



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
SOUTH GOA DISTRICT, GOA STATE**



**SOUTH WESTERN REGION
BANGALORE
JULY 2010**

FOREWORD

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 2 districts of Goa state.

The South 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 Sri S.Sudarshana, Superintending Hydrogeologist, under the guidance of Dr. K.Md. Najeeb, Regional Director, Central Ground Water Board, South Western Region, Bangalore. Smt. Sandhya Yadav, Scientist-C assisted in the compilation of data from various sources.

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.

Sd/-
(T.M.HUNSE)
Regional Director

SOUTH GOA DISTRICT AT A GLANCE

Sl. No.	Items	Statistics		
1.	General Information			
	(i) Geographical area (sq. km.)	1,966		
	(ii) Administrative Division (as on 2005 - 06)			
	(a) Number of Taluks	5 (Sanguem, Canacona, Quepem, Salcete, Marmugao)		
	(b) Number of Villages	359		
	(iii) Population (as per 2001 Census)	5,89,095		
	(iv) Average Annual Rainfall (mm)	3110 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 river is Galjibagh. Non-perennial rivers viz. Sal, Saleri & Talpona.		
3.	Land Use (sq. km.)			
	(i) Forest area (ha)	90,431 ha		
	(ii) Net area sown (ha)	53,016 ha		
4.	Major soil types	Lateritic soil, Saline soil, Marshy soil, Alluvial soil (along north western & western part).		
5.	Area under principal crops (as on 2005 - 06)	Crops	Area (ha)	
		Paddy	22572	
		Cereals millets/ pulses & oil seeds	2147	
		Sugarcane	870	
		Coconut	14157	
		Arecanut	220	
		Cashew nut	14912	
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	1239.17 ha	1261	
	(ii) Tube wells (Shallow; Deep)	43 ha (34.5 ha; 8.5 ha)	19 (16; 3)	
	(iii) Tanks / Ponds	-	161	
	(iv) Canals	6454 ha	3	
	(v) Other sources: (a) Lift Irrigation Schemes (b) Surface Flow irrigation	(a) 2031.25 ha (b) 2451.45 ha	(a) 539 (b) 982	
	(vi) Net irrigated area	12,218.87 ha		

7.	Number of ground water monitoring wells of Central Ground Water Board (as on 31.03.2007)	
	(i) Dug wells	19
	(ii) Piezometers	7
8.	Predominant Geological Formations	<p>(a) Mainly formations of Goa Group, comprising: Schist (major part), Greywacke with conglomerate, and Metabasalt.</p> <p>(b) Formations of Peninsular Gneissic Complex, comprising: Granite gneiss & Granite (small patches).</p> <p>Beach sand (thin strip towards western coastal part of the district).</p> <p>Vast portion of the rocks (viz. schist, greywacke with conglomerate & metabasalts) is lateritised.</p>
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 2009 (in m bgl)	1.49 to 14.90
	(iii) Post – monsoon depth to water level during Nov. 2009 (in m bgl)	0.74 to 14.50
	(iv) Long term water level trend in 10 years (1999 – 2009) (in m/year)	
	(a) Pre – monsoon – Range from a decline of 0.83 m – rise of 3.09m.	
	(b) Post – monsoon – Range from a decline of 1.40 m – rise of 3.41 m.	
10.	Ground water exploration by Central Ground Water Board (as on 31.03.07)	
	(i) Number of wells drilled	
	(a) Exploratory Drilling Programme	(a) 30EW; 11 OW; Total - 41
	(b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State)	(b) 12
	(c) Hydrology Project Phase - II	(c) 3 PZ
	(ii) Depth Range (m bgl)	
	(a) Exploratory Drilling Programme	(a) 12.40 - 202 m bgl
	(b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State)	(b) 28.20 – 126.50 m bgl
	(iii) Discharge (litres per second)	
	(a) Exploratory Drilling Programme	(a) 0.18 – 10.0 lps
	(b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State)	(b) 0.35 – 7.80 lps
	(iv) Sp. Capacity (m ³ /day/m)	
	(a) Exploratory Drilling Programme	(a) 0.46 – 200.78
	(b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State)	(b) – Not computed -

