जल वर्ष 2007 Water Year 2007

स्वच्छ सुरक्षित जल – सुन्दर खुशहाल कल

CONSERVE WATER - SAVE LIFE

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

GROUND WATER INFORMATION BOOKLET

NORTH GOA DISTRICT, GOA STATE

SOUTH WESTERN REGION
BENGALURU
MARCH 2013

सुशील गुप्ता
अध्यक्ष
केन्द्रीय भूमि जल बोर्ड,
जल संसाधन मंत्रालय,
भारत सरकार,
भूजल भवन, एन एच. - 4,
फरीदाबाद.

Sushil Gupta
Chairman
Central Ground Water Board,
Ministry of Water Resources,
Government of India,
Bhujal Bhawan, NH-IV,
Faridabad.

Foreword

The State of Goa is covered by rocks of Dharwar Super group with a small patch of Deccan basalts overlain by quaternary alluvium. Ground water occurs under unconfined and semi-confined conditions in these formations with spatial variability depending on the hydrogeological environment existing in each region. Scientific management of water resources is the need of the hour in the face of rising groundwater exploitation and pollution in the State of Goa. Central Ground Water Board has carried out various hydrogeological investigations in the State and joint studies on the water resources of Goa with the water resources department of Goa. The data generated from such studies could be effectively used in the preparation of this brochure.

Central Ground Water Board is providing all technical input for effective management of ground water resources in the state. The groundwater scenario compiled on administrative divisions gives a better perspective for planning various ground water management measures by local administrative bodies. With this objective, Central Ground Water Board is publishing the revised groundwater information booklet for all the districts of the state.

I do appreciate the efforts of Dr. K.Md.Najeeb, Regional Director and his fleet of dedicated Scientists of South Western Region, Bangalore and the Unit office at Belgaum for bringing out this booklet. I am sure these brochures will provide a portrait of the groundwater resources in each district for planning effective management measures by the administrators, planners and the stake holders.

Sushil Gupta
CHAIRMAN

PREFACE

Ground water contributes to about eighty percent of the drinking water requirements in the rural areas, fifty percent of the urban water requirements and more than fifty percent of the irrigation requirements of the nation. Central Ground Water Board has decided to bring out district level ground water information booklets highlighting the ground water scenario, its resource potential, quality aspects, recharge – discharge relationship, etc., for all the districts of the country. As part of this, Central Ground Water Board, South Western Region, Bangalore, is preparing such booklets for the two districts of Goa state.

The North Goa district Ground Water Information Booklet has been prepared based on the information available and data collected from various state and central government organisations by several hydro-scientists of Central Ground Water Board with utmost care and dedication. This booklet has been prepared by Dr.J. Davithuraj, Scientist 'B', Central Ground Water Board Unit Office, Belgaum. The figures were prepared by Sri. J.Sivaramakrishnan, Assistant Hydrogeologist. The efforts of Report processing section in finalising and bringing out the report in this format are commendable.

I take this opportunity to congratulate them for the diligent and careful compilation and observation in the form of this booklet, which will certainly serve as a guiding document for further work and help the planners, administrators, hydrogeologists and engineers to plan the water resources management in a better way in the district.

(Dr. K.Md. Najeeb)
Regional Director

NORTH GOA DISTRICT AT A GLANCE

Sl. No.	Items	Statistics	
1.	**General Information**		
	(i) Geographical area (sq. km.)	1,736	
	(ii) Administrative Division (as on 2009-10)		
	(a) Number of Taluks	6 (Tiswadi, Bardez, Pernem, Bicholim, Satari, Ponda)	
	(b) Number of Villages	213	
	(iii) Population (as per 2011 Census)	817761	
	(iv) Average Annual Rainfall (mm)	2932 mm	
2.	**Geomorphology**		
	(i) Major physiographic units	Coastal plain, vast etch plain towards the east, low dissected denudational hills and table land & deeply dissected high western ghat denudational hills occurring all along the eastern part.	
	(ii) Major Drainage	Principal perennial rivers are Terekhol, Chapora, Mandovi & Zuari rivers. Non-perennial river – Baga.	
3.	**Land Use (sq. km.)**		
	(i) Forest area (ha)	35,042 ha	
	(ii) Net area sown (ha)	79,908 ha	
4.	**Major soil types**	Lateritic soil, Saline soil, Alluvial soil (very thin strip along the coast line towards western part of the district).	
5.	**Area under principal crops (2009 –10)**	**Crops**	**Area (ha)**
		Paddy	26,889
		Cereals millets/ pulses & oil seeds	9,871
		Sugarcane	136
		Coconut	11,310
		Arecanut	1,456
		Cashew nut	40,586

6.	**Irrigation by different sources (Area (ha) & Number of structures) (As per Third Census of Minor Irrigation Schemes 2000-01)**	**Area irrigated (ha)**	**Number**
	(i) Dug wells	1867.91 ha	3359
	(ii) Tube wells (Shallow; Deep)	75.10 ha (23.7 ha; 51.40 ha)	71 (14; 57)
	(iii) Tanks / Ponds	-	68
	(iv) Canals	1149.40 ha	3
	(v) Other sources: (a) Lift Irrigation Schemes (b) Surface Flow irrigation	(a) 1383.54 ha (b) 3972.92 ha	(a) 417 (b) 2559
	(vi) Net irrigated area	8448.87 ha	
7.	**Number of ground water monitoring wells of Central Ground Water Board (as on 31.03.2009)**		
	(i) Dug wells	22	
	(ii) Piezometers	27	
8.	**Predominant Geological Formations**	**(a) Mainly formations of Goa Group, comprising**: Schist (major part), Greywacke with conglomerate, Dolomitic limestone (small patch towards northeastern part), Metabasalt (small patch towards southwestern part). **(b) Formations of Peninsular Gneissic Complex, comprising**: Granite gneiss, Granite (small patch towards northeastern part). **(c) Deccan Traps**: Basalt (thin strip towards north eastern most tip) **(d) Beach sand**: (very thin strip towards north western part of the district). **(e) Laterite:** Vast portion of the rocks (viz. schist, greywacke with conglomerate, granite & metabasalts) is lateritised.	

9.	**Hydrogeology**	
	(i) Major water bearing formation	Laterite, Alluvium, Granite, Granite Gneiss, Meta volcanics & Meta sedimentaries.
	(ii) Pre – monsoon depth to water level during May 2011 (in m bgl)	2.17 to 19.23
	(iii) Post – monsoon depth to water level during Nov. 2011 (in m bgl)	0.43 to 14.90
	(iv) Long term water level trend in 10 years (2001 – 2010) (in m/year)	
	(a) Pre – monsoon Range from a decline of 8.43 m to rise of 2.72 m	
	(b) Post – monsoon Range from a decline of 1.62 m to rise of 4.13 m	
10.	**Ground water exploration by Central Ground Water Board (as on 31.03.07)**	
	27 Number of wells drilled (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State) (c) Hydrology Project-II	 (a) 24 EW; 8 OW; Total – 32 (b) 12 (c) 22
	(ii) Depth Range (m bgl) (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State) (c) Hydrology Project-II	 (a) 17.60 – 184.25 m bgl (b) 22.05 – 79.0 m bgl (c) 28.00 to 100.00
	(iii) Discharge (litres per second) (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State) (c) Hydrology Project-II	 (a) 0.05 – 13.50 lps (b)1.00 – 25.00 lps (c) <1.00 to 6.10
	(iv) Sp. Capacity (m^3/day/m) (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State) (c) Hydrology Project-II	 (a) 0.47 – 988.47 (b) – Not computed (c)4.14 to 21.25 lpm/m/dd

	(v) Transmissivity (m^2/day) (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State) (c) Hydrology Project-II	 (a) 0.12 – 346.10 (b) Not computed (c)4.66- 28.85
11.	**Ground water quality**	
	(i) Presence of chemical constituents more than permissible limit	Saline due to sea water ingress in inland aquifers along tidal river courses. Ground water in general is of good quality.
	(ii) Type of water	Calcium – Bicarbonate Type
12.	**Dynamic ground water resource (March 2009)**	
	(i) Net ground water availability (ham)	7802
	(ii) Total Annual Ground Water Draft (ham)	2547
	(iii) Projected demand for domestic & industrial uses upto 2025 (ham)	2110
	(iv) Stage of ground water development (%)	33 % **(SAFE)**
13	**Awareness & Training activity**	
	(i) Mass awareness programmes organized	one (i) On "Ground water manage-ment" on 18/03/2002 at Panaji
	(ii) Water management Training Programmes (WMTP) organized	5 (i) WMTP on 29.03.04 at Goa Science Centre, Marine Highway, Miramar, Panaji, North Goa. (ii) "Hydrological Information System" – under Hydrology Project – II, on 12.03.08, Panjim, North Goa. (iii) "Hydrological Information System" – under Hydrology Project – II, on 17.03.10, Panjim, North Goa. (iv) "Water Use & Quality criteria" – under Hydrology Project – II, on 20.10.2010, Panjim, North Goa.

