ground water table during the ground water year 2019-2020 in Goa State has been studied by monitoring a set of dug wells and purpose-built piezometers during the months of May 2019, August 2019, November 2019 and January 2020. As of January 2020, Central Ground Water Board, South Western Region, monitors 85 dug wells and 47 piezometers to study the ground water scenario of Goa State.

The present compilation relates to the year 2019-2020. It provides information pertaining to ground 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 ground water levels are deep in the month of May (pre monsoon) and a rising trend of water levels was observed during November (Post-monsoon period). 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 to 10 mbgl are more prevelant in the State during premonsoon period. 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 to 10 mbgl are more prevelant in the State during premonsoon period. Depth to water level of less than 2 m bgl has been recorded in 23% of wells analysed and noted in all Taluks except Mormugao and Sanguem 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 2019 are also discussed for understanding the spatial variation of EC, Chloride, Fluoride and Nitrate concentration in the phreatic aquifer system of the state of Goa.

GROUND WATER YEAR BOOK OF GOA STATE (2019-2020)

1.0 INTRODUCTION

Central Ground Water Board, South Western Region, Bangalore is monitoring water levels in the State of Goa from the established network of 132 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 level. 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 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 with 11 Taluks. The Taluk wise distribution of Ground water monitoring stations being monitored by the Region is given in **Table 1.**

Table 1: District wise distribution of Ground water monitoring stations

Sl.No.	Taluk	Geographical Area (Sq. km) *	No. of Ground water monitoring stations
District: North Goa			
1	Tiswadi	213.6	7
2	Bardez	264.0	17
3	Pernem	251.7	17
4	Bicholim	238.8	11
5	Satari	495.1	14
6	Ponda	292.8	7
District: South Goa			
7	Sanguem	873.7	19
8	Cancona	352.0	14
9	Quepem	318.3	4
10	Salcete	292.9	20
11	Mormugao	109.1	2

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

1.1 Physiography

Goa State forms part of coastal tract of the west coast of India. Physiographically, the Goa State is divided into four morphological units namely 1. Costal plains with dominant Marie land forms on the west, followed successively towards the east 2. Vast etch plain. 3. Low dissected denudation hills and table land and 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.

1.2 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 the rivers Chapora, Baga, Saleri, Sal, Talpona and Galgibaga **(Table 2)**. Primarily the underlying rocks govern the drainage system in the area. The drainage pattern is generally of dentritic 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)**.

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 Cancona
Sal	301	8.13	Mormugao, Salcete, Quepem and Cancona
Saleri	149	4.03	Quepem and Cancona
Talpona	233	6.29	Cancona and Sanguem
Galgibaga	90	2.43	Cancona
Total	**3702**		

1.3 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 **(Plate II)**. 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.

The Deccan Trap basalts of Late Cretaceous to Early Eocene age occupy a small portion in the northeastern 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 m. 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.

Plate I

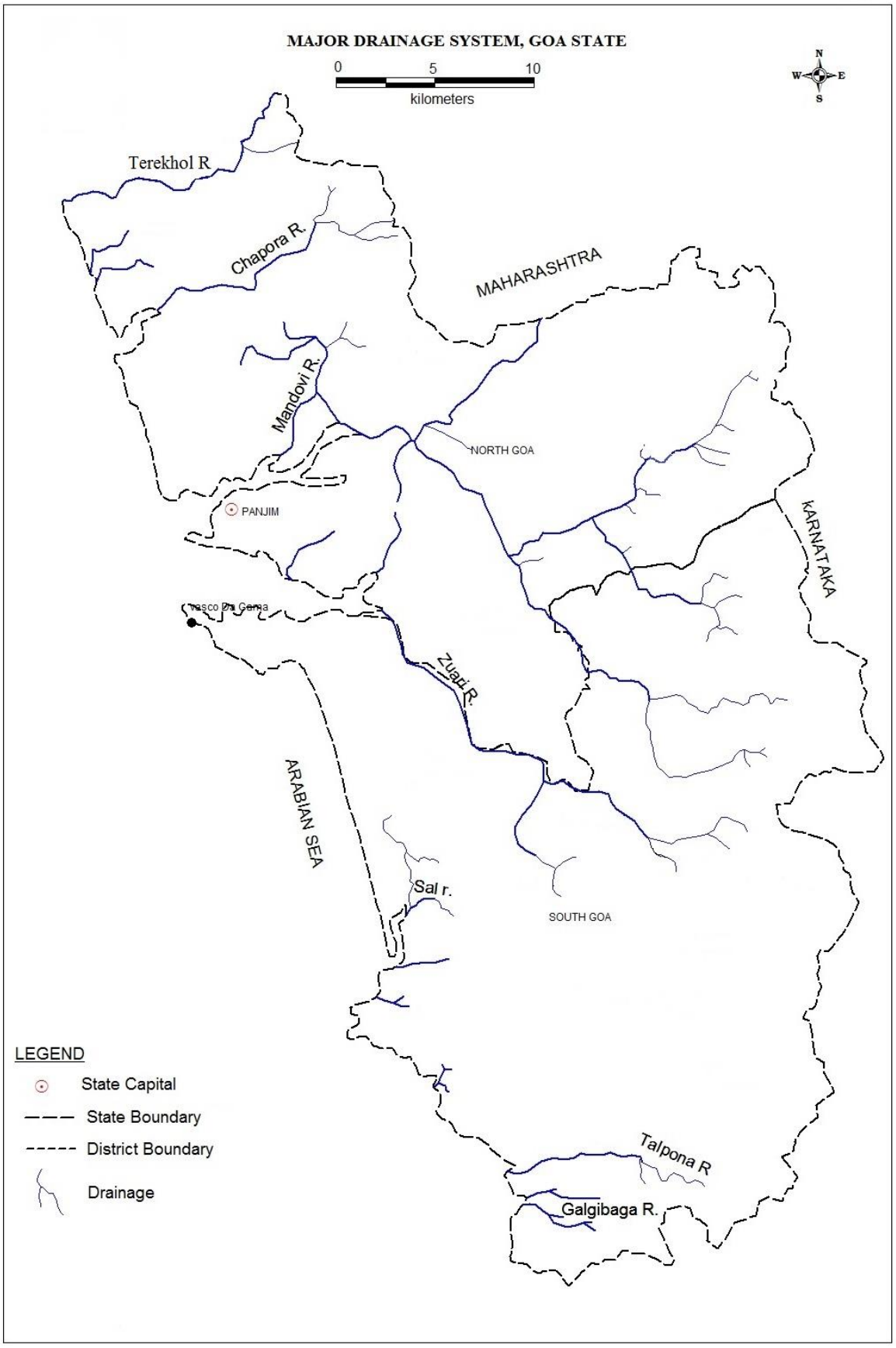
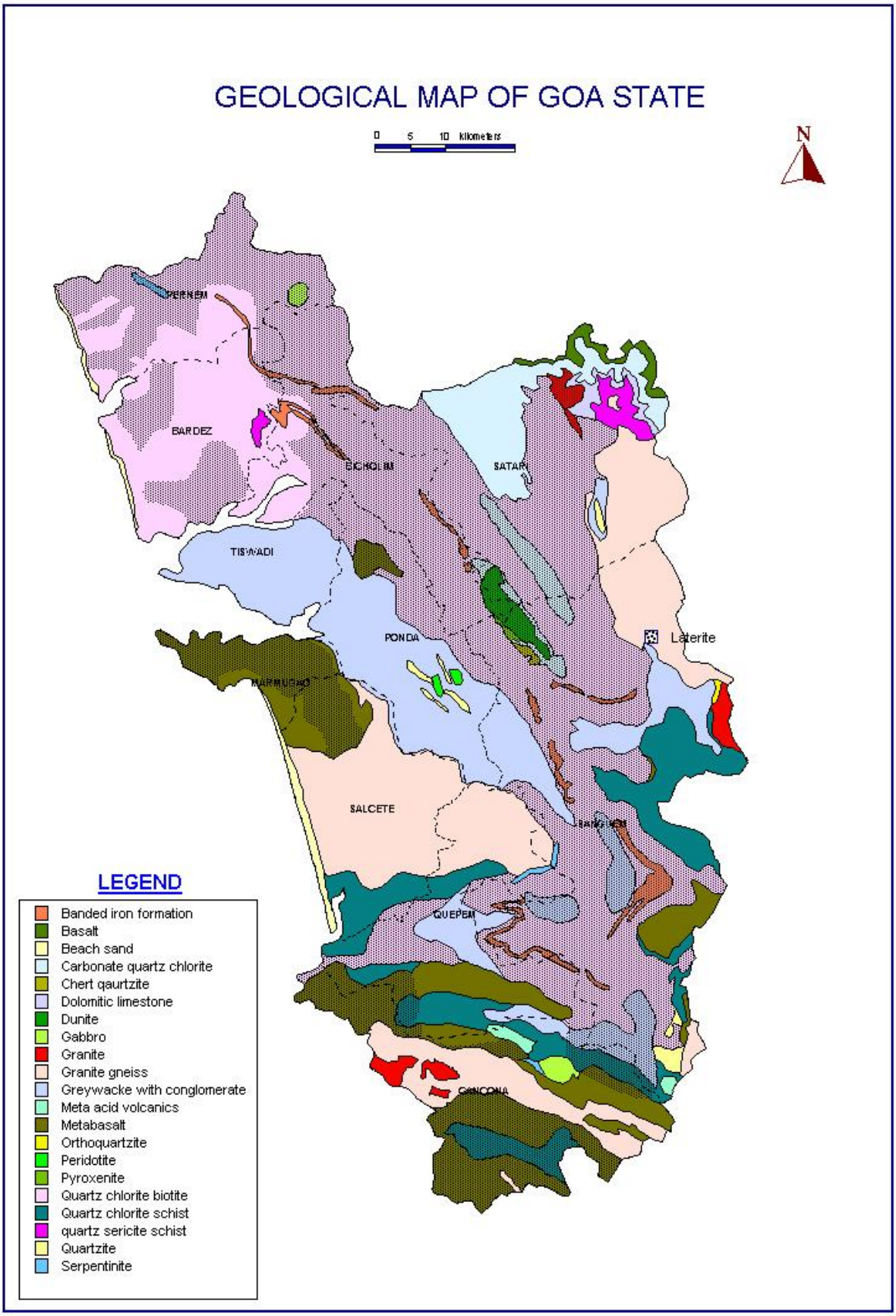

MAJOR DRAINAGE SYSTEM, GOA STATE
0
5
10
kilometers
N
W
E
S
Terekhol R
Chapora R.
MAHARASHTRA
Mandovi R.
NORTH GOA
PANJIM
KARNATAKA
Vasco Da Gama
Zuari R.
ARABIAN SEA
Sal r.
SOUTH GOA
Talpona R
Galgibaga R.
LEGEND
State Capital
State Boundary
District Boundary
Drainage

Plate II


GEOLOGICAL MAP OF GOA STATE
0 5 10 kilometers
N
PERNEM
BARDEZ
BICHOLIM
SATARI
TISWADI
PONDA
Laterite
MORMUGAO
SALCETE
QUEPEM
CANCONA
LEGEND
Banded iron formation
Basalt
Beach sand
Carbonate quartz chlorite
Chert qaurtzite
Dolomitic limestone
Dunite
Gabbro
Granite
Granite gneiss
Greywacke with conglomerate
Meta acid volcanics
Metabasalt
Orthoquartzite
Peridotite
Pyroxenite
Quartz chlorite biotite
Quartz chlorite schist
quartz sericite schist
Quartzite
Serpentinite

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 dry with clear skies and generally pleasant. May is the hottest month with temperature around 30°C and January the coolest month with temperature 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 3460.6 mm (90 % of annual rainfall), 218.1 mm (6%) during post monsoon period of October to December and 102.5 (4%) are from January to May months. The overall annual rainfall over the Goa state based on 30 years rainfall data is of 3483.3 mm. The minimum rainfall of 2611.7 mm is recorded at Mormugao station falls in South Goa district and maximum of 5090 mm is in Sanguem station also from South Goa.

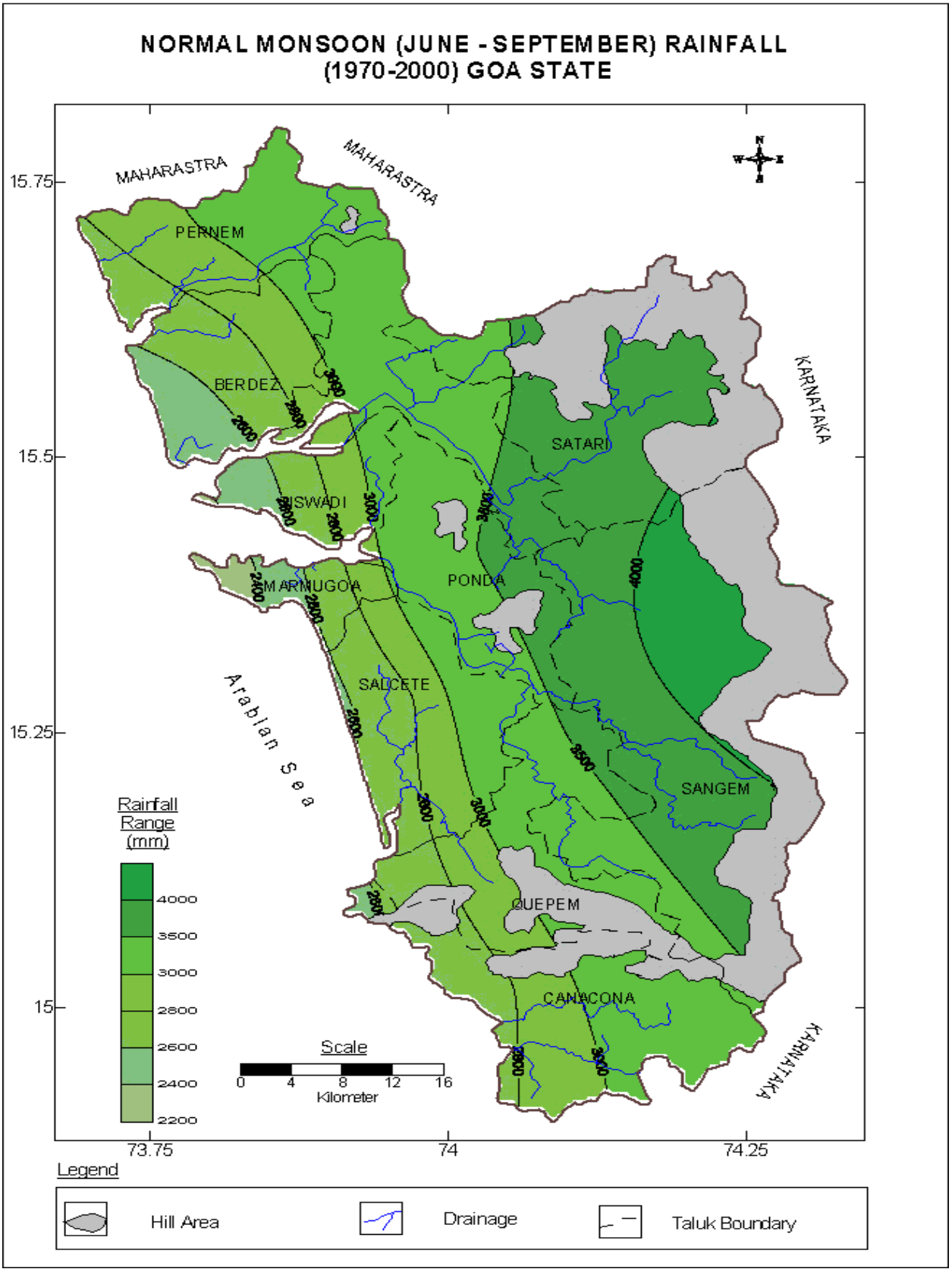
The annual normal rainfall in North Goa ranges from 2766.9 mm at Panaji along the west coast and highest at Valpoi in the east (Ghats section) indicating rainfall increases from west to east. Average rainfall in North Goa is 3400.1 mm. Similarly in South Goa it ranged 2611.7 mm at Mormugao in west coast and maximum at Sanguem in the east again ghat section indicating that the rainfall increases from west to east. The overall annual normal rainfall in South Goa is 3733.13 mm.

The months of June (940.7 mm) and July (1246.9 mm) are the wettest months with around 2187.6 mm (62.80% of annual normal rainfall) rainfall in two months. Rainfall during the months of January and February is negligible. Colem and Sanguem in the south Goa 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 of in respect of 12 stations of Goa state is presented in **Table 3**.

Table 3: Monthly Normal Rainfall of Goa State

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**

Plate III


NORMAL MONSOON (JUNE - SEPTEMBER) RAINFALL
(1970-2000) GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
SATARI
KARNATAKA
BISWADI
PONDA
MARMUGOA
SALCETE
Arabian Sea
SANGEM
QUEPEM
CANACONA
KARNATAKA
Rainfall Range (mm)
4000
3500
3000
2800
2600
2400
2200
Scale
0 4 8 12 16
Kilometer
15.75
15.5
15.25
15
73.75
74
74.25
Legend
Hill Area
Drainage
Taluk Boundary

3.0. WATER LEVELS

3.1 Depth to water level (May 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-4** and **Plate-IV** depicts the ground water scenario in May 2019. Salient features of the depth to water level scenario during May 2019 are given below-

1. A perusal of the water level data reveals that the depth to water level ranged from 1.71 m bgl (Ponda Taluk) to 14.95 m bgl (Canacona and Bardez Taluks).
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 88% of wells analysed, while 12% 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 5% of wells analysed and noted in Bardez, Ponda, Quepem and Salcete 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 Taluks.
5. Depth to water level in the range of 5 to 10 m bgl has been recorded in 39% of wells analysed and noted in all the Taluks except Mormugao Taluk.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 12% of wells analysed and noted as isolated patches in Bardez, Cancona, Salcete, Satari and Sanguem Taluks.