	(v) Transmissivity (m ² /day) (a) Exploratory Drilling Programme (b) Deposit well construction (Under Caboraj Niwas & Western Ghat Development Programme of Goa State)	(a) 0.19 - 1216 (b) – Not computed -
11.	Ground water quality	
	(i) Presence of chemical constituents more than permissible limit	Saline due to seawater ingress in inland aquifers along tidal river courses. Ground water in general is of good quality and free from fluoride, nitrate & alkali hazards.
	(ii) Type of water	Calcium – Bicarbonate Type
12.	Dynamic ground water resource (2004)	
	(i) Net ground water availability (ham)	9357.91
	(ii) Total Annual Ground Water Draft (ham)	2454.49
	(iii) Projected demand for domestic & industrial uses upto 2025 (ham)	1874.55
	(iv) Stage of ground water development (%)	26 % (SAFE)
13.	Awareness & Training activity	
	(i) Mass awareness programmes organized	1 (i) On “Hydrological Information System” – under Hydrology Project – II.
	(a) Date	(i) 27.11.2008
	(b) Place	(i) Madgaon, South Goa
	(ii) Training Programmes organized	1 (i) On “Hydrological Information System” – under Hydrology Project – II, on 27.11.2008, Madgaon, South 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.	<p>Major ground water problems & issues</p>	<ul style="list-style-type: none"> ● 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. ● Seawater ingress: Water table aquifers around Marmugao, especially locations close to and in the vicinity of creeks shows high electrical conductivity & chloride indicating brackish to saline nature of ground water. <p>In areas confined to the vicinity of creeks of Sal River, ground water is brackish and unsuitable for drinking. Salinity is more pronounced during May when fresh water flow is minimum and maximum seawater ingress takes place.</p>
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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. South Goa district lies in the southern part of Goa state. The geographical area of the district is 1966 sq.km, and is situated between north latitudes 14° 54' 00" & 15° 29' 30" and between east longitudes 73° 47' 00" & 74° 20' 30". The district is bounded by Tiswadi, Ponda and Satari taluks of North Goa district in the north, Uttara Kannada district of Karnataka in the east & south, and in the west by the Arabian Sea.

1.2 Administrative set up

Madgaon is the district headquarters of South Goa district. The district comprises of 5 taluks namely, Sanguem, Canacona, Quepem, Salcete and Marmugao (**Figure 1**). There are 359 villages and 17 towns, out of which, 7 are Municipal towns.

1.3 Population

Population of the district (as per 2001 Census) is 5,89,095 with a population density of 300 per sq. km.