		5 (v) "on Water Conservation & Groundwater Management" – under Hydrology Project – II, on 02.02.2012. Ponda , North Goa.
14.	**Artificial recharge & rainwater harvesting**	
	(i) Projects completed by CGWB (No. & amount spent)	Nil
15.	**Ground water control & Regulation**	
	(i) Number of OE blocks	Nil
	(ii) Number of Critical blocks	Nil
	(iii) Number of blocks notified	Nil
16.	**Major ground water problems & issues**	• Ground water in dug wells & borewells in areas around Baga & along Chapora river is brackish to saline due to seawater ingress. • Ground water in areas adjacent to stream course in NE of Panjim is polluted due to domestic sewage. • Scarcity of ground water during summer months due to high sub – surface run off in hilly topography and highly permeable nature of phreatic aquifer. This results in lowering of water level or drying of wells during summer months.

1.0 Introduction

1.1 Location

Goa state lies along the west coast of India. The state is sub – divided into two districts, North & South Goa district. North Goa district lies in the northern part of Goa state. The geographical area of the district is 1,736 sq.km, and is situated between north latitudes 15^{o} 16' 30" & 15^{o} 48' 15" and between east longitudes 73^{o} 40' 30" & 74^{o} 17' 15". The district is bounded by Sindhudurg district of Maharashtra in the north, Belgaum district of Karnataka in the north – east, Uttara Kannada district of Karnataka in the east, South Goa district in the south and in the west by the Arabian Sea.

1.2 Administrative set up

Panaji is the district headquarters of North Goa district. The district comprises of 6 taluks namely, Tiswadi, Bardez, Pernem, Bicholim, Satari and Ponda **(Figure 1)**. There are 213 villages and 27 towns, out of which, 7 are Municipal towns.

1.3 Population

Population of the district (as per 2011 Census) is 817761 with a population density of 471 persons/ sq. km.

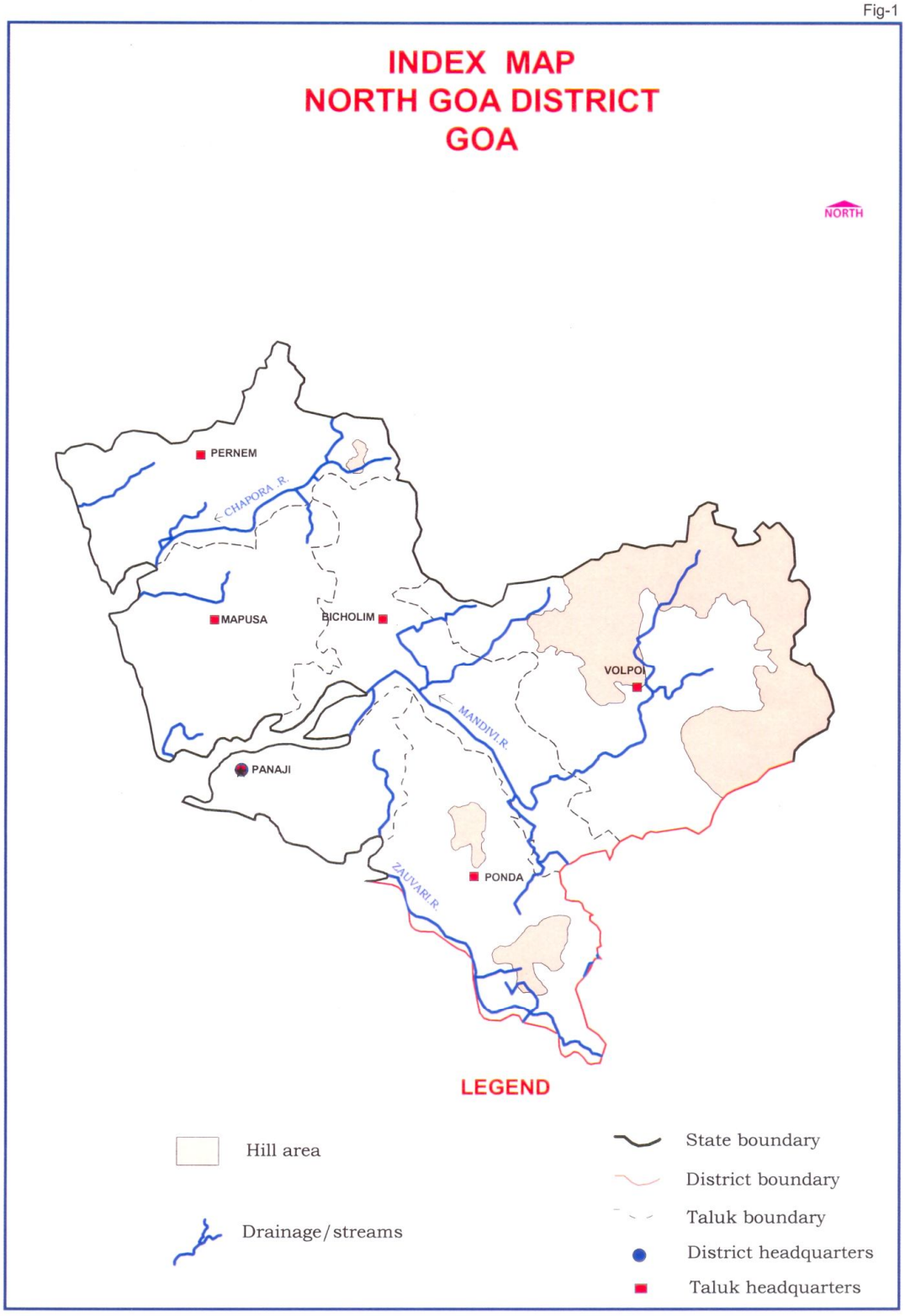
1.4 Physiography & Drainage

Physiographically North Goa district can be broadly divided onto four distinct morphological units from west to east namely,

(i) Coastal plain with marine land forms on the west,
(ii) Vast stretch of plains adjoining the coastal plain,
(iii) Low dissected denudational hills & tablelands towards the east, and
(iv) Deeply dissected high Western Ghats denudational hills along the eastern most part of the district.

Principal perennial rivers draining through the district are, Terekhol, Chapora, Mandovi & Zuari and non – perennial (seasonal) river Baga. The river basin of all these westerly flowing short rivers originate from Western Ghats and drain in the Arabian Sea in the west under estuarine environment. Primarily the underlying rocks govern the drainage system in the area. The drainage pattern is generally dendritic type. The major river Zuari follows the major NW synclinal axis. The river valleys are 'V' shaped in the western high hill ranges, but broadens in central midlands and become 'U' shaped in the low lands and coastal plains.

Fig-1


INDEX MAP
NORTH GOA DISTRICT
GOA
NORTH
PERNEM
CHAPORA R.
MAPUSA
BICHOLIM
VOLPOI
MANDIVI R.
PANAJI
PONDA
ZAUVARI R.
LEGEND
Hill area
Drainage/streams
State boundary
District boundary
Taluk boundary
District headquarters
Taluk headquarters

1.5 Crops & Irrigation practices

Agriculture is one of the important economic activities in the district. Rice is the staple food and paddy is the principal agricultural crop. Gross cropped area under paddy in 2008-09 was 26889 ha, accounting for nearly 27.07% of the Gross Cropped Area (99316 ha). Other crops grown are cereals, millets, pulses & oil seeds, which constitute an area of 9871 ha (9.93%), sugarcane 136 ha (0.13%), coconut 11310 ha (11.38%), arecanut 1456 ha (1.46%) and cashew nut 40586 ha (40.86%).

Irrigation potential created as on March 2000 by the Anjunem Irrigation Project was 2100 ha in Satari and Bicholim taluks of North Goa district. Irrigation by different sources, as per Third Census of Minor Irrigation Schemes 2000 – 01 is illustrated in Table 1.

Table 1: Irrigation by different sources (As per Third Census of Minor Irrigation Schemes 2000 – 01)

Sl. No.	Irrigation source	No. of schemes	Area irrigated (ha)
1.	Dug wells	3359	1867.91
2.	Shallow tube wells	14	23.70
3.	Deep tube wells	57	51.40
4.	Lift irrigation schemes	417	1383.54
5.	Surface flow irrigation	2559	3972.92
	TOTAL	**6406**	**7299.47**

1.6 Activities carried out by Central Ground Water Board (CGWB)

Twenty four deposit wells were constructed in Goa State for Caboraj Niwas and Western Ghat Development Programme, by CGWB, during the Field Season Programme (1984 – 86). Out of 24 deposit wells, 12 nos. were constructed in North Goa district, 5 nos. in Tiswadi and 7 nos. in Satari taluks respectively.

Under Exploratory Drilling Programme of CGWB, 24 exploratory wells & 8 observation wells were drilled to study the hydrogeological conditions, aquifer parameters and update ground water regime & quality in the district.

Monitoring of spatial and temporal change in ground water level in the district is being done by CGWB, South Western Region, four times annually (viz. May, September, November & January), through an established network of 27 monitoring stations (22 dug wells and 5 piezometers).

Under the aegis of activities of Central Ground Water Authority, one Mass Awareness Programme and one Water Management Training Programme was organized in the district in the year 2002 and 2004 respectively.

World Bank aided Hydrology Project for Peninsular States started during 1995 – 96, with a mandate to bring together all departments dealing with water under one umbrella. The sole objective of the Project was to deliver a reliable and functional Hydrological Information System. The Project is implemented in Karnataka, with CGWB, South Western Region, identified as one of the member and nodal agency dealing with ground water related issues.

Under Phase – II of Hydrology Project, 22 nos. of piezometers have been constructed in North Goa district. One mass awareness and four training programme have been organized on "Hydrological Information System" in the district.