3.2 Depth to Piezometric Surface (May 2019)

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 2019 are given below-

1. The depth to piezometric surface ranged from 1.1 m bgl (Mormugao Taluk) to 26.68 m bgl (Bicholim Taluk) in Goa State.
2. 49% of wells have recorded depth to piezometric surface within 10 m bgl and 51% 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 7% of wells analysed and this has been noted in Mormugao and Tiswadi Taluks.
4. Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in 19 % of wells analysed and noted in Bardez, Bicholim, Pernem and Salcete 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, Canacona, Sanguem, Pernem, Salcete and Satari Taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 42 % of wells analysed and noted in all Taluks except Mormugao, Salcete and Tiswadi Taluks.
7. Depth to piezometric surface in the range of 20 to 40 m bgl has been noted in 9 % of wells analysed and noticed in Bardez, Bicholim, Ponda and Satari Taluks.

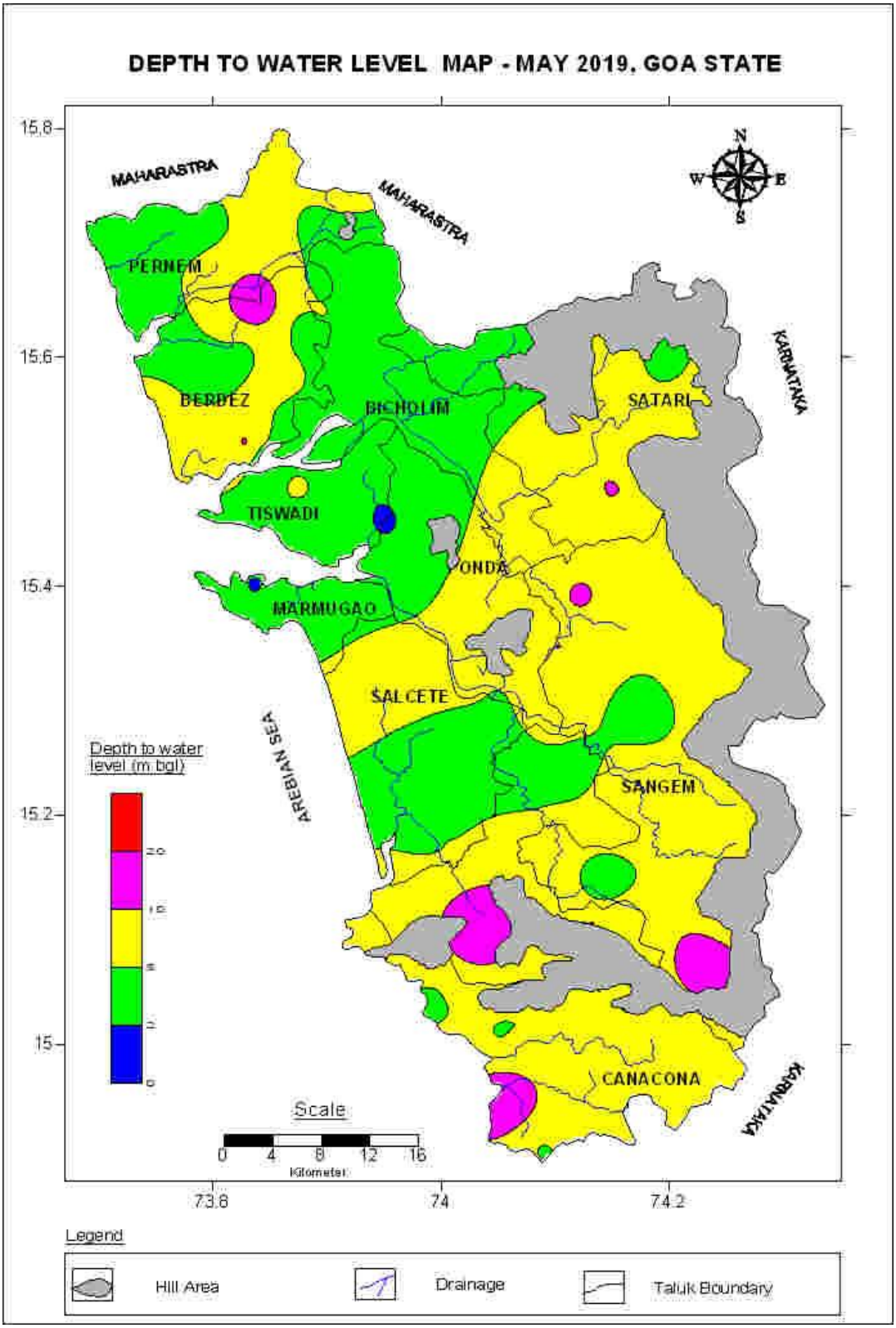
Table 4: DEPTH TO WATER LEVEL (MAY 2019)

Sl. No	Taluk Name	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	2	14.95	1	8	7	58	1	8	3	26	0	0	0	0
2	Bicholim	6	2.57	7.72	0	0	3	50	3	50	0	0	0	0	0	0
3	Cancona	6	4.05	14.95	0	0	4	66	1	17	1	17	0	0	0	0
4	Mormugao	1	3.46	3.46	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	8	2.23	7.70	0	0	5	63	3	37	0	0	0	0	0	0
6	Ponda	5	1.71	6.78	1	20	1	20	2	60	0	0	0	0	0	0
7	Quepem	3	1.75	6.78	1	33	1	33	1	34	0	0	0	0	0	0
8	Salcete	11	1.78	13.80	1	9	4	36	5	46	1	9	0	0	0	0
9	Sanguem	12	3.08	12.38	0	0	2	17	7	58	3	25	0	0	0	0
10	Satari	10	2.04	10.82	0	0	4	40	5	50	1	10	0	0	0	0
11	Tiswadi	4	2.24	8.95	0	0	2	50	2	50	0	0	0	0	0	0
	Total	**78**	**1.71**	**14.95**	**4**	**5**	**34**	**44**	**31**	**39**	**9**	**12**	**0**	**0**	**0**	**0**

Table 5: DEPTH TO PIEZOMETRIC SURFACE (MAY 2019)

Sl. No	Taluk Name	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	4.22	22.22	0	0	1	25	1	20	2	40	1	20	0	0
2	Bicholim	4	2.3	26.68	0	0	1	20	0	0	2	50	1	25	0	0
3	Cancona	5	8.9	12.99	0	0	0	0	1	20	4	80	0	0	0	0
4	Mormugao	1	1.1	1.1	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	7	3.43	19.17	0	0	2	25	2	25	4	50	0	0	0	0
6	Ponda	2	18.77	23.92	0	0	0	0	0	0	1	50	1	50	0	0
7	Quepem	1	17.22	17.22	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	8	3.11	7.68	0	0	4	57.1	3	42.9	0	0	0	0	0	0
9	Sanguem	4	5.94	12.1	0	0	0	0	2	50	2	50	0	0	0	0
10	Satari	4	5.76	20.98	0	0	0	0	1	25	2	50	1	25	0	0
11	Tiswadi	3	1.16	1.99	2	100	0	0	0	0	0	0	0	0	0	0
	Total	**43**	**1.1**	**26.68**	**3**	**7**	**8**	**18.6**	**10**	**23.3**	**18**	**41.9**	**4**	**9.3**	0	0

Plate IV


DEPTH TO WATER LEVEL MAP - MAY 2019, GOA STATE
15.8
15.6
15.4
15.2
15
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
CANACONA
KARNATAKA
N
W
E
S
Depth to water level (m bgl)
Scale
0 4 8 12 16
Kilometer
73.8
74
74.2
Legend
Hill Area
Drainage
Taluk Boundary

3.3 Depth to water level (August 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 6 and Plate V** depicts the ground water scenario in August 2019. Salient features of the depth to water level scenario during August 2019 are given below.

1. A perusal of the water level data reveals that the depth to water level ranged from ground level (Canacona Taluk) to 17.15 m bgl (Satari 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 96 % of wells analysed, while 4 % 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 35% of wells analysed and noted in all Taluks except Bicholim and Mormugao Taluks.
4. Depth to water level in the range of 2 to 5 m bgl has been recorded in 40% 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 21% of wells analysed and noted in Bardez, Canacona, Pernem, Ponda, Salcete and Sanguem Taluks.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 5% of wells analysed and noted as isolated patches in Bardez, Bicholim, Cancona and Satari Taluks.

3.4 Depth to Piezometric Surface (August 2019)

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 2019 are given below;

1. The depth to piezometric surface ranged from ground level (Mormugao and Salcete Taluks) to 17.75 m bgl (Ponda Taluk) in Goa State.
2. 80 % of wells have recorded depth to piezometric surface within 10 m bgl and 20 % 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 29 % of wells analysed and this has been observed in 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, Pernem, Sanguem, Tiswadi and Salcete 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 Bicholim, Canacona, Pernem, Sanguem 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 noticed in Bardez, Bicholim, Pernem, Ponda, Quepem and Satari Taluks.

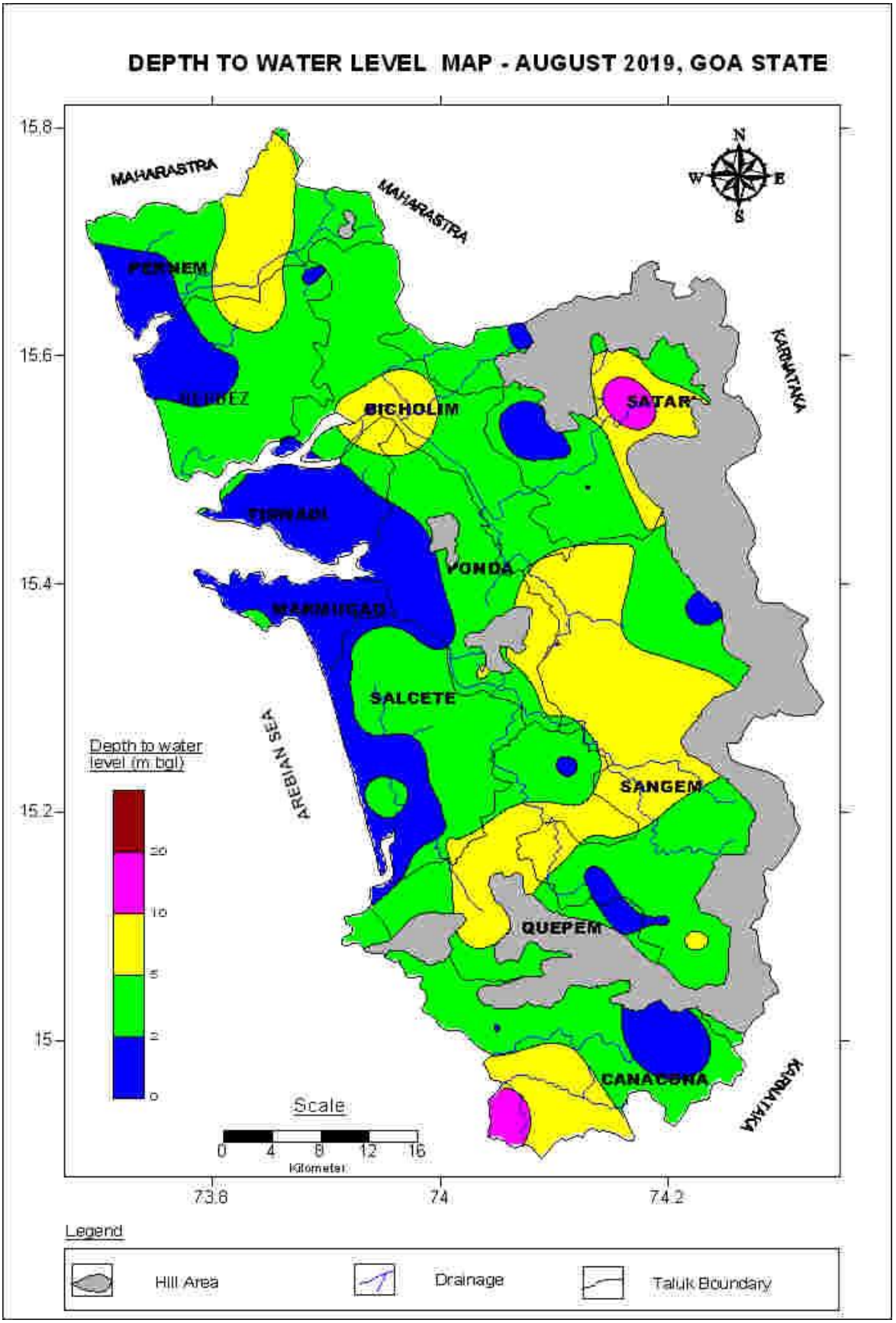
Table 6: Depth to Water Level (August 2019)

Sl No	Taluk Name	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	0.48	10.25	4	33.3	5	41.7	2	16.7	1	8.3	0	0	0	0
2	Bicholim	6	2.11	10.84	0	0	5	83.3	0	0	1	16.7	0	0	0	0
3	Cancona	6	0	11.44	2	33.3	2	33.3	1	16.7	1	16.7	0	0	0	0
4	Mormugao	1	2.45	2.45	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	0.65	7.46	3	33.3	4	44.4	2	22.2	0	0	0	0	0	0
6	Ponda	5	1.15	5.49	2	40	1	20	2	40	0	0	0	0	0	0
7	Quepem	2	1.07	3.6	1	50	1	50	0	0	0	0	0	0	0	0
8	Salcete	13	0.5	5.89	7	53.8	4	30.8	2	15.4	0	0	0	0	0	0
9	Sanguem	15	1.07	9.7	3	20	4	26.7	8	53.3	0	0	0	0	0	0
10	Satari	10	1.09	17.15	5	50	4	40	0	0	1	10	0	0	0	0
11	Tiswadi	2	1.54	4.35	1	50	1	50	0	0	0	0	0	0	0	0
	Total	**81**	**0**	**17.15**	**28**	**35**	**32**	**40**	**17**	**21**	**4**	**5**	**0**	**0**	**0**	**0**

Table 7: Depth to Piezometric Surface (August 2019)

Sl. No	Taluk Name	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	2	3.02	12.58	0	20	1	50	0	0	1	50	0	0	0	0
2	Bicholim	4	3.95	17.33	0	0	1	25	1	25	2	50	0	0	0	0
3	Canacona	4	5.45	7.68	0	0	0	0	4	100	0	0	0	0	0	0
4	Marmugoa	1	0	0	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	7	0.92	12.02	2	28.6	1	14.3	2	28.6	2	28.6	0	0	0	0
6	Ponda	2	13.55	17.75	0	0	0	0	0	0	2	100	0	0	0	0
7	Quepem	1	11.58	11.58	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	7	0	3.92	4	57.1	3	42.9	0	0	0	0	0	0	0	0
9	Sanguem	3	1.05	6.75	1	33.3	1	33.3	1	50	0	0	0	0	0	0
10	Satari	4	1.05	17.25	1	25	0	0	1	33.3	2	50	0	0	0	0
11	Tiswadi	3	0.35	2.35	2	66.7	1	33.3	0	25	0	0	0	0	0	0
	Total	**41**	**0.04**	**17.5**	**12**	**29**	**13**	**32**	**8**	**20**	**8**	**20**	**0**	**0**	**0**	**0**

Plate V


DEPTH TO WATER LEVEL MAP - AUGUST 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MORMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
Depth to water level (m bgl)
20
10
5
2
0
Scale
0 4 8 12 16
Kilometer
15.8
15.6
15.4
15.2
15
73.8
74
74.2
N
W
E
S
Legend
Hill Area
Drainage
Taluk Boundary

3.5 Depth to water level (November 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 8** and **Plate VI** depicts the ground water scenario in November 2019. Salient features of the depth to water level scenario during November 2019 are given below-

1. A perusal of the water level data reveals that the depth to water level ranged from 0.04 m bgl (Canacona Taluk) to 14.67 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 94 % of wells analysed, while 6% 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 23% of wells analysed and noted in all Taluks except Mormugao and Sanguem 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 23 % 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 6 % of wells analysed and noted as isolated pockets in Bardez, Bicholim, Cancona and Sanguem Taluks.

3.6 Depth to Piezometric Surface (November 2019)

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 2019 are given below-

1. The depth to piezometric surface ranged from 0.04 m bgl (Salcete Taluk) to 19.18 m bgl (Bicholim Taluk) in Goa State.
2. 72% of wells have recorded depth to piezometric surface within 10 m bgl and 28% 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 25% of wells analysed and this has been noted in 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 28% of wells analysed and noted in Bardez, Cancona, Pernem, Salcete, Sanguem and Tiswadi Taluks.

5. Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in 19 % of wells analysed and noted in Bicholim, Canacona, Sanguem and Satari Taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 28% of wells analysed and noted in Bardez, Bicholim, Pernem, Ponda and Satari Taluks.

