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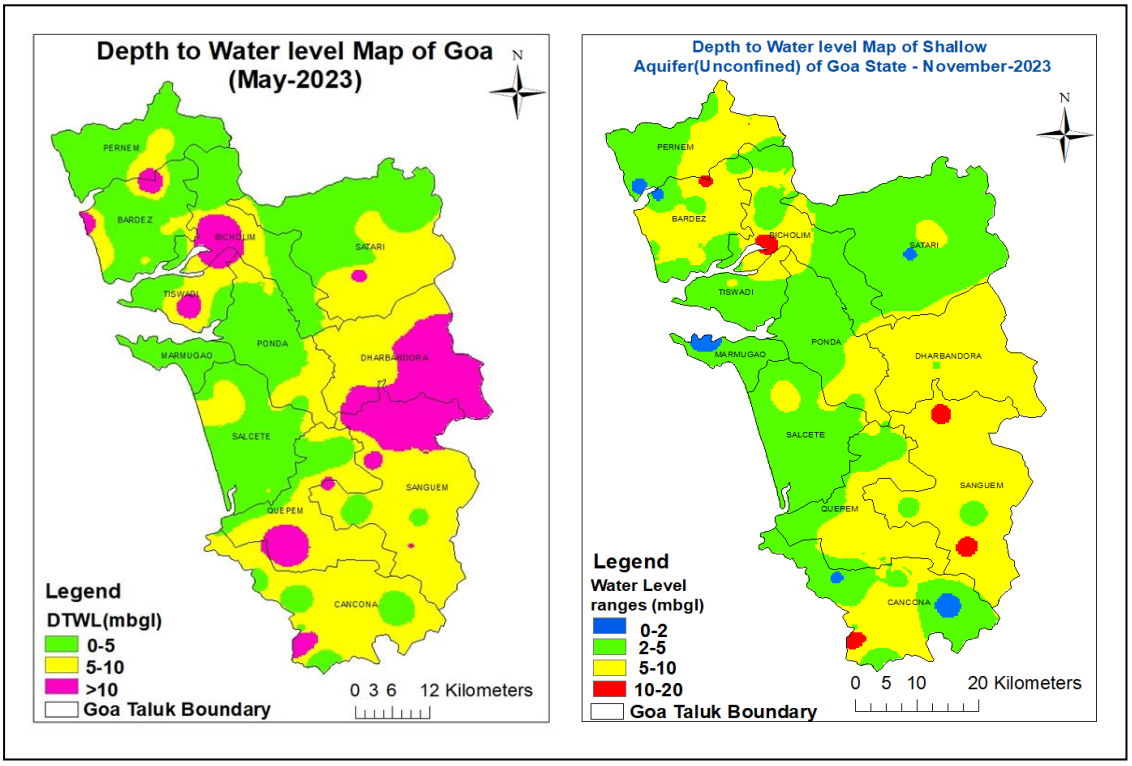
गोवा राज्य की भूजल वर्ष पुस्तिका
(2023-2024)
GROUND WATER YEAR BOOK OF GOA
(2023-2024)



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दक्षिण पश्चिम क्षेत्र /South Western Region
बेंगलुरु /Bengaluru

November 2024

GROUND WATER YEAR BOOK OF GOA
(2023-2024)

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EXECUTIVE SUMMARY

Central Ground Water Board, an apex Organization under Ministry of Water Resources, 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 2023-24 in Goa State has to be studied by monitoring a set of dug wells and purpose-built piezometers during the months of **May 2023, August 2023, November 2023 and January 2024**. During May 23 to Nov 23, Central Ground Water Board, South Western Region, monitored **83 dug wells and 45 piezometers**, total **128** monitoring stations in Goa state**.** As of January 2024, Central Ground Water Board, South Western Region, monitored **83 dug wells and 52 piezometers**, total **135** monitoring stations to study the ground water scenario of Goa State.

The present compilation relates to the year 2023-24. It provides information pertaining to water levels of the phreatic and fractured aquifer. Thematic maps depicting the ground water scenario of aquifers is 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 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.

In shallow aquifers, during pre-monsoon 2023, shows about 83 % of the wells are showing depth to water level within 10mbgl. During post monsoon 2023, about 92% of the wells showing depth to water level within 10mbgl. Annual fluctuation during pre-monsoon 2023(May 2022 to May 2023) it is observed that, 66 % of the wells in the State showing rise in water level and 34% of the wells in the state showing fall in water level. During post-monsoon 2023(November 2022 to November 2023) it is observed that, 86 % of the wells in the state showing rise in water level and 14% of the wells in the state showing fall in water level. Decadal mean water level of 2013-2022 with respect to Pre-monsoon 2023, 71% of wells recorded fall and 29% of wells recorded rise in water levels. During Post-monsoon 2023, 23% of wells recorded rise and 77% of wells recorded fall in water levels in comparison with decadal mean water level of 2013-2022.

In Deep aquifers, during pre-monsoon 2023, shows about 63% of the wells are showing depth to water level within 10mbgl. During post monsoon 2023, about 63% of the wells showing depth to water level within 10mbgl. Annual fluctuation during post-monsoon 2023(November 2022 to November 2023) it is observed that, 84 % of the wells in the state showing rise in water level and 16% of the wells in the state showing fall in water level.

GROUNDWATER YEAR BOOK OF GOA STATE (2023-24)

1.INTRODUCTION

In order to assess the real situation of ground water conditions, it is very essential to monitor the groundwater level and water quality over time and space. Central Ground Water Board, South Western Region, Bangalore, is monitoring water levels in the State of Goa from the established network of **135 monitoring stations** distributed throughout the state, 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°53'57" and 15°47'59" North latitudes and 73°40'35"and 74°20'11" East longitudes is situated on the western coast of peninsular India between Arabian Sea and Western Ghats. 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 12 taluks.

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.** Coastal plains with dominant Marine land forms on the west, followed successively towards the east by **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 832m above MSL. The Alluvial landforms are limited in aerial extent.

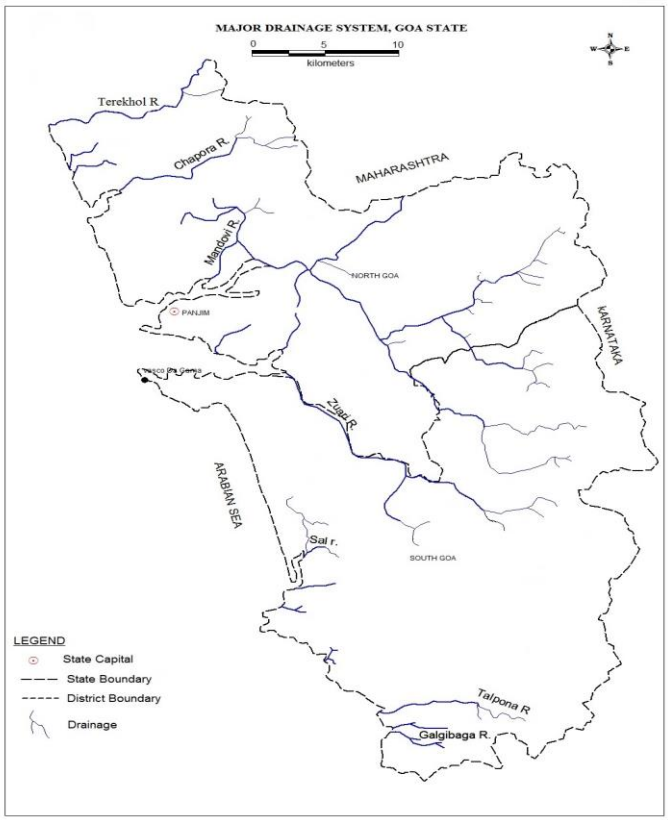
1.2 DRAINAGE

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 1)**. Primarily the underlying rocks govern the drainage system in the area. The drainage pattern is generally 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 1: 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, Bardez
Baga	50	1.35	Bardez
Mandovi	1580	42.68	Bicholim, Bardez, Satari, Sanguem, Tiswadi & Ponda
Zuari	973	26.28	Tiswadi, Ponda, Salcete, Quepem, Mormugao Sanguem & Cancona
Sal	301	8.13	Mormugao, Salcete, Quepem, & Cancona
Saleri	149	4.03	Quepem, & Cancona
Talpona	233	6.29	Cancona & Sanguem
Galgibaga	90	2.43	Cancona
Total	**3702**	**100%**	

PLATE 1: DRAINAGE SYSTEM OF GOA STATE (MAJOR DRAINAGE)



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 chart 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.

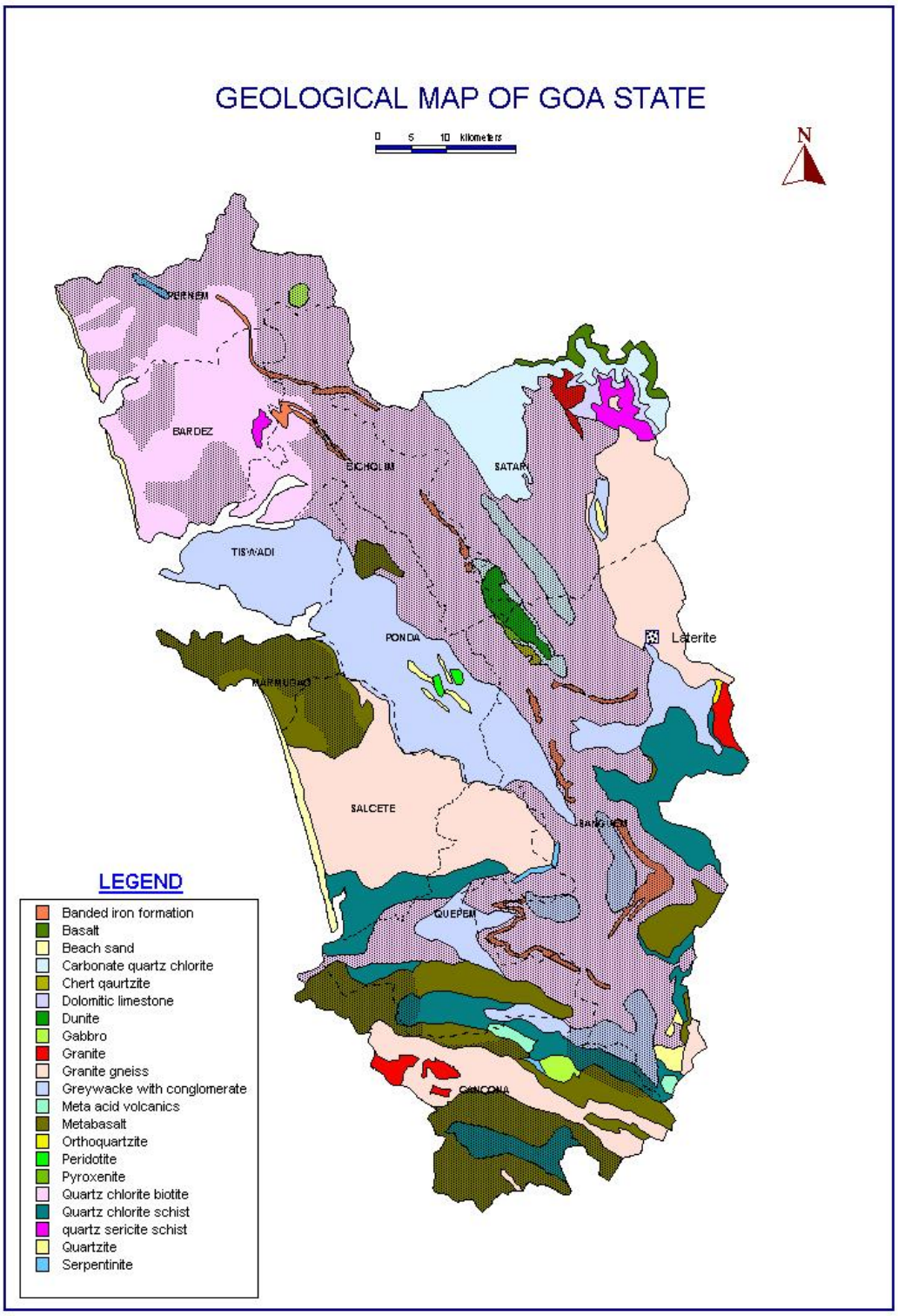
The Deccan Trap basalts of Late Cretaceous to Early Eocene age occupy a small portion in the northeastern part in the high altitudes.

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 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 **(Plate 2)**.

PLATE 2 GEOLOGY OF GOA STATE



2. CLIMATE AND RAINFALL

The State has a tropical-maritime monsoonal type climate. 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 June and July are the wettest months. 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 temp 25°C.

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.

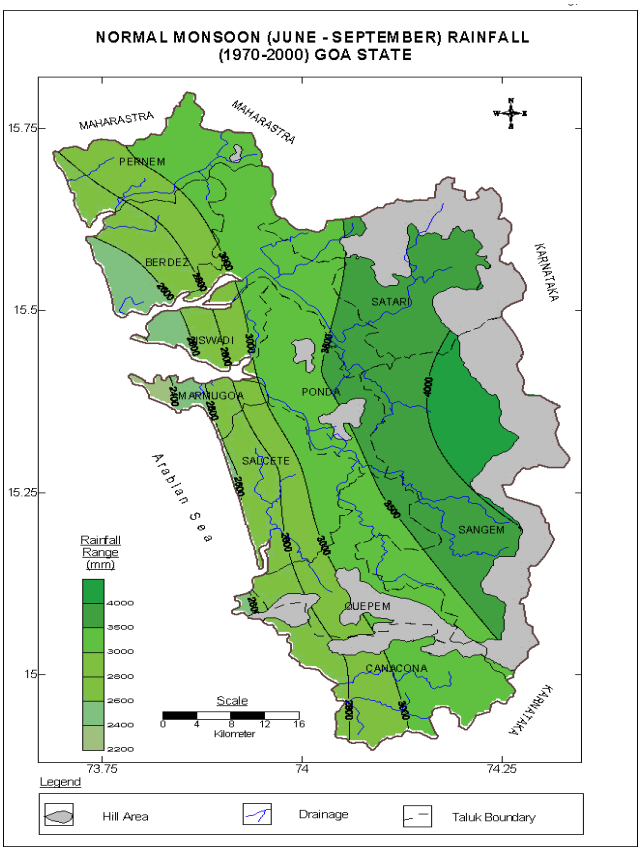
The analysis of Rainfall data for the period of **1970 to 2000** from 12 stations over the Goa state indicates that the monsoon rainfall is in the order of 3460mm (90 % of annual rainfall), 218.1mm (6%) during post monsoon period of October to December and 102.5(4%) are from January to May months. The overall annual rainfall over the Goa state based on 30 years rainfall data is of 3483.3mm. The minimum rainfall of **2611.7mm** is recorded at **Mormugao** station falls in South Goa district and maximum of **5090mm** is in **Sanguem** station also from South Goa. The annual normal rainfall in North Goa ranges from **2766.9mm** 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 east again 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 (1246.9mm) are the wettest months with around 2187.6mm (62.80% 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 3** Normal monthly rainfall in respect of 12 stations of Goa state is presented in **Table 2**.

TABLE 2: 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 3: NORMAL MONSOON RAINFALL OF GOA STATE (1970-2000)



3. GROUNDWATER MONITORING STATIONS OF GOA STATE

As of January 2024, Central Ground Water Board, South Western Region, monitored 83 dug wells and 52 piezometers to study the ground water scenario of Goa State. The ground water levels observed over a period of time provide valuable information on behaviour of the ground water regime, which is constantly subjected to changes due to recharge and discharge phenomena. A balance between these two factors results in the decline or rise in the ground water storage. When the recharge exceeds discharge there will be a rise in the ground water storage and vice versa. The decline in water level may be due to increase in draft (for different purposes) or decrease in precipitation (less recharge to ground water). On the other hand, a rise in water level may be due to an increase in rainfall and/or due to changes in irrigation practices. The dug wells tap the phreatic aquifer mostly limited to a depth of 20 m. The depth of piezometers which are tapping both the phreatic and deeper aquifers varies from 20 to 200 m. Hence the water level recorded in the piezometers may not be the same as that of dug wells for a particular period though both the structures are in the same place. In this report the water level data collected from unconfined aquifers (shallow depth) and semi-confined /confined is presented.

The purpose of water level data analysis is:

i) Four measurements of depth to water level give an overall idea regarding the ground water level in the state during the season of measurement.

ii) The fluctuation in comparison to the same month in the previous year gives an idea about the change in the ground water level for a particular period with respect to the water level during the same period in the previous year. This gives an idea about the change in the amount of draft and rainfall between the two period.

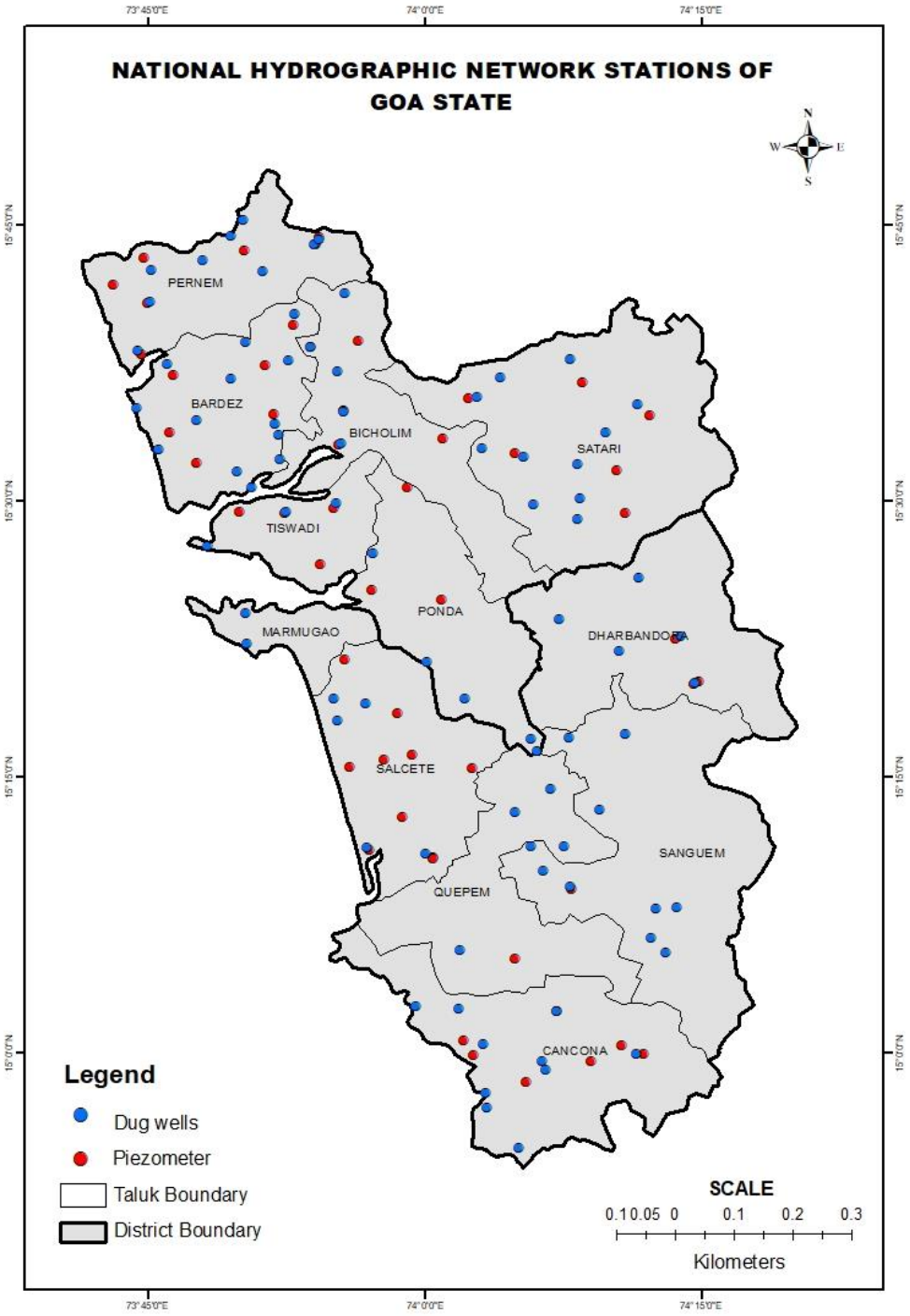
iii) The water level fluctuation during a particular month of measurement with reference to the decadal mean for the same months gives an idea of the behaviour of the ground water level on long-term basis.

Location Map of DW and Piezometers is presented in Plate-4. The district wise break-up of GWMS is given in the Table 3.

TABLE 3: DISTRICT WISE BREAKUP OF GWMS AS ON 31/01/2024

Sl.No	District	No of GW monitoring wellsas on 31.01.2024		
		DW	PZ	Total
1	**North Goa**	47	30	77
2	**South Goa**	36	22	58
Total		**83**	**52**	**135**

PLATE 4: LOCATION MAP OF MONITORING STATIONS OF GOA STATE



4. DEPTH TO WATER LEVEL

The depth to water level is being monitored through wells distributed throughout the state during the months of May (Pre-monsoon), August, November (Post-monsoon) and January. The water level data of GWMWs during 2023-24 is compiled in Annexure I. The depth to water level mostly depends on the hydrogeological conditions of the area as well as topography, rainfall pattern etc. The groundwater Scenario of Goa state for the month May 2023, August 2023, November 2023 and January 2024 are presented.