2.0 Climate & Rainfall

Due to maritime influence, the diurnal range of temperature during the day is not large. The diurnal range is the least being 4 to 6^{o} C during monsoon season and increases to the maximum of 10 to 20^{o}C during December & January. May is the hottest month where the mean daily temperature increases to 30^{o}C. January is the coolest with mean daily temperature of about 23^{o}C. It is noted that the day temperature is the lowest in monsoon months of July and August and not in the cool winter months of December and January. The temperature is highest (around 33^{o}C) in pre – monsoon months of April & May and again in post monsoon months of November & January. Due to proximity to the Arabian Sea, humidity throughout the year is more than 60% with range from 80 to 90% during monsoon period.

As a result of orographic influence, rainfall increases towards the Western Ghats, with average annual rainfall (1971 – 2001) 2828.70 mm (in Bardez taluk) to 3948.30 mm (in Satari taluk). Over 90% of annual rainfall occurs during monsoon months of June to September. About 32% of the annual rainfall is received during July.

3.0 Soil Types

Soils of the district can be classified into 3 types namely (i) Laterite soil (ii) Saline soil and (iii) Alluvial soil:

(i) Lateritic soil is the major soil type in the district. It is highly porous & permeable, slightly acidic with low pH values, low in organic matter, Calcium and Phosphorus.

(ii) Saline soil in the district occurs in the flood plains of Zuari and Mandovi rivers in Tiswadi, Bardez and Ponda taluks. It also occurs in Pernem taluk. The soil is deep, poorly drained and less permeable. It is saline, high in pH and contains humus and organic matter.

(iii) Alluvial soil occurs as very thin strip along the coastline towards western part of the district. It is reddish brown to yellowish, coarse

grained and confined to narrow valleys of rivers. It is well drained, acidic with low pH and organic content.

4.0 Geology

4.1 Stratigraphy

The stratigraphic succession of rocks in North Goa district is given in Table 2 below.

4.2 Distribution of rock types

North Goa district is dominantly covered by the formation of Goa Group belonging to Dharwar Super Group of Archaean to Proterozoic age. Deccan Trap of Upper Cretaceous occupies a narrow strip along the northeastern corner to Lower Eocene age.

The Goa Group comprises of metamorphic rocks of green schist facies, and is divided into Barcem, Sanvordem, Bicholim and Vageri formation in the ascending order of superposition. The Goa Group of rocks has been intruded by granite gneiss, feldspathic gneiss, hornblende gneiss and porphyritic granite, followed by basic intrusive.

During the Sub – Recent and Recent times, the rocks have been subjected to lateritisation of varying thickness. Thus, laterite occurs extensively covering almost all the formations in North Goa district.

Coastal alluvium occurring along the coastal plains consists of fine to coarse sands with intercalations of sandy loam, silt and clay.

4.3 Structural geology

The Goa group of rocks is disposed in a general NW – SE direction. The rock types indicate three cycles of folding. The straight coastline suggests the major fault along the west coast. Associated with this fault a number of weak planes have developed. Along these weak planes Terekhol, Chapora, Mandovi and Zuari rivers flow to meet the Arabian Sea. Western Ghats, which extends in NS to NNW – SSE direction represent a prominent fault zone. Even though the rock types of Goa Group have suffered considerable faulting, all the faults are not exposed on surface owing to the extensive cover of laterite.

Table 2: Stratigraphy Of North Goa District

AGE	GROUP	FORMATION	ROCK TYPE
Quaternary			Beach Sand
Cenozoic			Laterites
Upper Cretaceous to Eocene	Deccan Trap		Basalt
Lower Proterozoic	Clospet Granite		Granite
		Peridotite, Gabbro, Norite	Pyroxenite, Peridotite, Serpentinite, Gabbro
Archaean to Lower Proterozoic	Goa Group	Vageri Formation	Carbonate-quartz-chlorite schist with Greywacke
		Bicholim Formation	Dolomitic limestone
			Quartz- Sericite schist
			Banded iron formation
			Chert and quartzite
			Quartz-chlorite-biotite schist with layers of chert, iron oxide, carbonate, meta-basalt and meta gabbro
		Sanvordem Formation	Greywacke with conglomerate
			Quartzite
		Barcem Formation	Quartz-chlorite schist
			Meta-acid volcanics
			Meta-basalt
			Orthoquartzite
Archaean	Peninsular Gneissic complex		Granite Gneiss, Migmatites and Granites

5.0 Ground water scenario

5.1 Hydrogeology

Occurrence and movement of ground water depends upon the type of rock formation, structure, topography, rainfall, recharge etc. Ground water in the district occurs in rocks having primary porosity & permeability or in those having secondary porosity acquired due to weathering, leaking, tectonics, solutions etc.

Ground water bearing formations in the district are laterite, alluvium, granite, metavolcanics and metasedimentaries. Hydrogeological map is illustrated in **Figure-2**.

Fig-2

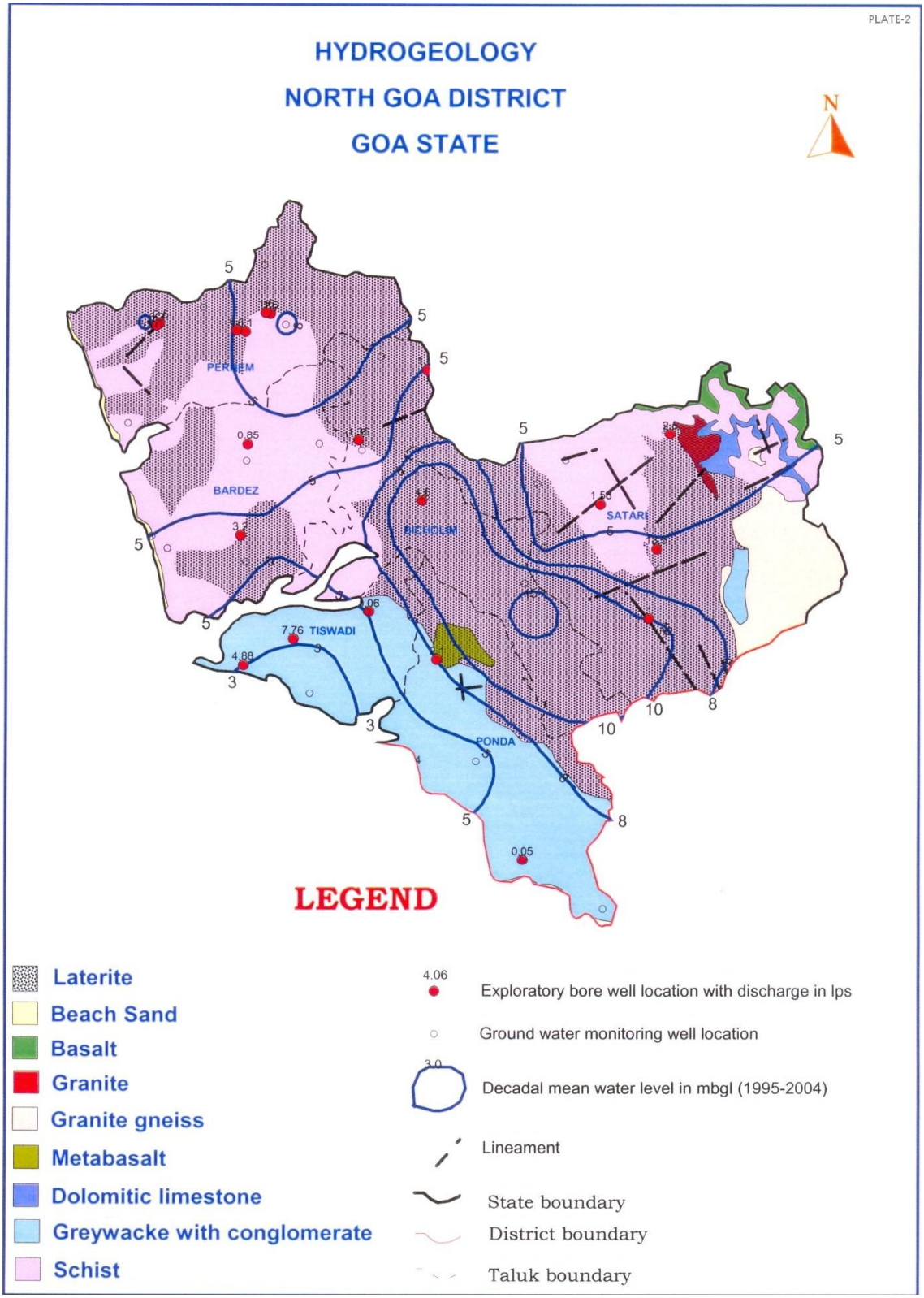


PLATE-2
HYDROGEOLOGY
NORTH GOA DISTRICT
GOA STATE
N
PERNEM
BARDEZ
BICHOLIM
SATARI
TISWADI
PONDA
0.85
3.1
1.06
7.76
4.88
0.05
LEGEND
Laterite
Beach Sand
Basalt
Granite
Granite gneiss
Metabasalt
Dolomitic limestone
Greywacke with conglomerate
Schist
4.06
Exploratory bore well location with discharge in lps
Ground water monitoring well location
Decadal mean water level in mbgl (1995-2004)
Lineament
State boundary
District boundary
Taluk boundary

5.1.1 Occurrence of ground water and aquifer characteristics of various formations

Laterites

Laterites are the important water bearing formations. Laterites are of two types, viz. *insitu*, occurring in plateau areas or of detrital origin generally occupying valley portions. Besides inherent porosity, the laterites are highly jointed and fractured, which control their water bearing capacity. The topographic settings of laterites control its ground water potential. The thickness of laterites extends up to 30 m. Ground water occurs under water table condition in lateritic formation. In the plateau area and high grounds, depth of wells range from 9.40 to 26.60 m bgl and depth to water level varies between 8.20 – 21.90 m bgl, whereas wells located in topographic lows range in depth from 3.10 – 11.95 m bgl and depth to water level varies from 1.5 – 8.40 m bgl. Specific capacities varies between 1.73 to 3205 m^3/day/m. Promising ground water bearing areas are located near Malpen and Tuem in Pernem taluk, Advalpal and Mayem in Bicholim Taluk.