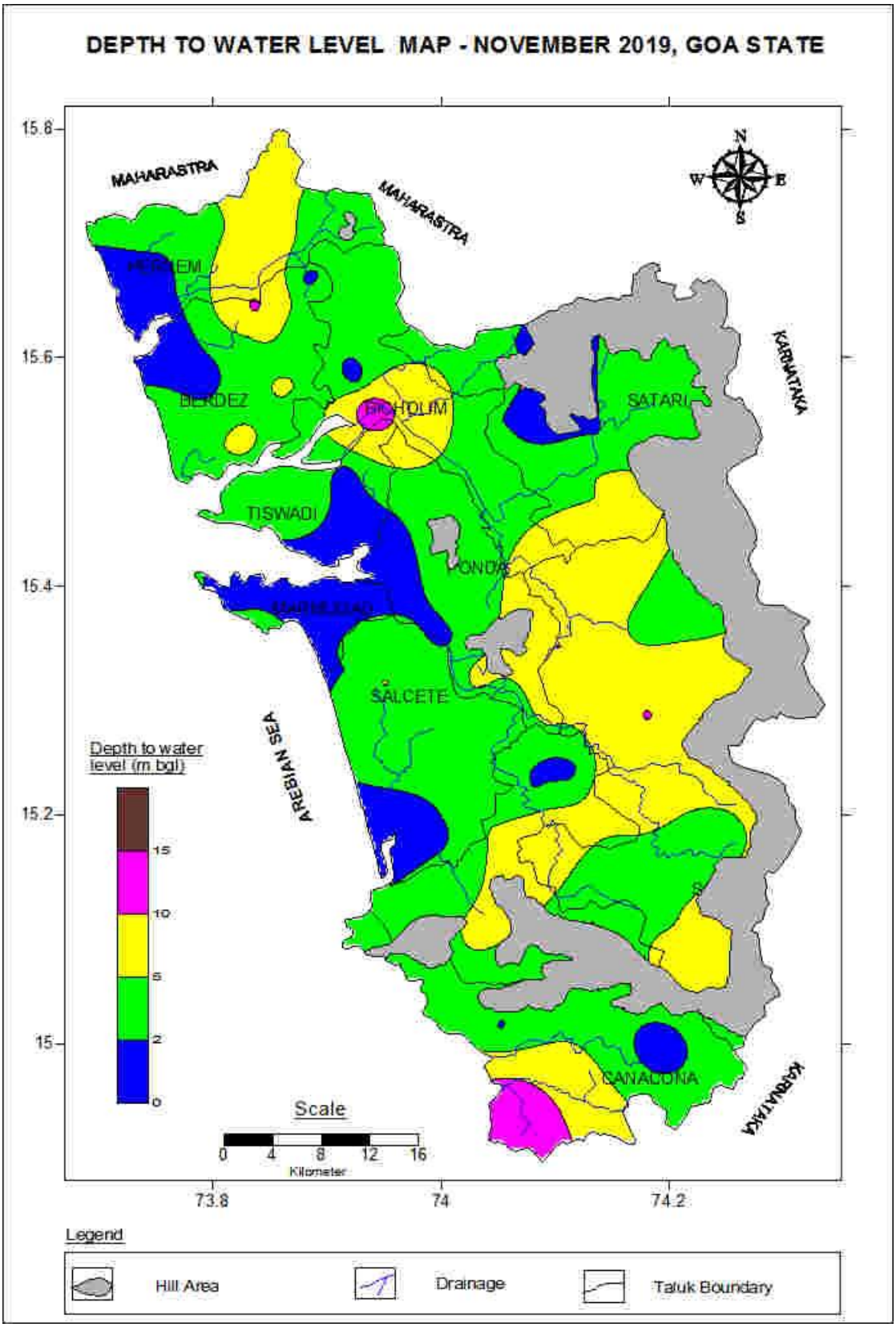
Table 8: Depth to Water Level (November 2019)

Sl No	Taluk Name	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	11	0.95	11.05	4	36.4	4	36.4	2	18.2	1	9.1	0	0	0	0
2	Bicholim	7	1.12	14	1	14.3	3	42.9	2	28.6	1	14.3	0	0	0	0
3	Cancona	7	0.04	14.67	1	14.3	4	57.1	1	14.3	1	14.3	0	0	0	0
4	Mormugao	1	2.65	2.65	0	0.0	1	100.0	0	0.0	0	0.0	0	0	0	0
5	Pernem	9	0.65	7.54	2	22.2	5	55.6	2	22.2	0	0.0	0	0	0	0
6	Ponda	5	1.4	6.08	2	40.0	1	20.0	2	40.0	0	0.0	0	0	0	0
7	Quepem	4	1.25	4.84	1	25.0	3	75.0	0	0.0	0	0.0	0	0	0	0
8	Salcete	9	0.64	5.82	4	44.4	3	33.3	2	22.2	0	0.0	0	0	0	0
9	Sanguem	15	2.31	10.25	0	0.0	7	46.7	6	40.0	2	13.3	0	0	0	0
10	Satari	10	1.23	6.51	3	30.0	6	60.0	1	10.0	0	0.0	0	0	0	0
11	Tiswadi	3	1	6.23	1	33.3	1	33.3	1	33.3	0	0.0	0	0	0	0
	Total	**81**	**0.04**	**14.67**	**19**	**23**	**38**	**47**	**19**	**23**	**5**	**6**	**0**	**0**	**0**	**0**

Table 9: Depth to Piezometric Surface (November 2019)

Sl. No	Taluk Name	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	3.67	17.95	0	0.0	2	50.0	0	0.0	2	50.0	0	0	0	0
2	Bicholim	4	5	19.18	0	0.0	0	0.0	2	50.0	2	50.0	0	0	0	0
3	Cancona	5	2.23	8.37	0	0.0	1	20.0	4	80.0	0	0.0	0	0	0	0
4	Mormugao	1	0.16	0.16	1	100.0	0	0.0	0	0.0	0	0.0	0	0	0	0
5	Pernem	6	1.53	17.7	1	16.7	2	33.3	0	0.0	3	50.0	0	0	0	0
6	Ponda	2	12.88	14.3	0	0.0	0	0.0	0	0.0	2	100.0	0	0	0	0
7	Quepem	0	1.25	4.84	0	0.0	0	0.0	0	0.0	0	0.0	0	0	0	0
8	Salcete	7	0.04	4.57	4	57.1	3	42.9	0	0.0	0	0.0	0	0	0	0
9	Sanguem	4	1.64	8.6	1	25.0	2	50.0	1	25.0	0	0.0	0	0	0	0
10	Satari	4	1.87	18.17	1	25.0	0	0.0	1	25.0	2	50.0	0	0	0	0
11	Tiswadi	3	0.43	3.36	2	66.7	1	33.3	0	0.0	0	0.0	0	0	0	0
	Total	**40**	**0.04**	**19.18**	**10**	**25**	**11**	**28**	**8**	**19**	**11**	**28**	**0**	**0**	**0**	**0**

Plate VI


DEPTH TO WATER LEVEL MAP - NOVEMBER 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BARDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MORMUGAO
SALCETE
ARABIAN SEA
CANACONA
KARNATAKA
N
S
E
W
15.8
15.6
15.4
15.2
15
73.8
74
74.2
Depth to water level (m bgl)
15
10
5
2
0
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

3.7 Depth to water level (January 2020)

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** depicts the ground water scenario in January 2020. Salient features of the depth to water level scenario during January 2020 are given below-

1. A perusal of the water level data reveals that the depth to water level ranged from 0.76 mbgl (Salcete Taluk) to 14.86 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 90 % of wells analysed, while 10% 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 13 % of wells analysed and noted in Bardez, Cancona, Pernem, Ponda, Salcete, Sanguem 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 28% of wells analysed and noted in all Taluks except Mormugao and Quepem Taluks.
6. Depth to water level in the range of 10 to 20 m bgl has been observed in 10% of wells analysed and noted as isolated patches in Bardez, Bicholim Cancona and Sanguem Taluks.

3.8 Depth to Piezometric Surface (January 2020)

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 2020 are given below-

1. The depth to piezometric surface ranged from 0.38 (Mormugao Taluk) to 25.29 m bgl (Bicholim Taluk) in Goa State.
2. 65 % of wells have recorded depth to piezometric surface within 10 m bgl and 35% 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 21 % 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 21 % of wells analysed and noted in Bardez, Bicholim, Pernem, Sanguem, Tiswadi, Satari and Salcete 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 Cancona, Pernem, Sanguem and Satari Taluks.
6. Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in 30% of wells analysed and and noticed in Bardez, Bicholim, Canacona, Pernem, Ponda, Quepem, Sanguem and Satari Taluks.
7. Depth to piezometric surface in the range of more than 20 m bgl has been observed in 5 % of wells analysed and noticed in Bardez and Bicholim Taluks.

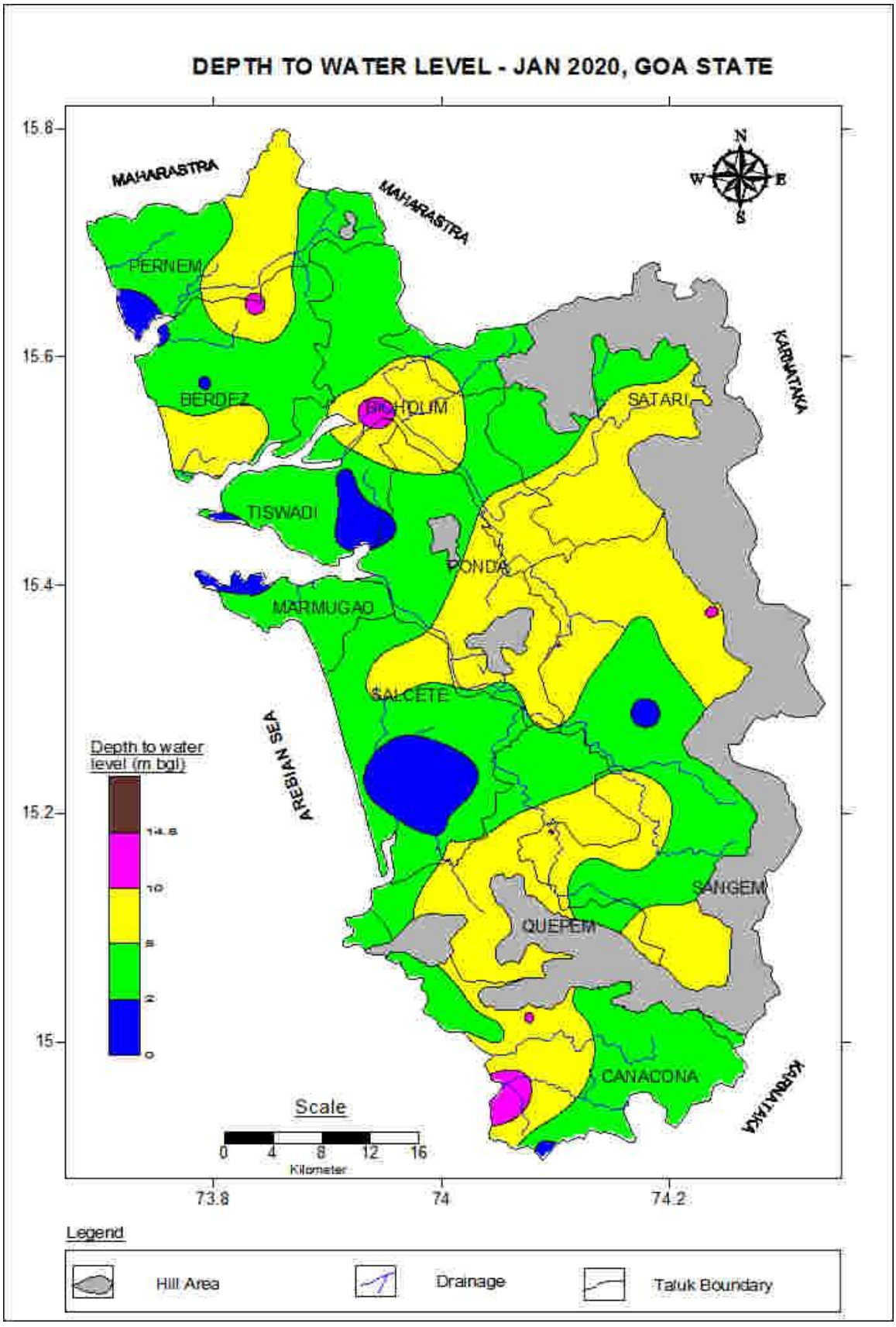
Table 10: Depth to Water Level (January 2020)

Sl No	Taluk Name	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	1.72	11.71	2	16.67	6	50	1	8.33	3	25	0	0	0	0
2	Bicholim	7	2.59	13.49	0	0	5	71.43	1	14.29	1	14.29	0	0	0	0
3	Cancona	9	1.44	14.86	1	11.11	5	55.56	1	11.11	2	22.22	0	0	0	0
4	Mormugao	1	2.94	2.94	0	0	1	100	0	0	0	0	0	0	0	0
5	Pernem	9	1.13	7.55	1	11.11	6	66.67	2	22.22	0	0	0	0	0	0
6	Ponda	5	1.53	6.52	1	20	1	20	3	60	0	0	0	0	0	0
7	Quepem	3	2.36	4.49	0	0	3	100	0	0	0	0	0	0	0	0
8	Salcete	10	0.76	8.07	3	30	4	40	3	30	0	0	0	0	0	0
9	Sanguem	15	1.05	10.17	1	6.67	4	26.67	8	53.33	2	13.33	0	0	0	0
10	Satari	10	2.11	7.83	0	0	6	60	4	40	0	0	0	0	0	0
11	Tiswadi	4	1.45	8.31	2	50	1	25	1	25	0	0	0	0	0	0
	Total	**85**	**0.76**	**14.86**	**11**	**13**	**42**	**49**	**4**	**28**	**8**	**10**	**0**	**0**	**0**	**0**

Table 11: Depth to Piezometric Surface (January 2020)

Sl. No	Taluk Name	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	1.24	20.19	1	20	1	20	1	20	1	20	1	20	0	0
2	Bicholim	4	5.5	25.29	0	0	0	0	2	50	1	25	1	25	0	0
3	Cancona	5	4.66	11.26	0	0	1	20	3	60	1	20	0	0	0	0
4	Mormugao	1	0.38	0.38	1	100	0	0	0	0	0	0	0	0	0	0
5	Pernem	8	1.98	17.96	1	12.5	2	25	1	12.5	4	50	0	0	0	0
6	Ponda	2	15.51	17.79	0	0	0	0	0	0	2	100	0	0	0	0
7	Quepem	1	13.79	13.79	0	0	0	0	0	0	1	100	0	0	0	0
8	Salcete	6	0.89	3.36	4	66.67	2	33.33	0	0	0	0	0	0	0	0
9	Sanguem	4	2.9	10.69	0	0	1	25	2	50	1	25	0	0	0	0
10	Satari	4	3.4	18.86	0	0	1	25	1	25	2	50	0	0	0	0
11	Tiswadi	3	0.55	3.38	2	66.67	1	33.33	0	0	0	0	0	0	0	0
	Total	**43**	**0.38**	**25.29**	**9**	**21**	**9**	**21**	**10**	**23**	**13**	**30**	**2**	**5**	**0**	**0**

Plate VII


DEPTH TO WATER LEVEL - JAN 2020, GOA STATE
MAHARASTRA
MAHARASTRA
KARNATAKA
KARNATAKA
PERNEM
BERDEZ
BICHOLIM
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
SANGEM
QUEPEM
CANACONA
ARABIAN SEA
N
S
E
W
15.8
15.6
15.4
15.2
15
73.8
74
74.2
Depth to water level (m bgl)
14.6
10
5
2
0
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.0 FLUCTUATION OF WATER LEVEL
4.1 May 2019 and November 2019

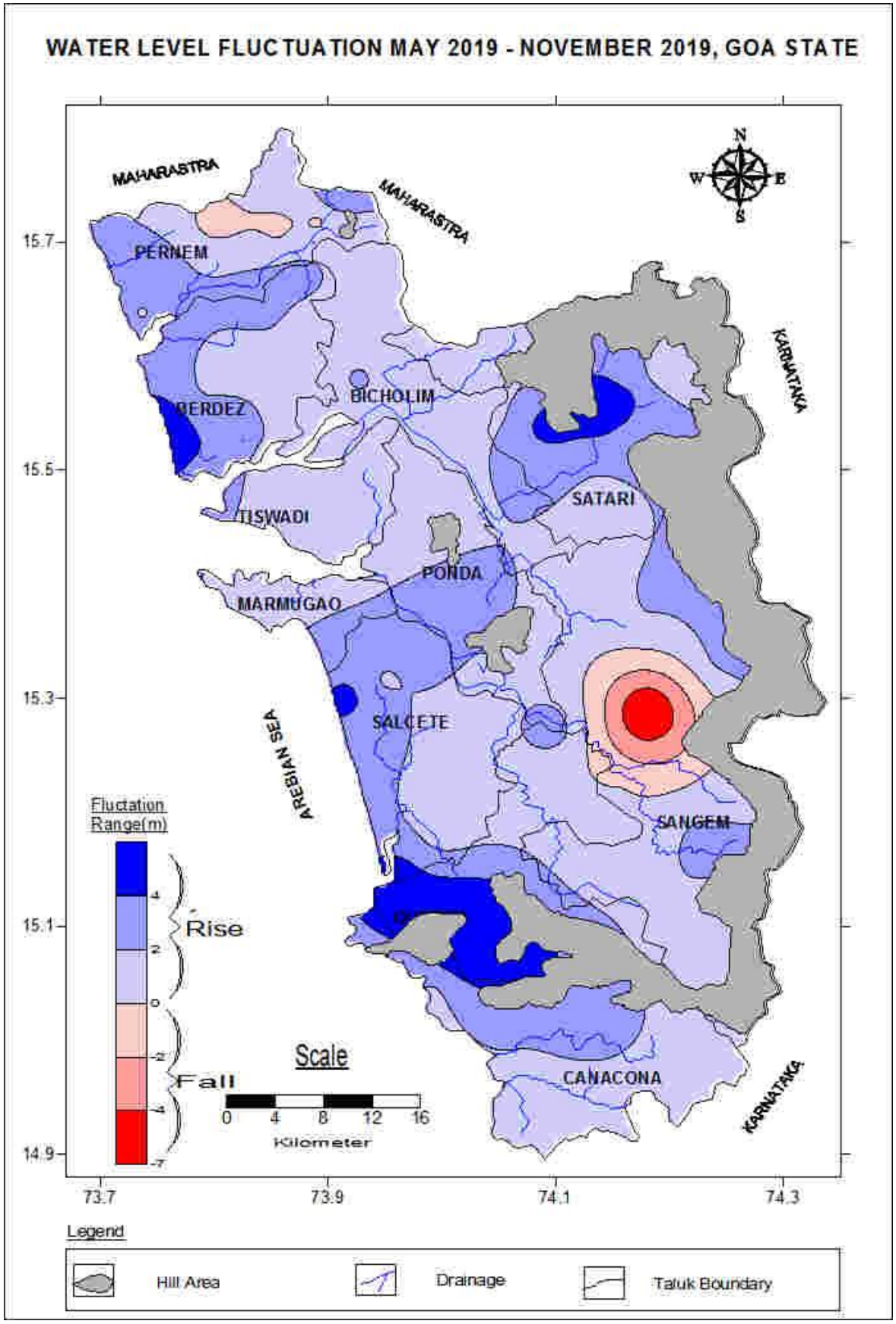
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 12** and **Plate VIII**. A comparison of water level shows that a rise in the water level is recorded in 94% of wells analysed, while 6% recorded fall.