4.1 MAY 2023

4.1.1 DEPTH TO WATER LEVEL OF SHALLOW AQUIFER

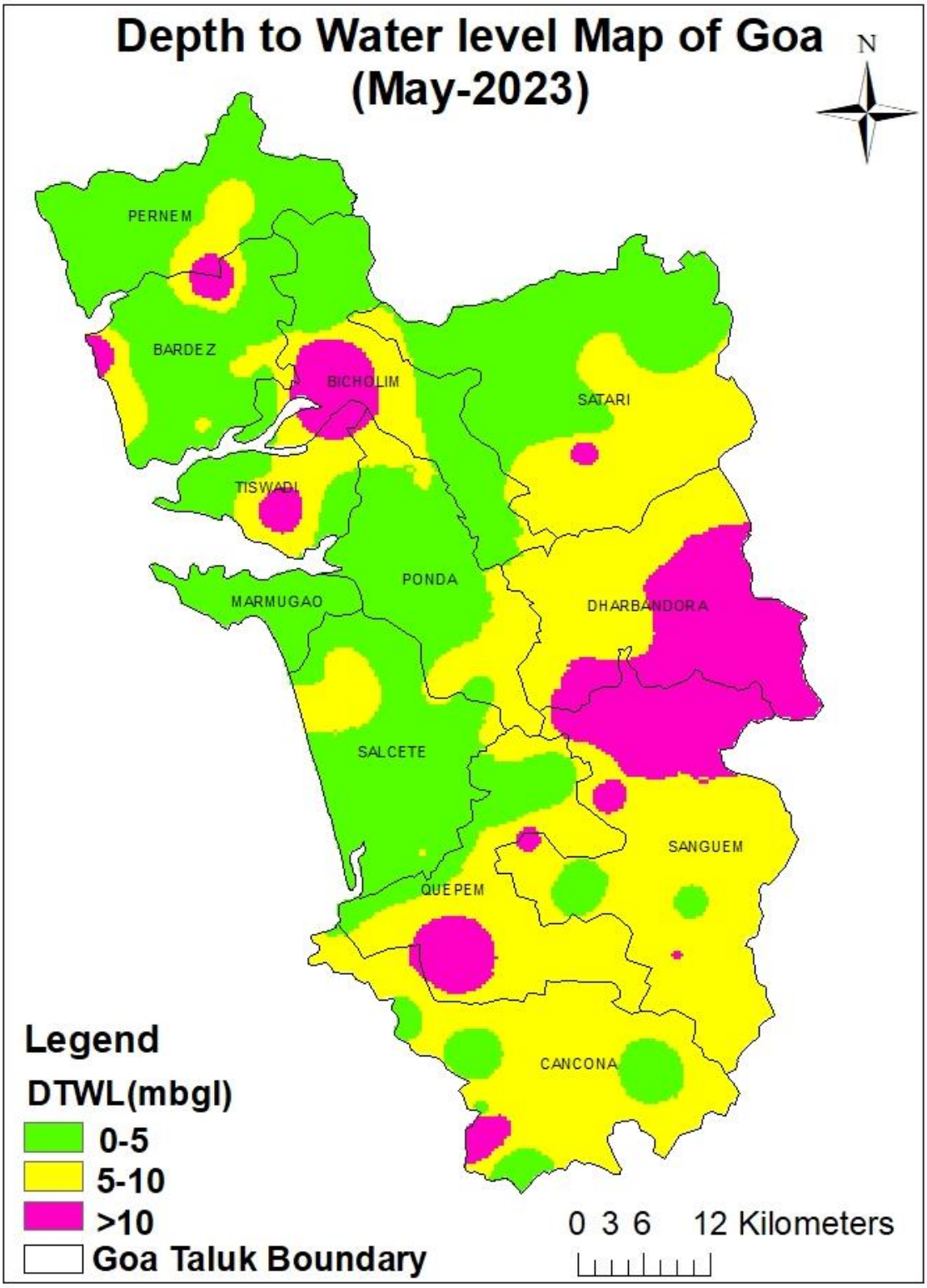
The statement showing the distribution of ground water monitoring wells along with depth to water level of phreatic aquifer in different depth ranges is presented in **Table-4** and **Plate-5** depicts the ground water scenario in May 2023. Salient features of the depth to water level scenario during May 2023 are given below.

- A perusal of the water level data reveals that the depth to water level ranged from **2.32** m bgl (Quepem taluk) to **16.38** m bgl (Canacona taluk).
- 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 **83** % of wells analysed, while **17** % of wells show depth to water level more than 10 m bgl.
- Depth to water level of less than 2 m bgl has not been recorded in any of the wells analysed.
- Depth to water level in the range of 2 to 5 m bgl has been recorded in **34%** of wells analysed and noted in all the taluks.
- Depth to water level in the range of 5 to 10 m bgl has been recorded in **49%** of wells analysed and noted in all the taluks except Bicholim and Quepem taluk.
- Depth to water level in the range of 10 to 20 m bgl has been observed in **17%** of wells analysed and noted in all the taluks except Ponda and Salcete taluk.

TABLE 4: DISTRICT WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF SHALLOW AQUIFER (MAY 2023)

S.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	%
1	Bardez	12	2.59	14.60	0	0	6	50	4	33	2	17	0	0
2	Bicholim	2	3.40	11.42	0	0	1	50	0	0	1	50	0	0
3	Pernem	6	2.78	11.71	0	0	4	66	1	17	1	17	0	0
4	Ponda	4	2.70	8.28	0	0	1	25	3	75	0	0	0	0
5	Sattari	9	2.47	11.39	0	0	2	22	6	67	1	11	0	0
6	Tiswadi	3	2.72	11.20	0	0	1	33	1	33	1	33	0	0
7	Canacona	9	4.63	16.38	0	0	1	10	6	60	2	20	0	0
8	Quepem	2	2.32	13.51	0	0	1	50	0	0	1	50	0	0
9	Salcete	5	2.54	9.42	0	0	3	60	2	40	0	0	0	0
10	Sanguem	13	4.26	15.67	0	0	2	15	9	69	2	15	0	0
	Total	**65**	**2.32**	**16.38**	**0**	**0**	**22**	**34**	**32**	**49**	**11**	**17**	**0**	**0**

PLATE 5: DEPTH TO WATER LEVEL MAP-SHALLOW AQUIFER MAY 2023



4.1.2 DEPTH TO WATER LEVEL OF DEEPER AQUIFER

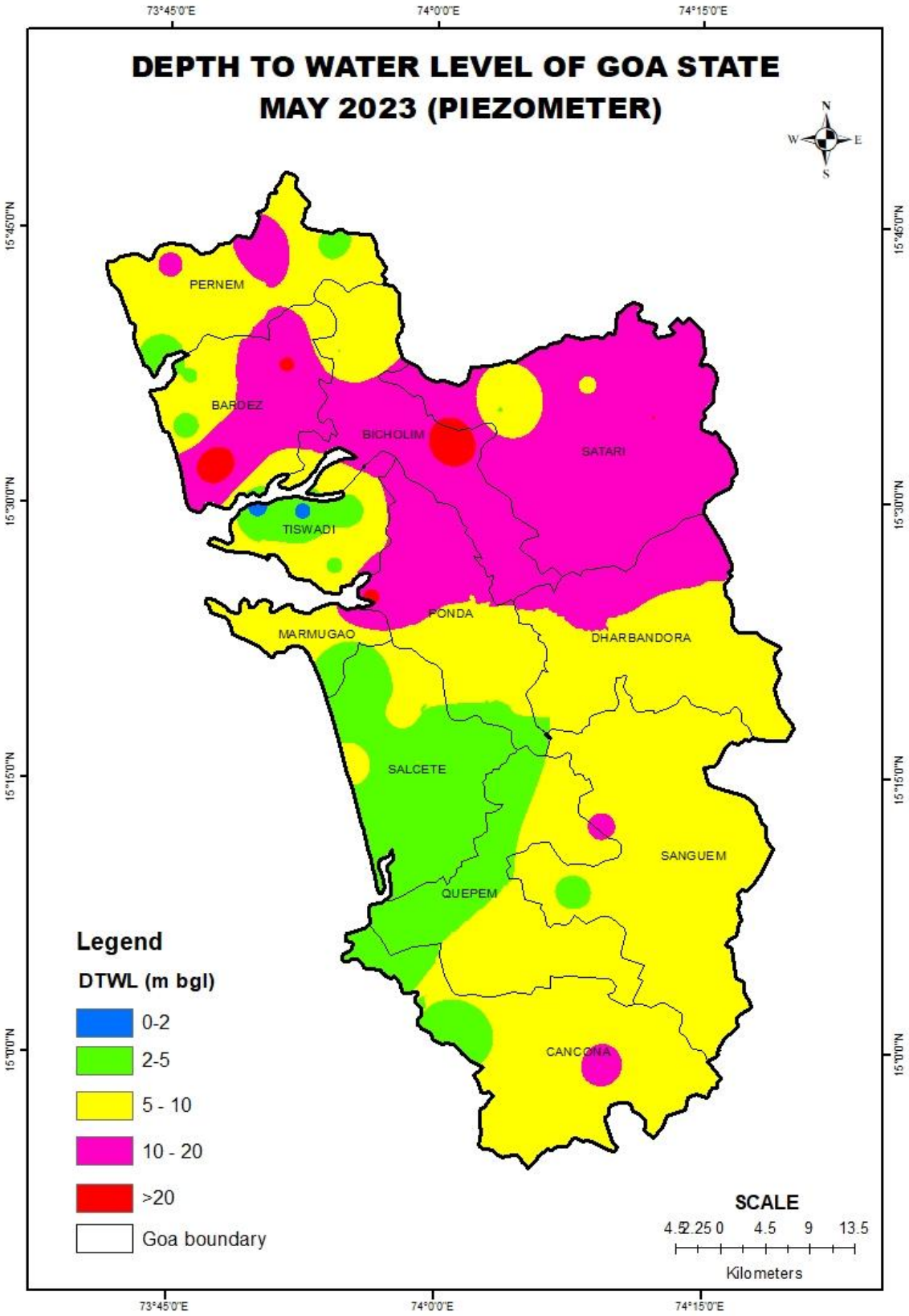
Depth to piezometric surface has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to piezometric surface is given in **Table 5**. and **Plate-6** depicts the piezometric surface in May 2023.Salient features of the depth to piezometric surface during May 2023 are given below;

- The depth to piezometric surface ranged from **1.32 m bgl** (Tiswadi taluk) to **27.63 m bgl** (Bardez taluk) in Goa State.
- **63%** of wells have recorded depth to piezometric surface within 10 m bgl and **37%** of wells show depth to piezometric surface more than 10 m bgl.
- Depth to piezometric surface of less than 2 m bgl has been recorded in **4%** of wells analysed and this has been noted in Tiswadi taluk.
- Depth to piezometric surface in the range of 2 to 5 m bgl has been recorded in **24%** of wells analysed and noted in Tiswadi, Salcete, Pernem and Bardez taluks.
- Depth to piezometric surface in the range of 5 to 10 m bgl has been recorded in **34%** of wells analysed and noted in all taluks except Bicholim and Ponda.
- Depth to piezometric surface in the range of 10 to 20 m bgl has been observed in **27**% of wells analysed and noted in all taluks except Tiswadi and Salcete taluks.
- Depth to piezometric surface in the range of more than 20 m bgl has been noted in **11 %** of wells analysed and noticed in Bicholim, Sattari, Bardez and Ponda taluks.

Table 5: DISTRICT WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO PIEZOMETRIC SURFACE OF DEEPER AQUIFER (MAY 2023)

S.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	%
1	Tiswadi	4	1.32	5.02	2	50	1	25	1	25	0	0	0	0
2	Sattari	4	5.45	20.45	0	0	0	0	1	25	2	50	1	25
3	Sangeum	4	5.1	11.27	0	0	0	0	3	75	1	25	0	0
4	Salcete	8	2.45	6.41	0	0	6	75	2	25	0	0	0	0
5	Ponda	2	17.23	21.42	0	0	0	0	0	0	1	50	1	50
6	Pernem	8	3.5	15.42	0	0	3	37	3	37	2	26	0	0
7	Canacona	6	6.95	12.49	0	0	0	0	3	50	3	50	0	0
8	Bicholim	3	10.29	26.3	0	0	0	0	0	0	2	67	1	33
9	Bardez	6	3.82	27.63	0	0	1	16	2	34	1	16	2	34
	Total	**45**	**1.32**	**27.63**	**2**	**4**	**11**	**24**	**15**	**34**	**12**	**27**	**5**	**11**

PLATE 6: DEPTH TO WATER LEVEL MAP- DEEPER AQUIFER MAY 2023



4.2 AUGUST 2023

4.2.1 DEPTH TO WATER LEVEL OF SHALLOW AQUIFER

The statement showing the distribution of ground water monitoring wells along with depth to water level of Shallow aquifer in different depth ranges is presented in table 6 and

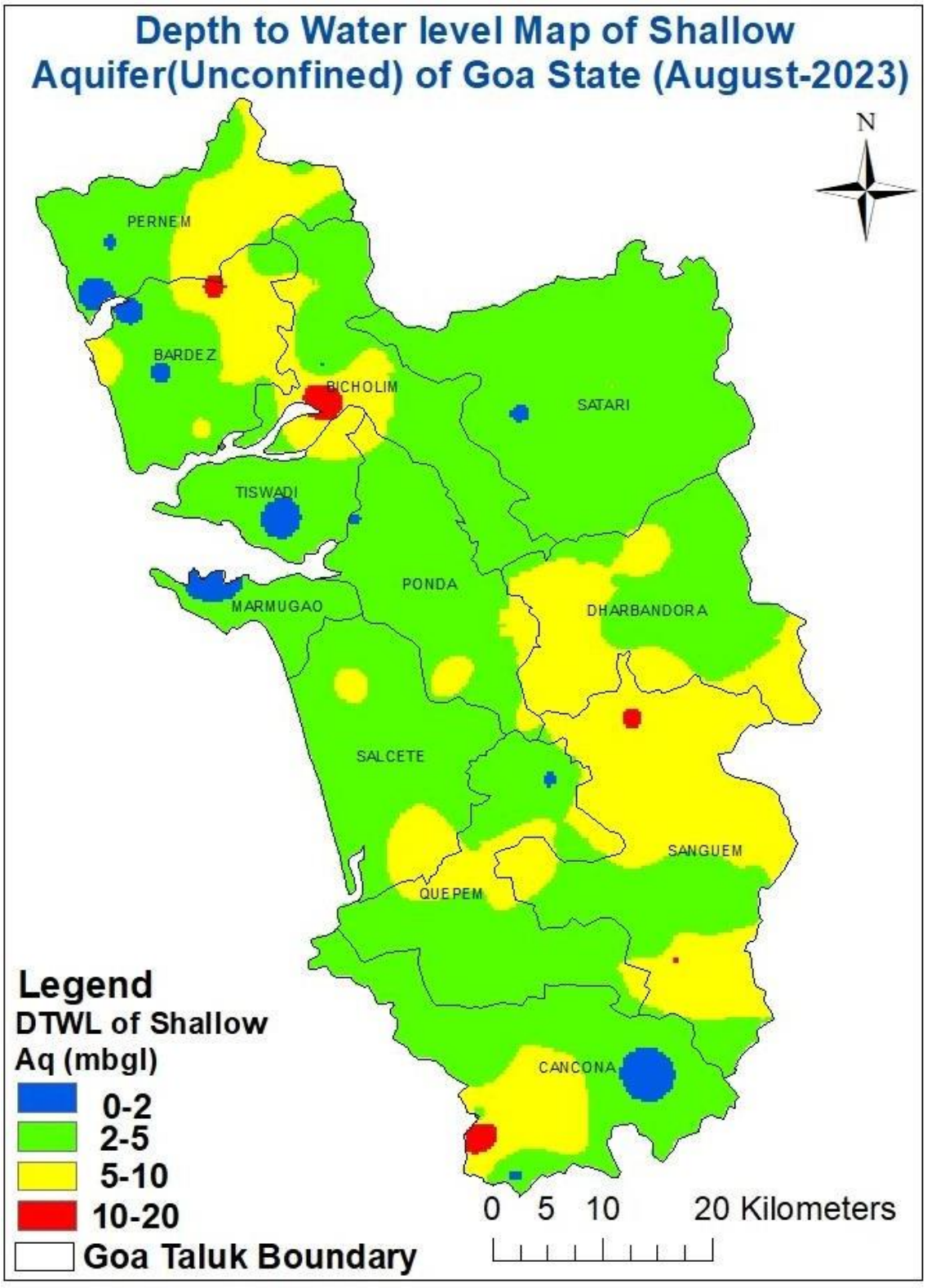
Plate 7 depicts the ground water scenario in August 2023. Salient features of the depth to water level scenario during August 2023 are given below.

- A perusal of the water level data reveals that the depth to water level ranged from 0.50 m bgl (Canacona taluk) to 15.81 m bgl (Canacona taluk).
- 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.
- Depth to water level of less than 2 m bgl has been recorded in 13% of wells analysed and noted in all taluks except Bicholim, Ponda, Salcete, Sanguem and Mormugao taluks.
- Depth to water level in the range of 2 to 5 m bgl has been recorded in 58% of wells analysed and noted in all the taluks.
- Depth to water level in the range of 5 to 10 m bgl has been recorded in 23% of wells analysed noted in all taluks except Sattari, Tiswadi, Quepem and Marmugoa taluks.
- 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 Bardez, Bicholim, Sanguem and Canacona taluks.

TABLE 6: DISTRICT WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF SHALLOW AQUIFER (AUGUST 2023)

S.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	%
1	Bardez	12	1.25	11.53	2	17	5	42	4	33	1	8	0	0
2	Bicholim	3	2.63	3.15	0	0	1	34	1	33	1	33	0	0
3	Pernem	6	1.11	8.50	2	33	3	50	1	17	0	0	0	0
4	Ponda	4	2.20	6.43	0	0	2	50	2	50	0	0	0	0
5	Sattari	9	1.80	4.10	1	11	8	89	0	0	0	0	0	0
6	Tiswadi	3	0.90	4.90	1	33	2	67	0	0	0	0	0	0
7	Canacona	7	0.50	15.81	2	28	3	44	1	14	1	14	0	0
8	Quepem	2	1.58	2.11	1	50	1	50	0	0	0	0	0	0
9	Salcete	5	2	6	0	0	3	60	2	40	0	0	0	0
10	Sangeum	14	2.80	10.50	0	0	8	57	4	29	2	14	0	0
11	Marmugoa	1	3.1	3.1	0	0	1	100	0	0	0	0	0	0
	Total	**66**	**0.5**	**15.81**	**9**	**13**	**37**	**58**	**15**	**23**	**5**	**6**	**0**	**0**

PLATE 7: DEPTH TO WATER LEVEL MAP-SHALLOW AQUIFER
AUGUST 2023



4.2.2 DEPTH TO WATER LEVEL OF DEEPER AQUIFER

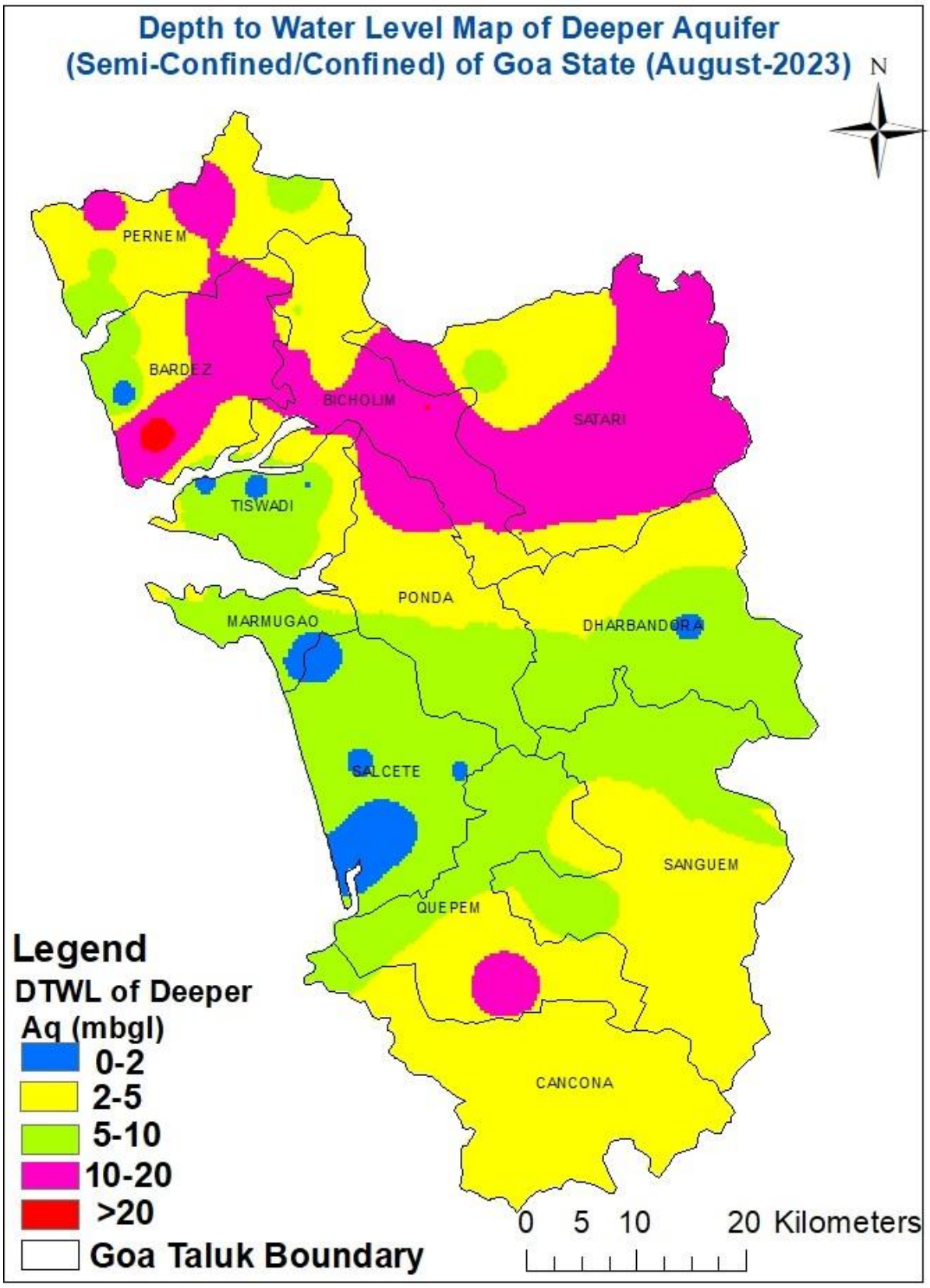
Depth to water level of deeper aquifer has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to water level of Deeper aquifer is given in **table 7** and **Plate-8** depicts the Piezometric ground water scenario in August 2023. Salient features of the depth to water level of deeper aquifer during August 2023 are given below;

- The depth to water level of deeper aquifer ranged from 0.34 m bgl (Bardez taluk) to 25.54 m bgl (Bardez taluk) in Goa State.
- 73% of wells have recorded depth to water level of deeper aquifer within 10 m bgl and
- 27% of wells show depth to water level of deeper aquifer more than 10 m bgl.
- Depth to water level of deeper aquifer of less than 2 m bgl has been recorded in 20% of wells analysed and this has been noted in Tiswadi, Salcete and Bardez taluks.
- Depth to water level of deeper aquifer in the range of 2 to 5 m bgl has been recorded in 36% of wells analysed and noted in all taluks except Ponda, Bicholim and Quepem taluks.
- Depth to water level of deeper aquifer in the range of 5 to 10 m bgl has been recorded in 17% of wells analysed and noted in Sattari, Sanguem, Bicholim, Canacona and Ponda taluks.
- Depth to water level of deeper aquifer in the range of 10 to 20 m bgl has been observed in 25% of wells analysed and noticed in Sattari, Ponda, Bicholim, Bardez, Quepem and Pernem taluks.
- Depth to water level of deeper aquifer in the range more than 20 m bgl has been observed in 2% of wells analysed and noticed in Bardez taluk.