Alluvium

Alluvium constitutes good aquifers and is restricted to banks of rivers, viz. Zuari and Mandovi. Thickness of the coastal alluvium varies from 5 – 22 m, and comprise of fine to coarse sand with intercalations of sandy loam, silt and clay. Depth range of 1.42 to 7.7 m bgl is being tapped by dug wells. Exploratory tube wells constructed in alluvium vary in depth from 15.50 – 22m. Depth to water level in these formations varies from 1.4 to 5.85 m bgl. The discharges recorded from these aquifers are between 1.88 – 3 lps. Specific capacities vary between 27.10 & 200.78 m^3/day/m and transmissivity varies from 25.44 – 177.50 m^2/day.

Granite

Ground water occurs under unconfined, semi – confined and confined conditions in weathered and fractured zones of granite and granite gneiss. Depth to water level in these formations in open wells varies from 3.8 to 6.25 m bgl, and specific capacities between 14.4 to 77.30 m^3/day/m. Exploratory bore holes drilled in granite are in the depth range of 70.70 to 124 m bgl. Discharge recorded is between 0.77 to 8.8 lps. Specific capacities in exploratory wells recorded, vary from 2.27 to 43 m^3/day/m and transmissivity from 0.87 to 34.60 m^2/day.

Metavolcanics

In unaltered state, metavolcanics are very poor in ground water. However, ground water is found to occur in zones having secondary porosity and permeability imparted due to weathering, joints and fractures. Ground water occurs both under water table and confined conditions. Water bearing zones extend up to depth of 40 to 100 m.

Irrigation dug wells having diameter from 2.2 to 6.1 m are found to tap the weathered zone up to 9.25 m bgl. Depth to water level in dug wells varies from 1.48 to 6.26 m bgl. Specific capacity varies from 10.60 to 228.70 m^3/day/m.

Exploratory wells, Pz Bore wells and deposit wells drilled by CGWB in this formation range in depth from 37.20 to 200.75 m bgl and the discharges recorded range from 0.18 to 25 lps. Productive zones were encountered even up to 119 m bgl. Specific capacities recorded from boreholes tested varied from 0.46 to 988.47 m^3/day/m and transmissivity varied from 0.25 to 346.10 m^2/day.

Studies have indicated that bore holes drilled in metavolcanics with thick lateritic cover in the plateau areas and close to lineaments have yields ranging from 2 to 5 lps.

Metasedimentaries

Metasedimentaries comprise shales, phyllites, schists, metagreywackes, argillites and quartzites. The irrigation dug wells tapping weathered zones extending from 8.5 to 19.85 m bgl in these rock units with varying well diameters from 2.2 to 6.1 m. Depth to water level during post and pre – monsoon periods are recorded respectively in the range between 0.48 to 12.06 m bgl and 1.79 to 14.88 m bgl with fluctuations between 0.86 to 8.0 m. Specific capacities vary from 0.85 to 82.80 m^3/day/m.

5.1.2 Depth to water level

The Central Ground Water Board has established 27 hydrograph stations. These hydrograph stations are measured four times a year, each year i.e. in January, May, August and November. Depth to water level varies within the area depending on the hydrogeological setup, incidence of rainfall, topographic setting and stage of groundwater development.

i) Pre-Monsoon of 2011:

The Depth to water level ranged from 1.69 to 26.09 m bgl. A map showing the dept to water level in the range of <2, 2 to 5, 5 to 10 and 10 to 20 m bgl is given in **Figure-3**. The map shows water level is in the range of 2 to 20 m bgl. Water level depicted in the range of <2 – 2 m bgl occur in small pockets of Tiswadi and Bardez taluks, 2 – 5 m bgl occur in major portions of the area in Tiswadi, Bardez, Pernem and Sattari taluks, 5 – 10 m bgl occur in bicholium, Ponda, Tiswadi taluks. Water level in the range of 10 – 20 m bgl occurs as a small pocket in Bicholium and Ponda taluk.

Fig-3

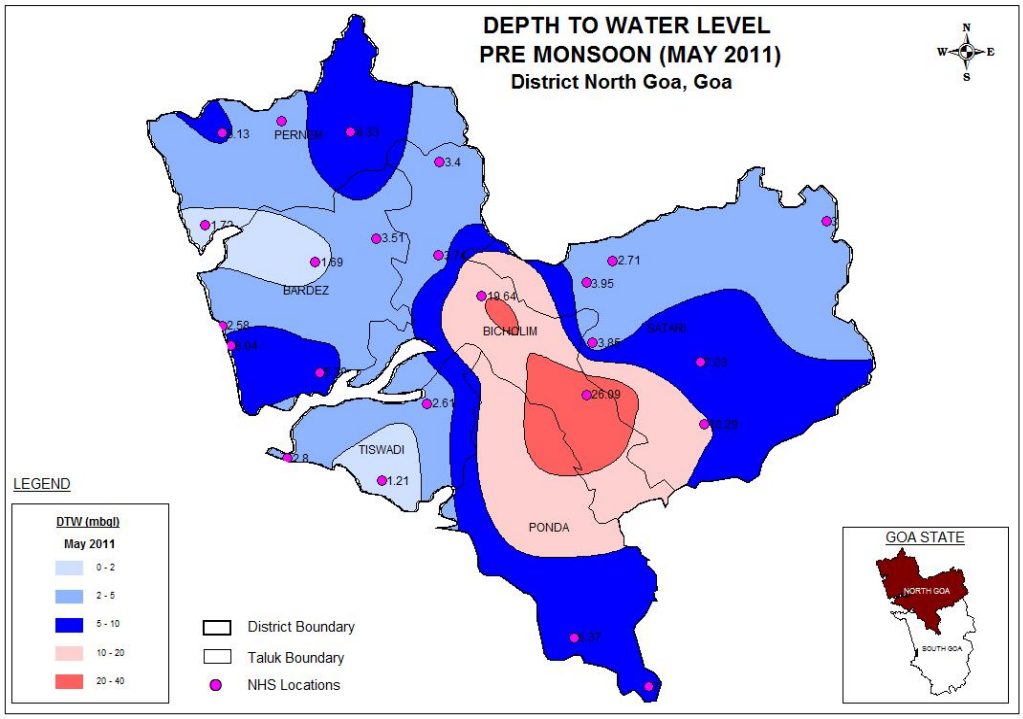
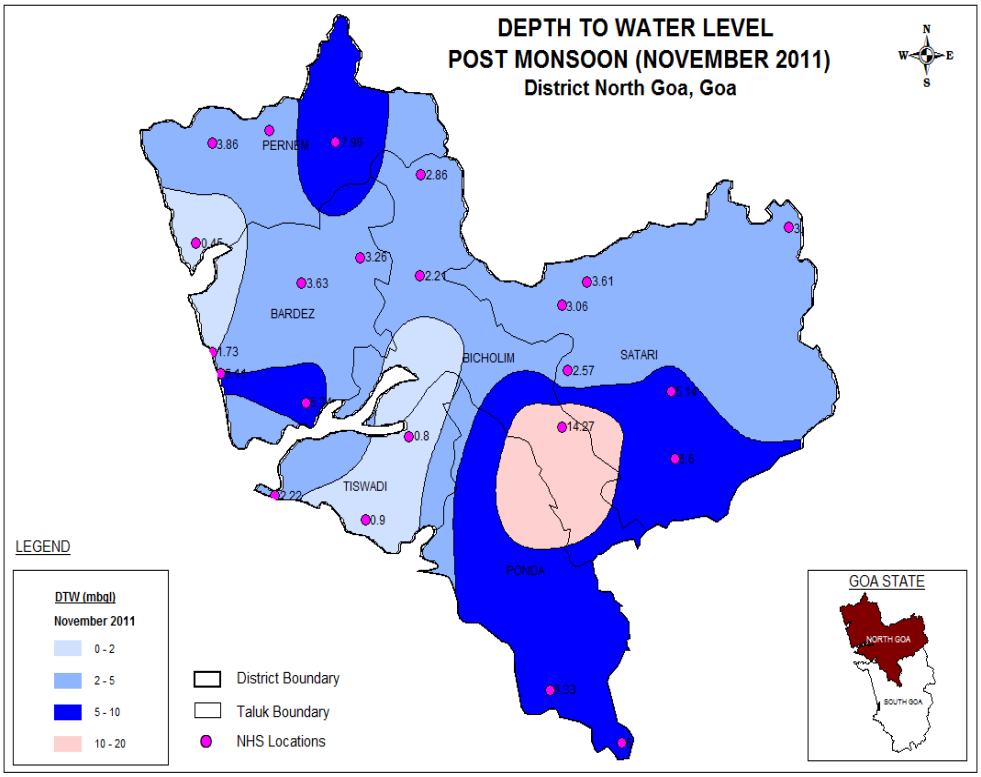