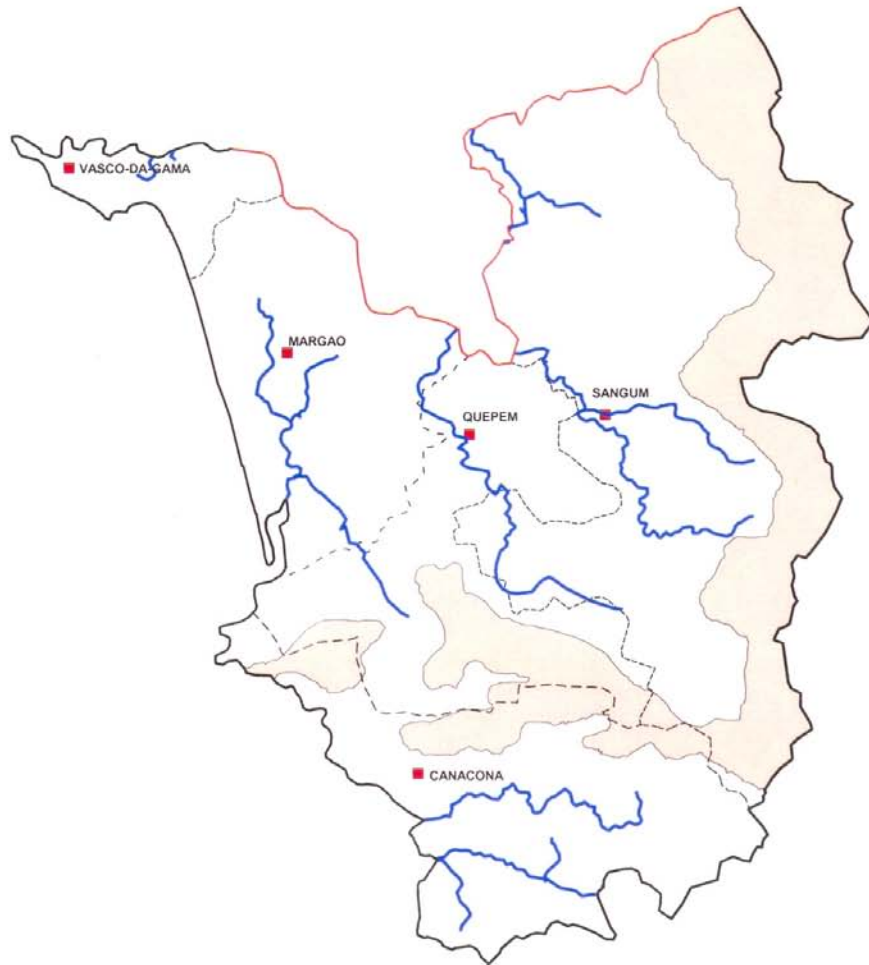
1.4 Physiography & Drainage

Physiographically South 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 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 river draining through the district is Galjibagh and non – perennial (seasonal) rivers are Sal, Saleri & Talpona. The river basin of westerly flowing Galjibagh river 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 river valley is 'V' shaped in the western high hill ranges, but broadens in central midlands and become 'U' shaped in the low lands and coastal plains.

INDEX MAP SOUTH GOA DISTRICT GOA STATE



LEGEND

- | | |
|--|--|
|  Hill area |  State boundary |
|  Drainage/streams |  District boundary |
| |  Taluk boundary |
| |  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 2005 – 06 was 22572 ha, accounting for nearly 35.32% of the Gross Cropped Area (63914 ha). Other crops grown are cereals, millets, pulses & oil seeds, which constitute an area of 2147 ha (3.36%), sugarcane 870 ha (1.36%), coconut 14157 ha (22.15%), arecanut 220 ha (0.34%) and cashewnut 14912 ha (23.33%).

Irrigation potential created as on March 2000 by the Salauli Irrigation Project was 4614 ha in Sanguem, Quepem and Salcete taluks of South Goa district. Irrigation by different sources, as per Third Census of Minor Irrigation Schemes 2000 – 01 is illustrated in Table 1.

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 South Goa district, 5 nos. in Canacona and 7 nos. in Sanguem taluks respectively.

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	1261	1239.17
2.	Shallow tube wells	16	34.50
3.	Deep tube wells	3	8.50
4.	Lift irrigation schemes	539	2031.25
5.	Surface flow irrigation	982	2451.45
TOTAL		2801	5764.87

Under Exploratory Drilling Programme of CGWB, 30 exploratory wells & 11 observation wells were drilled to study 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 26 monitoring stations (19 dug wells and 7 piezometers).

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, various activities have been taken up by CGWB in the state of Goa and in the district as well. The activities comprise, preliminary field investigations, interactive sessions of central with state agencies, establishment of ground water monitoring stations in consultation with state agencies, finalization of sites for piezometer construction, data compilation & digitization of relevant maps and meetings of the expert committee constituted for the project. 3 nos. of piezometers have been constructed in South Goa district. One mass awareness and one 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° C during monsoon season and increases to the maximum of 10 to 20°C during December & January. May is the hottest month where the mean daily temperature increases to 30°C. January is the coolest with mean daily temperature of about 23°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°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 Ghat, with average annual rainfall 2875 mm (in Salcete taluk) & 2466 mm (Marmugao taluk) respectively to 3825 mm (in Sanguem 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 Type

Soils of the district can be classified into 4 types namely (i) Laterite soil (ii) Saline soil (iii) Marshy soil and (iv) 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, Sal, Saleri, Talpona and Galjibagh rivers in Salcete, Marmugao, Quepem and Canacona taluks. It also occurs to a very limited extent in Sanguem taluk. The soil is deep, poorly drained and less permeable. It is saline, high in pH and contains humus and organic matter.
- (iii) Marshy soil occurs to a large extent in Salcete taluk and towards the western part of Canacona taluk. It also occurs in Marmugao taluk. This type of soil occurs in low-lying water logged and tidal affected areas.

- (iv) Alluvial soil occurs as very thin strip along the coastline towards western part of Salcete taluk and also a limited exposure occurs in Canacona taluk. 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 South Goa district is given as table-2.

4.2 Distribution of rock types

South Goa district is dominantly covered by the formation of Goa Group belonging to Dharwar Super Group of Archaean to Proterozoic 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.

Table 2: STRATIGRAPHY OF SOUTH 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, metabasalt and meta gabbro
		Sanvordem Formation	Greywacke with conglomerate
			Quartzite
		Barcem Formation	Quartz-chlorite schist
			Meta-acid volcanics
Metabasalt			
Orthoquartzite			
Archaean	Peninsular Gneissic complex		Granite Gneiss, Migmatites and Granites

Metabasalts are also extensively exposed in Canacona and Marmugao taluks and also as small outcrops in Salcete & Sanguem Taluks.