1. Rise in the water level in the range of 0-2 m has been observed in 54% of wells analysed and noticed in almost all Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 22% of wells analysed and noticed in all Taluks except Mormugao, Ponda and Satari Taluks.
3. Rise in water level more than 4 m has been observed in 18 % of wells analysed and noted in parts of Bardez, Ponda, Salcete, Sanguem and Satari Taluks.
4. The fall in water level in the range of 0-2 m has been observed in 4 % of wells analysed and noticed in parts of Pernem Taluk.
5. The fall in water level in the range of more than 4m has been observed in 2 % of wells analysed and noted in parts of Sanguem Taluk.

Table 12: District wise categorisation of water level fluctuation (May 2019-Nov 2019)

Sl No	Taluk 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	5	45.5	3	27.3	3	27.3	0	0	0	0	0	0	11	0
2	Bicholim	5	4	80	1	20	0	0	0	0	0	0	0	0	5	0
3	Canacona	5	2	40	3	60	0	0	0	0	0	0	0	0	5	0
4	Mormugoa	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
5	Pernem	8	3	37.5	2	25	0	0	3	37.5	0	0	0	0	5	3
6	Ponda	4	3	75	0	0	1	25	0	0	0	0	0	0	4	0
7	Quepem	3	2	66.7	1	33.3	0	0	0	0	0	0	0	0	3	0
8	Salcete	9	4	44.4	2	22.2	3	33.3	0	0	0	0	0	0	9	0
9	Sanguem	11	7	63.6	2	18.2	1	9.1	0	0	0	0	1	9.1	10	1
10	Satari	9	5	55.6	0	0	4	44.4	0	0	0	0	0	0	9	0
11	Tiswadi	2	1	50	1	50	0	0	0	0	0	0	0	0	2	0
	Total	**68**	**37**	**54**	**15**	**22**	**12**	**18**	**3**	**4**	**0**	**0**	**1**	**2**	**64**	**4**

Plate VIII


WATER LEVEL FLUCTUATION MAY 2019 - NOVEMBER 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BICHOLIM
SERDEZ
TISWADI
SATARI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
KARNATAKA
ARABIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
4
2
0
-2
-4
-7
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.2 May 2018 and May 2019

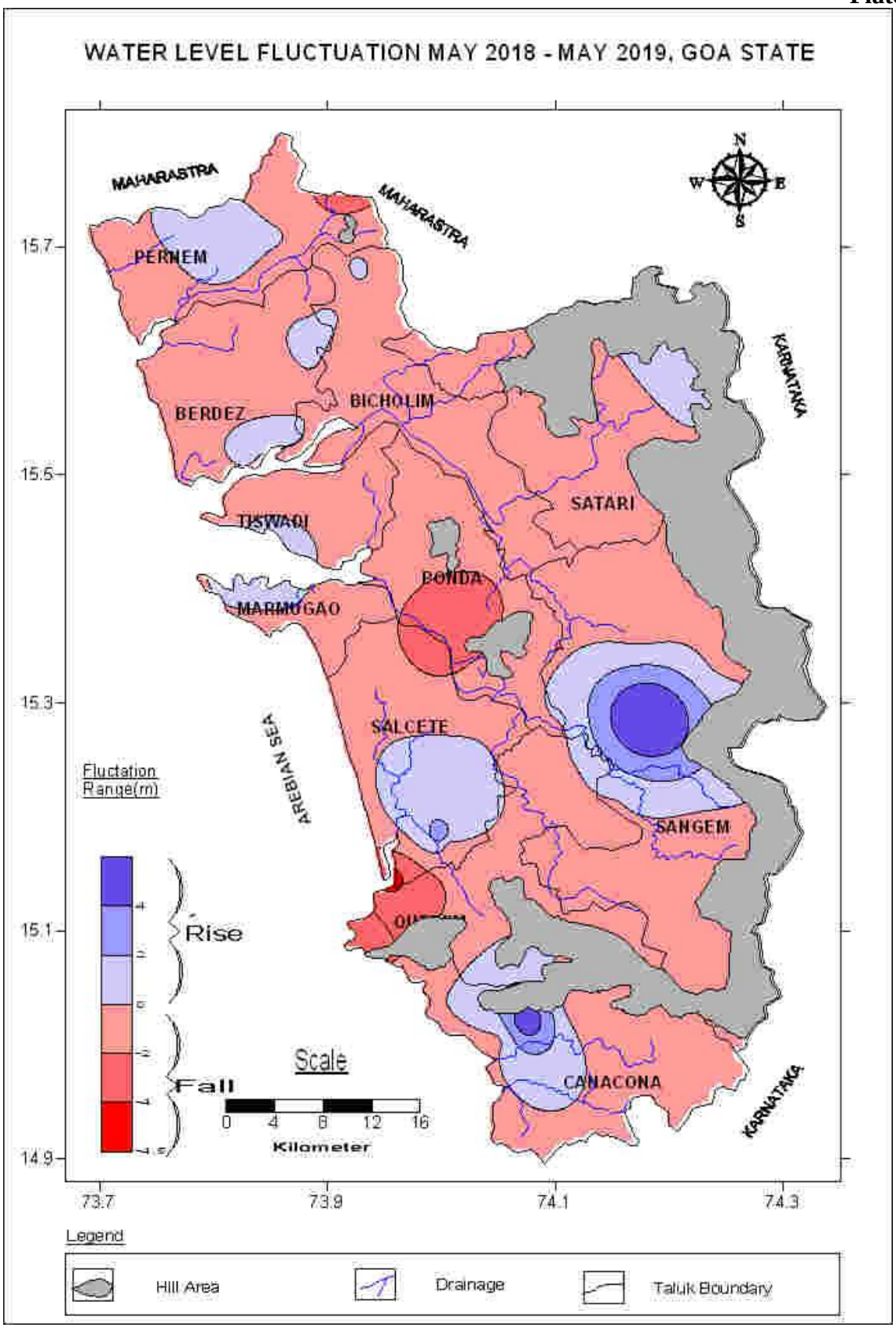
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 13**. A comparison of water level shows that a fall in the water level is recorded in 75% of wells analysed, while 25% recorded rise. The fluctuation in water level 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 21% of wells analysed and observed in Bardez, Bicholim, Pernem, Salcete, Sanguem and Satari 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 >4 m has been observed in 3% of wells analysed and observed in Canacona and Sanguem Taluks.
4. The fall in water level in the range of 0-2 m has been observed in 69% 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 4% of wells analysed and noted in Bardez, Canacona and Pernem Taluks.
6. The fall in water level more than 4 m has been observed in 3% of wells analysed and noted in Ponda and Salcete Taluks.

Table 13: District wise categorisation of water level fluctuation (May 2018- May 2019)

Sl. No	Taluk 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	12	4	33.3	0	0	0	0	7	58.3	1	8.3	0	0	4	8
2	Bicholim	6	2	33.3	0	0	0	0	4	66.7	0	0	0	0	2	4
3	Canacona	5	0	0	0	0	1	20	3	60	1	20	0	0	1	4
4	Marmugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Pernem	8	4	50	0	0	0	0	3	37.5	1	12.5	0	0	4	4
6	Ponda	5	0	0	0	0	0	0	4	80	0	0	1	20	0	5
7	Quepem	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
8	Salcete	11	2	18.2	1	9.1	0	0	7	63.6	0	0	1	9.1	3	8
9	Sanguem	12	1	8.3	0	0	1	8.3	10	83.3	0	0	0	0	2	10
10	Satari	10	3	30	0	0	0	0	7	70	0	0	0	0	3	7
11	Tiswadi	4	0	0	0	0	0	0	4	100	0	0	0	0	0	4
	Total	**77**	**16**	**20.8**	**1**	**1.3**	**2**	**2.6**	**53**	**68.8**	**3**	**3.9**	**2**	**2.6**	**19**	**58**

Plate IX


WATER LEVEL FLUCTUATION MAY 2018 - MAY 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
KARNATAKA
AREBIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.3 August 2018 andAugust 2019

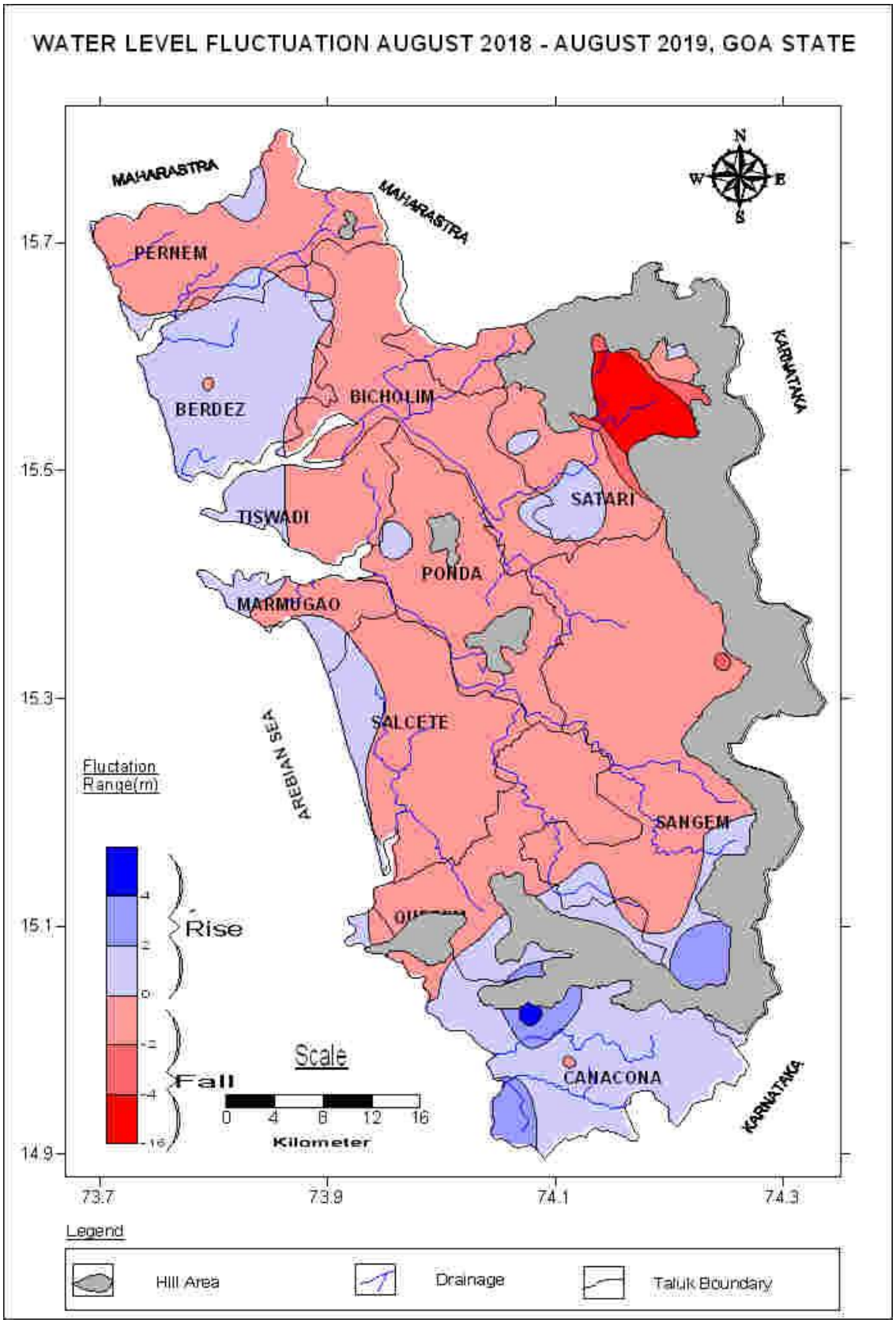
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 14**. A comparison of water level shows that a fall in the water level is recorded in 69% of wells analysed, while 31% recorded rise. The fluctuation in water level 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 27% of wells analysed and observed in all Taluks except Mormugao, Quepem and Tiswadi Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 3% of wells analysed and observed in Canacona and Sanguem Taluks.
3. Rise in the water level in the range of >4 m has been observed in 1% of wells analysed and observed Canacona Taluk.
4. The fall in water level in the range of 0-2 m has been observed in 67% of wells analysed and noted in almost all Taluks.
5. Fall in the water level in the range of 2-4 m has been observed in 1% of wells analysed and observed in Tiswadi Taluk.
6. The fall in water level more than 4 m has been observed in 1% of wells analysed and noted in Satari Taluk.

Table 14: District wise categorisation of water level fluctuation (August 2018-August 2019)

Sl. 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	12	9	75	0	0	0	0	3	25	0	0	0	0	9	3
2	Bicholim	5	2	40	0	0	0	0	3	60	0	0	0	0	2	3
3	Canacona	6	1	16.7	1	17	1	17	3	50	0	0	0	0	3	3
4	Marmugoa	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	2	40	0	0	0	0	3	60	0	0	0	0	2	3
7	Quepem	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
8	Salcete	11	4	36.4	0	0	0	0	7	63.6	0	0	0	0	4	7
9	Sanguem	15	1	6.7	1	6.7	0	0	13	86.7	0	0	0	0	2	13
10	Satari	10	1	10	0	0	0	0	8	80	0	0	1	10	1	9
11	Tiswadi	2	0	0	0	0	0	0	1	50	1	50	0	0	0	2
	Total	**78**	**21**	**27**	**2**	**3**	**1**	**1**	**52**	**67**	**1**	**1**	**1**	**1**	**24**	**54**

Plate X


WATER LEVEL FLUCTUATION AUGUST 2018 - AUGUST 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
KARNATAKA
ARABIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.3 November 2018 and November 2019

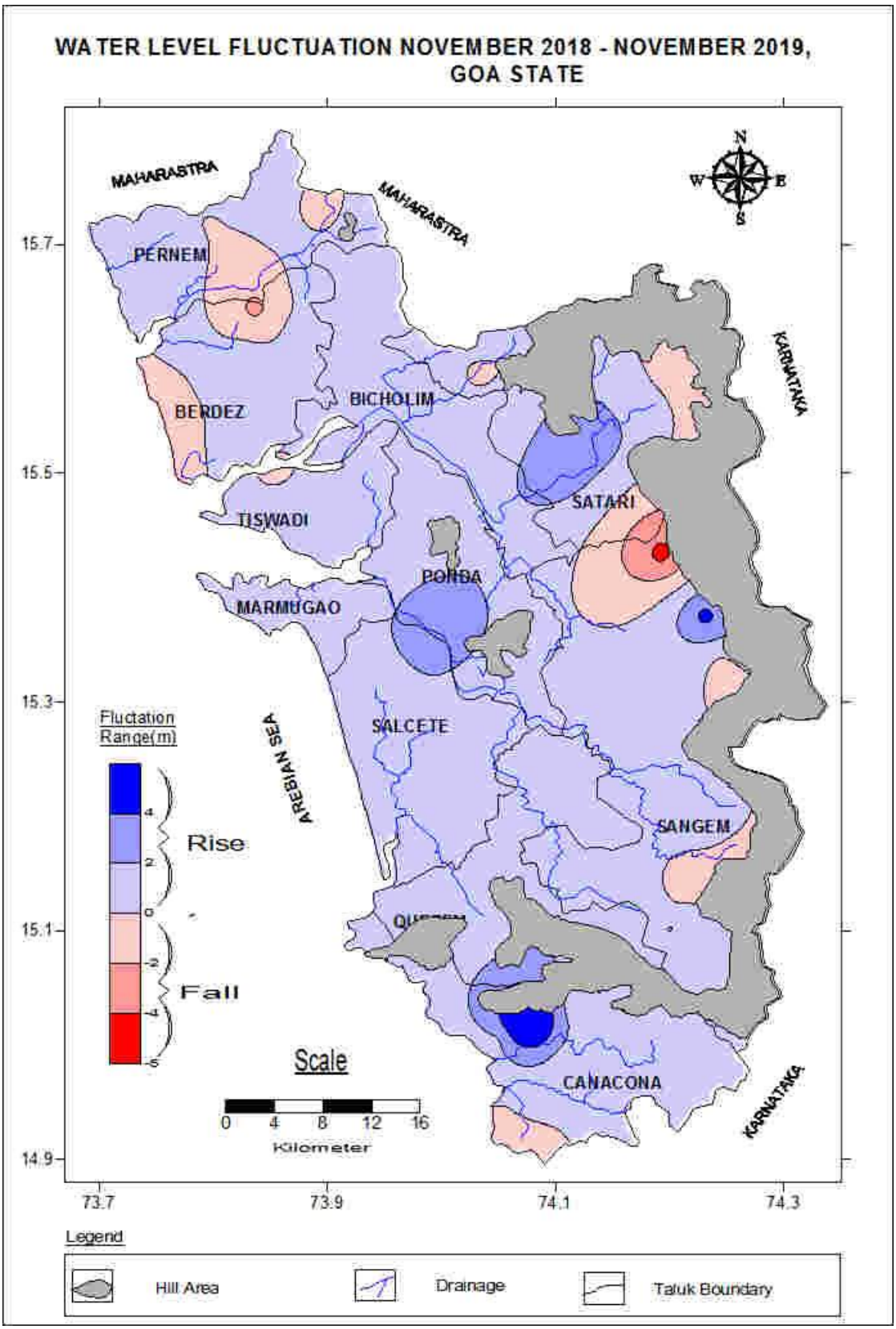
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 15**. A comparison of water level shows that a rise in the water level is recorded in 85% of wells analysed, while 15% recorded fall. The fluctuation in water level 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 76% of wells analysed and observed in almost all Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 5% of wells analysed and observed in Bardez, Bicholim, Sanguem and Satari Taluks.
3. Rise in the water level in the range of >4 m has been observed in 4% of wells analysed and observed Canacon, Ponda and Sanguem Taluks.
4. The fall in water level in the range of 0-2 m has been observed in 13% of wells analysed and noted in Bardez, Pernem, Sanguem and Satari 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 Bardez Taluk.
6. The fall in water level more than 4 m has been observed in 1% of wells analysed and noted in Sanguem Taluk.