DEPTH TO WATER LEVEL
PRE MONSOON (MAY 2011)
District North Goa, Goa
N
W
E
S
PERNEM
BARDEZ
BICHOLIM
SATARI
TISWADI
PONDA
3.4
3.51
1.69
2.71
3.95
19.64
3.85
26.09
2.61
10.29
2.8
1.21
LEGEND
DTW (mbgl)
May 2011
0 - 2
2 - 5
5 - 10
10 - 20
20 - 40
District Boundary
Taluk Boundary
NHS Locations
GOA STATE
NORTH GOA
SOUTH GOA

Fig-4


DEPTH TO WATER LEVEL
POST MONSOON (NOVEMBER 2011)
District North Goa, Goa
N
W
E
S
3.86
PERNEM
7.96
2.86
3.28
3.63
2.21
3.61
3.06
BARDEZ
1.73
BICHOLIM
SATARI
2.57
14.27
0.8
TISWADI
2.22
0.9
PONDA
LEGEND
DTW (mbgl)
November 2011
0 - 2
2 - 5
5 - 10
10 - 20
District Boundary
Taluk Boundary
NHS Locations
GOA STATE
NORTH GOA
SOUTH GOA

ii) Post-Monsoon of 2009:
The Depth to water level ranged from 2.17 to 19.23 m bgl. A map showing the dept to water level in the range of <2, 2 to 5, 5 to 10 and 10 to 20 m bgl is given in **Figure-4.** The map shows water level is in the range of 2 to 20 m bgl. Water level depicted in the range of <2 – 2 m bgl occur in small pockets of Tiswadi, Permem and Bardez taluks, 2 – 5 m bgl occur in major portions of the area in Tiswadi taluk, 5 – 10 m bgl occur in Bicholium, Ponda, Tiswadi, Bardex and Pernem taluks. Water level in the range of 10 – 20 m bgl occurs as a small pocket in Bicholium and Ponda taluk.

5.1.3 Seasonal ground water level fluctuation

Water levels from 23 stations were compared to know the change in water level between pre-monsoon and post monsoon of 2011. While 20 stations recorded rise in water levels 3 stations recorded fall in water level.

5.1.4 Long – term water level trend

Ground water is a renewable resource it gets depleted when the aquifer is over drafted. The aquifer gets recharged during monsoon period. Rainfall is the main source of recharge to ground water. In order to study the long-term trends of ground water level in the district, water level data has been analyzed for NHS observation wells for pre monsoon and post-monsoon established by Central Ground Water Board, for the periods from 2001-2010. Talukawise long-term water level trend data of south Goa district is presented in Table-3.

Table.3. Talukawise Long Term Water Level Trend of South Goa district

Sr.No	Name of the Taluk	Ranges of long-term water level trend m/year			
		Pre-monsoon		Post- monsoon	
		Fall	Rise	Fall	Rise
1	Bardez	0.0-0.0	0.292-3.580	0.0-0.12	0.13-1.86
2	Bicholium	0.320-7.509	0.0-0.426	0.0-0.16	0.65-3.50
3	Pernem	0.255-1.590	0.414-1.590	0.04-1.49	0.0-0.67
4	Ponda	0.0-0.285	0.0-0.280	0.0-0.26	0.0-0.0
5	Sattari	0.281-1.341	0.281-1.195	0.19-0.22	0.06-1.26
6	Tiswadi	0.0-0.0	0.258-1.984	0.0-0.06	0.03-2.24

i) Pre monsoon:

The decadal change in water level for the period May 2001 to May 2010 was compared with the groundwater level in May 2011 in the North Goa district. It is seen that out of the 23 stations compared, 17 wells accounting for 73.91% of

Fig-5

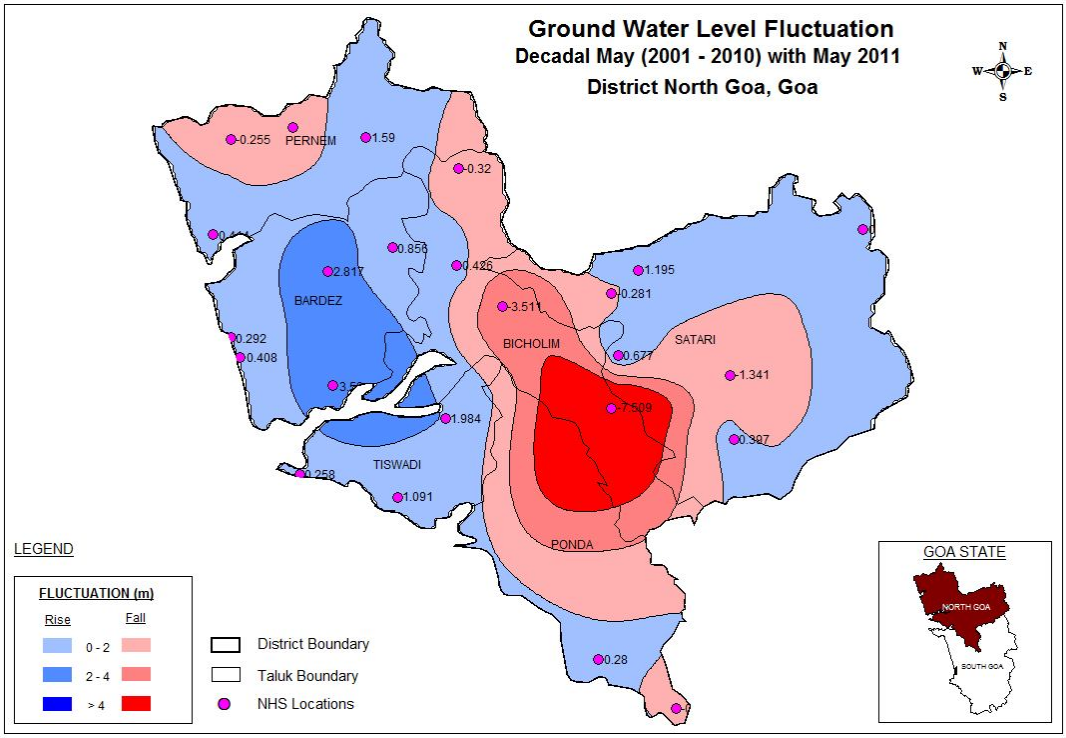
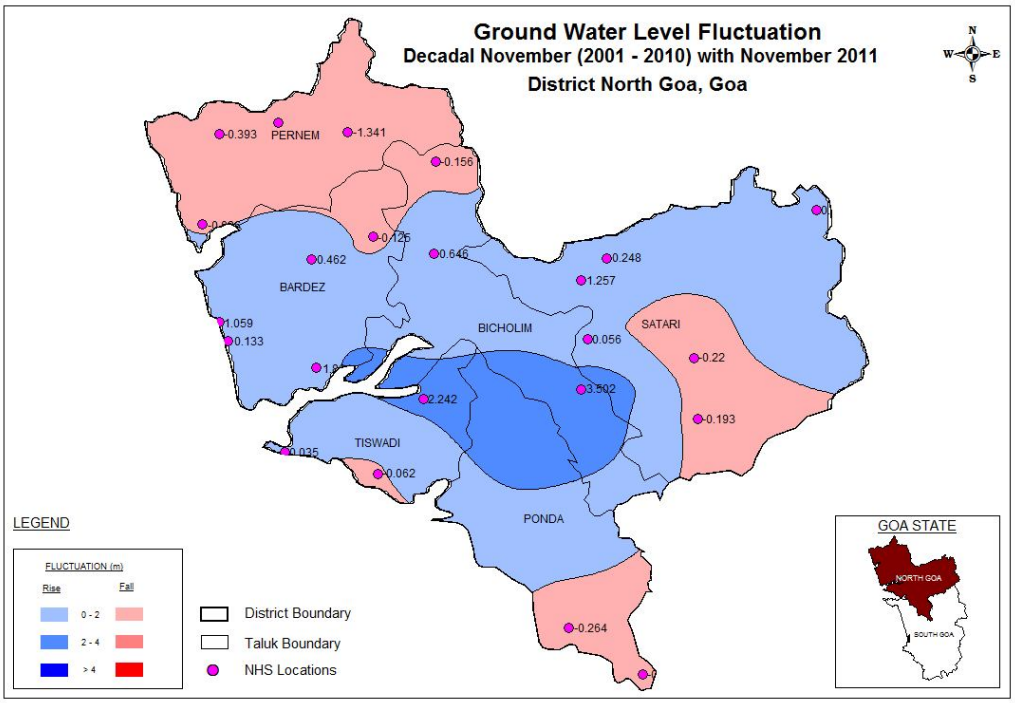

Ground Water Level Fluctuation
Decadal May (2001 - 2010) with May 2011
District North Goa, Goa
N
W
E
S
-0.255
PERNEM
1.59
-0.32
0.858
2.817
0.426
BARDEZ
1.195
0.281
-3.511
BICHOLIM
SATARI
0.292
0.408
0.677
-1.341
-7.509
1.984
0.397
TISWADI
0.258
1.091
PONDA
0.28
LEGEND
FLUCTUATION (m)
Rise
Fall
0 - 2
2 - 4
> 4
District Boundary
Taluk Boundary
NHS Locations
GOA STATE
NORTH GOA
SOUTH GOA

Fig-6


Ground Water Level Fluctuation
Decadal November (2001 - 2010) with November 2011
District North Goa, Goa
N
W
E
S
-0.393
PERNEM
-1.341
-0.156
-0.126
0.462
0.646
0.248
1.257
BARDEZ
1.059
0.133
BICHOLIM
SATARI
0.056
0.22
3.502
2.242
-0.193
TISWADI
0.035
0.062
PONDA
-0.264
LEGEND
FLUCTUATION (m)
Rise
Fall
0 - 2
2 - 4
> 4
District Boundary
Taluk Boundary
NHS Locations
GOA STATE
NORTH GOA
SOUTH GOA

analysed wells have shown a rise in water level. The remaining 6 wells accounting for26.06 % showed a fall in water level. The pre monsoon water level trend shows the effect of ground water development.