TABLE 7: DISTRICT WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF DEEPER AQUIFER (AUGUST 2023)

S.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	%
1	Tiswadi	4	1.13	3.86	3	75	1	25	0	0	0	0	0	0
2	Sattari	4	2.36	18.58	0	0	1	25	1	25	2	50	0	0
3	Sangeum	4	1.72	6.79	0	0	3	75	1	25	0	0	0	0
4	Salcete	8	0.7	4.2	5	65	3	35	0	0	0	0	0	0
5	Ponda	2	7.5	15.03	0	0	0	0	1	50	1	50	0	0
6	Pernem	7	2.37	13.11	0	0	5	70	0	0	2	30	0	0
7	Canacona	5	2.81	9.05	0	0	2	40	3	60	0	0	0	0
8	Bicholim	5	5.6	20	0	0	0	0	2	40	3	60	0	0
9	Bardez	5	0.34	25.54	1	20	1	20	0	0	2	40	1	20
10	Quepem	1	12.5	12.5	0	0	0	0	0	0	1	100	0	0
	Total	**45**	**0.34**	**25.54**	**9**	**20**	**16**	**36**	**8**	**17**	**11**	**25**	**1**	2

PLATE-8: DEPTH TO WATER LEVEL MAP- DEEPER AQUIFER AUGUST 2022



4.3 NOVEMBER 2023
4.3.1 DEPTH TO WATER LEVEL OF SHALLOW AQUIFER

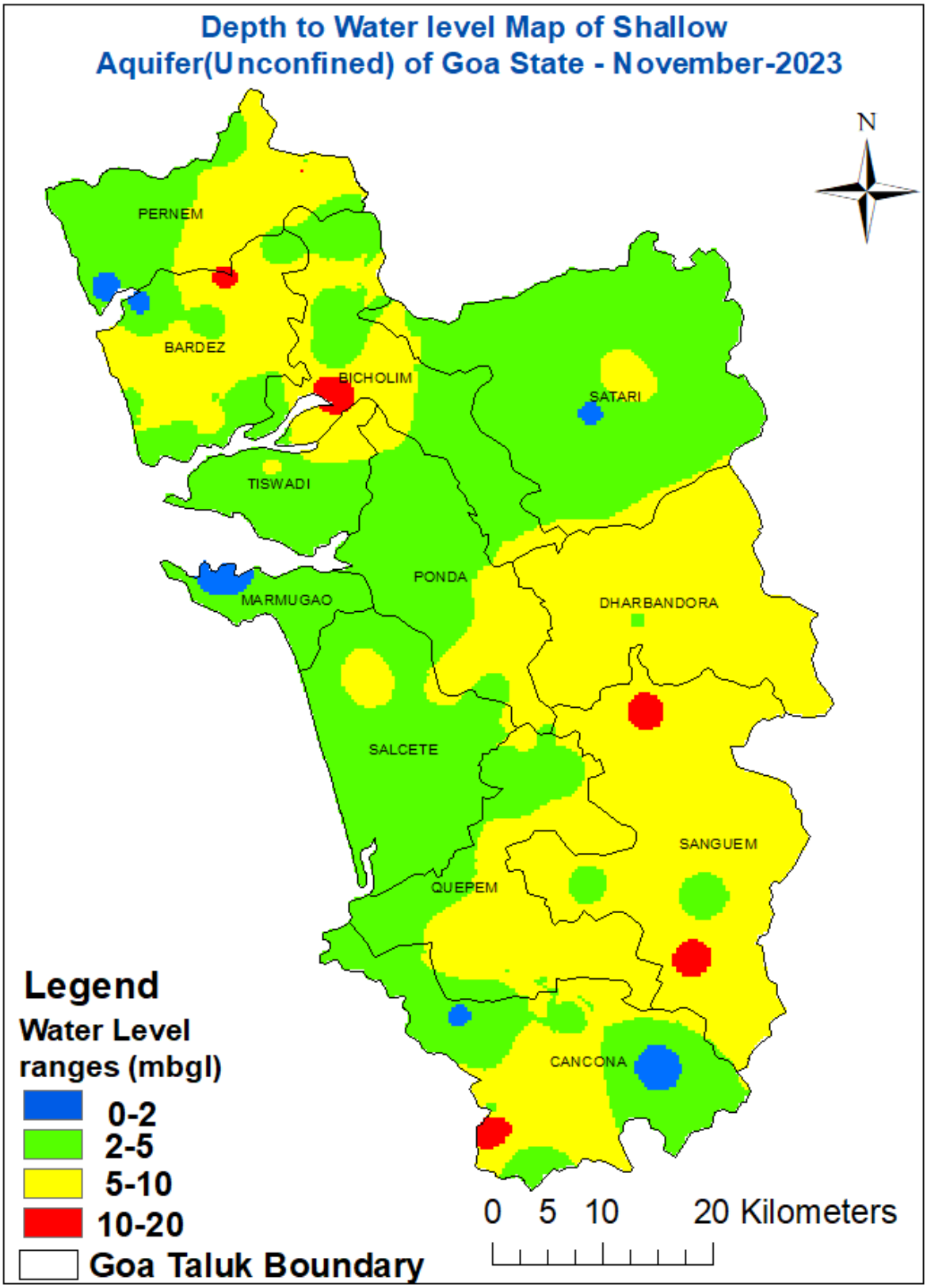
The statement showing the distribution of ground water monitoring wells along with depth to water level of Shallow aquifer in different depth ranges is presented in **table 8** and **Plate-9** depicts the ground water scenario in November 2023. Salient features of the depth to water level scenario during November 2023 are given below.

- A perusal of the water level data reveals that the depth to water level ranged from **0.2m bgl** (Canacona taluk) to **12.14 m bgl** (Sanguem taluk).
- 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 **92%** of wells analysed, while **8%** of wells show depth to water level more than 10 m bgl.
- Depth to water level of less than 2 m bgl has been recorded in **21%** of wells analysed and noted in all taluks except Bicholim and Sanguem taluks.
- 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.
- Depth to water level in the range of 5 to 10 m bgl has been recorded in **27%** of wells analysed noted in all taluks except Bicholim, Sattari, Tiswadi and Quepem taluks.
- Depth to water level in the range of 10 to 20 m bgl has been observed in **8%** of wells analysed and noted as isolated Bardez, Sanguem and Canacona taluks.

TABLE 8: DISTRICT WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF SHALLOW AQUIFER (NOVEMBER 2023)

S.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	%
1	**Bardez**	11	1.75	10.83	2	18	4	36	4	36	1	10	0	0
2	**Bicholim**	2	2.01	2.78	0	0	2	100	0	0	0	0	0	0
3	**Pernem**	6	0.68	7.83	2	33	3	50	1	17	0	0	0	0
4	**Ponda**	4	1.7	6.2	1	25	1	25	2	50	0	0	0	0
5	**Satari**	9	1.18	4.95	2	22	7	78	0	0	0	0	0	0
6	**Tiswadi**	2	1.2	4.5	1	50	1	50	0	0	0	0	0	0
7	**Canacona**	9	0.2	14.9	3	33	3	33	1	12	2	22	0	0
8	**Quepem**	2	1.47	2.1	1	50	1	50	0	0	0	0	0	0
9	**Salcete**	6	1.65	5.92	2	33	1	17	3	50	0	0	0	0
10	**Sanguem**	14	2.22	12.14	0	0	5	36	7	50	2	14	0	0
	Total	**65**	**0.2**	**12.14**	**14**	**21**	**28**	**44**	**18**	**27**	**5**	**8**	**0**	0

PLATE 9: DEPTH TO WATER LEVEL MAP-SHALLOW AQUIFER NOVEMBER 2023



4.3.2: DEPTH TO WATER LEVEL OF DEEPER AQUIFER

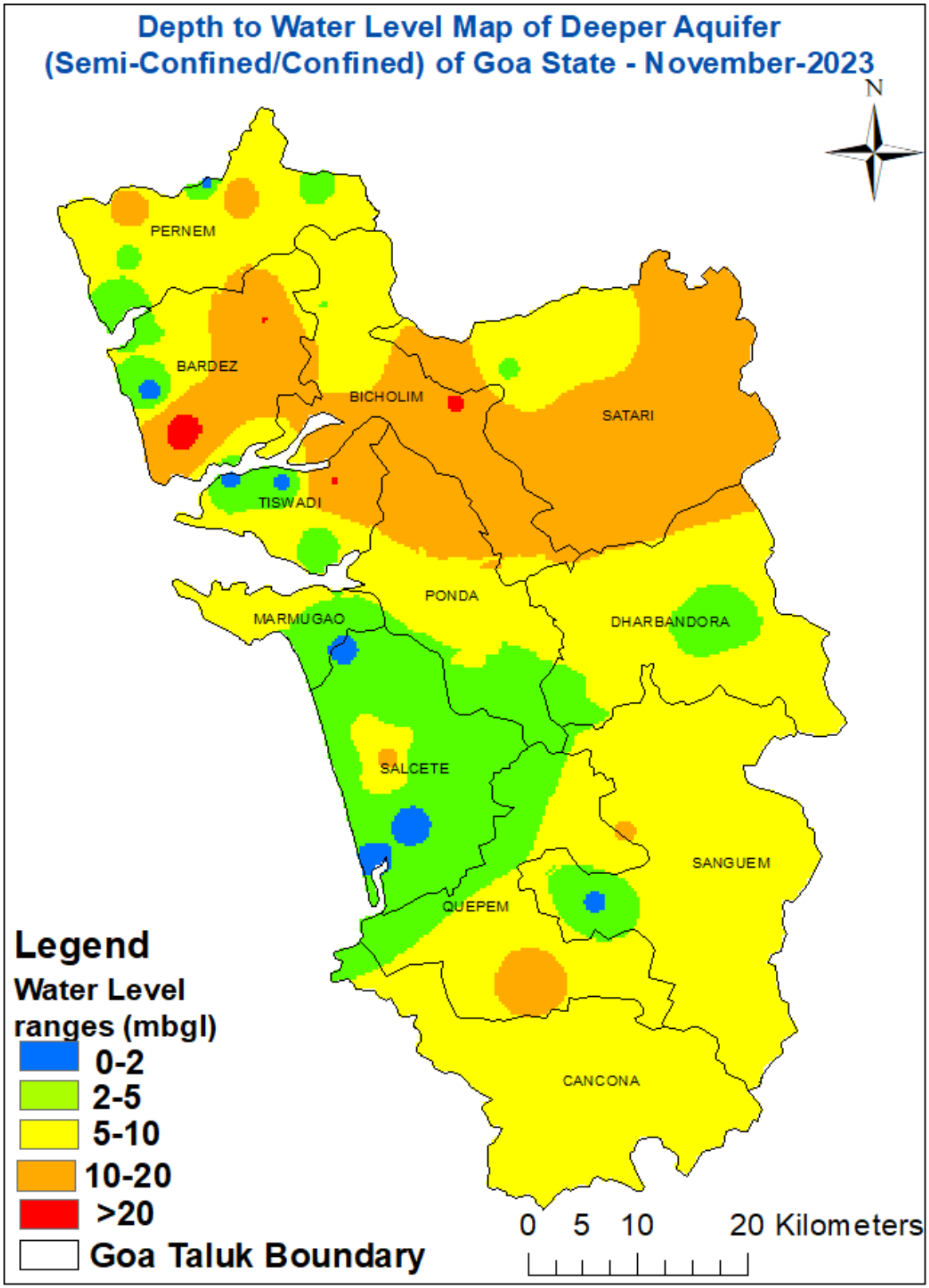
Depth to water level of deeper aquifer has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to water level of Deeper aquifer is given in **table 9** and **Plate-10** depicts the Piezometric ground water scenario in November 2023. Salient features of the depth to water level of deeper aquifer during November 2023 are given below;

- The depth to water level of deeper aquifer ranged from **0.75 m bgl** (Bardez taluk) to **25.53 m bgl** (Bardez taluk) in Goa State.
- **63%** of wells have recorded depth to water level of deeper aquifer within 10 m bgl and **37%** of wells show depth to water level of deeper aquifer more than 10 m bgl.
- Depth to water level of deeper aquifer of less than 2 m bgl has been recorded in **19%** of wells analysed and this has been noted in all taluks except Ponda, Bicholim and Quepem taluks.
- Depth to water level of deeper aquifer in the range of 2 to 5 m bgl has been recorded in **25%** of wells analysed and noted in all taluks except Ponda, Bicholim and Quepem taluks.
- Depth to water level of deeper aquifer in the range of 5 to 10 m bgl has been recorded in **19 %** of wells analysed and noted in Sattari, Sanguem, Bicholim, Canacona and Bardez taluks.
- Depth to water level of deeper aquifer in the range of 10 to 20 m bgl has been observed in **28%** of wells analysed and noticed in all taluks except Tiswadi and Canacona taluks.
- Depth to water level of deeper aquifer in the range more than 20 m bgl has been observed in **9%** of wells analysed and noticed in Bardez, Bicholim and Tiswadi taluk.

TABLE 9: TALUK WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF DEEPER AQUIFER (NOVEMBER 2023)

S.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	%
1	**Tiswadi**	4	1.04	20.11	2	50	1	25	0	0	0	0	1	25
2	**Sattari**	4	4.35	19.86	0	0	1	25	1	25	2	50	0	0
3	**Sangeum**	5	1.59	10.29	1	20	1	20	2	40	1	20	0	0
4	**Salcete**	8	0.94	12.24	3	38	4	50	0	0	1	12	0	0
5	**Ponda**	1	15.05	15.05	0	0	0	0	0	0	1	100	0	0
6	**Pernem**	8	1.53	13.15	1	12	5	63	0	0	2	25	0	0
7	**Canacona**	5	3.53	9.2	1	20	1	20	3	60	0	0	0	0
8	**Bicholim**	4	5.77	20.61	0	0	0	0	2	50	1	25	1	25
9	**Bardez**	6	0.75	25.53	1	16	1	16	1	16	1	16	2	36
10	**Quepem**	1	12.6	12.6	0	0	0	0	0	0	1	100	0	0
	Total	**46**	**0.75**	**25.53**	**9**	**19**	**14**	**25**	**9**	**19**	**10**	**28**	**4**	**9**

PLATE 10: DEPTH TO WATER LEVEL MAP OF DEEPER AQUIFER NOVEMBER 2023



4.4 JANUARY 2024

4.4.1 DEPTH TO WATER LEVEL OF SHALLOW AQUIFER

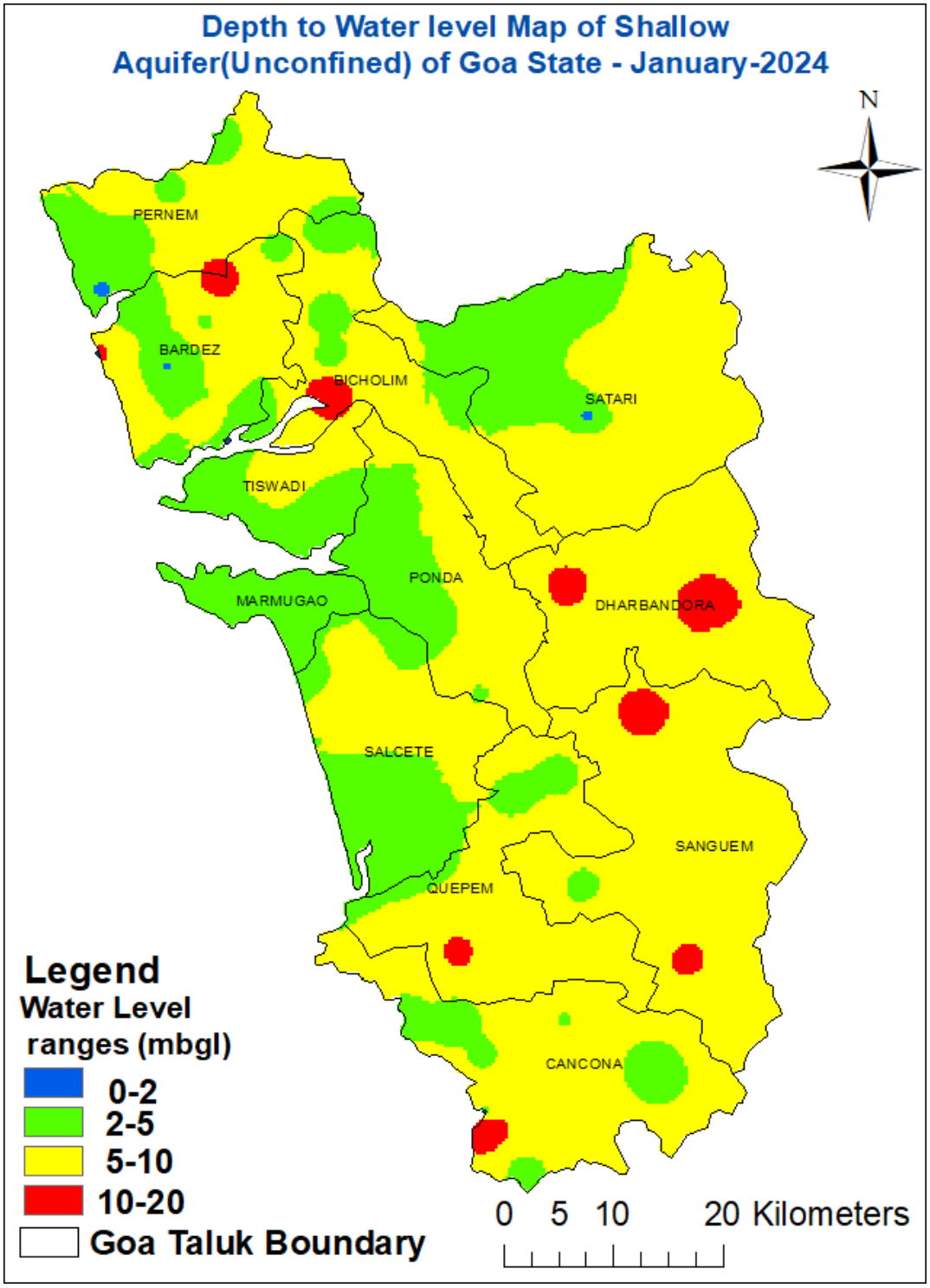
The statement showing the distribution of ground water monitoring wells along with depth to water level of Shallow aquifer in different depth ranges is presented in **table 10** and **Plate-11** depicts the ground water scenario in January 2024. Salient features of the depth to water level scenario during January 2024 are given below.

- A perusal of the water level data reveals that the depth to water level ranged from **01.3 m bgl** (Ponda taluk) to **16 m bgl** (Canacona taluk).
- 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.
- Depth to water level of less than 2 m bgl has been recorded in **7%** of wells analysed and noted in Bardez, Pernem, Ponda and Tiswadi taluks.
- Depth to water level in the range of 2 to 5 m bgl has been recorded in **43%** of wells analysed and noted in all the taluks.
- Depth to water level in the range of 5 to 10 m bgl has been recorded in **39%** of wells analysed noted in all taluks except Bicholim and Quepem taluks .
- 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 Bardez, Sanguem and Canacona taluks.

TABLE 10: TALUK WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF SHALLOW AQUIFER (JANUARY 2024)

S.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	%
1	**Bardez**	12	1.91	13.87	2	17	4	33	5	42	1	8	0	0
2	**Bicholim**	2	3.4	3.5	0	0	2	100	0	0	0	0	0	0
3	**Pernem**	6	1.63	8.42	1	17	3	50	2	33	0	0	0	0
4	**Ponda**	4	1.3	7.83	1	25	1	25	2	50	0	0	0	0
5	**Satari**	9	3.39	8.5	0	0	5	56	4	44	0	0	0	0
6	**Tiswadi**	3	1.52	5.7	1	33	1	34	1	33	0	0	0	0
7	**Canacona**	8	3.72	16	0	0	5	62	1	13	2	25	0	0
8	**Quepem**	2	2.55	3.34	0	0	2	100	0	0	0	0	0	0
9	**Salcete**	6	2	11	0	0	3	50	3	50	0	0	0	0
10	**Sanguem**	14	3.65	11.9	0	0	2	14	8	57	4	29	0	0
	Total	**66**	**1.3**	**16**	**5**	**7**	**28**	**43**	**26**	**39**	**7**	**11**	**0**	**0**

PLATE 11: DEPTH TO WATER LEVEL MAP OF SHALLOW AQUIFER JANUARY 2024



4.4.2 *DEPTH TO WATER LEVEL OF DEEPER AQUIFER*

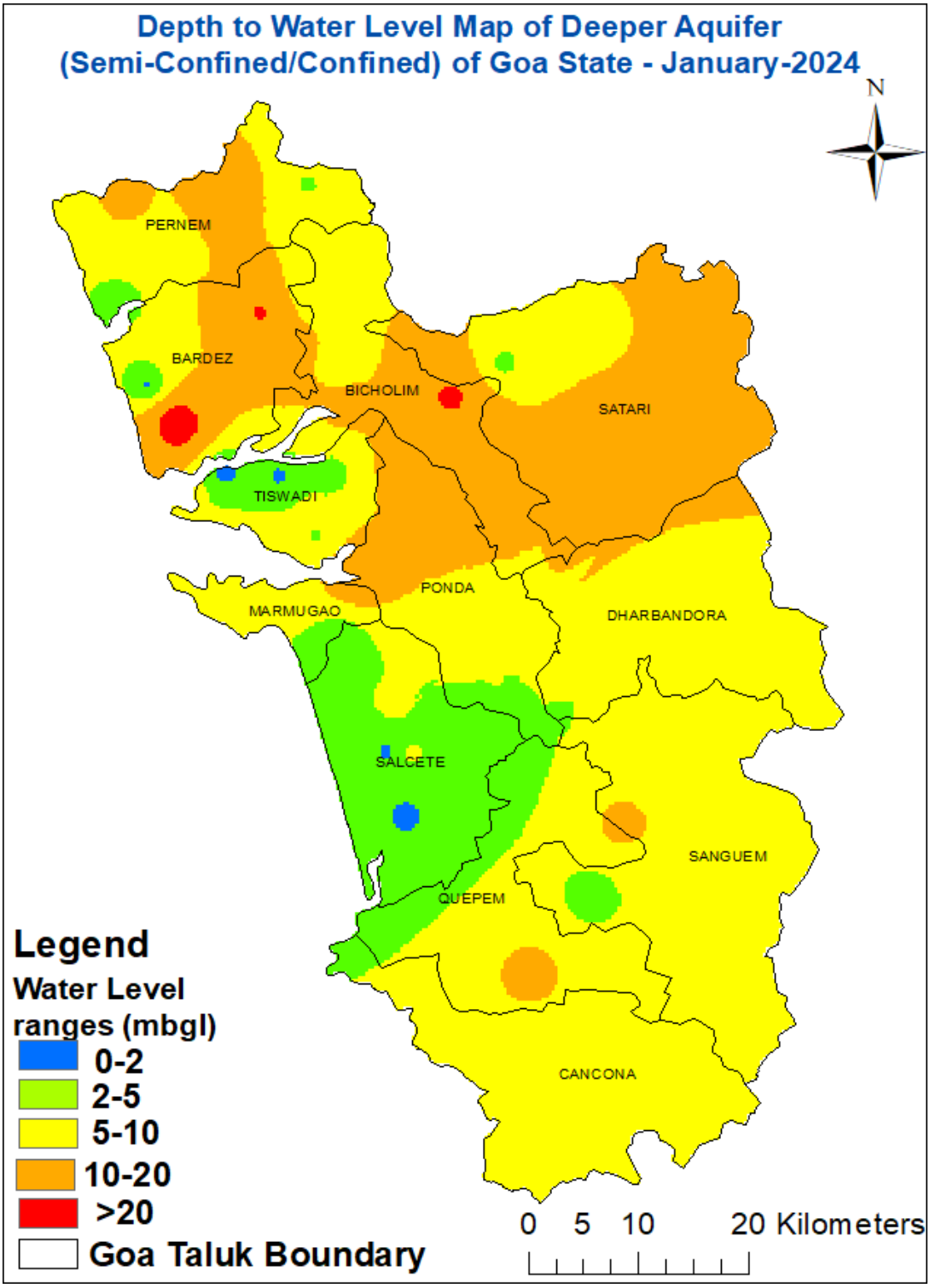
Depth to water level of deeper aquifer has been recorded from piezometers spread all over the State in hard rock areas. The statement showing depth to water level of Deeper aquifer is given in **table 11** and **Plate-12** depicts the Piezometric ground water scenario in January 2024. Salient features of the depth to water level of deeper aquifer during January 2024 are given below;

- The depth to water level of deeper aquifer ranged from 1.15 m bgl (Tiswadi taluk) to 26.88 m bgl (Bardez taluk) in Goa State.
- 73% of wells have recorded depth to water level of deeper aquifer within 10 m bgl and 27% of wells show depth to water level of deeper aquifer more than 10 m bgl.
- Depth to water level of deeper aquifer of less than 2 m bgl has been recorded in **14%** of wells analysed and this has been noted in Bardez, Salcete and Tiswadi taluks.
- Depth to water level of deeper aquifer in the range of 2 to 5 m bgl has been recorded in **22%** of wells analysed and noted in all taluks except Bardez, Ponda, Bicholim and Quepem taluks.
- Depth to water level of deeper aquifer in the range of 5 to 10 m bgl has been recorded in **37 %** of wells analysed and noted in all taluks except Ponda, Tiswadi and Quepem taluks.
- Depth to water level of deeper aquifer in the range of 10 to 20 m bgl has been observed in 20% of wells analysed and noticed in all taluks except Salcete, Tiswadi and Canacona taluks.
- Depth to water level of deeper aquifer in the range more than 20 m bgl has been observed in 7% of wells analysed and noticed in Bardez and Bicholim taluks.