Table 15: District wise categorisation of water level fluctuation (Nov 2018-Nov 2019)

Sl.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	7	63.6	1	9.1	0	0	2	18.2	1	9.1	0	0	8	3
2	Bicholim	7	6	85.7	1	14.3	0	0	0	0	0	0	0	0	7	0
3	Canacona	7	6	85.7	0	0	1	14.3	0	0	0	0	0	0	7	0
4	Mormugoa	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
5	Pernem	9	6	66.7	0	0	0	0	3	33.3	0	0	0	0	6	3
6	Ponda	5	4	80	0	0	1	20	0	0	0	0	0	0	5	0
7	Quepem	3	3	100.0	0	0	0	0	0	0	0	0	0	0	3	0
8	Salcete	9	9	100.0	0	0	0	0	0	0	0	0	0	0	9	0
9	Sanguem	15	10	66.7	1	6.7	1	6.7	2	13.3	0	0	1	6.7	12	3
10	Satari	9	6	66.7	1	11.1	0	0	2	22.2	0	0	0	0	7	2
11	Tiswadi	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
	Total	**78**	**59**	**76**	**4**	**5**	**3**	**4**	**10**	**13**	**1**	**1**	**1**	**1**	**66**	**12**

Plate XI


WATER LEVEL FLUCTUATION NOVEMBER 2018 - NOVEMBER 2019,
GOA STATE
MAHARASTRA
MAHARASTRA
KARNATAKA
PERNEM
BICHOLIM
BERDEZ
TISWADI
SATARI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
ARABIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
4
2
0
-2
-4
-5
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.4 January 2019 and January 2020

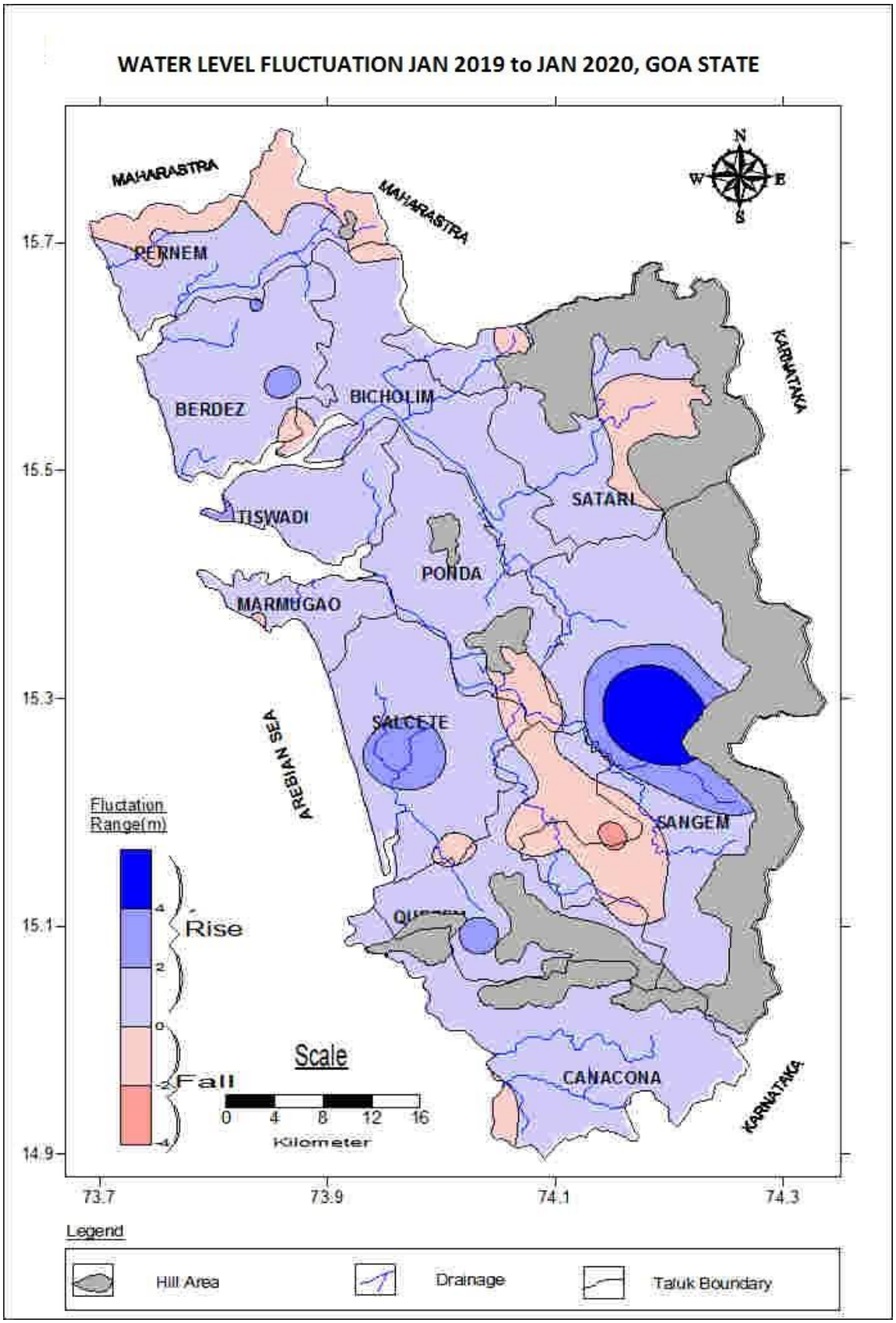
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 16**. A comparison of water level shows that a rise in the water level is recorded in 79% of wells analysed, while 21% recorded fall. The fluctuation in water level 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 72% of wells analysed and observed in all Taluks except Mormugao Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 6% of wells analysed and observed in Bardez, Bicholim, Salcete and Tiswadi Taluks.
3. Rise in the water level in the range of >4 m has been observed in 1% of wells analysed and observed in Sanguem Taluk.
4. The fall in water level in the range of 0-2 m has been observed in 20% of wells analysed and noted in almost all Taluks except Tiswadi Taluk.
5. Fall in the water level in the range of 2-4 m has been observed in 1% of wells analysed and observed in Sanguem Taluk.

Table 16: District wise categorisation of water level fluctuation (Jan 2019-Jan 2020)

Sl.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	12	9	75	1	8.33	0	0	2	16.67	0	0	0	0	10	2
2	Bicholim	7	5	71.43	1	14.29	0	0	1	14.29	0	0	0	0	6	1
3	Canacona	8	7	87.5	0	0	0	0	1	12.5	0	0	0	0	7	1
4	Mormugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Pernem	9	5	55.56	0	0	0	0	4	44.44	0	0	0	0	5	4
6	Ponda	5	4	80	0	0	0	0	1	20	0	0	0	0	4	1
7	Quepem	3	1	33.33	0	0	0	0	2	66.67	0	0	0	0	1	2
8	Salcete	10	7	70	2	20	0	0	1	10	0	0	0	0	9	1
9	Sanguem	15	11	73.33	0	0	1	6.67	2	13.33	1	6.67	0	0	12	3
10	Satari	10	8	80	0	0	0	0	2	20	0	0	0	0	8	2
11	Tiswadi	4	3	75	1	25	0	0	0	0	0	0	0	0	4	0
	Total	**84**	**60**	**72**	**5**	**6**	**1**	**1**	**17**	**20**	**1**	**1**	**0**	**0**	**66**	**18**

Plate XII


WATER LEVEL FLUCTUATION JAN 2019 to JAN 2020, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
KARNATAKA
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
4
2
0
-2
-4
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.5 Fluctuation Between Decadal Mean Water Level and Water Level

The fluctuation of water level recorded during the particular period with respect to decadal means 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 fluctuation indicates increased ground water development over and above the recharge.

4.5.1 Mean Water Levels for the Period May 2008-2017 and May 2018:

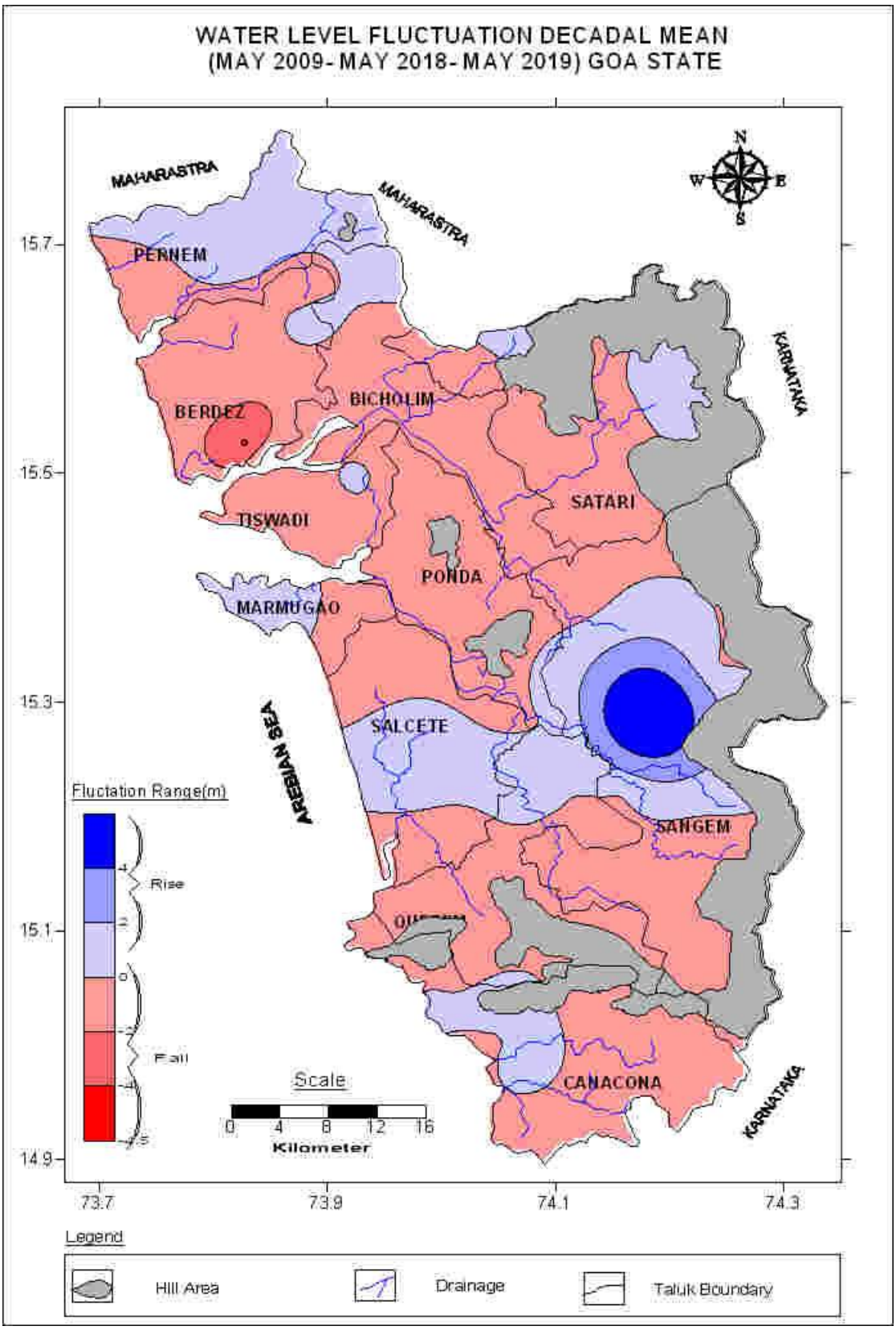
The water level data for May 2019 were compared with mean water level for the period May 2009-2018. The district-wise distribution of Ground water monitoring wells falling in different ranges of water level fluctuation is presented in **Table 17** and **Plate XIII**. A comparison of water level shows a rise in 27% and a fall in 73% of the wells.

1. Rise in the water level in the range of 0-2 m has been observed in 26% of wells analysed, noted in all Taluks except Mormugao and Sanguem Taluks.
2. Rise in the water level more than 4 m has been observed in 2 % of wells analysed, noted in Sanguem Taluk.
3. The fall in water level in the range of 0-2 m has been observed in 71 % of wells analysed and noted in all Taluks except Mormugao Taluk.
4. The fall in water level of more than 4 m is observed in 2 % of wells analysed and noted in Bardez Taluk.

Table 17: District wise categorisation of water level fluctuation (Decadal mean 2009-2018 and May 2019)

Sl. No	Taluk 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	9	2	22.2	0	0	0	0	6	66.7	0	0	1	11.1	2	7
2	Bicholim	4	2	50	0	0	0	0	2	50	0	0	0	0	2	2
3	Cancona	6	2	33.3	0	0	0	0	4	66.7	0	0	0	0	2	4
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	2	40	0	0	0	0	3	60	0	0	0	0	2	3
6	Ponda	3	1	33.3	0	0	0	0	2	66.7	0	0	0	0	1	2
7	Quepem	2	2	100	0	0	0	0	3	100	0	0	0	0	2	3
8	Salcete	9	2	22.2	0	0	0	0	7	77.8	0	0	0	0	2	7
9	Sanguem	10	0	0	0	0	1	100	9	90	0	0	0	0	1	9
10	Satari	10	2	20	0	0	0	0	8	80	0	0	0	0	2	8
11	Tiswadi	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
	Total	**62**	**16**	**25.8**	**0**	**0**	**1**	**1.6**	**44**	**71**	**0**	**0**	**1**	**1.6**	**17**	**45**

Plate XIII


WATER LEVEL FLUCTUATION DECADAL MEAN
(MAY 2009- MAY 2018- MAY 2019) GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
KARNATAKA
ARABIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.5.2 Mean Water Levels for the Period August 2009-2018 and August 2019:

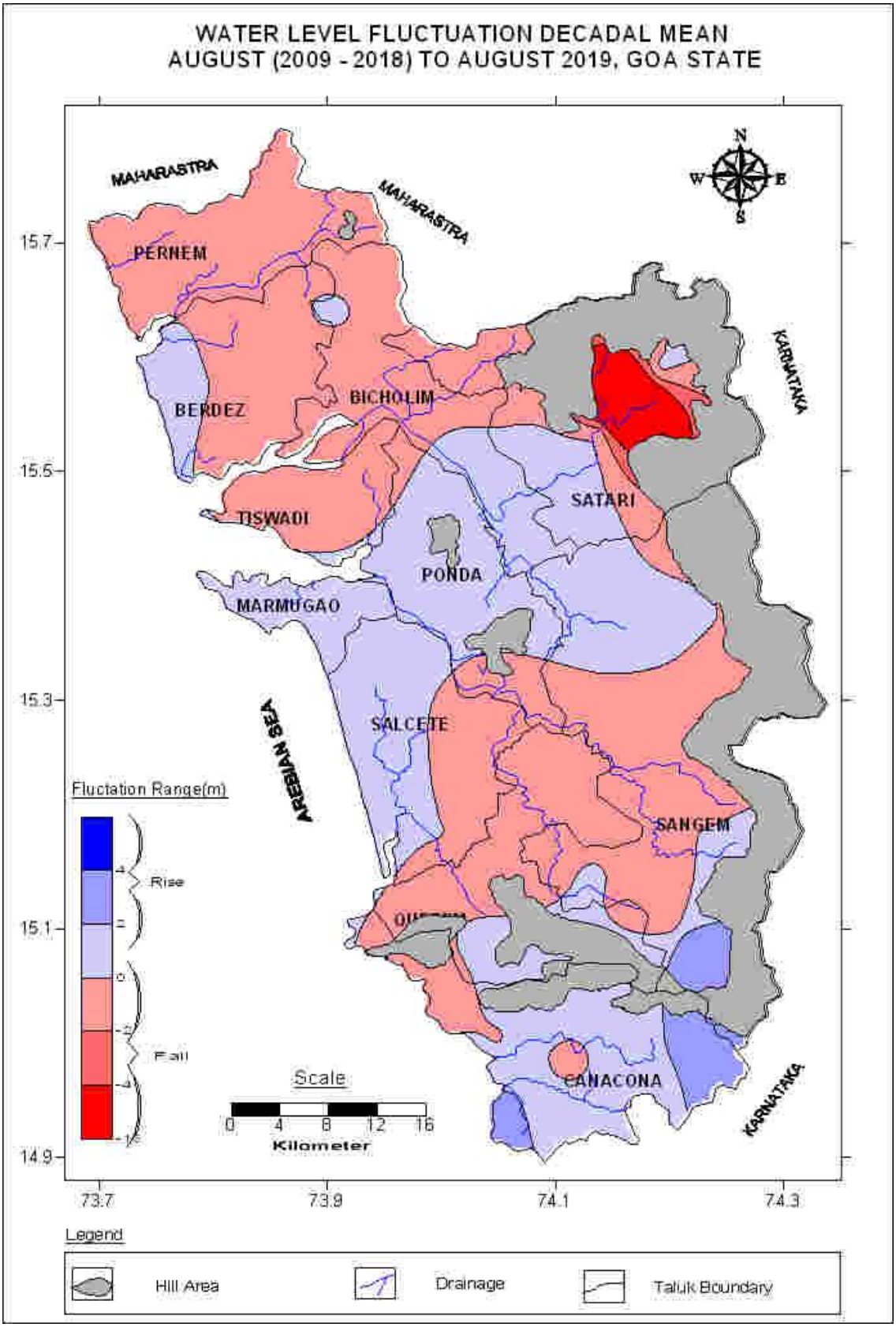
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 18** and **Plate XIV**. A comparison of water level shows that a rise in the water level is recorded in 56% of wells analysed, while 44% recorded fall. Salient features 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 39% of wells analysed, noted in Bardez, Bicholim, Canacona, Ponda, Salcete, Sanguem and Satari Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 3% of wells analysed, noted in Canacona and Sanguem Taluks.
3. Rise in the water level more than 4 m has been observed in 14% of wells analysed, noted in Pernem, Quepem and Tiswadi Taluks.
4. The fall in water level in the range of 0-2 m has been observed in 42% of wells analysed and noted Bardez, Bicholim, Canacona, Ponda, Salcete, Sanguem and Satari Taluks.
5. The fall in water level of more than 4 m is observed in 2% of wells analysed and noted in Satari Taluk.