A map showing the change in water levels, with rise/fall in the ranges of 0-2 m, 2-4m and >4m is presented in **Fig-5** . The map shows that the 73.91% of the area rise in water level the remaining area shows a fall in water level. Rise in water level in the range of 0-2 m was noticed in Tiswadi, Bardez, Pernem, Sattari and Bicholium taluks. A small patch in Bardez and Tiswadi taluks shows a rise in water level in the range of 2-4 m. Fall in water level in the range of 0-2 m observed Pernem, bicholium, Sattari and Ponda taluks. Fall in the range of 2-4 m observed in Bicholium and Ponda taluks. Fall in the range of >4 m observed in Bicholium and Ponda taluks.

ii) Post monsoon:

The decadal change in water level for the period November 2001 to November 2010 was compared with the groundwater level in November 2011 in the North Goa district. It is seen that out of the 23 stations compared, 12 wells accounting for 52.17% of analysed wells have shown a rise in water level. The remaining 11 wells accounting for 47.82% showed a fall in water level. The post monsoon water level trend indicates whether the ground water body has been fully recharged or not. If water level trend is declining, it suggests that the aquifer is getting desaturated year after year. The water level decline in post monsoon may be due to poor rainfall or large development of ground water in that area.
A map showing the change in water levels, with rise/fall in the ranges of 0-2 m, 2-4m and >4m is presented in **Fig- 6**. The map shows that the 52% of the area rise in water level the remaining area shows a rise in water level. Rise in water level in the range of 0-2 m was noticed in Tiswadi, Bardez, Pernem, Sattari and Bicholium taluks. A small patch in Tiswadi and Ponda taluks shows a rise in water level in the range of 2-4 m. Fall in water level in the range of 0-2 m observed Pernem, Sattari, Ponda and Tiswadi taluks.

5.2 Aquifer system encountered in the district

Under ground water exploration programme of CGWB, in North Goa district, attempt has been made to study aquifer geometry & parameters through drilling of exploratory bore wells. The selection of sites of all such bore wells was done based on detailed hydrogeological investigations and geophysical surveys.
The major aquifers encountered in the district during exploratory drilling are in granite, granite gneiss, metabasalts, metasedimentaries and alluvium. Formation wise aquifer parameters recorded during exploratory drilling in the district is illustrated in Table 4.

Table 4: Formation wise aquifer parameters in North Goa district

Formation/Aquifers	Yield (lps)	Drawdown (m)	Sp. Capacity (m^3/d/m)	Transmi-ssivity (m^2/day)
1. Granites & Gneisses	0.34 – 8.8	17.68 – 34.61	0.27 – 43.00	0.2 – 30.6
2. Metabasalts	0.18 – 9.9	1.9 – 33.78	0.46 – 141.20	0.2 – 232
3. Metasedimentaries	0.22 – 10	1.32 – 34.40	0.47 – 159.60	0.12 – 346
4. Alluvium	1.8 – 2.5	0.87 – 9.1	27 - 200	21 - 1776

5.3 Ground water resources

Taluk wise ground water resource potential of the district estimated by CGWB, South Western Region, Bangalore and Water Resources Department of Goa, based on the recommendations of Ground Water Resources Estimation Methodology – 97 (as on March 2009) is mentioned in Table 5.

Table 5: Taluk wise ground water resource potential of North Goa district, Goa.

GROUND WATER RESOURCES OF NORTH GOA DISTRICT AS ON MARCH 2004											
TALUK	Net Ground water Availability (HAM)	Irrigation draft (HAM)	Domestic and industrial draft (HAM)	Total annual ground water draft (HAM)	Projected domestic and industrial draft 2025 (HAM)	Ground water availability for future irrigation** (HAM)	Average Stage of development (%)	STAGE OF DEVELOPMENT AS ON MARCH 2009			
								Safe Area (%)	Semi-Critical Area (%)	Critical Area (%)	OE Area (%)
Tiswadi	**996.83**	**184.95**	**359.67**	**544.62**	**445.35**	**366.53**	**55**	**100**	**-**	**-**	**-**
Bardez	**1821.34**	**149.85**	**511.55**	**661.40**	**633.42**	**1038.07**	**36**	**100**	**-**	**-**	**-**
Pernem	**1750.28**	**49.95**	**161.76**	**211.71**	**200.29**	**1500.04**	**12**	**100**	**-**	**-**	**-**
Bicholim	**1760.97**	**173.34**	**203.85**	**377.19**	**252.41**	**1335.22**	**21**	**100**	**-**	**-**	**-**
Satari	**578.13**	**95.31**	**131.68**	**226.99**	**163.05**	**319.76**	**39**	**100**	**-**	**-**	**-**
Ponda	**893.97**	**189.00**	**335.74**	**524.74**	**415.73**	**289.25**	**59**	**100**	**-**	**-**	**-**
TOTAL	**7802**	**842**	**1704**	**2547**	**2110**	**4849**	**33**	**100**	**-**	**-**	**-**

The Status of groundwater utilization in South Goa district as on March-2009 is presented in **Figure-7**. It is observed from Figure-7 that entire district comes under safe category and is good scope of ground water exploitation.

5.4 Unit area annual groundwater recharge

Sustainability of groundwater resource depends mainly on two factors viz. Annual groundwater recharge and annual groundwater draft. The annual groundwater

Fig-7

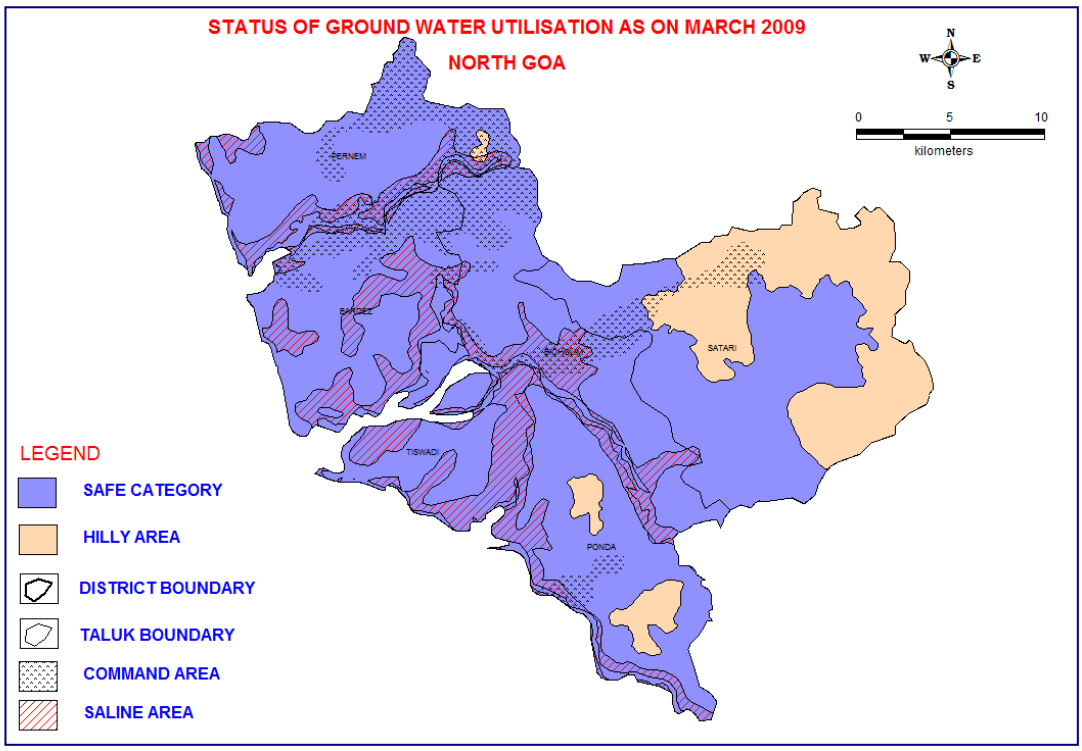
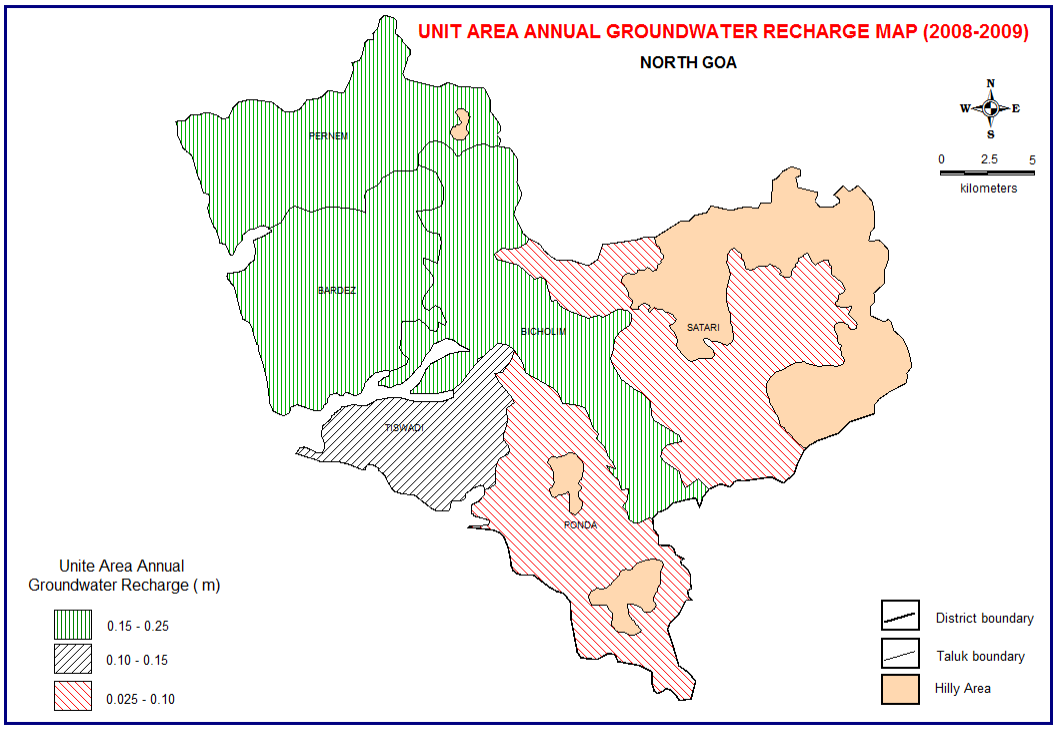