TABLE 11: TALUK WISE WELL FREQUENCY FOR DIFFERENT RANGES OF DEPTH TO WATER LEVEL OF DEEPER AQUIFER (JANUARY 2024)

S.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	%
1	**Bardez**	6	1.92	26.88	1	16	0	0	2	34	1	16	2	34
2	**Satari**	3	4.41	19.94	0	0	1	33	1	34	1	33	0	0
3	**Sangeum**	4	3.65	11	0	0	1	25	2	50	1	25	0	0
4	**Salcete**	8	1.59	5.53	3	37	3	37	2	26	0	0	0	0
5	**Ponda**	2	16.26	18.72	0	0	0	0	0	0	2	100	0	0
6	**Pernem**	7	2.78	14.92	0	0	2	28	3	44	2	28	0	0
7	**Canacona**	5	4.98	9.29	0	0	1	20	4	80	0	0	0	0
8	**Bicholim**	4	6.4	21.4	0	0	0	0	2	50	1	25	1	25
9	**Tiswadi**	4	1.15	4.86	2	50	2	50	0	0	0	0	0	0
10	**Quepem**	1	11.34	11.34	0	0	0	0	0	0	1	100	0	0
	Total	**44**	**1.15**	**26.88**	**6**	**14**	**10**	**22**	**16**	**37**	**9**	**20**	**3**	**7**

PLATE 82: DEPTH TO WATER LEVEL MAP OF DEEPER AQUIFER -JANUARY 2024



5. FLUCTUATION OF WATER LEVEL

5.1 MAY 2022 TO MAY 2023

5.1.1 SHALLOW AQUIFER

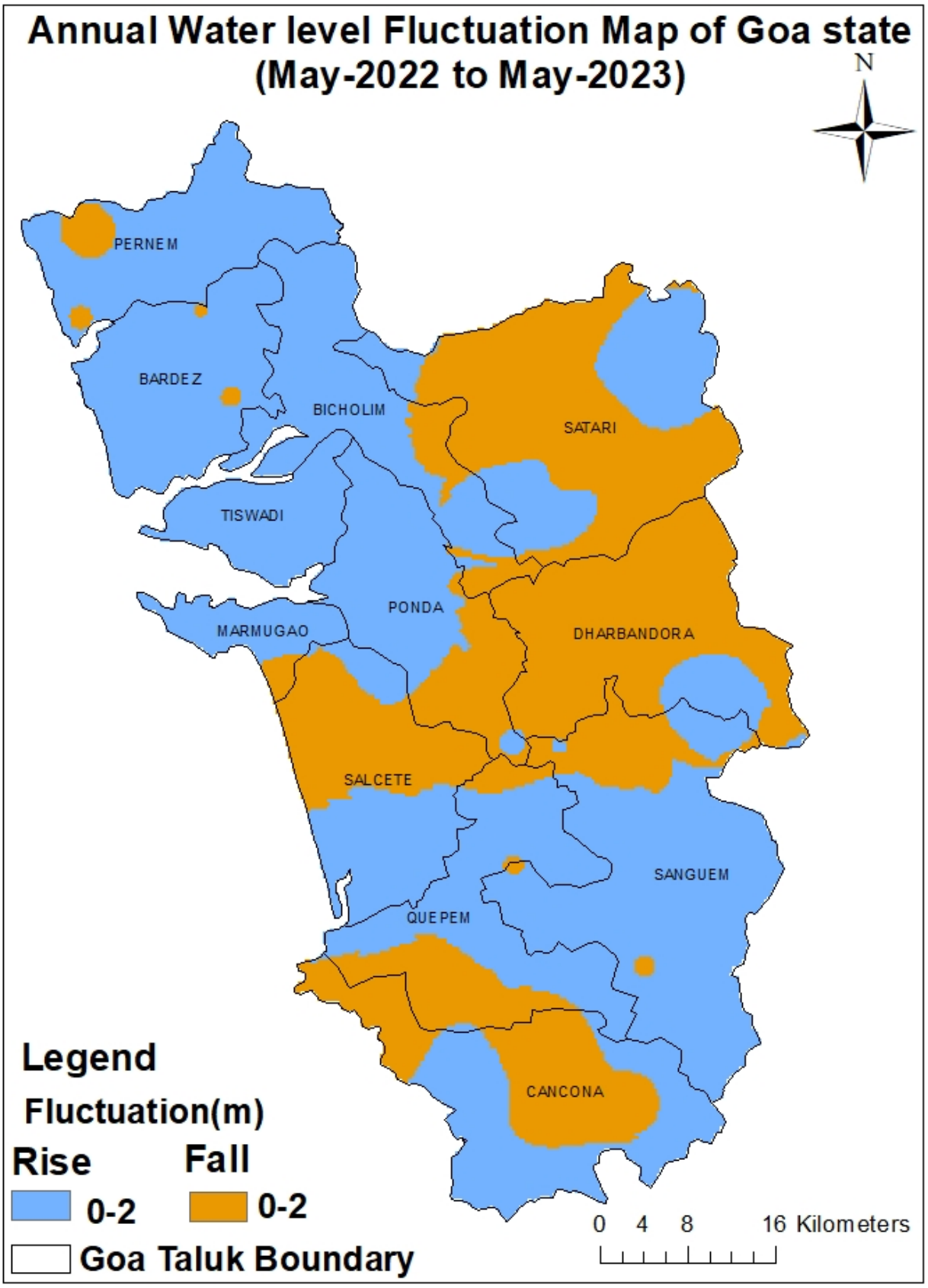
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **table 12. A comparison of ground water level between May 2022 and May 2023 shows that a fall in the water level is recorded in 34% of wells analysed, while 66% recorded rise i.e majority of the state is showing rising water level.** The fluctuation in water level has been plotted in **Plate 13.** 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, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **66%** of wells analysed and observed in parts of all taluks.
- The fall in water level in the range of 0-2 m has been observed in **34%** of wells analysed and noted in parts of all the taluks except Bicholim, Tiswadi and Quepem taluk.

TABLE 12: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF SHALLOW AQUIFER (MAY 2022-MAY 2023)

S.No	Taluk Name	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)					
			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	8	73	0	0	0	0	3	27	0	0	0	0
2	Bicholim	2	2	100	0	0	0	0	0	0	0	0	0	0
3	Pernem	6	5	84	0	0	0	0	1	16	0	0	0	0
4	Ponda	3	2	67	0	0	0	0	1	33	0	0	0	0
5	Sattari	6	2	33	0	0	0	0	4	67	0	0	0	0
6	Tiswadi	1	1	100	0	0	0	0	0	0	0	0	0	0
7	Canacona	7	4	57	0	0	0	0	3	43	0	0	0	0
8	Quepem	1	1	100	0	0	0	0	0	0	0	0	0	0
9	Salcete	4	2	50	0	0	0	0	2	50	0	0	**0**	**0**
10	Sangeum	12	8	67	0	0	0	0	4	33	0	0	0	0
	Total	**53**	**35**	**66**	**0**	**0**	**0**	**0**	**18**	**34**	**0**	**0**	**0**	**0**

PLATE 13: WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (MAY 2022 - MAY 2023)



5.2 AUGUST 2022 TO AUGUST 2023

5.2.1 SHALLOW AQUIFER

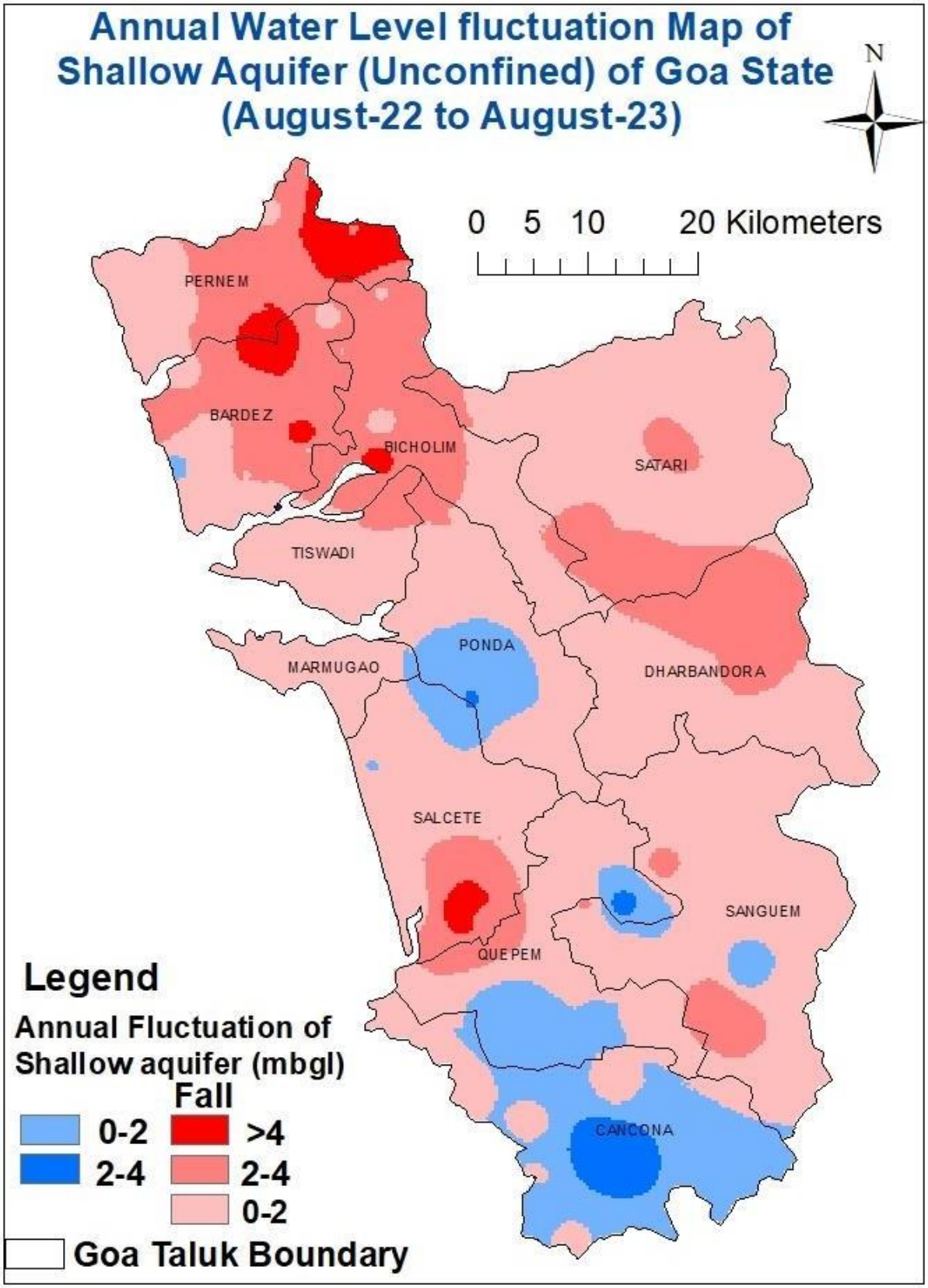
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Shallow aquifer is presented in **table 13**. **A comparison of water level shows that a rise in the water level is recorded in 12% of wells analyzed, while 88% recorded fall i.e majority of the state is showing falling water level.** The Annual fluctuation in water level of Shallow aquifer has been plotted in **Plate 14**. 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, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **11%** of wells analysed and observed in all taluks except Bicholim, Sattari, Tiswadi, Mormugao and Pernem taluks.
- Rise in the water level in the range of 2-4 m has been observed in **1%** of wells analysed in Canacona taluk.
- The Fall in water level in the range of 0-2 m has been observed in 60**%** of wells analysed and noted in almost all taluks except Bicholim taluk.
- The Fall in the water level in the range of 2-4 m has been observed in **20%** of wells analysed and observed in all taluks except Marmugao, Ponda, Canacona and Quepem taluks.
- The fall in water level more than 4 m has been observed in **8%** of wells analysed and noted in Bardez, Bicholim and Salcete taluks.

TABLE 13: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF SHALLOW AQUIFER (AUG 2022-AUG 2023)

S.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	1	9	0	0	0	0	8	73	1	9	1	9	1	10
2	Bicholim	2	0	0	0	0	0	0	0	0	1	50	1	50	0	2
3	Pernem	6	0	0	0	0	0	0	1	16	3	52	2	32	0	6
4	Marmugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Ponda	3	1	33	0	0	0	0	2	67	0	0	0	0	1	2
6	Sattari	8	0	0	0	0	0	0	4	50	4	50	0	0	0	8
7	Tiswadi	3	0	0	0	0	0	0	2	67	1	33	0	0	0	3
8	Canacona	8	2	24	1	13	0	0	5	63	0	0	0	0	3	5
9	Quepem	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
10	Salcete	5	1	20	0	0	0	0	2	40	1	20	1	20	1	4
11	Sanguem	14	1	7	0	0	0	0	11	79	2	14	0	0	1	13
	Total	**63**	**7**	**11**	**1**	**1**	**0**	**0**	**37**	**60**	**13**	**20**	**5**	**8**	**8**	**55**

PLATE 94: WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (AUGUST 2021 TO AUGUST 2022)



5.2.2 DEEPER AQUIFER

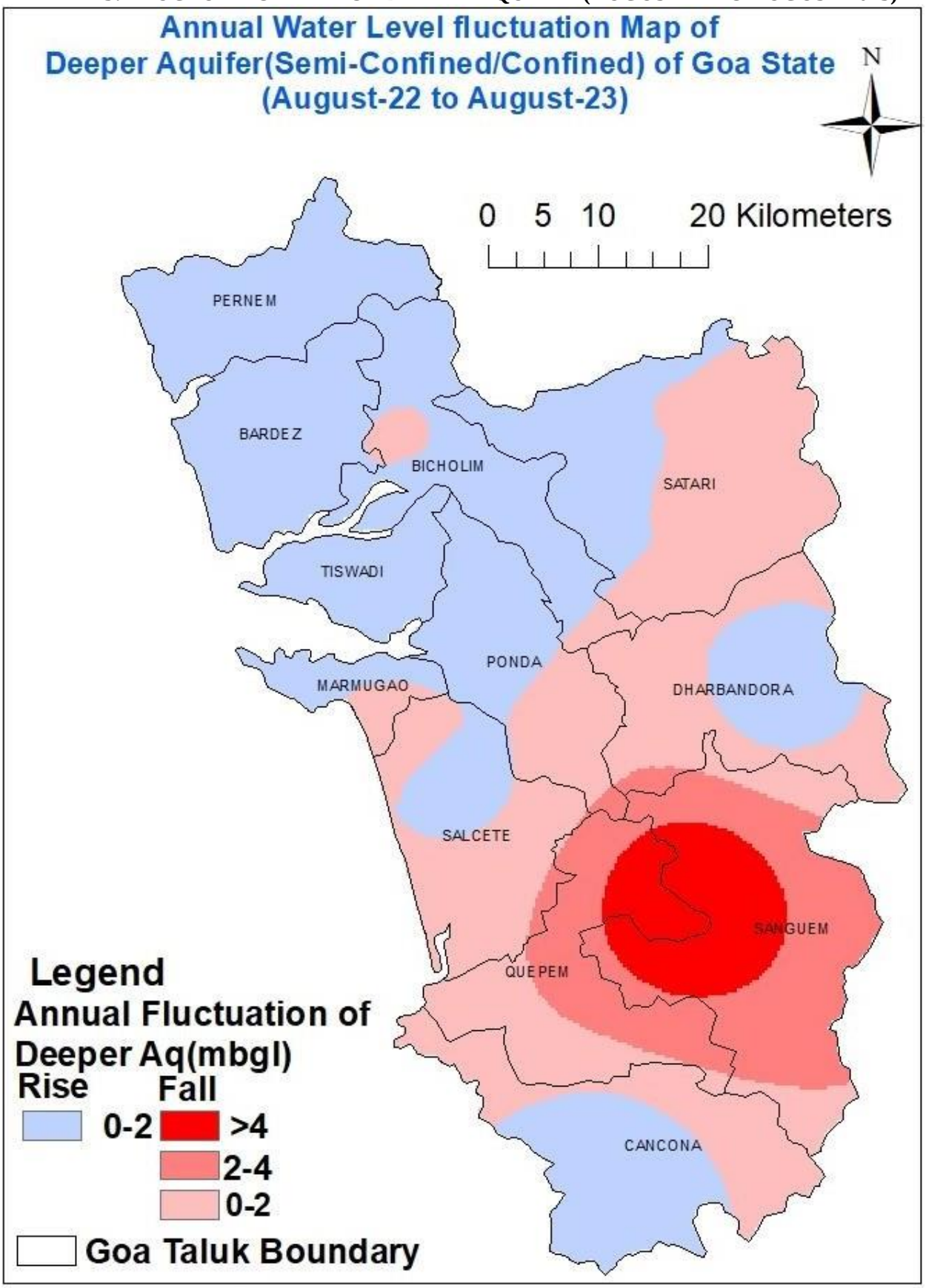
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Deeper aquifer is presented in **table 14**. **A comparison of water level shows that a rise in the water level is recorded in 56% of wells analyzed, while 44 % recorded fall i.e majority of the state is showing rising water level.** The Annual fluctuation in water level of Deeper aquifer has been plotted in **Plate 15**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **56%** of wells analysed and observed in all taluks except Ponda, Quepem and Sanguem taluks.
- The Fall in water level in the range of 0-2 m has been observed in 26**%** of wells analysed and noted in Bicholim, Ponda, Sattari, Canacona and Salcete taluks..
- The Fall in the water level in the range of 2-4 m has been observed in **9%** of wells analysed and noted in Quepem and Sanguem taluks.
- The fall in water level more than 4 m has been observed in **9%** of wells analysed and and noted in Quepem and Sanguem taluks.

TABLE 14: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF DEEPER AQUIFER (AUG 2022-AUG 2023)

S.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	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
2	Bicholim	3	2	67	0	0	0	0	1	34	0	0	0	0	2	1
3	Pernem	4	4	100	0	0	0	0	0	0	0	0	0	0	4	0
4	Ponda	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Sattari	4	2	50	0	0	0	0	2	50	0	0	0	0	2	2
6	Tiswadi	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
7	Canacona	3	2	67	0	0	0	0	1	34	0	0	0	0	2	1
8	Quepem	2	0	0	0	0	0	0	0	0	1	50	1	50	0	2
9	Salcete	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
10	Sanguem	2	0	0	0	0	0	0	0	0	1	50	1	50	0	2
	Total	**23**	**13**	**56**	**0**	0	**0**	0	**6**	**26**	**2**	**9**	**2**	**9**	**13**	**10**

PLATE 15: FLUCTUATION MAP OF DEEPER AQUIFER (AUGUST 22 TO AUGUST 2023)



5.3 NOVEMBER 2022 TO NOVEMBER 2023

5.3.1 SHALLOW AQUIFER

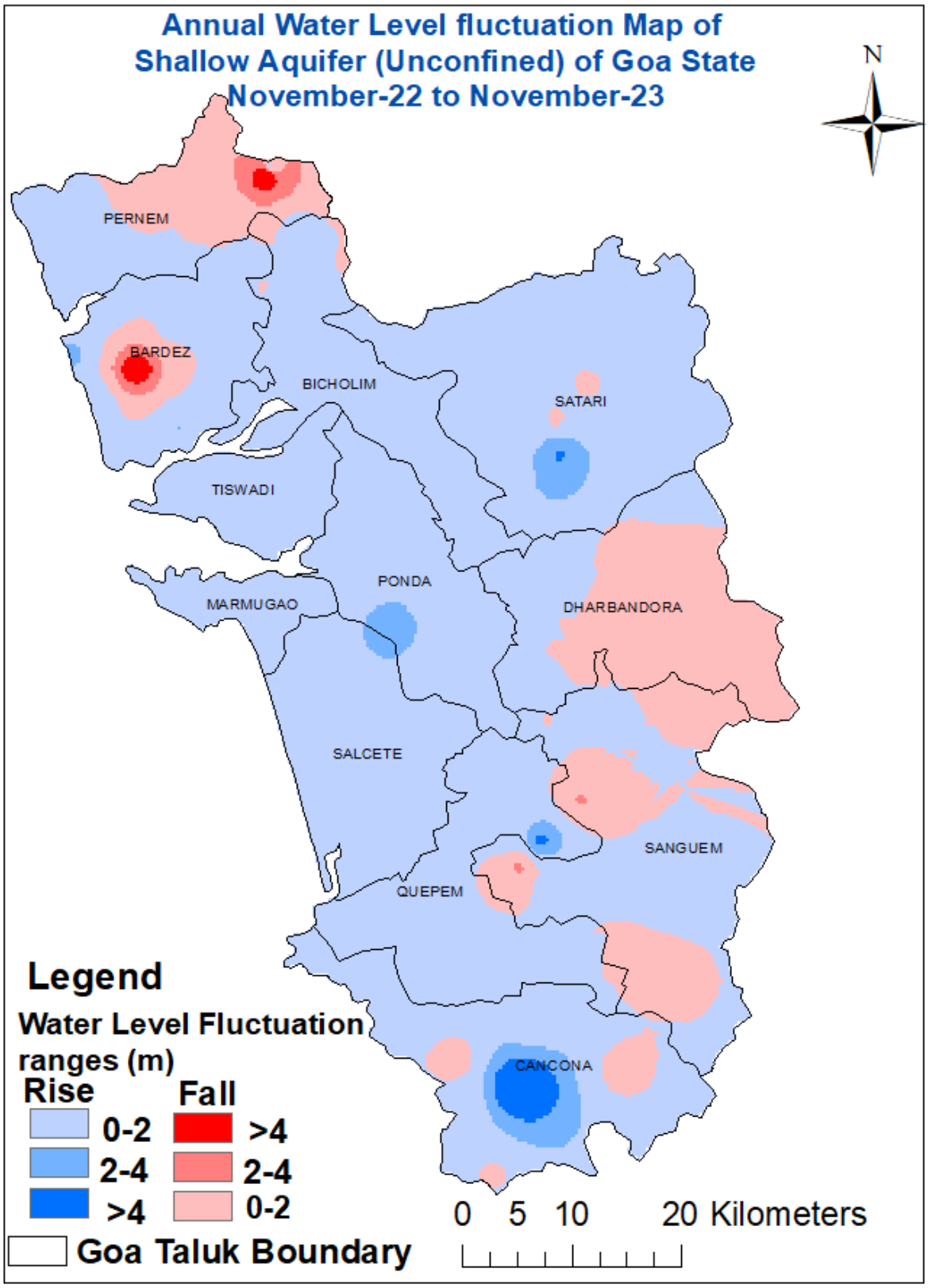
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Shallow aquifer is presented in **table 15**. **A comparison of water level shows that a rise in the water level is recorded in 86% of wells analyzed, while 14% recorded fall i.e majority of the state is showing rising water level.** The Annual fluctuation in water level of Shallow aquifer has been plotted in **Plate 16**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **69%** of wells analysed and observed in all taluks.
- Rise in the water level in the range of 2-4 m has been observed in **10%** of wells analysed in Bardez, Pernem, Satari and Sanguem taluks.
- Rise in water level more than 4 m has been observed in **7%** of wells analysed and noted in Ponda, Satari, Canacona and Sanguem taluks.
- The Fall in water level in the range of 0-2 m has been observed in 12**%** of wells analysed and noted in Pernem, Canacona and Sanguem taluks.
- The fall in water level more than 4 m has been observed in **2%** of wells analysed and noted in Bardez taluk.