Table 18: District wise categorisation of water level fluctuation (Decadal mean 2009-2018 and August 2019)

Sl. No	Taluk 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	7	3	42.9	0	0	0	0	4	57.1	0	0	0	0	3	4
2	Bicholim	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
3	Cancona	6	2	33.3	1	16.7	0	0	3	50	0	0	0	0	3	3
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	0	0	0	0	5	100	0	0	0	0	0	0	5	0
6	Ponda	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
7	Quepem	1	0	0	0	0	1	100	0	0	0	0	0	0	1	0
8	Salcete	10	9	90	0	0	0	0	1	10	0	0	0	0	9	1
9	Sanguem	13	4	30.8	1	7.7	0	0	8	61.5	0	0	0	0	5	8
10	Satari	9	3	33.3	0	0	0	0	5	55.6	0	0	1	11	3	6
11	Tiswadi	2	0	0	0	0	2	100	0	0	0	0	0	0	2	0
	Total	**59**	**23**	**39**	**2**	**3**	**8**	**14**	**25**	**42**	**0**	**0**	**1**	**2**	**33**	**26**

Plate XIV


WATER LEVEL FLUCTUATION DECADAL MEAN
AUGUST (2009 - 2018) TO AUGUST 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
TISWADI
SATARI
PONDA
MARMUGAO
SALCETE
SANGEM
CANACONA
KARNATAKA
KARNATAKA
ARABIAN SEA
N
S
E
W
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.5.3 Mean Water Levels for the Period November 2009-2018 and November 2019:

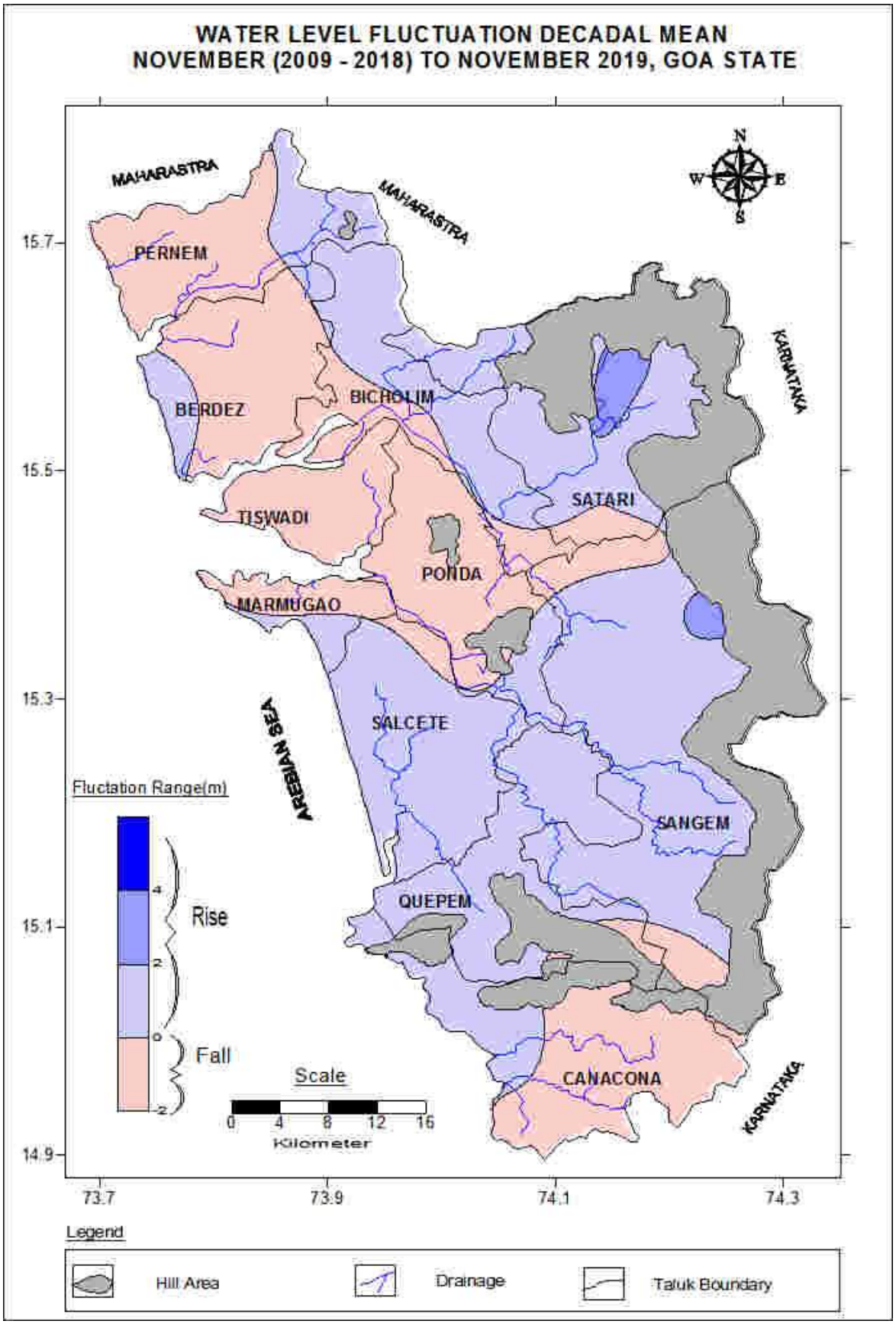
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 19**. The fluctuation in water level has been plotted in **Plate XV**. A comparison of water level shows that a rise in the water level is recorded in 62% of wells analysed, while 38% recorded fall. 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 59% of wells analysed, noted in almost all Taluks except Mormugao.
2. Rise in the water level in the range of 2-4 m has been observed in 3% of wells analysed, noted in Satari Taluk.
3. The fall in water level in the range of 0-2 m has been observed in 38% of wells analysed and noted in Bardez, Bicholim, Canacona, Pernem, Ponda and Sanguem Taluks.

Table 19: District wise categorisation of water level fluctuation (Decadal mean 2009-2018 and Nov 2019)

Sl.No	Taluk 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	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
2	Bicholim	3	2	66.7	0	0	0	0	1	33.3	0	0	0	0	2	1
3	Cancona	5	2	40	0	0	0	0	3	60	0	0	0	0	2	3
4	Mormugao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Pernem	5	2	40	0	0	0	0	3	60	0	0	0	0	2	3
6	Ponda	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
7	Quepem	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
8	Salcete	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
9	Sanguem	3	2	66.7	0	0	0	0	1	33.3	0	0	0	0	2	1
10	Satari	5	4	80	1	20	0	0	0	0	0	0	0	0	5	0
11	Tiswadi	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
	Total	**32**	**19**	**59**	**1**	**3**	**0**	**0**	**12**	**38**	**0**	**0**	**0**	**0**	**20**	**12**

Plate XV


WATER LEVEL FLUCTUATION DECADAL MEAN
NOVEMBER (2009 - 2018) TO NOVEMBER 2019, GOA STATE
MAHARASTRA
MAHARASTRA
KARNATAKA
PERNEM
BERDEZ
BICHOLIM
SATARI
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
4
2
0
-2
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.5.4 Mean Water Levels for the Period January 2010-2019 and January 2020:

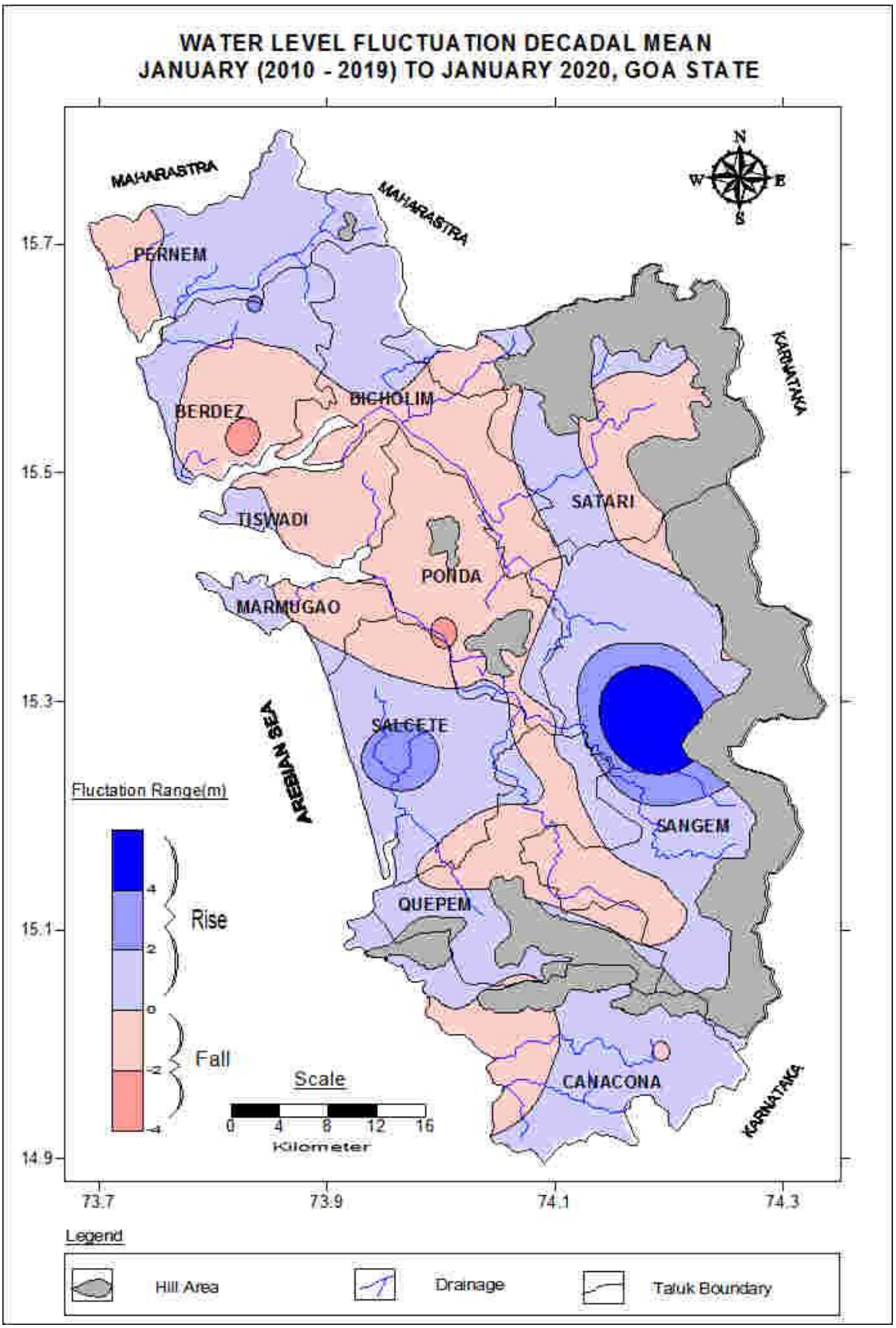
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 20**. The fluctuation in water level has been plotted in **Plate XVI**. A comparison of water level shows that a rise in the water level is recorded in 60% of wells analysed, while 40% recorded fall. 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 56 % of wells analysed and is noted in almost all Taluks.
2. Rise in the water level in the range of 2-4 m has been observed in 1% of wells analysed, noted in Bardez Taluk.
3. Rise in the water level more than 4 m has been observed in 3% of wells analysed, noted in Salcete and Sanguem Taluks.
4. The fall in water level in the range of 0-2 m has been observed in 36 % of wells analysed and noted in all Taluks except Mormugao and Bicholim Taluks.
5. The fall in water level in the range of 2-4 m is observed in 4% of wells analysed and noted in Bardez and Ponda Taluk.

Table 20: District wise categorisation of water level fluctuation (Decadal mean 2010-2019 and Jan 2020)

Sl. No	Taluk 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	10	5	50	1	10	0	0	2	20	2	20	0	0	6	4
2	Bicholim	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
3	Cancona	9	4	44.4	0	0	0	0	5	55.6	0	0	0	0	4	5
4	Mormugao	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	1	50	0	0	0	0	1	50	0	0	0	0	1	1
8	Salcete	10	8	80	0	0	1	10	1	0	0	0	0	0	9	1
9	Sanguem	12	6	50	0	0	1	8.3	5	41.7	0	0	0	0	7	5
10	Satari	10	5	50	0	0	0	0	5	50	0	0	0	0	5	5
11	Tiswadi	4	2	50	0	0	0	0	2	50	0	0	0	0	2	2
	Total	**70**	**39**	**56**	**1**	**1**	**2**	**3**	**25**	**36**	**3**	**4**	**0**	**0**	**42**	**28**

Plate XVI


WATER LEVEL FLUCTUATION DECADAL MEAN
JANUARY (2010 - 2019) TO JANUARY 2020, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
TISWADI
PONDA
MARMUGAO
SALCETE
SATARI
SANGEM
QUEPEM
CANACONA
KARNATAKA
KARNATAKA
ARABIAN SEA
N
W
E
S
15.7
15.5
15.3
15.1
14.9
73.7
73.9
74.1
74.3
Fluctation Range(m)
4
2
0
-2
-4
Rise
Fall
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.0. 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 71 Groundwater Monitoring wells were monitored for water quality during May 2019 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 2019)

S. No.	Parameters		Range	No. of sample	Percentage
1	Electrical Coductivity µs/cm at 25°c	Fresh	< 750	70	98.5
		Moderate	751- 2250	01	1.5
		Slightly mineralized	2251- 3000	NIL	0.0
		Highly mineralized	> 3000	NIL	0.0
2	Chloride mg/l	Desirable limit	< 250	71	100.00
		Permissible limit	251-1000	NIL	0.00
		Beyond permissible limit	> 1000	NIL	0.00
3	Fluoride mg/l	Desirable limit	< 1.0	71	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	67	93.00
		Beyond permissible limit	> 45	04	7.00

4.1 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 pH < 7 is called acidic, and having 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 (encrustation).

In the shallow groundwater of the state, the pH ranged between 6.72 and 9.73. Analysis of the data shows that a major part of state has pH 7 to 8.3. Based on the NHS 2019 data, in about 8%

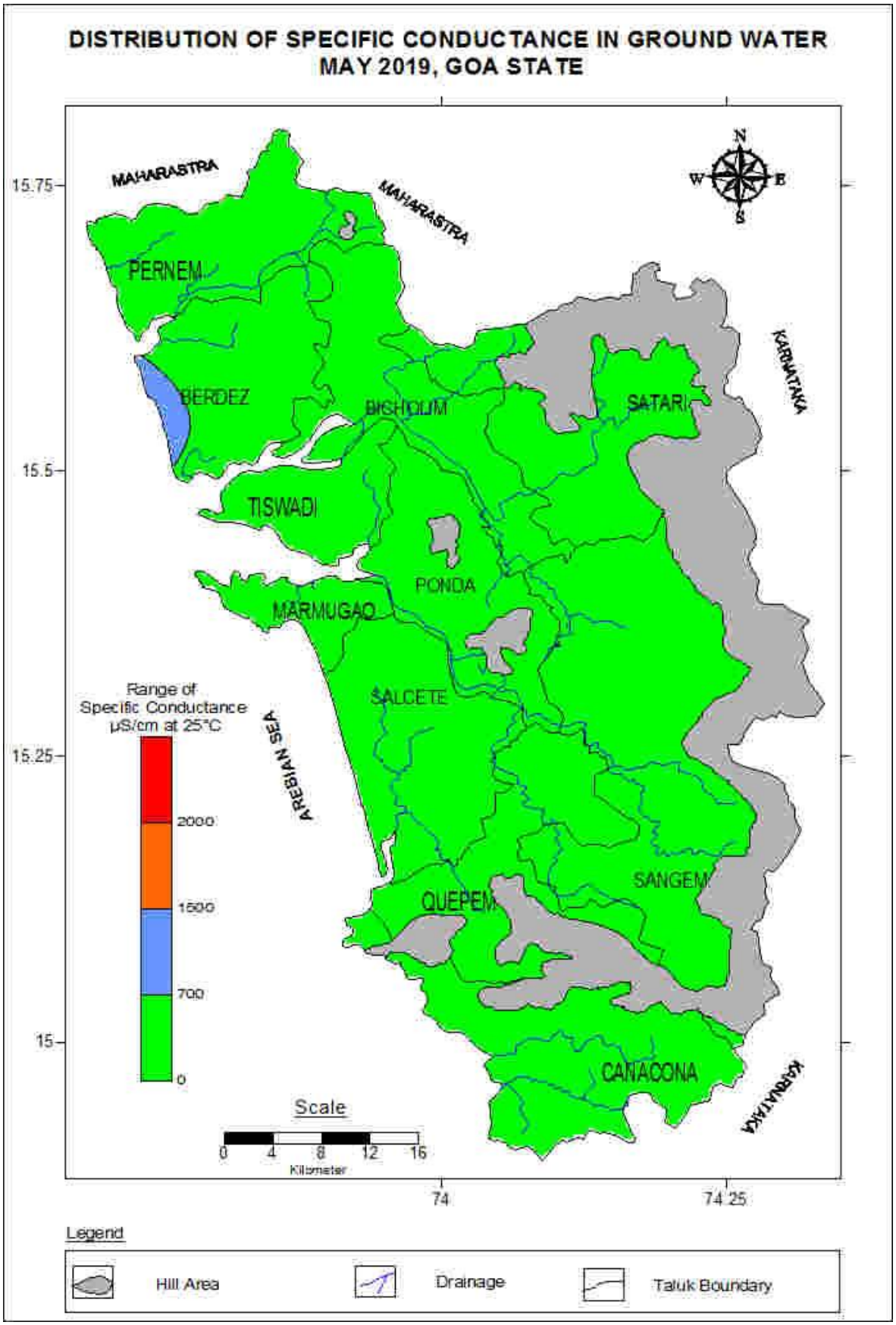
of the area the groundwater pH is between 8.3 and 9.60. The occurrence of pH <7 are sporadic and is insignificant. No pattern of spatial variation is observed with respect to the distribution of pH. In recharge areas, where fresh rainwater gets recharged, groundwater without much dissolution is characterized 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.

4.2 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.**

Electrical conductivity ranged between 121 and 930 µs/cm at 25ºC with an average of 317 µs/cm at 25ºC during May 2019. In general, the groundwater quality in the state is fresh in about 98.5 % of the Groundwater Monitoring wells as indicated by the EC value less than 750 µs/cm at 25ºC. In about 1.5 % of the Groundwater Monitoring wells, the EC is between 751-2250 µs/cm at 25ºC indicating that the groundwater is moderate quality.