STATUS OF GROUND WATER UTILISATION AS ON MARCH 2009
NORTH GOA
N
W
E
S
0
5
10
kilometers
PERNEM
BARDEZ
SATARI
TISWADI
PONDA
LEGEND
SAFE CATEGORY
HILLY AREA
DISTRICT BOUNDARY
TALUK BOUNDARY
COMMAND AREA
SALINE AREA

Fig-8


UNIT AREA ANNUAL GROUNDWATER RECHARGE MAP (2008-2009)
NORTH GOA
N
W
E
S
0
2.5
5
kilometers
PERNEM
BARDEZ
BICHOLIM
SATARI
TISWADI
PONDA
Unite Area Annual
Groundwater Recharge (m)
0.15 - 0.25
0.10 - 0.15
0.025 - 0.10
District boundary
Taluk boundary
Hilly Area

recharge depends on the quantity and intensity of rain fall, the infiltration characteristics of the soil, the depth to groundwater level, the slope of the area and the geomorphology. The groundwater recharge is assessed separately for the monsoon and non monsoon period due to rainfall as well as due to other sources. The annual groundwater recharge includes all the above.
The recharge from other sources includes return seepage from irrigated area, seepage from canals, seepage from water bodies, seepage from influent rivers etc. The recharge can be expressed in metres. The unit area recharge is grouped into three categories viz. 0.025-0.10m, 0.10-0.15m and 0.15-0.25m. In North Goa district the unit area annual recharge is in the range of 0.025-0.10m in Ponda, sattari and parts of Bicholim taluks, 0.10-0.15m in Tiswadi taluk and in the range of 0.15-0.25m in Pernem, Bardez and parts of Bicholim taluks (**Figure-8).**

5.5 Ground water quality

In general the quality is good and potable. However, high EC and chloride indicating brackish to saline nature of ground water has been reported around Baga. This can be due to seawater ingress in inland aquifers along tidal river courses. The spatial distribution of saline water is given in **Figure-9.** Ground water of the district is free from fluoride, nitrate and alkali hazards.

5.6 Status of groundwater development

Dug wells are mainly the ground water abstraction structure in use for irrigation purposes in all the taluks. Shallow and deep tube wells are not much in use for irrigation purposes. Surface water irrigation is found to be extensively used in all the taluks of the district. Lift irrigation schemes are also being executed in Pernem, Bicholim, Satari and Ponda taluks respectively. The details of ground water abstraction structures constructed under various minor irrigation schemes in North Goa district are mentioned in Table 5.

Table 5: Taluk wise ground water abstraction structures constructed under various minor irrigation schemes in North Goa district.

Sl. No.	Taluk	Dug wells	Shallow tube wells	Deep tube wells	Surface flow irrigation	Lift irrigation
1	Tiswadi	595	-	-	23	-
2	Bardez	966	-	-	1272	-
3	Pernem	316	-	-	155	77
4	Bicholim	487	-	-	111	54
5	Satari	372	9	57	242	207
6	Ponda	623	5	-	756	79
	TOTAL	**3559**	**14**	**57**	**2559**	**417**

Source: IIIrd Census of Minor Irrigation Schemes 2000 – 01

6.0 Ground water management strategy

6.1 Ground water development

Stage of ground water development in the district is 27% as a whole and the district falls in SAFE category. There is lot of Scope for further development of ground water resource.

Due to complexities of formations, structure and morphological control, bore wells have to be properly located with respect to lineaments. The areas having pre - monsoon water levels less than 9 m and fluctuations less than 6 m have been recommended for dug well development and in areas having greater than 9m pre – monsoon water levels and greater than 6m fluctuations, bore wells have been suggested for resource development

Bore wells of 150 to 200 mm dia may be drilled upto a depth of 45 to 150 m depending upon local hydrogeological conditions.

Deeper ground water abstraction structures should be at least 0.5 km away from creeks and 400m away from coastline in low-lying areas to avoid quality problems.

6.2 Water conservation & Artificial recharge

Due to thin soil cover and highly rugged topography, in spite of heavy rainfall, the drainage system tends to be lean during summer months. Likewise due to steep hydraulic gradient and highly permeable phreatic aquifers, the dynamic ground water resource also gets depleted quickly rendering scarcity even for drinking water during summer months. Therefore, there is need for augmenting recharge by construction of water harvesting structures like bhandaras, sub – surface dykes, percolation ponds etc., so that these surface water bodies will help in augmenting ground water resources. . Area suitable for artificial recharge in South Goa district is shown in **Fig-10.**

In this regard, Department of Water Resources, Govt. of Goa, has taken up various projects pertaining to inter linking of rivers in the district and post – monsoon water harvesting. The State Govt. has endeavored in inter linking of Zuari River with Kalay River in Mandovi basin through canal and Chapora River with Assonora River in Mandovi basin. Series of bhandaras have also been constructed in Khandepar and Assonora (Sub – basin of Madei basin).