TABLE 15: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF SHALLOW AQUIFER (NOV 2022-NOV 2023)

S.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	7	70	2	20	0	0	0	0	0	0	1	10	9	1
2	**Bicholim**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
3	**Pernem**	5	3	60	1	20	0	0	1	20	0	0	0	0	4	1
4	**Ponda**	3	2	67	0	0	1	33	0	0	0	0	0	0	3	0
5	**Satari**	9	6	67	2	22	1	11	0	0	0	0	0	0	9	0
6	**Tiswadi**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
7	**Canacona**	5	3	60	0	0	1	20	1	20	0	0	0	0	4	1
8	**Quepem**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
9	**Salcete**	6	6	100	0	0	0	0	0	0	0	0	0	0	6	0
10	**Sanguem**	14	7	50	1	7	1	7	5	36	0	0	0	0	9	5
	Total	**58**	**40**	**69**	**6**	**10**	**4**	**7**	**7**	**12**	**0**	**0**	**1**	**2**	**50**	**8**

PLATE 16: WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (NOVEMBER 2022 TO NOVEMBER 2023)



5.3.2 DEEPER AQUIFER

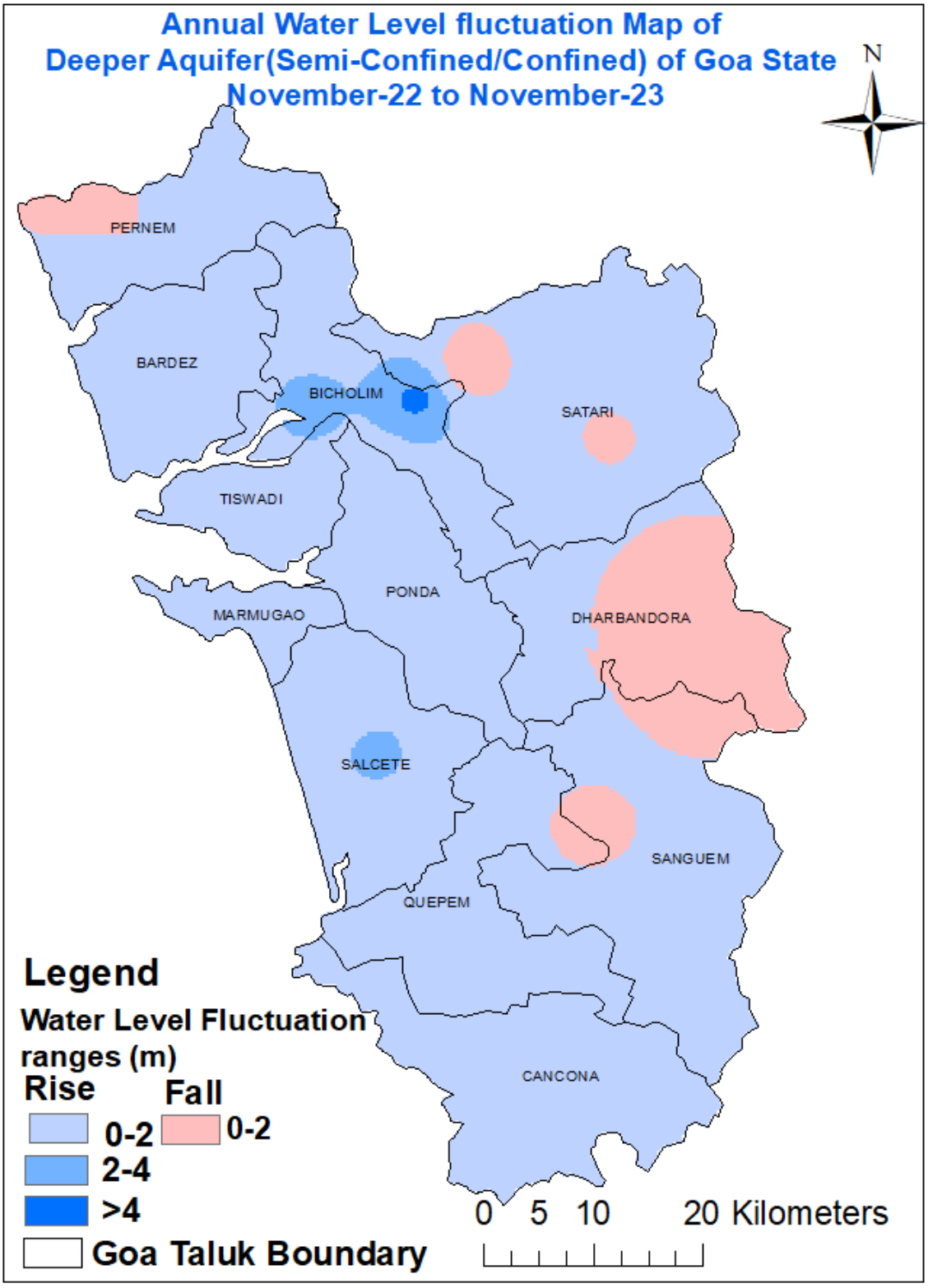
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Deeper aquifer is presented in **table 16**. **A comparison of water level shows that a rise in the water level is recorded in 84% of wells analyzed, while 16% recorded fall i.e majority of the state is showing rising water level.** The Annual fluctuation in water level of Deeper aquifer has been plotted in **Plate 17**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **73%** of wells analysed and observed in all taluks except Sanguem taluk.
- Rise in the water level in the range of 2-4 m has been observed in **8%** of wells analysed and noted in Bicholim, Canacona and Salcete taluks.
- Rise in water level more than 4 m has been observed in **3%** of wells analysed and noted in Bicholim taluk.
- The Fall in water level in the range of 0-2 m has been observed in 16**%** of wells analysed and noted in Pernem Sattari and Sanguem taluks.

TABLE 16: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF DEEPER AQUIFER (NOV 2022-NOV 2023)

S.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**	5	5	100	0	0	0	0	0	0	0	0	0	0	5	0
2	**Bicholim**	3	1	34	1	33	1	33	0	0	0	0	0	0	3	0
3	**Pernem**	6	5	84	0	0	0	0	1	16	0	0	0	0	5	1
4	**Ponda**	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
5	**Sattari**	4	2	50	0	0	0	0	2	50	0	0	0	0	2	2
6	**Tiswadi**	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
7	**Canacona**	5	4	80	1	20	0	0	0	0	0	0	0	0	5	0
8	**Quepem**	1	1	100	0	0	0	0	0	0	0	0	0	0	1	0
9	**Salcete**	7	6	86	1	14	0	0	0	0	0	0	0	0	7	0
10	**Sanguem**	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
	Total	**38**	**28**	**73**	**3**	**8**	**1**	**3**	**6**	**16**	**0**	**0**	**0**	**0**	**32**	**6**

PLATE 107: FLUCTUATION MAP OF DEEPER AQUIFER (NOV 22-NOV-23)



5.4 JANUARY 2022 TO JANUARY 2023

5.4.1 SHALLOW AQUIFER

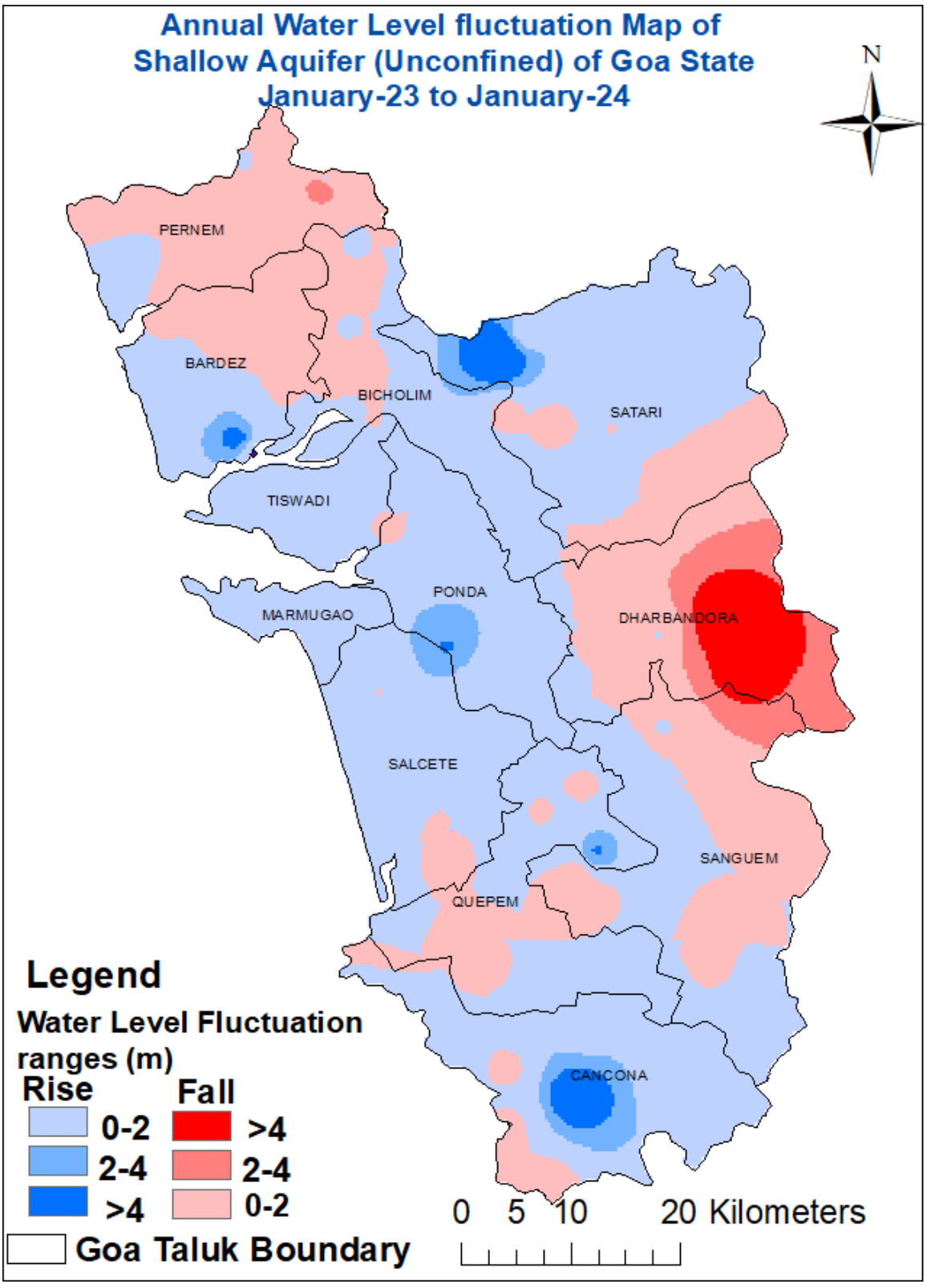
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Shallow aquifer is presented in **Table 17.A comparison of water level shows that a rise in the water level is recorded in 54% of wells analyzed, while 46% recorded fall i.e majority of the state is showing rising water level.** The Annual fluctuation in water level of Shallow aquifer has been plotted in **Plate 18**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **47%** of wells analysed and observed in all taluks except Quepem taluk.
- Rise in the water level in the range of 2-4 m has been observed in **1%** of wells analysed in Bardez taluk.
- Rise in water level more than 4 m has been observed in **6%** of wells analysed and noted in Bardez, Ponda, Satari and Canacona taluks.
- The Fall in water level in the range of 0-2 m has been observed in 41**%** of wells analysed and noted in all taluks except Bicholim, Ponda and Tiswadi taluks.
- The Fall in the water level in the range of 2-4 m has been observed in **1%** of wells analysed and noted in Satari taluk.
- The fall in water level more than 4 m has been observed in **4%** of wells analysed and noted in Satari and Sanguem taluks.

TABLE 17: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF SHALLOW AQUIFER (JAN 2023-JAN 2024)

S.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	34	1	8	1	8	6	50	0	0	0	0	6	6
2	**Bicholim**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
3	**Pernem**	6	3	50	0	0	0	0	3	50	0	0	0	0	3	3
4	**Ponda**	4	3	75	0	0	1	25	0	0	0	0	0	0	4	0
5	**Satari**	9	4	45	0	0	1	11	2	22	1	11	1	11	5	4
6	**Tiswadi**	3	3	100	0	0	0	0	0	0	0	0	0	0	3	0
7	**Canacona**	7	2	25	0	0	1	25	4	50	0	0	0	0	3	4
8	**Quepem**	2	0	0	0	0	0	0	2	100	0	0	0	0	0	2
9	**Salcete**	6	2	33	0	0	0	0	4	67	0	0	0	0	2	4
10	**Sanguem**	14	7	50	0	0	0	0	5	36	0	0	2	14	7	7
	Total	**65**	**30**	**47**	**1**	**1**	**4**	**6**	**26**	**41**	**1**	**1**	**3**	**4**	**35**	**30**

PLATE 118: WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (JANUARY-2023 - JANUARY 2024)



5.4.2 DEEPER AQUIFER

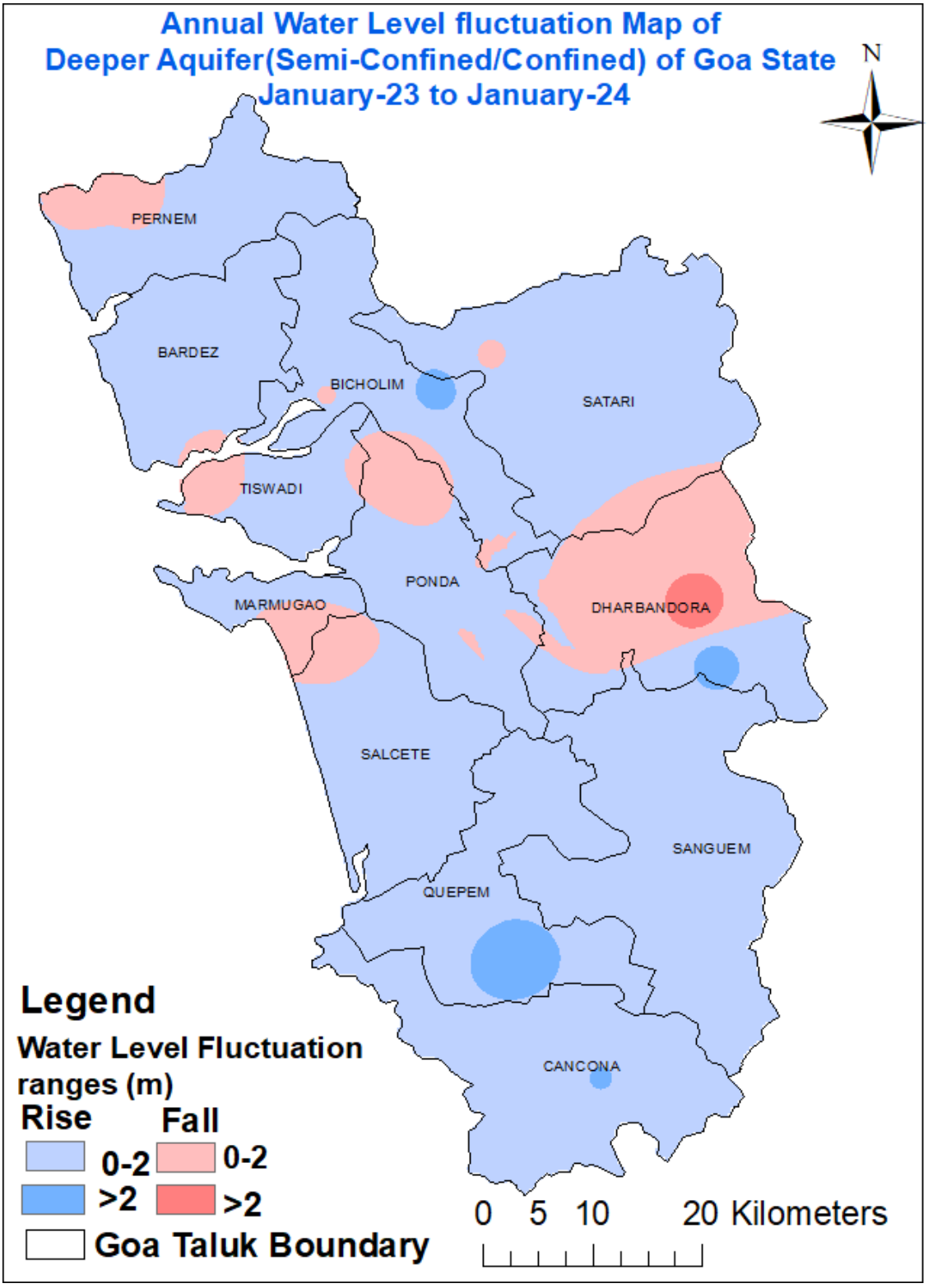
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of annual fluctuation in Deeper aquifer is presented in **table 18**. **A comparison of water level shows that a rise in the water level is recorded in 82% of wells analyzed, while 18% recorded fall i.e majority of the state is showing rising water level.** The Annual fluctuation in water level of Deeper aquifer has been plotted in **Plate 19**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- 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 Quepem taluk.
- Rise in the water level in the range of 2-4 m has been observed in **10%** of wells analysed and noted in Bicholim, Canacona, Quepem and Sanguem taluks.
- Fall in the water level in the range of 0-2 m has been observed in **16%** of wells analysed and observed in all taluks except Bardez, Canacona,Quepem, sanfeum taluk.
- Fall in the water level in the range of 2-4 m has been observed in **2%** of wells analysed and observed in Satari taluk..

TABLE 18: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF DEEPER AQUIFER (JANUARY 2023 - JANUARY 2024)

S.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	5	5	100	0	0	0	0	0	0	0	0	0	0	5	0
2	Bicholim	4	2	50	1	25	0	0	1	25	0	0	0	0	3	1
3	Pernem	6	5	84	0	0	0	0	1	16	0	0	0	0	5	1
4	Ponda	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
5	Satari	3	1	33	0	0	0	0	1	33	1	34	0	0	1	2
6	Tiswadi	3	2	67	0	0	0	0	1	33	0	0	0	0	2	1
7	Canacona	5	4	80	1	20	0	0	0	0	0	0	0	0	5	0
8	Quepem	1	0	0	1	100	0	0	0	0	0	0	0	0	1	0
9	Salcete	7	6	86	0	0	0	0	1	14	0	0	0	0	6	1
10	Sanguem	3	2	67	1	33	0	0	0	0	0	0	0	0	3	0
	Total	**39**	**28**	**72**	**4**	**10**	**0**	**0**	**6**	**16**	**1**	**2**	**0**	**0**	**32**	**7**

PLATE 129: WATER LEVEL FLUCTUATION MAP-DEEPER AQUIFER (JANUARY 2023 - JANUARY 2024)



5.5 MAY 2023 TO NOVEMBER 2023

5.1.1 SHALLOW AQUIFER

The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of seasonal fluctuation in Shallow aquifer is presented in **table 19**. **A comparison of water level shows that a rise in the water level is recorded in 92% of wells analyzed, while 8% recorded fall i.e majority of the state is showing rising water level.** The Seasonal fluctuation in water level of Shallow aquifer has been plotted in **Plate 20**. A perusal of the plate shows that a general rise in the range of

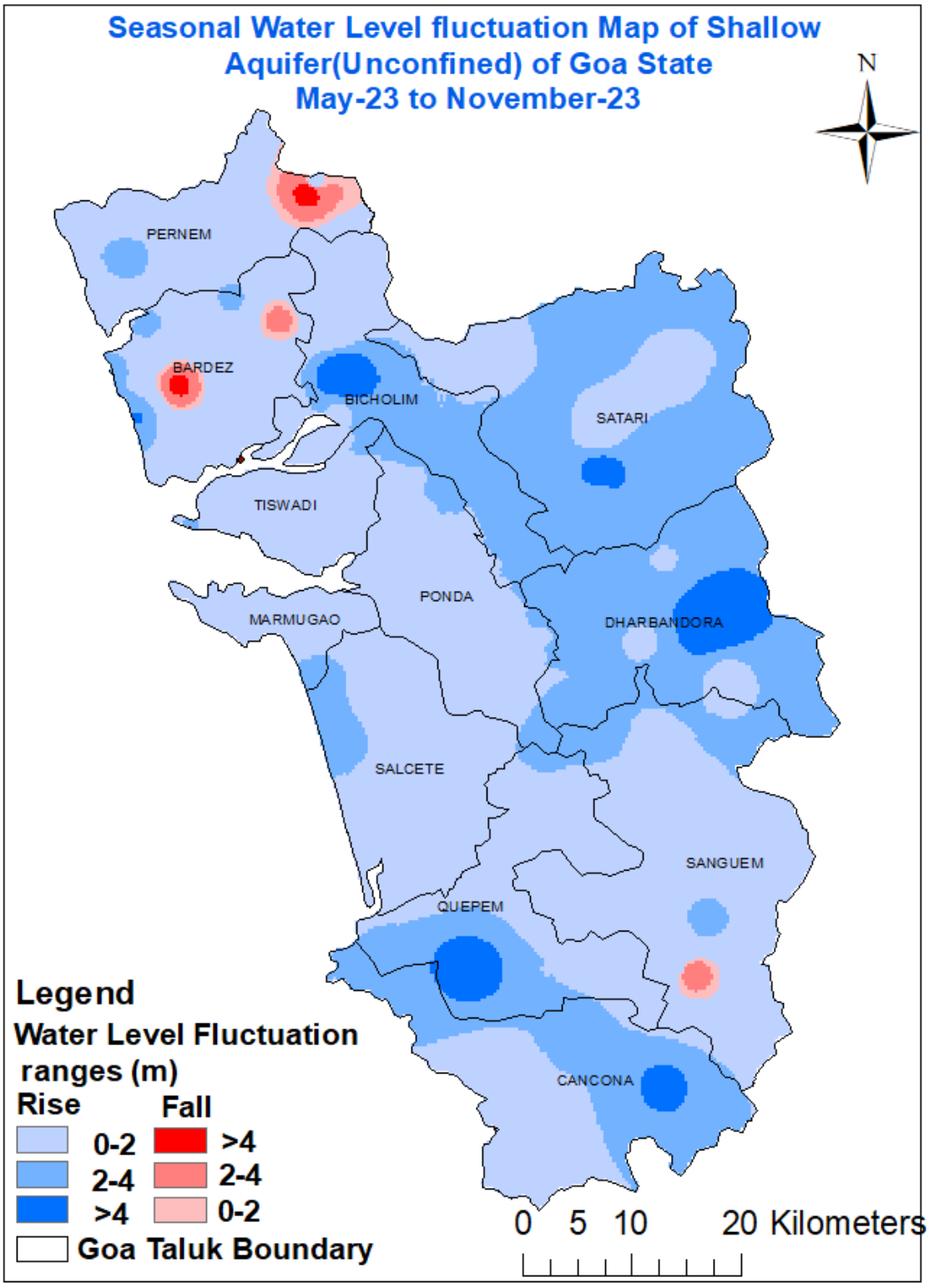
0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **39%** of wells analysed and observed in all taluks.
- Rise in the water level in the range of 2-4 m has been observed in **37%** of wells analysed in all taluks except Bicholim and Quepem taluks. .
- Rise in the water level in the range of >4 m has been observed in **16%** of wells analysed and observed in all taluks except Bicholim, Ponda, Tiswadi and Quepem taluks.
- The fall in water level in the range of 0-2 m has been observed in **2%** of wells analysed and noted in Pernem taluk.
- The fall in the water level in the range of 2-4 m has been observed in **4%** of wells analysed in all taluks except Salcete and Sanguem taluks. .
- The fall in the water level in the range of >4 m has been observed in **2%** of wells analysed and observed in Bardez taluk.