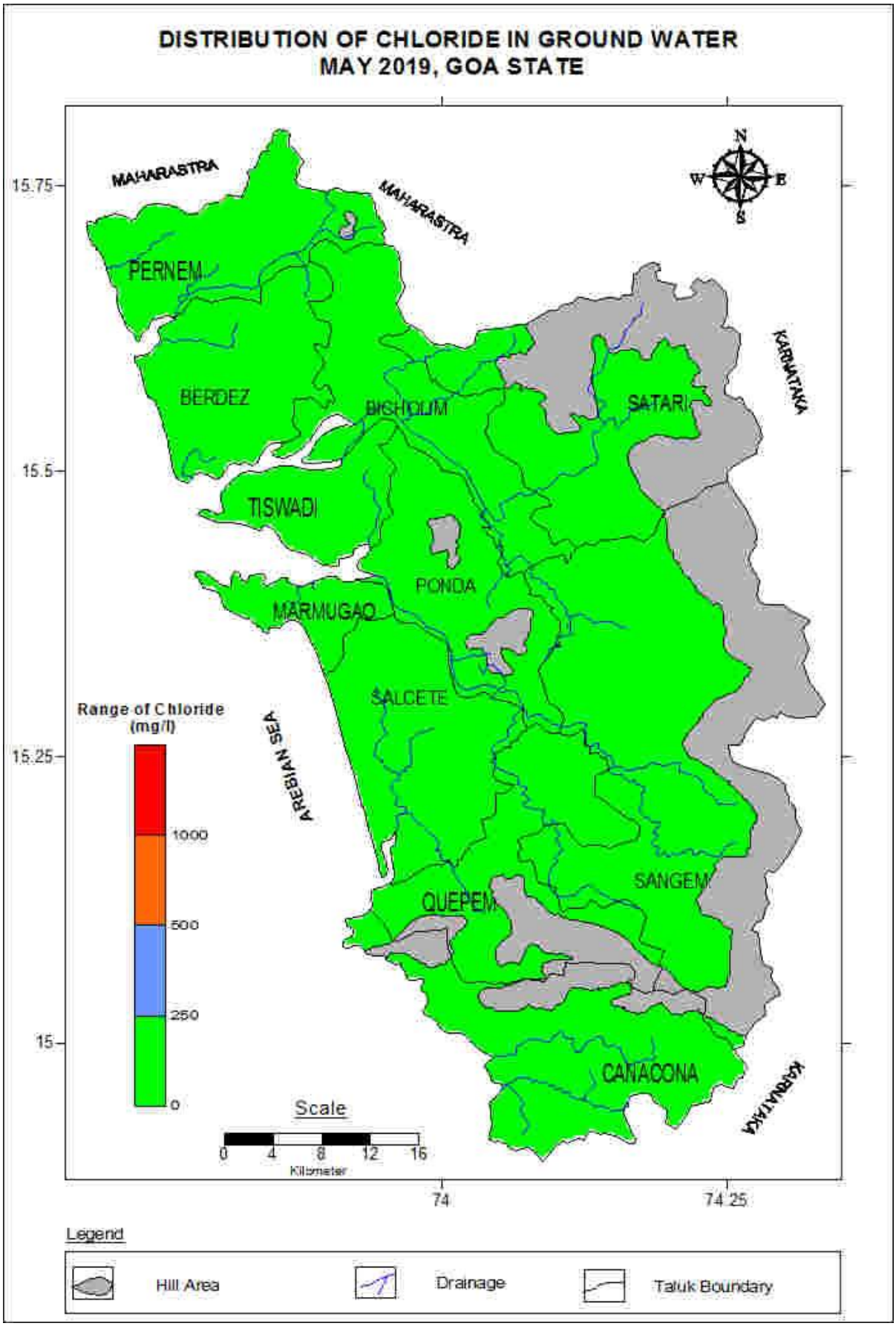
Plate XVII


DISTRIBUTION OF SPECIFIC CONDUCTANCE IN GROUND WATER
MAY 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
N
W
E
S
15.75
15.5
15.25
15
74
74 25
Range of
Specific Conductance
µS/cm at 25°C
2000
1500
700
0
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.3 Chloride

Chloride is one of the major anions 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 imports 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. Chloride concentration ranged between 11 and 99 mg/l with an average concentration of 24 mg/l during May 2019. The chloride content is less than the desirable limit of 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


DISTRIBUTION OF CHLORIDE IN GROUND WATER
MAY 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
QUEPEM
SANGEM
CANACONA
KARNATAKA
N
W
E
S
15.75
15.5
15.25
15
74
74.25
Range of Chloride (mg/l)
1000
500
250
0
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

4.4 Nitrate (NO_3)

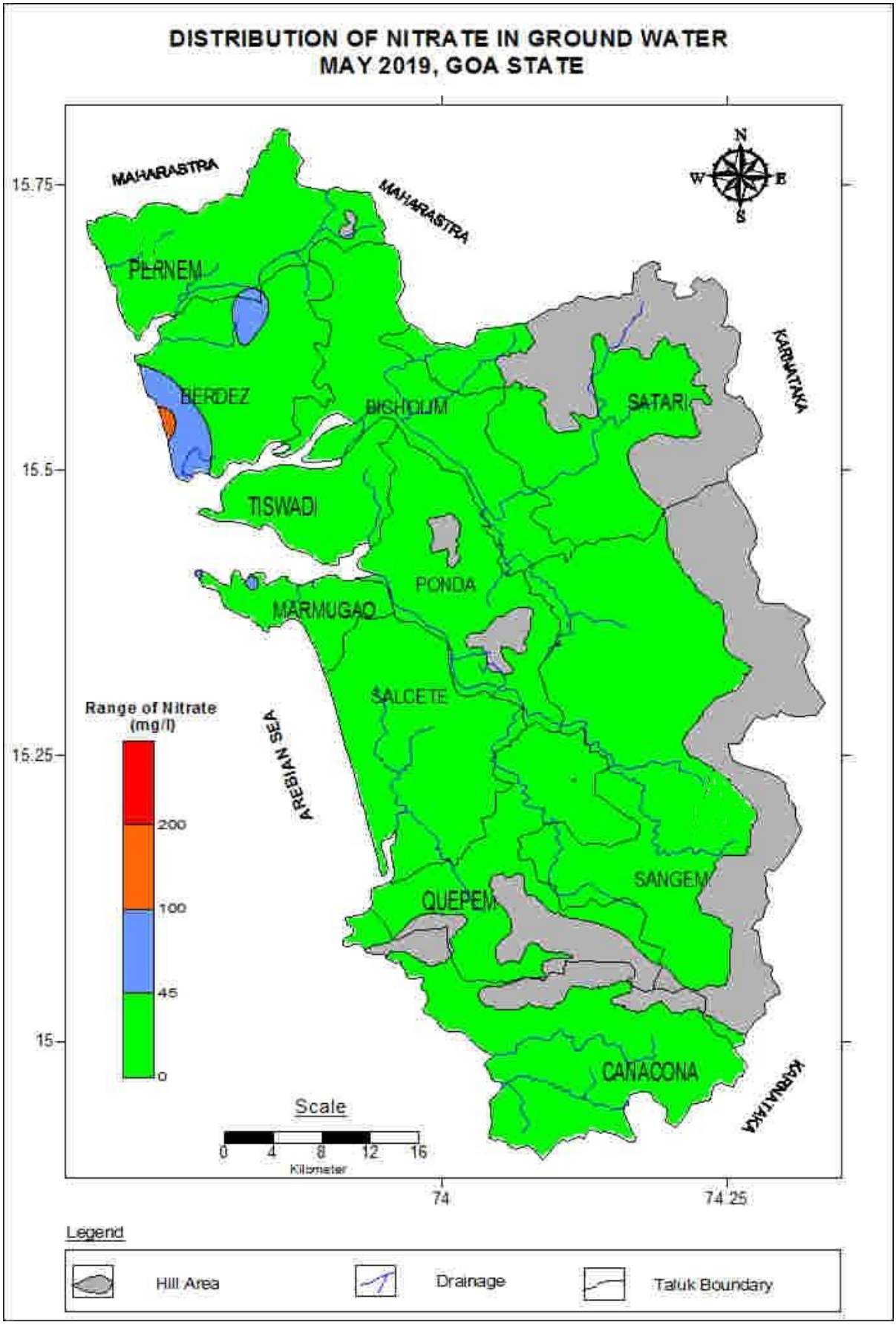
Nitrate is one of the major indicators of anthropogenic sources of pollution. The negative charge and high mobility favors its persistence in nature and transport along the groundwater flow path. Nitrate is the ultimate oxidized product of all nitrogen containing matter and its occurrence in groundwater 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.

NO_3 is an oxidizing agent and is readily oxidizes haemoglobin (Hb) in to methaemoglobin (MeHb) a blue coloured pigment and gets reduced to NO_2. 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 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 $\propto_2\gamma_2$ type has greater affinity for oxygen (O_2) than adult Hb which is $\propto_2\beta_2$ 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 gets reduced to Nitrite (NO_2) 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 45mg/l as the as the permissible limit for drinking water.

Nitrate concentration ranged between 0 and 122 mg/l with an average concentration of 9 mg/l during May 2019. The Nitrate content is less than 45 mg/l in about 93 % of the sample analyzed and and 7 % of sample shows more than 45 mg/l which are from North Goa district. The distribution of nitrate in shallow groundwater is shown as contour map in **Plate XIX**.

Plate XIX


DISTRIBUTION OF NITRATE IN GROUND WATER
MAY 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
Range of Nitrate (mg/l)
200
100
45
0
Scale
0 4 8 12 16
Kilometer
15.75
15.5
15.25
15
74
74.25
N
S
E
W
Legend
Hill Area
Drainage
Taluk Boundary

4.5 Fluoride

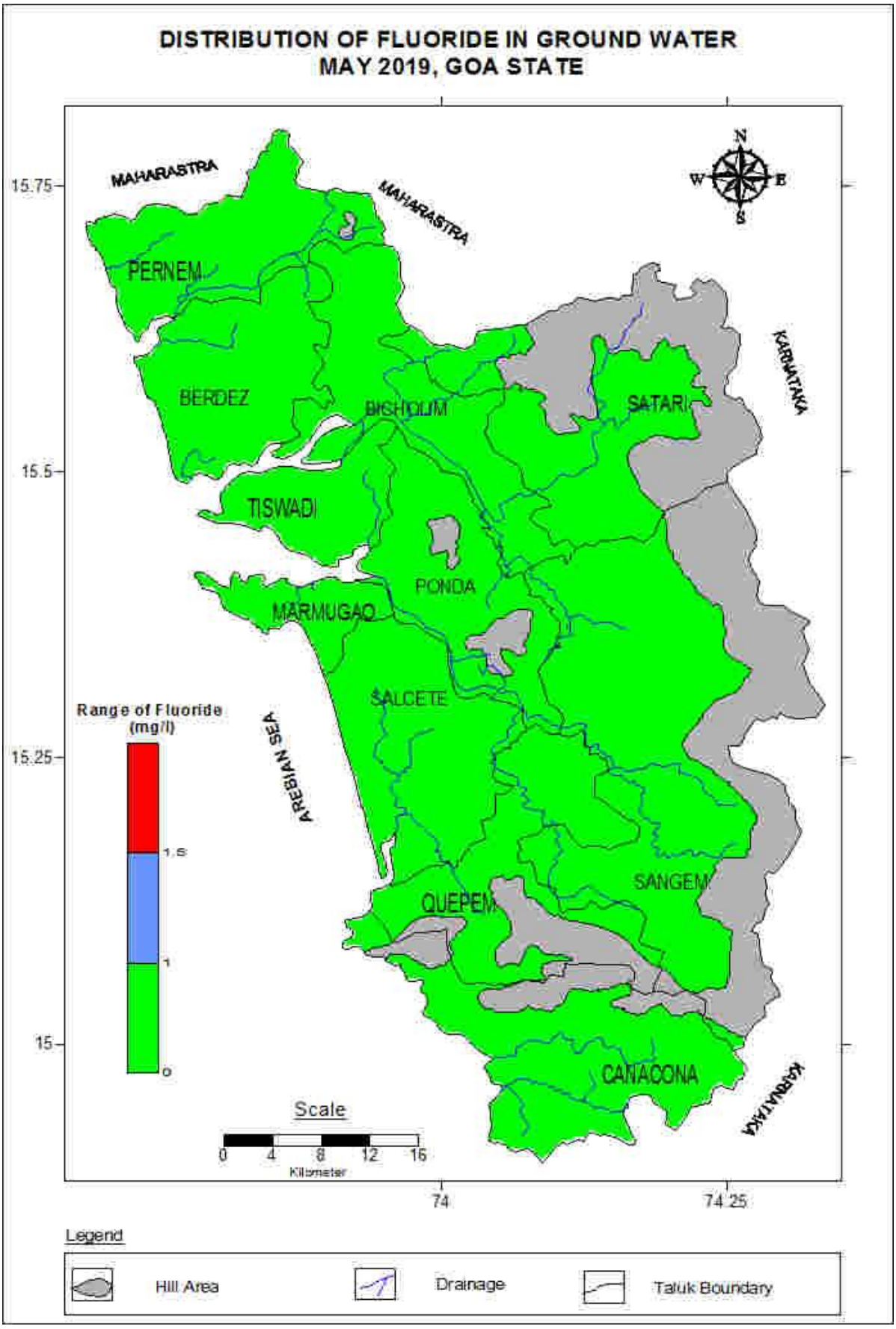
Fluorine is the most electronegative element and highly reactive, thus combining with all other elements to form covalent fluorides. Fluoride exists naturally in all waters derived from the dissolution of fluoride containing minerals. Surface water generally has low fluoride while groundwater may have 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 ($Ca_{10}F_2(PO_4)_6$), 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 1.5 mg/l as the permissible limit in the absence of alternate sources for drinking water.

Fluoride concentration ranged between 0.01 and 0.88 mg/l with an average concentration of 0.51 mg/l during May 2019. The Fluoride content is less than 1.5 mg/l in all the 71 samples collected from National Hydrograph stations. Distribution of fluoride is shown in **Plate XX**.

Plate XX


DISTRIBUTION OF FLUORIDE IN GROUND WATER
MAY 2019, GOA STATE
MAHARASTRA
MAHARASTRA
PERNEM
BERDEZ
BICHOLIM
SATARI
KARNATAKA
TISWADI
PONDA
MARMUGAO
SALCETE
ARABIAN SEA
SANGEM
QUEPEM
CANACONA
KARNATAKA
N
W
E
S
15.75
15.5
15.25
15
74
74.25
Range of Fluoride (mg/l)
1.5
1
0
Scale
0 4 8 12 16
Kilometer
Legend
Hill Area
Drainage
Taluk Boundary

5.0 CONCLUSIONS

The behaviour of ground water table during May 2019 to January 2020 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 under-

1. 88 % of wells have recorded depth to water level within 10 m bgl during premonsoon period (May 2019), whereas during post-monsoon period (November 2019) about 94 % of wells recorded water level less than 10 m bgl.
2. 95 % of wells have recorded depth to water level within 10 m bgl during August 2019 and 90 % during January 2020.
3. 94 % of wells have recorded rise in water levels and 6% of wells have recorded fall in water levels during Nov 2019 (post- monsoon) in comparision to May 2019 (pre-monsoon).
4. The rise in water level is due to the excess rainfall received during the year 2019.
5. 73 % of wells have recorded fall in water levels and 27% of wells recorded rise in water levels during May 2019 in comparision to decadal mean.
6. 62 % of wells have recorded rise in water levels and 38 % of wells have recorded fall in water level during November 2019 with respect to respective decadal means.
7. Fall in water levels may in isolated patches may be due to localised over extraction of ground water.
8. In general, the groundwater quality in the state is fresh in about 98.5 % of the Groundwater Monitoring wells as indicated by the EC value less than 750 μs/cm at 25^{o}C. In about 1.5 % of the Groundwater Monitoring wells, the EC is more than 3000 μs/cm at 25^{o}C indicating that the groundwater is highly mineralized.
9. The chloride content is less than 250 mg/l in the entire sample analyzed.
10. The Fluoride content is less than 1.5 mg/l in all the 71 samples collected from Ground Water Level Monitoring stations.
11. The Nitrate content is less than 45 mg/l in about 93 % of the sample analyzed and and 7 % of sample shows more than 45 mg/l which are from North Goa district.