Fig-9

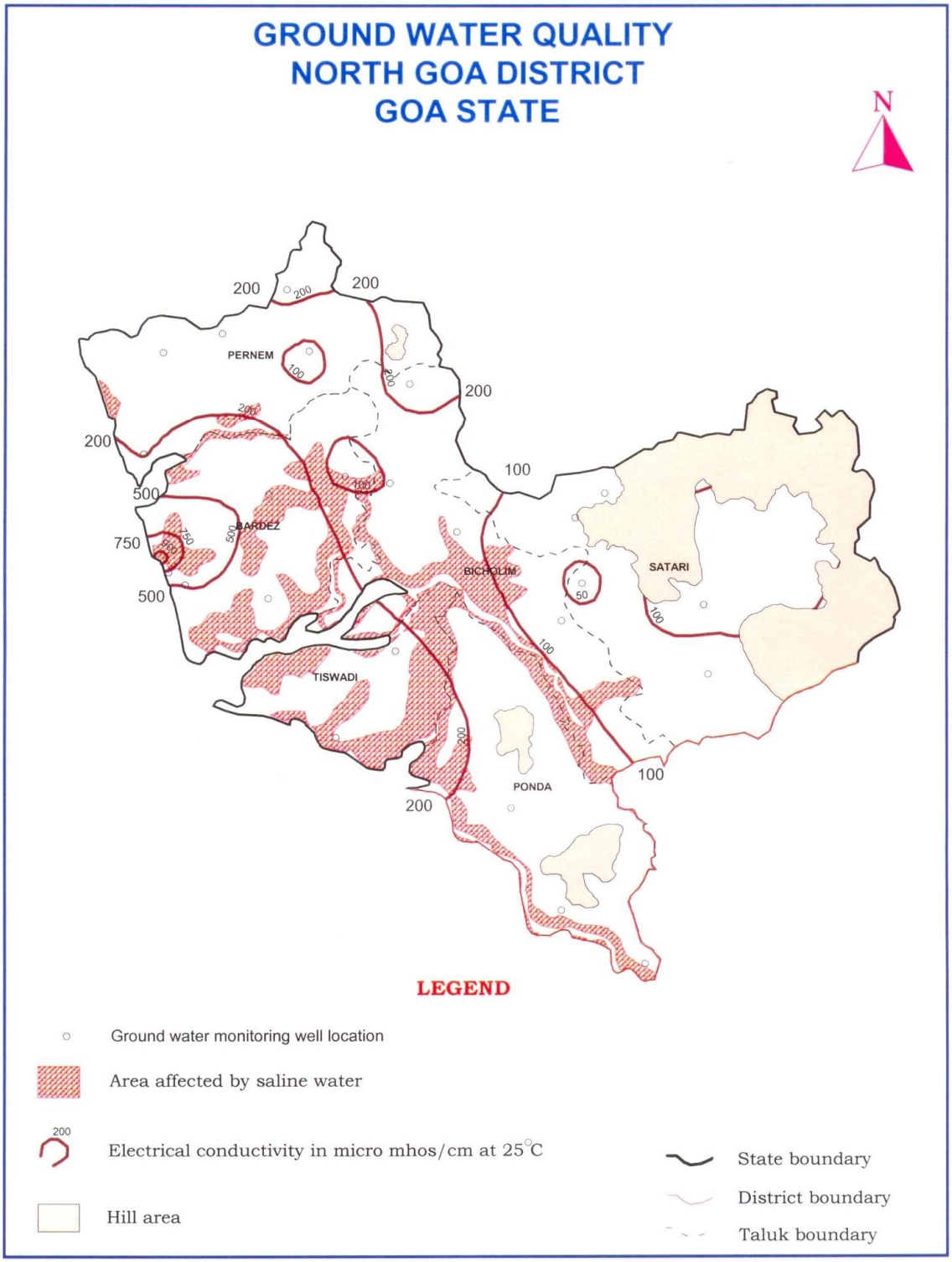
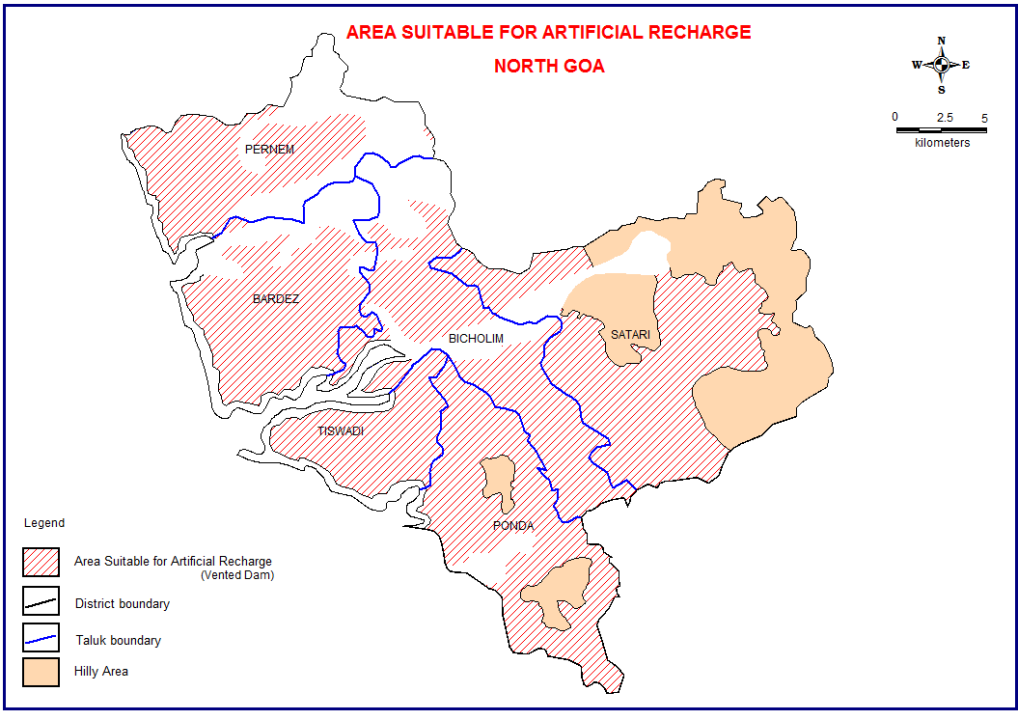

GROUND WATER QUALITY
NORTH GOA DISTRICT
GOA STATE
N
PERNEM
BARDEZ
BICHOLIM
SATARI
TISWADI
PONDA
200
100
500
750
50
LEGEND
Ground water monitoring well location
Area affected by saline water
Electrical conductivity in micro mhos/cm at 25°C
Hill area
State boundary
District boundary
Taluk boundary

Fig-10



7.0 Ground water related issues & problems

Ground water occurring in dug wells as well as bore wells is brackish to saline in areas around Baga and those along river Chapora, due to sea water ingress in inland aquifers along tidal river courses. Salinity is more pronounced during May when fresh water flow is minimum and maximum seawater ingress takes place.

Investigations have revealed that ground water adjacent to stream course in the NE of Panjim is also polluted due to domestic sewage in addition to salinity problem.

Scarcity of ground water is observed during summer months as a result of high sub – surface and surface run off due to hilly topography and highly permeable nature of phreatic aquifer system. This results in lowering of water levels or drying of wells in some areas in summer months.

8.0 Awareness & Training Activity

8.1 Mass Awareness Programme (MAP) & Awareness Programme on "Hydrological Information System" under Hydrology Project, organized by Central Ground Water Board

Central Ground Water Authority (CGWA) organized MAP on the theme "Conservation & Protection of ground water", on 18.03.2002 at International Centre, Panaji, North Goa. Representatives of Central & State agencies and general public attended the programme. An interaction session was held on the themes, viz. water conservation, artificial recharge, ground water legislation and ground water authority.

Awareness Programme on "Hydrological Information System", was organized under Hydrology Project – II, on 12.03.2008 at Panaji, North Goa.

Awareness Programme on "Hydrological Information System", was organized under Hydrology Project – II, on 17.03.2010 at Panaji, North Goa.

Awareness Programme on "Water Use and Quality criteria", was organized under Hydrology Project – II, on 20.10.2010 at Panaji, North Goa.

Awareness Programme on " Water conservation and Ground water Management", was organized under Hydrology Project – II, on 02.02.2012 at Ponda, North Goa.

The representatives of State Govt. departments and members of Hydrology Project user group attended the programme.

8.2 Water Management Training Programme (WMTP) & Training Programme on "Hydrological Information System" under Hydrology Project, organized by Central Ground Water Board

One day 'Water Management Training Programme' was organized by CGWA in association with Govt. of Goa on 29.03.2004 at Goa Science Centre, Marine Highway, Miramar, Panaji.. Representatives from State Govt. departments, Watershed Development Society, Gram Vikas Kendra, educational & research institutes attended the programme.

Training programme on "Hydrological Information System", was organized under Hydrology Project – II, on 12.03.2008, at Panaji, North Goa. Basic objective of the training programme was to train the members of Hydrology Project user group on the modules of Hydrological Information System developed under Hydrology Project.

8.3 Presentations and lectures delivered in public forum

Lectures on various aspects of ground water development, management and “Hydrological Information System”, were delivered by the scientists of CGWB on occasions of mass awareness and training programmes, organized at different venues in North Goa district.

9.0 Areas Notified by Central Ground Water Authority (CGWA)

Based on status of ground water utilization and available ground water resource, the entire district is categorized as SAFE from the point of view of ground water development. Therefore, no area has been considered for notification by CGWA.

10.0 Recommendations

(i) Due to thin soil cover and highly rugged topography, in spite of heavy rainfall, the drainage system tends to be lean during summer months. Likewise due to steep hydraulic gradient and highly permeable phreatic aquifers, the dynamic ground water resource also gets depleted quickly rendering scarcity even for drinking water during summer months. Therefore, there is need for augmenting recharge by construction of water harvesting structures like bhandaras, sub – surface dykes, percolation ponds etc., so that these surface water bodies will help in augmenting ground water resources.

(ii) Investigations have revealed that ground water adjacent to stream course in the NE of Panjim is also polluted due to domestic sewage in addition to salinity problem. Hence, indiscriminate sewage disposal should be regulated.

(iii) Due to complexities of formations, structure and morphological control, bore wells have to be properly located with respect to lineaments. The areas having pre - monsoon water levels less than 9 m and fluctuations less than 6 m have been recommended for dug well development and in areas having greater than 9m pre – monsoon water levels and greater than 6m fluctuations, bore wells have been suggested for resource development.

(iv) The depth of the dug wells, which can be, developed in this district range between 8 to 15 m bgl depending upon topographic setup and thickness of the weathered zone. The depth of the well may be decided more precisely by referring to the depth to water level (Fig-3).

(v) Bore wells of 150 to 200 mm dia may be drilled upto a depth of 45 to 150 m depending upon local hydrogeological conditions.

(vi) Deeper ground water abstraction structures should be at least 0.5 km away from creeks and 400m away from coastline in low-lying areas to avoid quality problems.

---------- O ----------

CENTRAL GROUND WATER BOARD

MåüÇSìÏrÉ pÉÔÍqÉ eÉsÉ oÉÉåQïû

SOUTH WESTERN REGION,

SÍ¤ÉhÉ mÉÍ¶ÉqÉ ¤Éå§É,

27TH MAIN, 7TH CROSS, SECTOR I,

27uÉÉ qÉælÉ, 7uÉÉ ¢üÉxÉ, xÉåYOûU I

HSR LAYOUT, BENGALURU-560102

LcÉ LxÉ AÉU sÉå AÉEOû, oÉåÇaÉsÉÔÂ- 560102

PH – 080-22586965 FAX – 080-22586940

VISIT US AT – www.cgwb.gov.in