TABLE 19: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF SHALLOW AQUIFER (MAY 2023-NOV 2023)

S.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	4	36	5	46	1	9	0	0	0	0	1	9	10	1
2	**Bicholim**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
3	**Pernem**	6	2	33	2	33	1	17	1	17	0	0	0	0	5	1
4	**Ponda**	4	1	25	3	75	0	0	0	0	0	0	0	0	4	0
5	**Satari**	8	2	25	2	25	4	50	0	0	0	0	0	0	8	0
6	**Tiswadi**	2	1	50	1	50	0	0	0	0	0	0	0	0	2	0
7	**Canacona**	8	3	38	3	38	2	24	0	0	0	0	0	0	8	0
8	**Quepem**	2	2	100	0	0	0	0	0	0	0	0	0	0	2	0
9	**Salcete**	5	1	20	2	40	1	20	0	0	1	20	0	0	4	1
10	**Sanguem**	13	6	46	5	38	1	8	0	0	1	8	0	0	12	1
	Total	**61**	**24**	**39**	**23**	**37**	**10**	**16**	**1**	**2**	**2**	**4**	**1**	**2**	**57**	**4**

PLATE 20: WATER LEVEL FLUCTUATION MAP- SHALLOW AQUIFER (MAY 2023- NOV 2023)



5.1.2 DEEPER AQUIFER

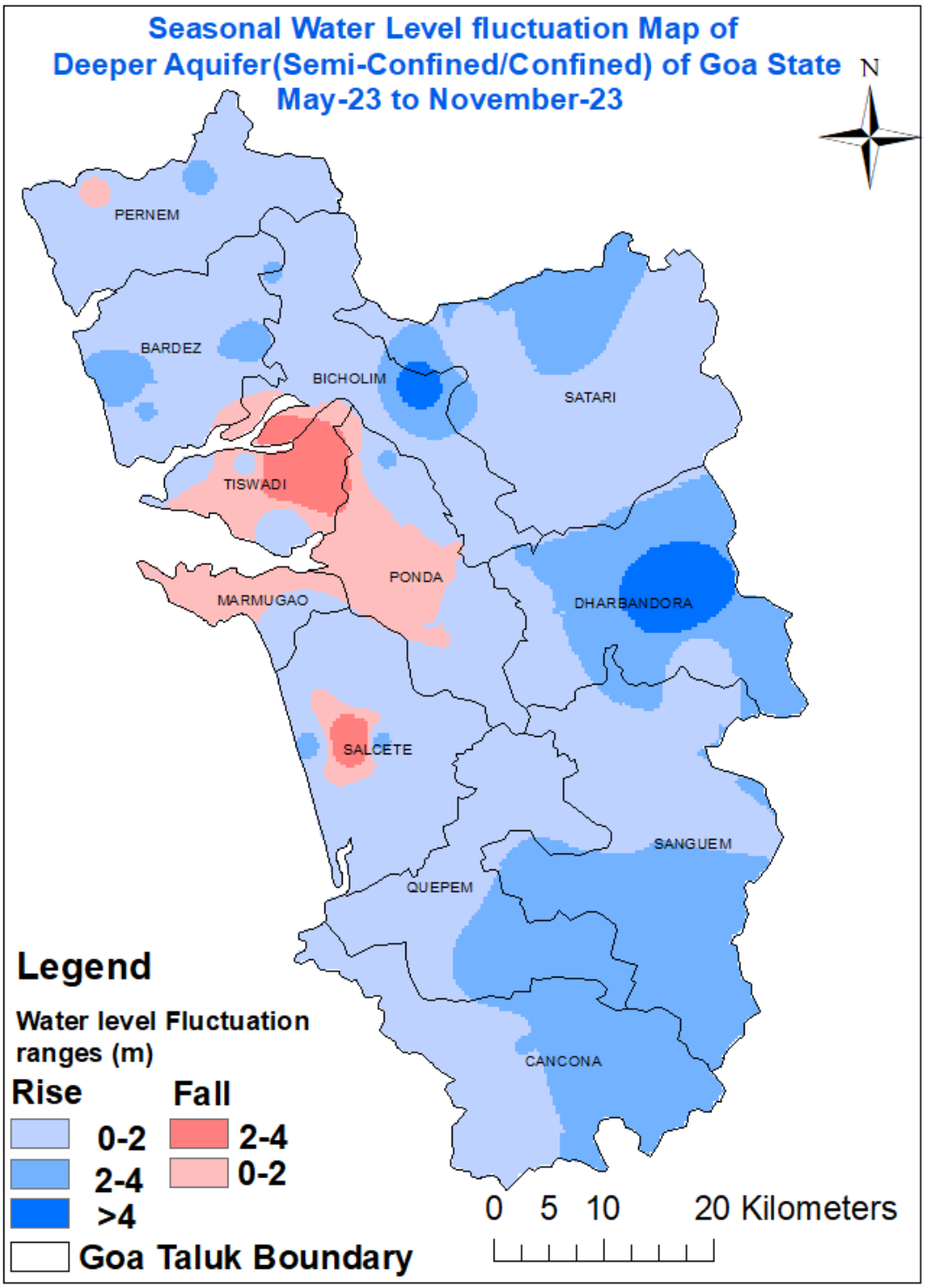
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of seasonal fluctuation in Deeper aquifer is presented in **Table 20**. **A comparison of water level shows that a rise in the water level is recorded in 94% of wells analyzed, while 6% recorded fall i.e majority of the state is showing rising water level.** The Seasonal fluctuation in water level of Deeper aquifer has been plotted in **Plate 21**. A perusal of the plate shows that a general rise in the range of 0 – 2 m is noticed in major part of the area, and further breakup given below.

- Rise in the water level in the range of 0-2 m has been observed in **53%** of wells analysed and observed in all taluks except Ponda and Quepem taluks.
- Rise in the water level in the range of 2-4 m has been observed in **32%** of wells analysed and observed in all taluks except Tiswadi and Bicholim taluks. .
- Rise in the water level in the range of >4 m has been observed in **9%** of wells analysed and observed in Bicholim, Canacona and Sanguem taluks.
- The Fall in the water level in the range of 0-2 m has been observed in **2%** of wells analysed and observed in Pernem taluk.
- The Fall in the water level in the range of 2-4 m has been observed in **0%** of wells analysed.
- The Fall in the water level in the range of >4 m has been observed in **4%** of wells analysed and observed in Tiswadi and Salcete taluks.

TABLE 20: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES OF DEEPER AQUIFER (MAY 2023-NOV 2023)

S.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**	6	2	33	4	67	0	0	0	0	0	0	0	0	6	0
2	**Bicholim**	4	3	75	0	0	1	25	0	0	0	0	0	0	4	0
3	**Pernem**	7	5	72	1	14	0	0	1	14	0	0	0	0	6	1
4	**Ponda**	1	0	0	1	100	0	0	0	0	0	0	0	0	1	0
5	**Sattari**	4	3	75	1	25	0	0	0	0	0	0	0	0	4	0
6	**Tiswadi**	4	3	75	0	0	0	0	0	0	0	0	1	25	3	1
7	**Canacona**	5	1	20	3	60	1	20	0	0	0	0	0	0	5	0
8	**Quepem**	1	0	0	1	100	0	0	0	0	0	0	0	0	1	0
9	**Salcete**	8	5	63	2	25	0	0	0	0	0	0	1	12	7	1
10	**Sanguem**	4	2	50	1	25	1	25	0	0	0	0	0	0	4	0
	Total	**44**	**24**	**53**	**14**	**32**	**3**	**9**	**1**	**2**	**0**	**0**	**2**	**4**	**41**	**3**

PLATE 131: WATER LEVEL FLUCTUATION MAP-DEEPER AQUIFER (MAY 2023-NOV-2023)



6. FLUCTUATION BETWEEN DECADAL MEAN WATER LEVEL & 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.

6.1 DECADAL WATER LEVEL FLUCTUATION FOR THE PERIOD MAY 2013-2022 & MAY 2023

SHALLOW AQUIFER

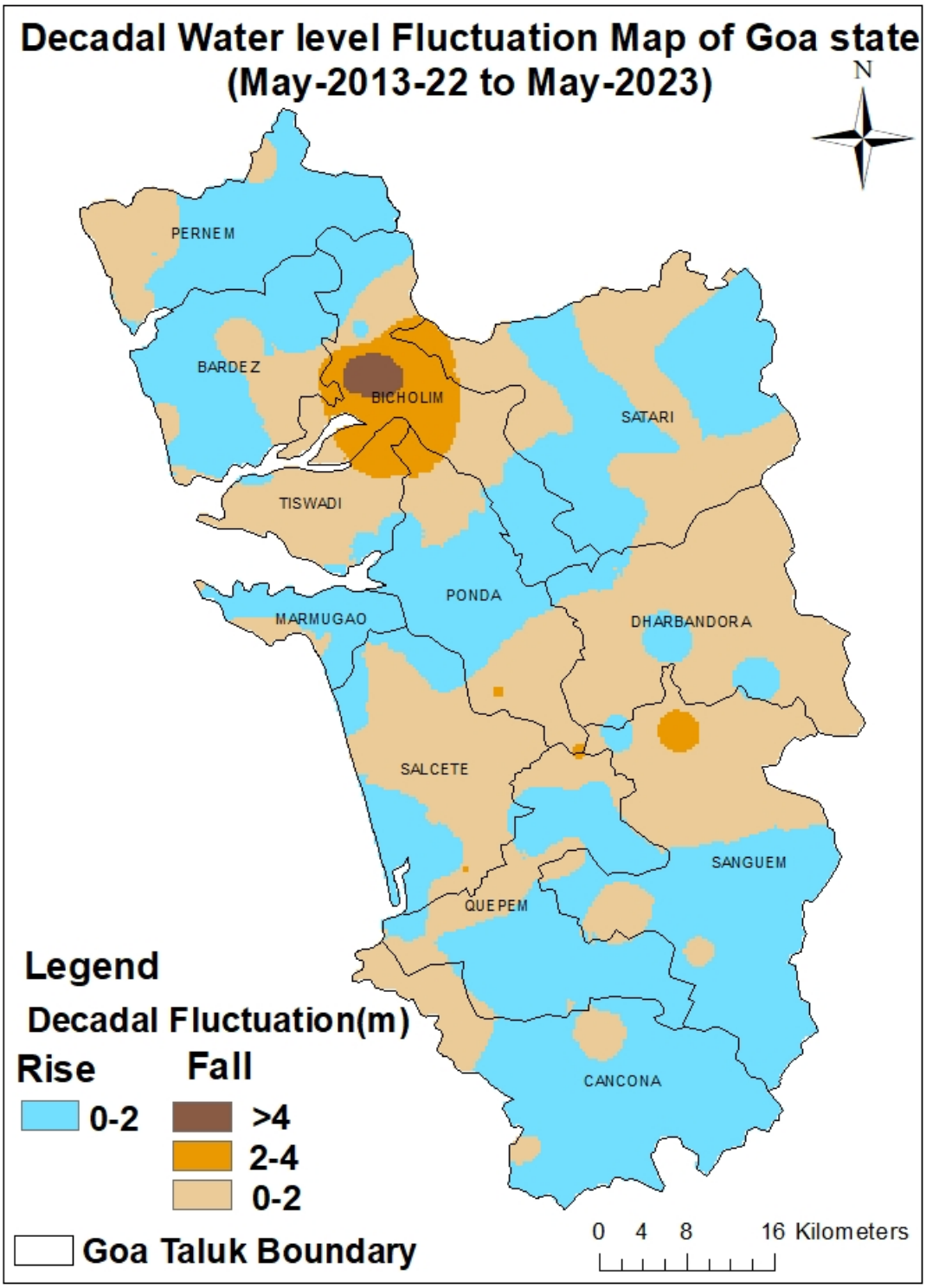
The statement showing the distribution of ground water monitoring wells falling in different ranges of fluctuation is presented in **Table 21**. The fluctuation in water level has been plotted in **Plate 22. A comparison of water level shows that a fall in the water level is recorded in 71% of wells analysed, while 29% recorded rise i.e majority of the state is showing falling water level.** Salient features of the comparison of water levels are given below.

- Rise in the water level in the range of 0-2 m has been observed in **29%** of wells analysed, noted in parts of all taluks except Bicholim and Tiswadi taluk.
- The fall in water level in the range of 0-2 m has been observed in **62%** of wells analysed and noted in parts of all taluks.
- The fall in water level in the range of 2-4 m is observed in **6%** of wells analysed and noted in parts of Tiswadi, Bicholim, Ponda and Sanguem taluk.
- The fall in water level in the range of more than 4 m is observed in **3%** of wells analysed and noted in parts of Bicholim and Pernem taluk.

TABLE 21 TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES FROM DECADAL MEAN MAY (2013-2022) TO MAY 2023 OF SHALLOW AQUIFER

S.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	2	17	0	0	0	0	10	83	0	0	0	0	2	10
2	Bicholim	3	0	0	0	0	0	0	1	33.33	1	33.33	1	33.33	0	3
3	Pernem	6	4	66	0	0	0	0	2	34	0	0	1	17	4	2
4	Ponda	4	1	25	0	0	0	0	2	50	1	25	0	0	1	3
5	Sattari	9	1	11	0	0	0	0	8	89	0	0	0	0	1	8
6	Tiswadi	3	0	0	0	0	0	0	2	67	1	33	0	0	0	3
7	Canacona	8	6	67	0	0	0	0	2	33	0	0	0	0	6	2
8	Quepem	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
9	Salcete	5	1	20	0	0	0	0	4	80	0	0	0	0	1	4
10	Sangeum	12	3	23	0	0	0	0	8	69	1	8	0	0	3	10
	Total	**65**	**19**	**29**	**0**	**0**	**0**	**0**	**40**	**62**	**4**	**6**	**2**	**3**	**19**	**46**

PLATE 142: DECADAL WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (MAY 2013- 2022 TO MAY 2023)



6.2 DECADAL WATER LEVEL FLUCTUATION FOR THE PERIOD AUGUST (2013-2022) TO AUGUST 2023

SHALLOW AQUIFER

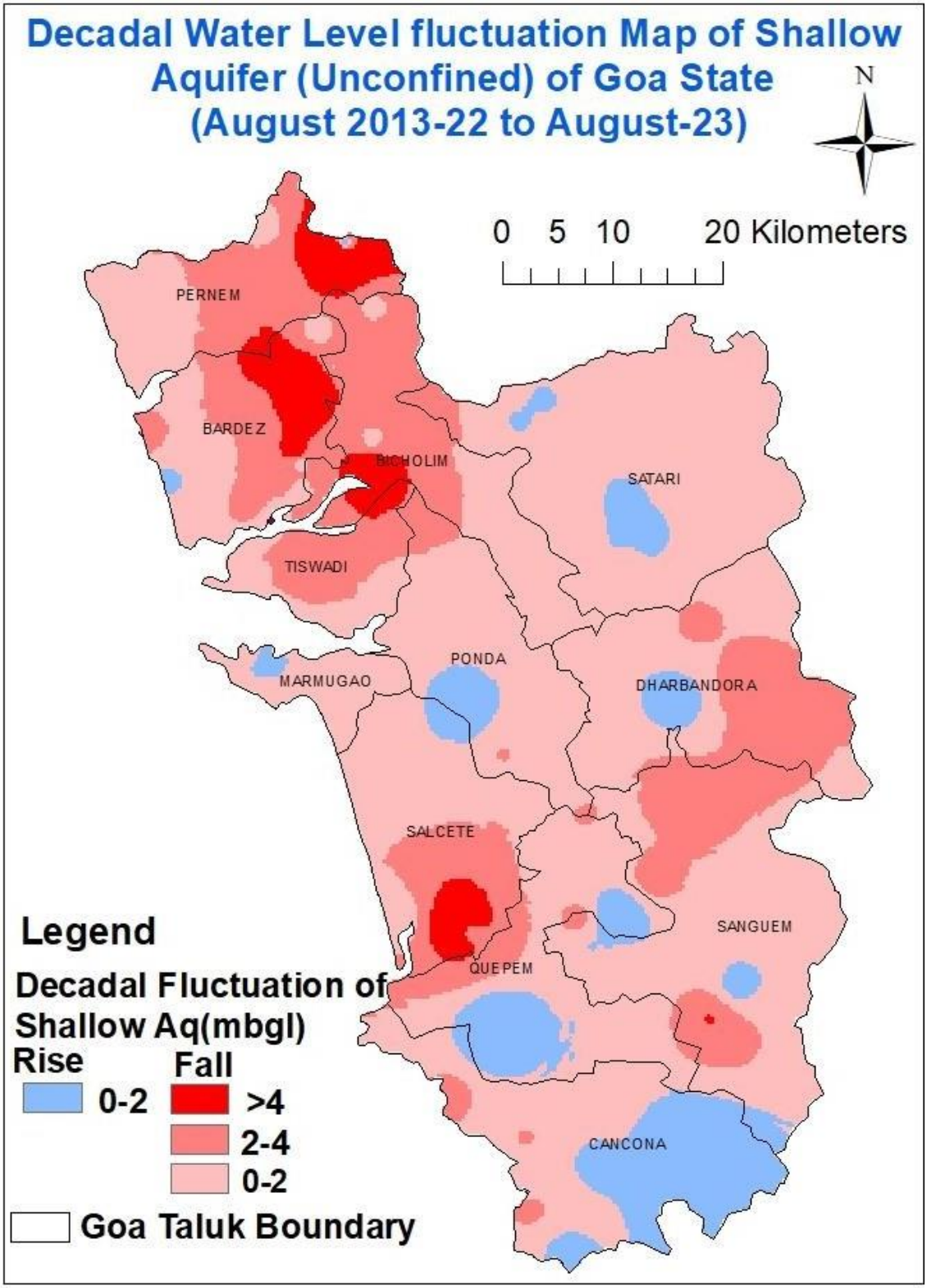
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of decadal fluctuation in Shallow aquifer is presented in **Table 22**. The Decadal fluctuation of water level of Shallow aquifer has been plotted in **Plate 23**. **A comparison of water level shows that a fall in the water level is recorded in 89% of wells analysed, while 11% recorded rise. i.e majority of the state is showing falling water level.** Salient features of the comparison of water levels are given below.

- The Fall in water level in the range of 0-2 m has been observed in **57%** of wells analysed and noted in all taluks.
- The Fall in water level in the range of 2-4 m has been observed in **21%** of wells analysed and noted in all taluks except Marmugao and Quepem taluks.
- The Fall in water level of more than 4 m is observed in **11%** of wells analysed and noted in Bardez, Bicholim, Pernem, Ponda and Salcete taluks.
- Rise in the water level in the range of 0-2 m has been observed in **11%** of wells analysed, noted in Bardez, Sattari, Canacona, Quepem, Salcete and Sanguem taluks.