ACKNOWLEDGEMENT

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Annexure I: Water level data of Goa State (May 2019 to January 2020)						
District	**Site Type**	**Site Name**	**May-2019**	**Aug-2019**	**Nov-2019**	**Jan-2020**
North Goa	Bore Well	Adavapal	5.46	3.02	3.67	4.59
North Goa	Bore Well	Ajosi	-	2.35	3.36	3.38
North Goa	Bore Well	Aldona	17.33	12.58	11.8	15.03
North Goa	Bore Well	Aropora	4.22	-	-	1.24
North Goa	Bore Well	Asapur	6.63	5.22	4.21	5.19
North Goa	Bore Well	Betki	18.77	13.55	14.3	15.51
North Goa	Bore Well	Colvale	13.78	10.75	-	12.69
North Goa	Bore Well	Kasar Pal	10.04	8.07	8.97	8.96
North Goa	Bore Well	Kirl Pirna	10.08	-	4.67	7.5
North Goa	Bore Well	Korgoan	11.62	10	10.13	10.59
North Goa	Bore Well	Krilwada	1.99	1.03	1	1.31
North Goa	Bore Well	Madakai	23.92	17.75	12.88	17.79
North Goa	Bore Well	Mayam	2.3	3.95	5	5.5
North Goa	Bore Well	Mola	1.16	0.35	0.43	0.55
North Goa	Bore Well	Morjum	3.43	1.45	1.53	1.98
North Goa	Bore Well	Narve	13.46	10.58	11.82	12.6
North Goa	Bore Well	Parsekarwada	19.17	-	17.7	17.96
North Goa	Bore Well	Sanqulim	26.68	17.33	19.18	25.29
North Goa	Bore Well	Sawantwada	3.98	0.92	-	4.68
North Goa	Bore Well	Silolieum	5.88	3.25	3.7	4.81
North Goa	Bore Well	Tivim	22.22	-	17.95	20.19
North Goa	Bore Well	Varkhand	15.93	12.02	12.4	14.35
North Goa	Dug Well	Adavapal	5.25	4.29	5.07	3.79
North Goa	Dug Well	Alto Betim Porvorim	10.48	5.08	6.41	10.28
North Goa	Dug Well	Amberem	7.07	6.2	6.65	6.99
North Goa	Dug Well	Anjuna Beach	13.95	8.44	9.48	13.68
North Goa	Dug Well	Bayalwadikeri(Querim)	2.04	1.84	1.9	2.11
North Goa	Dug Well	Bhamber (Nanoda Cross)	4.27	2.7	3.35	4.51
North Goa	Dug Well	Bhujpal	5.91	1.09	1.23	3.02
North Goa	Dug Well	Bori	5.58	1.2	1.49	5.29
North Goa	Dug Well	Britona	2	1.21	1.74	1.9
North Goa	Dug Well	Calangute	8.93	2.95	3.91	6.14
North Goa	Dug Well	Charayode	5.99	1.73	1.89	2.57
North Goa	Dug Well	Colval	14.95	10.25	11.05	11.71
North Goa	Dug Well	Devulawada Narve	-	10.84	14	13.49
North Goa	Dug Well	Dhatwado Vante	7.72	2.6	3.74	5.4
North Goa	Dug Well	Gavalebhat	5.91	-	4.68	4.59
North Goa	Dug Well	Hasaravanni Vaipal	2.23	1.98	2.5	2.25
North Goa	Dug Well	Haspur	7.7	4.01	4.22	4.63
North Goa	Dug Well	Honda	4.46	2	2.06	3.36
North Goa	Dug Well	Jambhul Batt (Mayam Lake)	3.72	2.38	1.12	2.59
North Goa	Dug Well	Karanjhalen	3.41	-	2.73	1.45
North Goa	Dug Well	Khadki (Harijanwada)	10.82	3.74	6.51	7.83

North Goa	Dug Well	Khotodem	6	1.77	4.8	5.78
North Goa	Dug Well	Korgaon	-	3.52	3.7	3.9
North Goa	Dug Well	Kundel Dassolwada	1.71	1.15	1.4	1.53
North Goa	Dug Well	Mankem	4.53	2.95	3.37	3.64
North Goa	Dug Well	Mapuca	4.16	2.43	3.25	3.81
North Goa	Dug Well	Morji	2.51	0.65	0.65	1.13
North Goa	Dug Well	Morlem	3.87	3.3	3.48	3.71
North Goa	Dug Well	Mulgaon Shivalkherwad	3.64	-	2.55	2.74
North Goa	Dug Well	Nagargoan	7.53	17.15	3.03	5.7
North Goa	Dug Well	Nagjhar	7.2	7.46	7.54	7.55
North Goa	Dug Well	Olaulim	7.34	3.3	5.9	3.17
North Goa	Dug Well	Panchawadi (pz)	-	5.2	5.95	6.52
North Goa	Dug Well	Parra	2.56	0.71	1.02	1.72
North Goa	Dug Well	Pernem	2.81	3.72	3.8	2.32
North Goa	Dug Well	Pirna	4.96	1.5	1.52	2.84
North Goa	Dug Well	Pomburpa Palmar	3.3	2.85	3.13	3.26
North Goa	Dug Well	Sal	2.57	2.11	2.27	2.65
North Goa	Dug Well	Salwardhar Dumun	2.75	2.15	-	2.74
North Goa	Dug Well	Sawanthwada (Mandrem)	4.25	1.25	1.03	3.42
North Goa	Dug Well	Shiroda	6.78	5.49	6.08	6.47
North Goa	Dug Well	Shivoli (Brahmanwada)	3.54	0.48	0.95	2.21
North Goa	Dug Well	Sirsaim	3.53	2.17	2.94	3.27
North Goa	Dug Well	Uguem (Ugawe)	3.65	3.01	3.33	3.19
North Goa	Dug Well	Valpoi	6.12	3.01	2	5.8
North Goa	Dug Well	Velha Goa	-	1.54	1	1.5
South Goa	Bore Well	Aven	11.5	7.5	7.55	8.51
South Goa	Bore Well	Bogmola	1.1	0	0.16	0.38
South Goa	Bore Well	Canabonulim	6.86	2.52	2.92	2.58
South Goa	Bore Well	Carmona	7.68	2.65	3.42	-
South Goa	Bore Well	Cavelosim	3.42	0.46	0.6	1.32
South Goa	Bore Well	Chandavar	3.3	1.4	1.5	1.97
South Goa	Bore Well	Chinchinim	3.54	-	0.04	0.89
South Goa	Bore Well	Collem	7.08	-	4.43	5.2
South Goa	Bore Well	Dabel	12.99	7.68	8.83	11.26
South Goa	Bore Well	Kalay	5.94	2.6	2.82	2.9
South Goa	Bore Well	Manora Rai	5.8	3.92	4.57	3.36
South Goa	Bore Well	Meidawada	12.1	6.75	8.6	10.69
South Goa	Bore Well	Molem	10.64	1.05	1.64	6.48
South Goa	Bore Well	Morlem	5.76	1.05	1.87	3.4
South Goa	Bore Well	Nanoda	20.98	17.25	18.17	18.86
South Goa	Bore Well	Paddi Quiescend	17.22	11.58	-	13.79
South Goa	Bore Well	Patnem	8.9	-	2.23	4.66
South Goa	Bore Well	Ponquini	10.21	5.45	8.37	8.91
South Goa	Bore Well	Severdem	15.54	10.9	13.1	11.92
South Goa	Bore Well	Thane	11.48	5.85	6.83	7.65

South Goa	Bore Well	Verna	3.11	0.5	1	1.62
South Goa	Bore Well	Yedda	11.55	5.6	7.15	8.65
South Goa	Dug Well	Agonda Desaiwada	4.05	2.38	2.63	3.56
South Goa	Dug Well	Akamol Ambavalli	-	-	4.84	
South Goa	Dug Well	Bagmola	3.46	2.45	2.65	2.94
South Goa	Dug Well	Ballynuvhen	6.99	4.73	5.23	6.17
South Goa	Dug Well	Barodi Velni (Betul)	6.7	1.47	1.77	4.49
South Goa	Dug Well	Betalbatti	6.85	1.81	2.38	3.65
South Goa	Dug Well	Bhati	5.78	2.62	3.27	5.97
South Goa	Dug Well	Bolkharnem	7.19	4.8	5.08	3.72
South Goa	Dug Well	Canacona	4.78	1.76	2.03	
South Goa	Dug Well	Carmona	-	2.65	-	
South Goa	Dug Well	Chikalim	1.78	0.5	0.64	1.73
South Goa	Dug Well	Collem (Kolamba)	8.95	4.35	6.23	8.31
South Goa	Dug Well	Cuncalim	2.11	1.02	1.4	1.79
South Goa	Dug Well	Cuncalim (pz)	14.95	5.4	-	5.25
South Goa	Dug Well	Daptamol Lolien	-	11.44	14.67	14.86
South Goa	Dug Well	Darbandahra (pz)	-	8.17	9.04	9.73
South Goa	Dug Well	Deulwada Kolamba	3.08	1.41	2.31	2.61
South Goa	Dug Well	Fathorda Margao (pz)	-	2.48	-	2.36
South Goa	Dug Well	Ghadiawada	1.75	1.07	1.25	9.35
South Goa	Dug Well	Guddemal	12.38	7.05	7.8	
South Goa	Dug Well	Gulem Velipwada	-	-	-	2.63
South Goa	Dug Well	Hattipal Poinguinem	-	6.01	6.57	6.79
South Goa	Dug Well	Jambavli	9.61	7.55	8.55	10.4
South Goa	Dug Well	Kalay	3.27	9.7	10.25	1.05
South Goa	Dug Well	Kapsa	6.78	3.6	3.68	4.49
South Goa	Dug Well	Kaveslium	4.14	1.2	1.5	2.68
South Goa	Dug Well	Majorda Bpada Curilo	5.61	1.68	2.06	3.5
South Goa	Dug Well	Malkarnem	-	5.14	4.68	8.74
South Goa	Dug Well	Mashe	4.62	2.39	3.24	3.83
South Goa	Dug Well	Molem	-	1.07	3.9	10.17
South Goa	Dug Well	Navelim	3.76	1.64	-	0.76
South Goa	Dug Well	Netrolim	10.78	5.59	10.24	8.43
South Goa	Dug Well	Padi	13.8	5.89	5.82	8.07
South Goa	Dug Well	Polem (Polen)	4.75	-	-	
South Goa	Dug Well	Quepem	2.75	-	2.2	2.69
South Goa	Dug Well	Revona	8.47	5.81	7.39	7.44
South Goa	Dug Well	Shrishtal Gaondongar	8.07	-	4.17	4.43
South Goa	Dug Well	Sristal	4.93	3.39	2.38	10.69
South Goa	Dug Well	Suktali (Molem)	5.53	3.36	3.7	4.11
South Goa	Dug Well	Themchewada	8.77	7.23	8.63	6.96
South Goa	Dug Well	Vadam	5.89	3.78	4.03	3.56
South Goa	Dug Well	Vichundrem	-	1.75	4.65	7.09
South Goa	Dug Well	Yedda	-	0	0.04	2.92

Annexure- II

HYDROCHEMICAL DATA OF NATIONAL HYDROGRAPH STATIONS (NHS), GOA, MAY-2019

SL No	SITE_NAME	DISTRICT_NAME	Date of Collection	PH	EC	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F
					µS/cm	<.....mg/l.....>										
1	Keri	North Goa	01-06-2019	7.78	199	30	10	1	26	2	0	12	18	41	19	0.27
2	Morlem	North Goa	01-06-2019	8.03	191	25	6	2	24	1	0	31	18	33	1	0.43
3	Honda	North Goa	01-06-2019	7.14	186	33	6	4	29	1	0	31	18	49	0	0.62
4	Bhujpal	North Goa	01-06-2019	7.71	381	38	8	4	42	1	0	46	21	61	2	0.49
5	Charayode	North Goa	01-06-2019	7.78	446	65	16	6	52	2	0	76	21	93	3	0.25
6	Nagargoan	North Goa	01-06-2019	7.93	283	35	6	5	31	1	0	24	18	58	3	0.28
7	Bhamber (Nanoda Cross)	North Goa	01-06-2019	8.03	198	45	6	7	23	0	0	43	14	45	0	0.54
8	Khadki (Harijanwada)	North Goa	01-06-2019	7.85	189	40	6	6	20	1	0	31	18	38	0	0.78
9	Khotodem	North Goa	01-06-2019	7.91	331	45	4	9	37	0	0	27	14	68	4	0.59
10	Dhatwado Vante	North Goa	01-06-2019	7.83	295	35	6	5	35	1	0	46	18	54	1	0.65
11	Jambhul Batt (Mayam Lake)	North Goa	04-06-2019	7.52	337	45	10	5	27	3	0	37	18	44	7	0.74
12	Mulgaon Shivalkherwad	North Goa	04-06-2019	8.15	236	35	10	2	26	1	0	31	18	44	1	0.20
13	Parra	North Goa	02-06-2019	7.85	501	125	28	13	39	7	0	128	46	58	3	0.56
14	Calangute (Kalangot Beach)	North Goa	02-06-2019	7.69	930	200	42	23	85	10	0	85	99	113	122	0.37
15	Anjuna Beach	North Goa	02-06-2019	8.01	260	50	8	7	26	1	0	37	25	39	6	0.59
16	Silolium	North Goa	02-06-2019	7.83	504	120	28	12	46	5	0	140	25	87	1	0.42
17	Morji	North Goa	02-06-2019	7.79	626	70	12	10	57	2	0	49	28	120	2	0.20

18	Sawanthwada (Mandrem)	North Goa	02-06-2019	8.15	201	35	8	4	21	1	0	37	18	33	0	0.01
19	Korgaon	North Goa	02-06-2019	8.19	198	35	6	5	21	1	0	31	18	36	0	0.33
20	Pernem	North Goa	02-06-2019	7.59	453	75	18	7	38	4	0	73	21	71	11	0.51
21	Uguem (Ugawe)	North Goa	02-06-2019	8.20	227	30	8	2	22	3	0	24	21	29	5	0.77
22	Amberem	North Goa	02-06-2019	7.81	305	55	16	4	20	11	0	49	18	43	3	0.21
23	Nagjhar	North Goa	02-06-2019	8.24	342	40	4	7	32	2	0	24	21	58	11	0.54
24	Valpoi	North Goa	02-06-2019	7.89	264	25	8	1	31	1	0	18	18	54	1	0.30
25	Haspur	North Goa	02-06-2019	8.57	468	90	28	5	48	11	12	55	39	90	6	0.71
26	Colval	North Goa	03-06-2019	6.72	522	135	30	15	58	5	0	110	36	94	62	0.38
27	Pirna	North Goa	03-06-2019	6.95	121	20	4	2	15	1	0	18	14	20	1	0.54
28	Adavapal	North Goa	03-06-2019	7.75	231	35	6	5	21	1	0	31	14	38	4	0.17
29	Sal	North Goa	03-06-2019	7.93	227	35	10	2	20	8	0	24	18	46	3	0.32
30	Sirsaim	North Goa	03-06-2019	8.23	236	30	8	2	25	1	0	31	18	40	1	0.27
31	Mapuca	North Goa	03-06-2019	8.25	612	90	14	13	58	5	0	49	43	95	47	0.06
32	Olaulim	North Goa	03-06-2019	8.23	301	35	6	5	34	1	0	31	21	60	1	0.31
33	Pomburpa Palmar	North Goa	03-06-2019	8.24	396	50	8	7	46	1	0	37	32	72	13	0.55
34	Salwardhar Dumun	North Goa	03-06-2019	8.19	253	45	8	6	32	1	0	37	18	61	1	0.38
35	Britona	North Goa	03-06-2019	7.91	182	50	14	4	15	1	0	49	18	19	0	0.82
36	Gavalebhat, Chimbel (Kirl)	North Goa	03-06-2019	8.24	243	40	6	6	25	2	0	31	25	33	6	0.57
37	Velha Goa	North Goa	03-06-2019	8.82	492	85	22	7	29	1	12	61	25	50	0	0.49

38	Karanjhalen	North Goa	03-06-2019	9.73	438	90	16	12	40	5	18	18	46	59	29	0.34
39	Chikalim	South Goa	05-06-2019	8.22	386	85	20	9	38	3	0	43	43	44	48	0.54
40	Bagmola	South Goa	05-06-2019	7.80	269	60	14	6	28	2	0	49	28	34	22	0.46
41	Ballynuvhen	South Goa	05-06-2019	7.75	234	50	14	4	28	1	0	67	25	25	6	0.54
42	Betalbatti	South Goa	05-06-2019	7.35	390	45	14	2	57	2	0	18	32	81	29	0.49
43	Cavellosim	South Goa	05-06-2019	8.10	367	65	24	1	43	2	0	61	43	57	9	0.88
44	Cuncalim	South Goa	05-06-2019	9.02	438	45	14	2	63	2	24	12	28	99	7	0.71
45	Agonda Desaiwada	South Goa	05-06-2019	7.70	479	50	18	1	68	6	0	55	28	98	7	0.55
46	Canacona	South Goa	05-06-2019	7.48	312	60	14	6	36	2	0	79	28	38	4	0.54
47	Padi	South Goa	05-06-2019	7.54	204	60	12	7	24	1	0	55	14	37	0	0.63
48	Sristal	South Goa	05-06-2019	7.76	331	60	18	4	43	1	0	79	18	71	1	0.64
49	Mashe	South Goa	01-06-2019	7.71	241	20	6	1	42	1	0	24	21	65	0	0.64
50	Polem (Polen)	South Goa	06-06-2019	8.31	443	140	22	21	38	4	24	122	39	30	1	0.42
51	Daptamol Lolien	South Goa	06-06-2019	7.71	285	25	6	2	42	0	0	24	18	66	1	0.72
52	Shrishtal Gaondongar	South Goa	06-06-2019	7.68	375	40	12	2	58	1	0	67	14	96	6	0.65
53	Netrolim	South Goa	06-06-2019	7.57	325	80	20	7	36	4	0	92	14	66	1	0.48
54	Vadam	South Goa	06-06-2019	8.27	253	30	6	4	42	0	0	12	14	76	4	0.72
55	Bhati	South Goa	06-06-2019	8.11	222	10	4	0	40	0	0	24	11	68	0	0.64
56	Deulwada Kolamba	South Goa	06-06-2019	7.57	274	50	8	7	36	2	0	55	14	57	1	0.67
57	Revona	South Goa	06-06-2019	7.74	269	50	12	5	30	4	0	37	25	41	15	0.52

58	Jambavli	South Goa	06-06-2019	7.53	264	35	8	4	42	1	0	31	14	66	2	0.51
59	Quepem	South Goa	06-06-2019	7.81	406	45	12	4	61	2	0	49	18	102	1	0.77
60	Ghadiawada	South Goa	07-06-2019	7.95	240	30	8	2	25	6	0	24	25	36	0	0.61
61	Kalay	South Goa	07-06-2019	8.27	251	30	8	2	31	1	0	31	25	36	2	0.52
62	Kapsa	South Goa	07-06-2019	7.97	479	85	18	10	54	9	0	61	39	71	23	0.69
63	Panchawadi(pz)	North Goa	07-06-2019	8.21	185	25	6	2	26	2	0	37	18	30	1	0.60
64	Guddemal	South Goa	07-06-2019	7.37	228	45	10	5	30	2	0	49	18	37	6	0.66
65	Shiroda	North Goa	07-06-2019	7.94	243	50	12	5	30	3	0	43	25	40	14	0.61
66	Mankem	North Goa	07-06-2019	7.83	270	45	6	7	40	4	0	37	25	58	0	0.67
67	Bori	North Goa	07-06-2019	7.83	279	30	8	2	46	1	0	37	18	66	7	0.55
68	Sukkal	North Goa	07-06-2019	7.94	214	20	4	2	37	1	0	37	14	52	1	0.58
69	Bolkharnem	South Goa	07-06-2019	7.59	176	30	6	4	23	2	0	31	14	36	5	0.64
70	Collem (Kolamba)	South Goa	07-06-2019	8.27	194	20	6	1	32	1	0	37	14	45	0	0.47
71	Kundel Dassolwada	North Goa	07-06-2019	8.19	189	20	4	2	30	1	0	37	18	36	2	0.40

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