TABLE 22: TALUK WISE – WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES FROM DECADAL MEAN AUG (2013-2022) TO AUG 2023 OF SHALLOW AQUIFER

S.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	1	8	0	0	0	0	4	34	4	34	3	24	1	11
2	Bicholim	3	0	0	0	0	0	0	1	33	1	33	1	34	0	3
3	Pernem	6	0	0	0	0	0	0	2	34	2	33	2	33	0	6
4	Marmugoa	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
5	Ponda	4	0	0	0	0	0	0	2	50	1	25	1	25	0	4
6	Sattari	9	1	11	0	0	0	0	7	78	1	11	0	0	1	8
7	Tiswadi	4	0	0	0	0	0	0	2	50	2	50	0	0	0	4
8	Canacona	9	2	22	0	0	0	0	6	67	1	11	0	0	2	7
9	Quepem	2	1	50	0	0	0	0	1	50	0	0	0	0	1	1
10	Salcete	5	1	20	0	0	0	0	2	40	1	20	1	20	1	4
11	Sanguem	14	2	14	0	0	0	0	10	72	2	14	0	0	2	12
	Total	**69**	**8**	**11**	**0**	**0**	**0**	**0**	**38**	**57**	**15**	**21**	**8**	**11**	**8**	**61**

PLATE 23: DECADAL WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (AUGUST 2013- 2022 TO AUGUST 2023)



6.3 DECADAL MEAN WATER LEVELS FOR THE PERIOD NOVEMBER 2013-2022 TO NOVEMBER 2023

SHALLOW AQUIFER

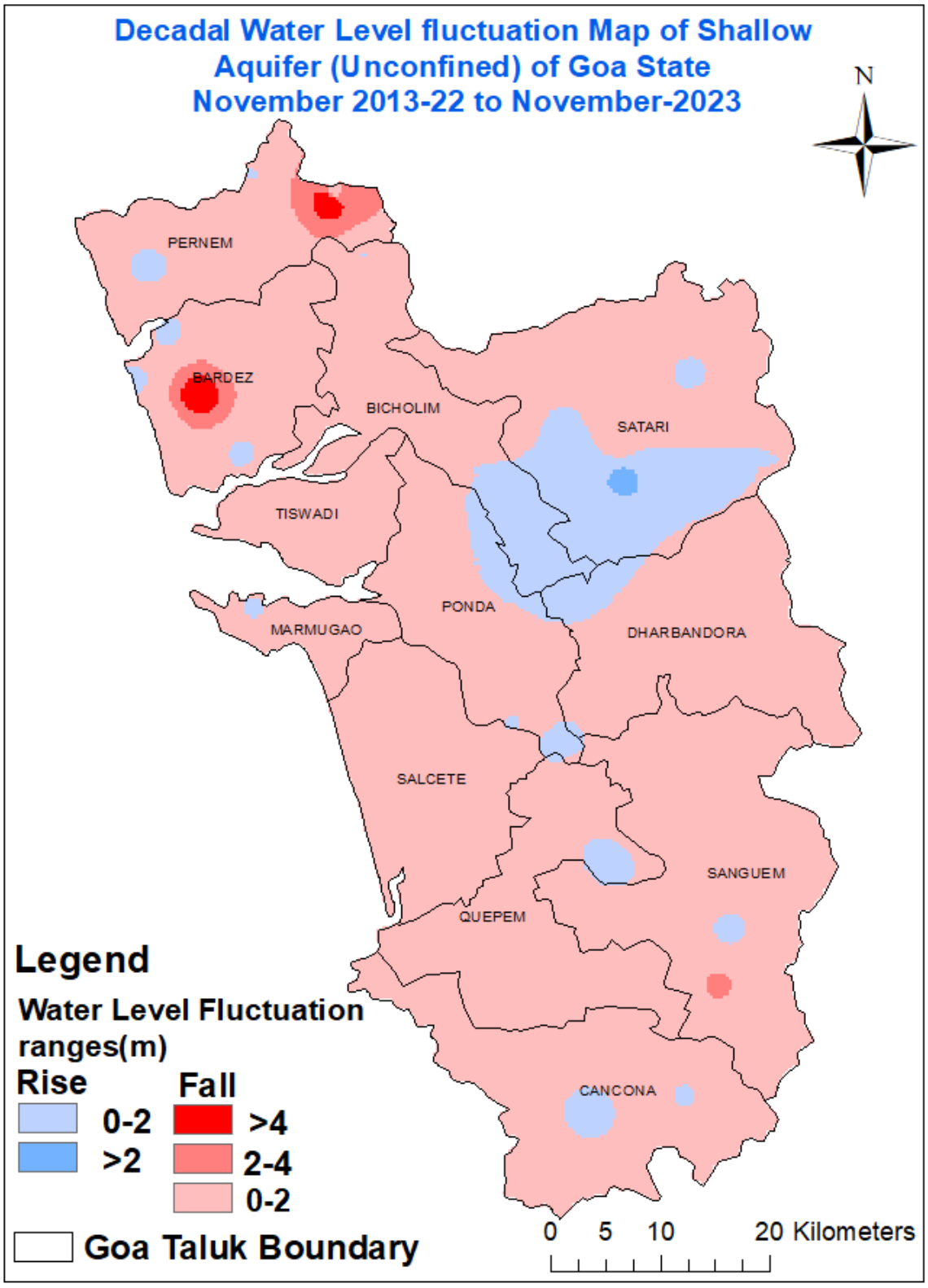
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of decadal fluctuation in Shallow aquifer is presented in **Table 23**. The Decadal fluctuation of water level of Shallow aquifer has been plotted in **Plate 24**. **A comparison of water level shows that a fall in the water level is recorded in 77% of wells analysed, while 23% recorded rise i.e majority of the state is showing falling water level.** Salient features of the comparison of water levels are given below.

- Rise in the water level in the range of 0-2 m has been observed in **22%** of wells analysed, noted in all taluks except Quepem and Marmugoa taluks.
- Rise in water level in the range of 2-4 m has been observed in **1%** of wells analysed and noted in Satari taluk.
- The Fall in water level in the range of 0-2 m has been observed in **73%** of wells analysed and noted in all taluks.
- The Fall in water level in the range of 2-4 m has been observed in **2%** of wells analysed and noted in Bardez and Sanguem taluks.
- The Fall in water level of more than 4 m is observed in 2% of wells analysed and noted in Bardez and Pernem taluks.

TABLE 23: TALUK WISE – DECADAL WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES FROM MEAN NOV (2013-2022) TO NOV 2023 OF SHALLOW AQUIFER

S.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	3	25	0	0	0	0	7	59	1	8	1	8	3	9
2	**Bicholim**	7	2	28	0	0	0	0	5	72	0	0	0	0	2	5
3	**Pernem**	9	2	22	0	0	0	0	6	67	0	0	1	11	2	7
4	**Ponda**	5	2	40	0	0	0	0	3	60	0	0	0	0	2	3
5	**Satari**	9	3	33	1	11	0	0	5	56	0	0	0	0	4	5
6	**Tiswadi**	4	1	25	0	0	0	0	3	75	0	0	0	0	1	3
7	**Canacona**	9	2	22	0	0	0	0	7	78	0	0	0	0	2	7
8	**Quepem**	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
9	**Salcete**	8	1	13	0	0	0	0	7	87	0	0	0	0	1	7
10	**Sanguem**	14	2	14	0	0	0	0	11	79	1	7	0	0	2	12
11	**Marmugoa**	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
	Total	**81**	**18**	**22**	**1**	**1**	**0**	**0**	**58**	**73**	**2**	**2**	**2**	**2**	**19**	**62**

PLATE 24: DECADAL WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (NOV 2013- 2022 TO NOV 2023)



6.4 DECADAL MEAN WATER LEVELS FOR THE PERIOD JANUARY (2014-2023) & JANUARY 2024:

SHALLOW AQUIFER

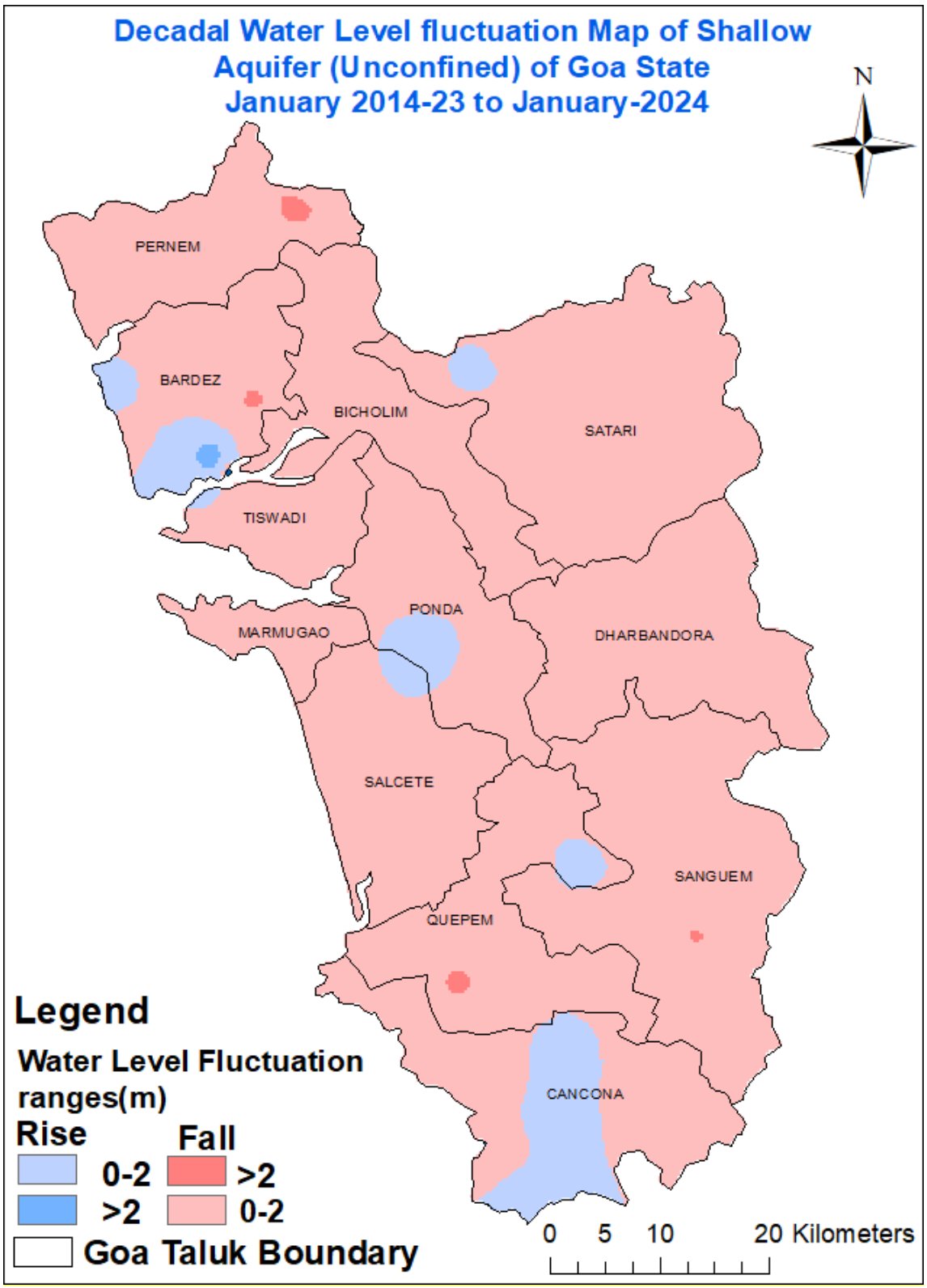
The statement showing the distribution of ground water monitoring wells which is rising and falling in different ranges of decadal fluctuation in Shallow aquifer is presented in **Annexure-V.** The Decadal fluctuation of water level of Shallow aquifer has been plotted in **Plate 25**. **A comparison of water level shows that a rise in the water level is recorded in 8% of wells analysed, while 92% recorded fall i.e majority of the state is showing falling water level.** 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 **7%** of wells analysed, noted in Bardez, Ponda, Satari and Canacona taluks.
2. Rise in water level in the range of 2-4 m has been observed in **1%** of wells analysed and noted in Bardez and Sanguem taluks.
3. The Fall in water level in the range of 0-2 m has been observed in **86%** of wells analysed and noted in all taluks.
4. 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, Pernem, Salcete and Sanguem taluks.

TABLE 24: TALUK WISE – DECADAL WATER LEVEL FLUCTUATION AND FREQUENCY DISTRIBUTION FOR DIFFERENT RANGES FROM MEAN JAN (2013-2022) TO JAN 2023 OF SHALLOW AQUIFER

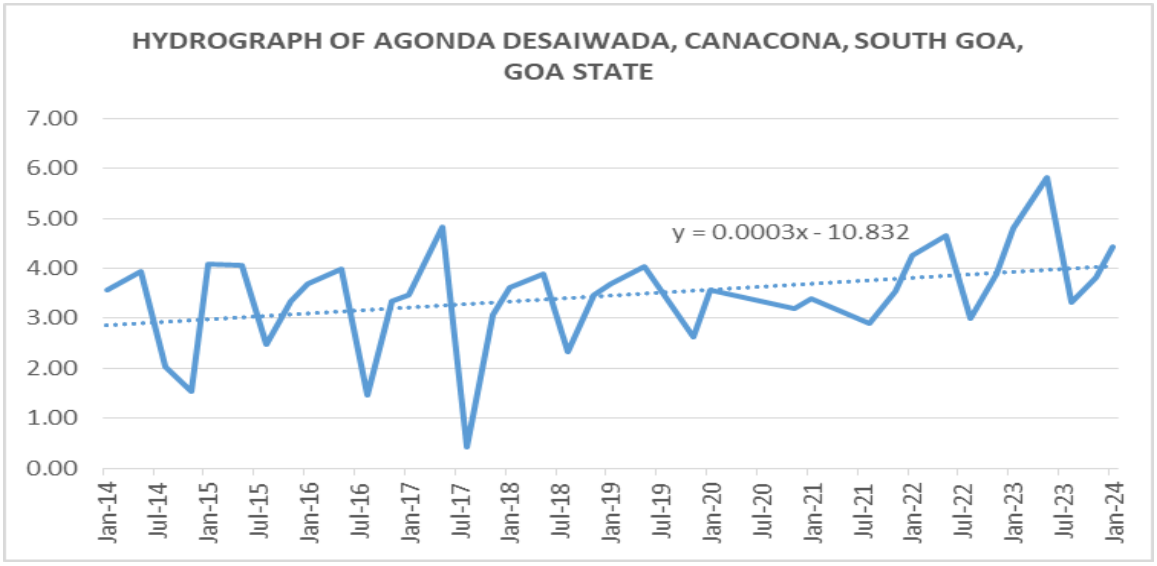
S.No	Taluk Name	No. of Wells analysed	Rise_Range of Fluctuation (m)						Fall_Range of Fluctuation (m)						Rise	Fall
			0-2		2-4		>4		0-2		2-4		>4			
			No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%	No of wells	%		
1	**Bardez**	11	1	9	1	9	0	0	8	73	1	9	0	0	2	9
2	**Bicholim**	7	0	0	0	0	0	0	6	86	1	14	0	0	0	7
3	**Pernem**	9	0	0	0	0	0	0	8	89	1	11	0	0	0	9
4	**Ponda**	5	1	20	0	0	0	0	4	80	0	0	0	0	1	4
5	**Satari**	9	1	11	0	0	0	0	8	89	0	0	0	0	1	8
6	**Tiswadi**	4	0	0	0	0	0	0	4	100	0	0	0	0	0	4
7	**Canacona**	9	3	33	0	0	0	0	6	67	0	0	0	0	3	6
8	**Quepem**	3	0	0	0	0	0	0	3	100	0	0	0	0	0	3
9	**Salcete**	6	0	0	0	0	0	0	5	84	1	16	0	0	0	6
10	**Sanguem**	14	0	0	1	7	0	0	12	86	1	7	0	0	1	13
11	**Marmugoa**	1	0	0	0	0	0	0	1	100	0	0	0	0	0	1
	Total	**67**	**5**	**7**	**1**	**1**	**0**	**0**	**57**	**86**	**4**	**6**	**0**	**0**	**6**	**61**

PLATE 25: DECADAL WATER LEVEL FLUCTUATION MAP-SHALLOW AQUIFER (JANUARY 2014- 2023 TO JANUARY 2024)

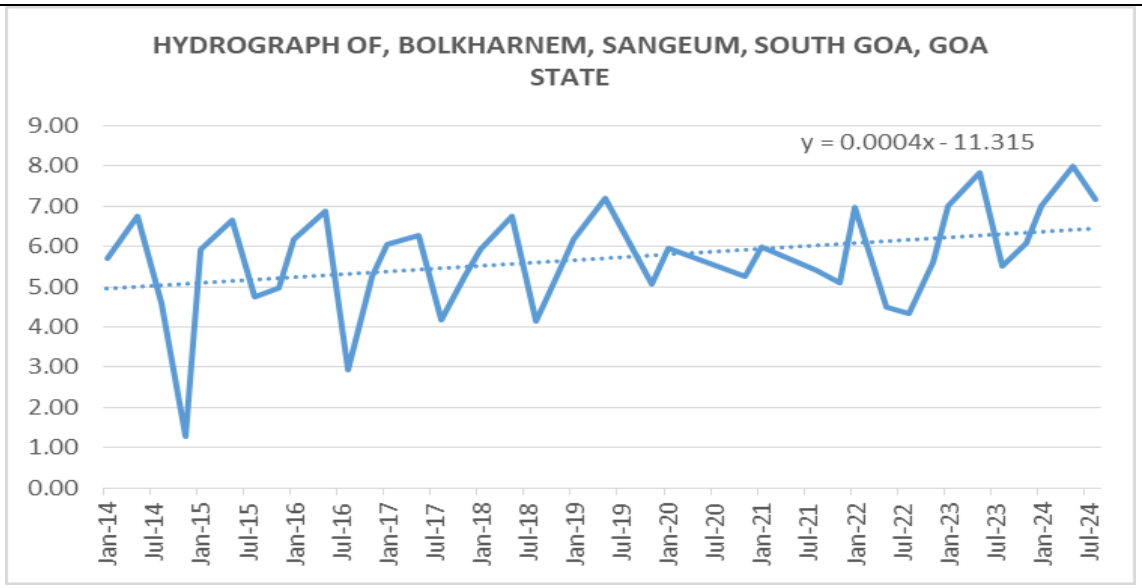


7. HYDROGRAPHS

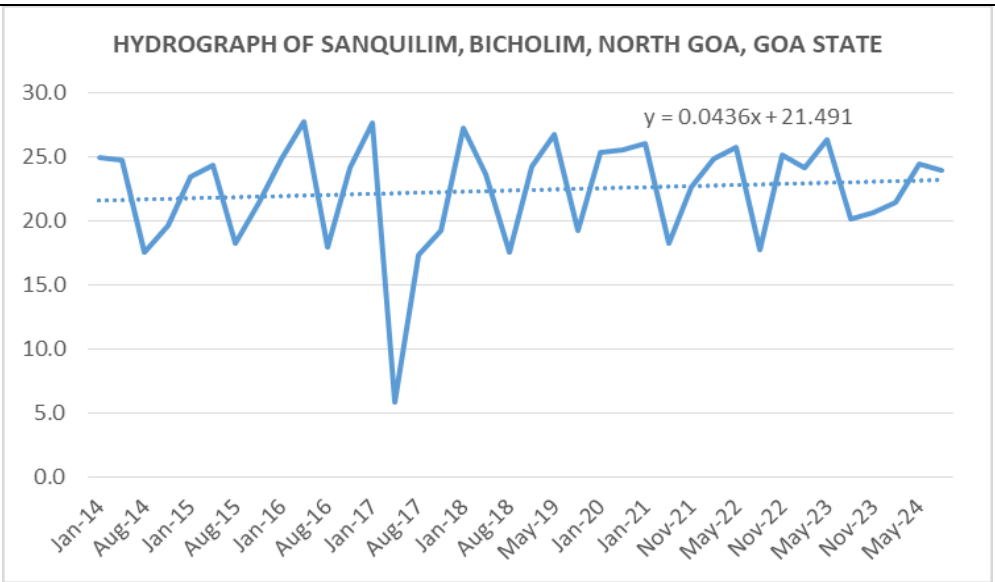
Hydrographs are the representation of water level behavior and fluctuations. Here are some of the representatives of rising and falling trend of Dug wells and Piezometers.



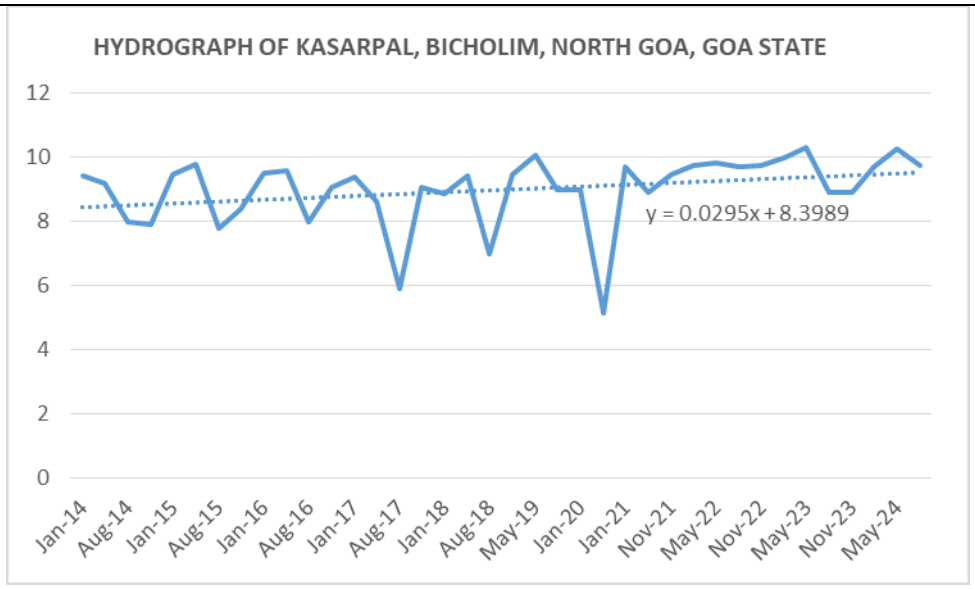
- Hydrograph of Agonda Desaiwada, Canacona taluk, South Goa District dug well shows water level fluctuation from 2014 to 2024 with falling trend value of 0.0003m/y.



- Hydrograph of Bolkharnem, Sanguem taluk, South Goa District dug well shows water level fluctuation from 2014 to 2024 with falling trend value of 0.0004m/y.



- Hydrograph of Sanquilim, Bicholim taluk, North Goa District dug well shows water level fluctuation from 2014 to 2024 with rising trend value of 0.0436m/y.

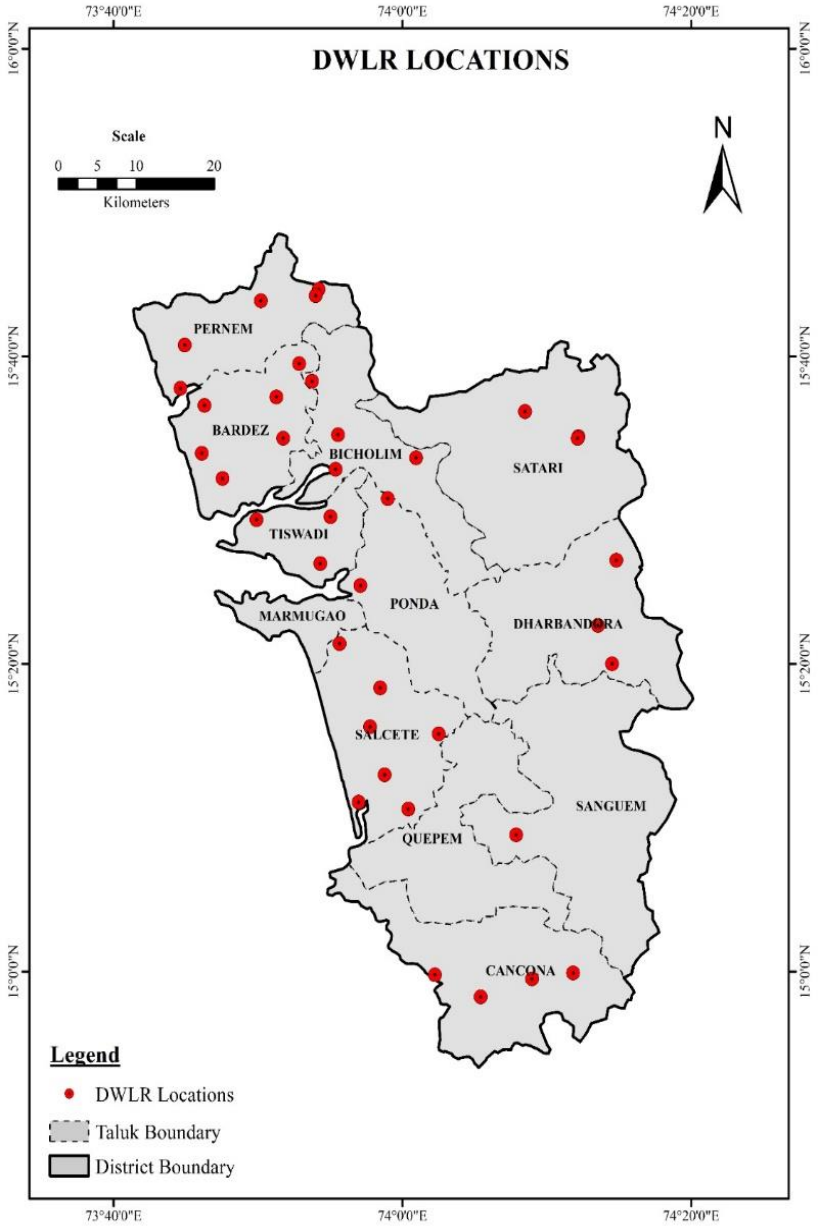


- Hydrograph of Kasarpal, Bicholim taluk, North Goa District dug well shows water level fluctuation from 2014 to 2024 with rising trend value of 0.0295m/y.

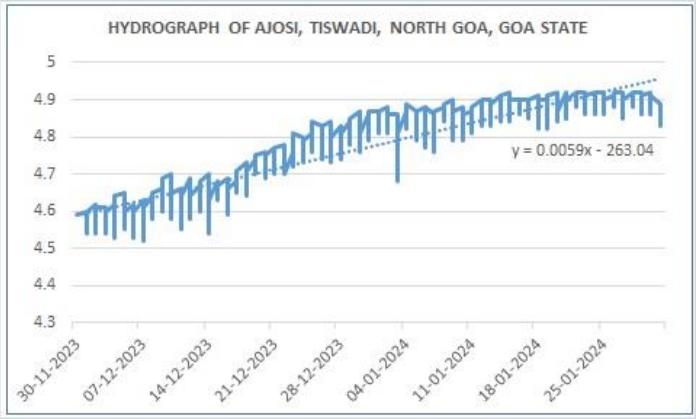
8.0 DWLR STATUS OF GOA

A real-time data acquisition system provides an effective means of monitoring changes in the groundwater regime. DWLR allows for the collection of high-frequency water level data trends. In phase II, 39 nos of DWLR have been **installed** in Goa state, all 39 nos of DWLR are **commissioned**. The location map of DWLR locations in Goa state are in plate no.26.

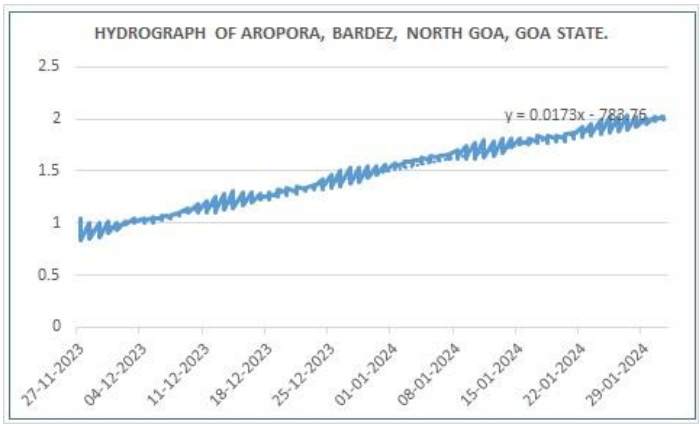
PLATE 26: LOCATION MAP OF DWLR LOCATIONS IN GOA STATE



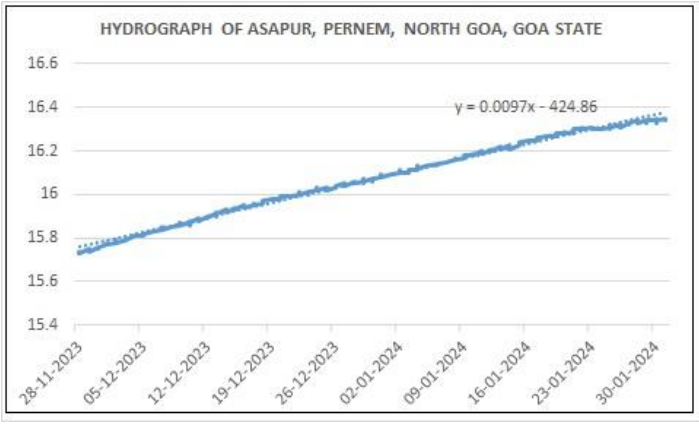
8.1. DWLR HYDROGRAPHS



Hydrograph of Ajoshi, Tiswadi taluk, North Goa District DWLR shows water level fluctuation November 2023 to January 2024 with falling trend value of 0.0059m/y.



Hydrograph of Aropora, Bardez taluk, North Goa District DWLR shows water level fluctuation November 2023 to January 2024 with falling trend value of 0.0173m/y.



Hydrograph of Asapur, Pernem taluk, North Goa District DWLR shows water level fluctuation November 2023 to January 2024 with falling trend value of 0.00973m/y.

9. CONCLUSIONS

The behaviour of ground water table during **May 2023 to January 2024** in Goa State has been studied by monitoring the dug wells tapping phreatic aquifers and piezometers tapping deeper aquifers. The data on water levels was analysed in detail and salient features are as under.

- In shallow aquifers, 83% of wells have recorded depth to water level within 10 m bgl during pre-monsoon period (May 2023), whereas during post-monsoon period (November 2023) about 92% of wells recorded water level less than 10 m bgl. 89% of wells have recorded depth to water level within 10m bgl during January 2024 and 94% during August 2023.
- In deeper aquifers 63 % of wells have recorded depth to water level of **Piezometric Surface** is within 10 m bgl during pre-monsoon period (May 2023) as well as post-monsoon (November 2023). 73% of wells have recorded depth to water level of **Piezometric Surface** is within 10m bgl during January 2024 and August 2023.
- In shallow aquifer 66 % of wells have recorded rise in water levels and 34% of wells recorded fall in water levels during May 2023 in comparison to May 2022. 12% of wells have recorded rise in water levels and 88 % of wells recorded fall in water levels during August 2023 in comparison to August 2022. 86% of wells have recorded rise in water levels and 14% of wells recorded fall in water levels during November 2023 in comparison to November 2022. 54% of wells have recorded rise in water levels and 46% of wells recorded fall in water levels during January 2024 in comparison to January 2023.
- In shallow aquifer 71% of wells have recorded rise in water levels and 29 % of wells have recorded fall in water level during May 2023 wrt respective decadal means. 89% of wells have recorded rise in water levels and 11 % of wells have recorded fall in water level during August 2023 wrt respective decadal means. 23% of wells have recorded rise in water levels and 77 % of wells have recorded fall in water level during November 2023 wrt respective decadal means. 8% of wells have recorded rise in water levels and 92 % of wells have recorded fall in water level during January 2024 wrt respective decadal means.
- In Deeper aquifers during post monsoon 2023, about 63% of the wells showing depth to water level within 10mbgl. Annual fluctuation during post-monsoon 2023(November 2022 to November 2023) it is observed that, 84 % of the wells in the state showing rise in water level and 16% of the wells in the state showing fall in water level. Fall in water levels may be due to localised over extraction of ground water.

10.ACKNOWLEDGEMENT

The authors express their gratitude to. Shri.N.Jyothi Kumar, Regional Director, Central Ground Water Board, South Western Region, Bangalore, for his constant encouragement throughout the task of compilation and analysis of voluminous data. They express their gratitude to him for the keen interest evinced by him in the report as also for the suggestions offered by him vis-à-vis some aspects for improving their lucidity, which have enhanced not only the form but also the contents of the final report. The authors also profusely thank the hard and arduous work put in by various field officers who diligently collected data from the field, which forms the base for this report. The authors would be failing in their duty if they do not acknowledge the unstinting cooperation offered by their various colleagues who have contributed in a major way in bringing out this report.

ANNEXURE 1: WATER LEVEL DATA OF GWMS IN GOA STATE DURING MONITORING PERIODS OF 2023-2024

Sl no	District	Well id	Taluk	Location	Well Type	May_2023	Aug_2023	Nov_2023	Jan-24
1	North Goa	GAJY1307	Bicholim	Adavapal	Dugwell	6.32	5.75	6.5	6.35
2	South Goa	48I4D3	Canacona	Agonda Desaiwada	Dugwell	5.83	3.33	3.82	4.43
3	North Goa	48E2D12	Bardez	Alto Betim Porvorim	Dugwell	6.9	5.68	5.7	6.4
4	North Goa	MY1403	Pernem	Amberem	Dugwell	8.1	7.47	7.91	8.05
5	North Goa	GAJY1302	Bardez	Anjuna Beach	Dugwell	11.91	8.96	9.52	10.64
6	South Goa	MY1411	Marmugoa	Bagmola	Dugwell	4.19	3.1	2.95	3.5
7	South Goa	48E3D6	Salcete	Ballynuvhen	Dugwell	7.51	6	6.8	7.37
8	North Goa	48I2A2	Sattari	Bayalwadikeri(querim)	Dugwell	2.47	2.05	-	2.33
9	South Goa	Jy13116	Salcete	Betalbatti	Dugwell	7.18	3.25	3.6	-
10	North Goa	GAJY1303	Sattari	Bhamber(Nanoda Cross)	Dugwell	5.58	4.04	4.1	-
11	South Goa	Jy13114	Sangeum	Bhati	Dugwell	5.82	2.8	3	6.2
12	North Goa	GAJY1311	Sattari	Bhujpal	Dugwell	5.83	1.8	2.02	4.23
13	South Goa	48I3A2	Sangeum	Bolkharnem	Dugwell	7.84	5.52	6.07	7
14	North Goa		Ponda	Bori	Dugwell	-	2.2	2.8	2.4
15	North Goa	GAMY1301	Bardez	Britona	Dugwell	2.59	2.25	2.4	2.56

16	North Goa	48E2D11	Bardez	Calangute	Dugwell	8.96	4.17	4.8	6.84
17	South Goa	48I4A12	Canacona	Canacona	Dugwell	4.63	2.92	4.62	4.55
18	North Goa	GAJY1312	Sattari	Charayode	Dugwell	6.31	2	2.4	4.4
19	South Goa	Jy1306	Salcete	Chikalim	Dugwell	2.4	1	0.95	-
20	South Goa	48I3A6	Tiswadi	Collem(kolamba)	Dugwell	9.31	4.85	8.4	8.95
21	North Goa	GAMY1303	Bardez	Colval	Dugwell	14.6	11.53	11.58	13.87
22	South Goa	Jy13118	Salcete	Cuncalim	Dugwell	2.54	5.92	2.25	2.34
23	South Goa	48I4A6	Salcete	Cuncalim(pz)	Dugwell	6.87	5.92	-	-
24	South Goa	48J1A2	Canacona	Daptamol Lolien	Dugwell	15.92	15.81	12	16
25	South Goa	48I4A7	Sangeum	Deulwada Kolamba	Dugwell	4.26	2.8	3.35	3.65
26	North Goa	MY 1407	Bicholim	Devulawada Narve	Dugwell	16.38	14.9	12	15.45
27	South Goa		Dharbandara	Dharbandara DW	Dugwell	-	5.92	9.35	10.96
28	North Goa	MY1408	Bicholim	Dhatwado Vante	Dugwell	6.53	4.3	4.35	7.2
29	North Goa	GAJY1305	Tiswadi	Gavalebhat, Chimbel(kirl)	Dugwell	6.2	4.9	5.1	5.7
30	South Goa	48I4A1	Quepem	Ghadiawada	Dugwell	2.46	1.58	2.2	2.55
31	North Goa	48E3D3	Tiswadi	Goa Velha	Dugwell	12.05	0.9	1.1	1.52
32	South Goa	Jy1312	Sangeum	Guddemal	Dugwell	12.05	7.2	8.7	9.98

33	North Goa	MY1410	Pernem	Hasaravanni Vaipal	Dugwell	2.5	10	10.14	6.15
34	North Goa	MY1409	Pernem	Haspur	Dugwell	5.45	2.32	4.78	5.15
35	South Goa	48J1A1	Canacona	Hattipal Poinguinem	Dugwell	8.79	6.8	6.9	7.3
36	North Goa	48I2A4	Sattari	Honda	Dugwell	5.07	2.9	3.04	4.6
37	South Goa	Jy13120	Sangeum	Jambavli	Dugwell	10.49	7.8	9.25	10
38	North Goa		Bicholim	Jambhul Batt(mayam Lake)	Dugwell	13	1.95	2.1	3.4
39	South Goa	Jy1311	Sangeum	Kalay	Dugwell	13	10.5	11.25	11.59
40	South Goa	MY1402	Quepem	Kapsa	Dugwell	7.97	4.35	4.5	5.8
41	North Goa	48E3D2	Tiswadi	Karanjhalen	Dugwell	4.16	2.53	2.1	3
42	South Goa	Jy1305	Salcete	Kaveslium	Dugwell	4.16	2	2.43	3.16
43	North Goa	48I3A1	Sattari	Khadki(harijanwada)	Dugwell	11.39	3.34	3.5	8.5
44	North Goa	GAJY1313	Sattari	Khotodem	Dugwell	6.73	4.1	4.2	6.92
45	North Goa	48E2D3	Pernem	Korgaon	Dugwell	6.29	4.7	4.85	5.53
46	North Goa	MY1404	Ponda	Kundel Dassolwada	Dugwell	2.32	1.96	2.05	1.3
47	South Goa	48E3D5	Salcete	Majorda Bpada Curilo	Dugwell	6.1	3.07	3.5	4.49
48	South Goa	Jy1301	Sangeum	Malkarnem	Dugwell	6.52	4.6	5.5	6.12
49	North Goa	GAJY1309	Ponda	Mankem	Dugwell	5.14	3.21	3.5	4.6

50	North Goa	48E2D7	Bardez	Mapuca	Dugwell	4.72	3.68	3.68	4.75
51	South Goa	Jy1309	Salcete	Mashe	Dugwell	4.86	3.72	3.95	4.42
52	South Goa	48I3A5	Sangeum	Molem	Dugwell	15.67	3.15	7.2	11.9
53	North Goa	48E2C1	Pernem	Morji	Dugwell	2.78	1.11	1.15	1.63
54	North Goa	48I2A3	Sattari	Morlem	Dugwell	4.4	3.24	4.55	4.09
55	North Goa	48E2D6	Bicholim	Mulgaon Shivalkherwad	Dugwell	3.4	3.15	3.65	3.4
56	North Goa	GAJY1304	Sattari	Nagargoan	Dugwell	8.2	2.12	4.6	5.92
57	North Goa	48E2D2	Pernem	Nagjhar	Dugwell	8.22	8.5	8.6	8.42
58	South Goa	48I4A9	Sangeum	Netrolim	Dugwell	9.15	10.3	12.14	11.6
59	North Goa	GAMY1302	Bicholim	Olaulim	Dugwell	7.72	6.05	6.1	7.29
60	South Goa	Jy13119	Salcete	Padi	Dugwell	13.42	4.7	6.7	11
61	North Goa	48I3A8	Ponda	Panchawadi(pz)	Dugwell	7.92	5.25	5.9	7.33
62	North Goa	GAJY1301	Bardez	Parra	Dugwell	2.61	1.5	8	1.92
63	North Goa	48E2D1	Pernem	Pernem	Dugwell	3.6	4.4	4.5	4.8
64	North Goa	GAMY1304	Bardez	Pirna	Dugwell	4.34	2.24	2.7	3.75
65	South Goa	48J1A3	Canacona	Polem(polen)	Dugwell	3.94	1.8	2.1	3.75
66	North Goa	MY1405	Bardez	Pomburpa Palmar	Dugwell	3.94	3.64	3.72	3.93

67	South Goa	48I4A4	Quepem	Quepem	Dugwell	3.51	2.11	2.7	3.34
68	South Goa	Jy13121	Sangeum	Revona	Dugwell	8.52	5.7	8.65	8.05
69	North Goa	48E2D4	Bicholim	Sal	Dugwell	3.42	2.63	2.7	3.5
70	North Goa	MY1406	Bardez	Salwardhar Dumun	Dugwell	3.95	3.2	3.38	3.65
71	North Goa	GAJY1306	Pernem	Sawanthwada(mandrem)	Dugwell	4.7	1.8	2	4
72	North Goa	48I3A7	Ponda	Shiroda	Dugwell	8.28	6.43	7.25	7.83
73	North Goa	GAJY1308	Bardez	Shivoli (brahmanwada)	Dugwell	3.7	1.25	1.3	2.62
74	South Goa	48I4A10	Canacona	Shrishtal Gaondongar	Dugwell	7.58	4.43	4.77	4.92
75	North Goa	48E2D5	Bardez	Sirsaim	Dugwell	4.06	3.1	3.2	4.29
76	South Goa	Jy1307	Canacona	Sristal	Dugwell	4.52	11.3	11.08	11.7
77	South Goa	Jy1310	Sangeum	Suktali (molem)	Dugwell	6.46	4.45	4.86	5.15
78	South Goa	Jy13113	Sangeum	Themchewada	Dugwell	9.93	8.15	9.8	7.71
79	North Goa	48E1D1	Pernem	Uguem(ugawe)	Dugwell	4.52	3.36	3.4	4
80	South Goa	Jy1303	Sangeum	Vadam	Dugwell	4.7	4	4	4
81	North Goa	48I2A5	Sattari	Valpoi	Dugwell	6.07	3.3	5.75	6.15
82	South Goa	48E3D1	Tiswadi	Velha Goa	Dugwell	1.72	0.9	1.1	1.52
83	South Goa	Jy1302	Sangeum	Vichundrem	Dugwell	8.88	3	7.05	7.75

84	South Goa	Jy1304	Canacona	Yedda	Dugwell	5.62	0.5	0.2	3.85
85	North Goa	GAJY1307	Bardez	Adavapal	Borewell	6.32	4.31	6.5	6.35
86	North Goa	PzGoa1031	Tiswadi	Ajosi	Borewell	5.02	3.86	3.23	4.86
87	North Goa	PzGoa1027	Bardez	Aropora	Borewell	3.82	0.34	0.75	1.92
88	North Goa		Pernem	Asapur	Borewell	-	3.3	-	-
89	South Goa	PzGoa1004	Canacona	Aven	Borewell	10.08	7.91	8.05	8.7
90	North Goa	PzGoa1047	Ponda	Betki	Borewell	17.23	15.03	15.05	16.26
91	South Goa	PzGoa1013	Salcete	Canabonulim	Borewell	6.41	3.8	3.62	4.63
92	South Goa	PzGoa1008	Salcete	Chandavar	Borewell	3.12	1.92	2.18	2.5
93	North Goa	New well	Pernem	Chandel OW	Borewell	4.86	4.26	4.26	4.43
94	South Goa	PzGoa1007	Salcete	Chinchinim	Borewell	2.78	0.79	0.94	1.59
95	South Goa	PzGoa1018	Sangeum	Collem	Borewell	6.95	3.3	5.9	6.13
96	South Goa	New well	Sanguem	Columba	Borewell	5.1	3.02	1.59	3.65
97	South Goa	PzGoa1001	Canacona	Dabel	Borewell	12.49	9.05	9.2	8.7
98	South Goa	PzGoa1016	Salcete	Dovorlim	Borewell	5.55	4.2	2.25	5.43
99	North Goa	PzGoa1046	Bicholim	Kasar Pal	Borewell	10.29	8.88	8.9	9.68
100	South Goa	PzGoa1011	Salcete	Kavelosim	Borewell	2.9	1.35	1.59	2

101	North Goa	PzGoa1039	Bardez	Kirl Pirna	Borewell	9.57	11.5	7.09	8.41
102	North Goa	PzGoa1033	Pernem	Korgoan	Borewell	11.71	11.59	12.01	11.52
103	North Goa	PzGoa1032	Tiswadi	Krilwada	Borewell	1.79	1.23	1.26	1.67
104	North Goa	PzGoa1048	Ponda	Madakai	Borewell	21.42	7.5	-	18.72
105	South Goa	PzGoa1010	Salcete	Manora Rai	Borewell	5.82	4.17	4.27	5.53
106	South Goa	New well	Salcete	Margoa	Borewell	2.66	1.04	12.24	1.67
107	North Goa		Bicholim	Mayam	Borewell	-	16	-	-
108	North Goa		Bicholim	Mayam (GOVT. PRIMARY SCHOOL)	Borewell		5.6	5.77	6.4
109	South Goa	PzGoa1019	Sangeum	Meidawada	Borewell	11.27	6.79	10.29	11
110	North Goa	PzGoa1030	Tiswadi	Mola	Borewell	1.32	1.13	1.04	1.15
111	South Goa	48I3A5	Sangeum	Molem	Borewell	15.67	1.72	7.2	11.9
112	North Goa	PzGoa1028	Pernem	Morjum	Borewell	3.5	2.37	2.5	2.78
113	South Goa	48I2A3	Sattari	Morlem	Borewell	4.4	2.36	4.55	4.09
114	South Goa	PzGoa1037	Sattari	Nanoda	Borewell	20.25	18.58	19.86	19.94
115	North Goa	PzGoa1044	Bicholim	Narve	Borewell	13.04	11.68	12.24	12.62
116	North Goa	New well	Tiswadi	Old Goa	Borewell	3.47	1.92	20.11	3.1
117	South Goa		Quepem	Paddi Quiescend	Borewell	-	12.5	12.6	11.34

118	South Goa	PzGoa1006	Canacona	Patnem	Borewell	7.07	2.81	3.53	4.98
119	South Goa	PzGoa1005	Canacona	Ponquini	Borewell	9.54	9.01	9.09	9.29
120	North Goa	New well	Bardez	Saligao	Borewell	27.63	25.54	25.53	26.88
121	North Goa	PzGoa1045	Bicholim	Sanqulim	Borewell	26.3	20.07	20.61	21.4
122	North Goa	PzGoa1029	Pernem	Sawantwada	Borewell	5.6	4.24	4.35	5.1
123	South Goa	PzGoa1038	Sattari	Severdem	Borewell	15	12.87	14.24	-
124	North Goa	PzGoa1026	Pernem	Silolieum	Borewell	5.34	4.54	4.85	5.13
125	South Goa	PzGoa1036	Sattari	Thane	Borewell	10.59	6.72	6.78	8.09
126	North Goa	PzGoa1042	Bardez	Tivim	Borewell	21.25	18.59	20.11	20.62
127	North Goa	PzGoa1023	Pernem	Varkhand	Borewell	15.42	13.11	13.15	14.92
128	South Goa	PzGoa1014	Salcete	Verna	Borewell	2.45	0.7	1.53	2.21
129	South Goa	Jy1304	Canacona	Yedda	Borewell	5.62	4.61	0.2	3.85

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