Exposures of greywacke with conglomerate are found to occur in Quepem, Canacona and Sanguem taluks.

Granite gneiss is found to occur in large portion of Salcete taluk and limited exposures are in Quepem, Canacona and Sanguem taluks.

Small outcrops of granite are found to occur in Canacona and Sanguem taluks.

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 South Goa district.

Coastal alluvium occurs as thin strip along the coastal plains in western part of Salcete taluk. It consists of fine to coarse sands with intercalations of sandy loam, silt and clay.

4.3 Structural geology

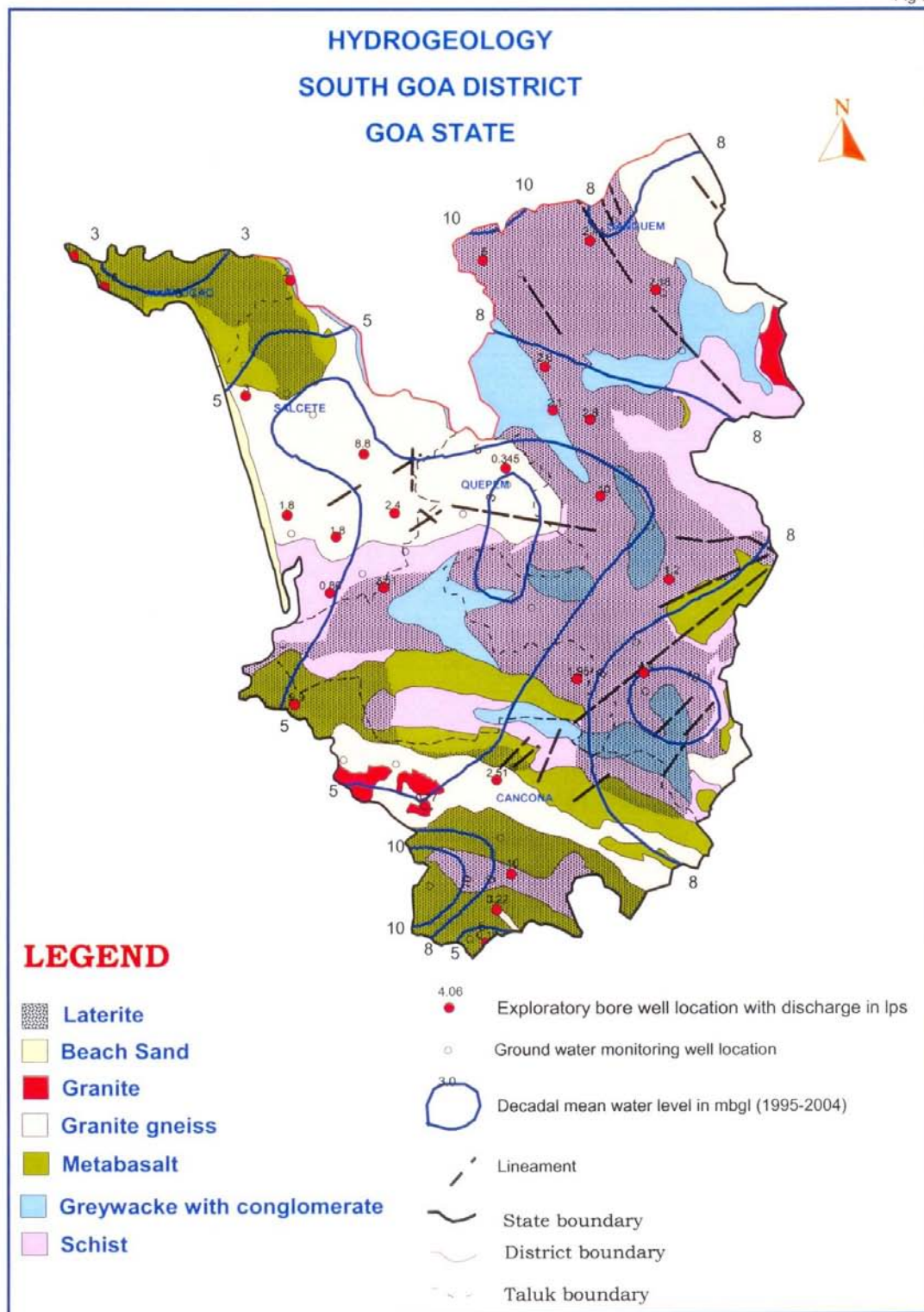
The Goa group of rocks is disposed in a general NW – SE direction. The rock types indicate three cycles of folding. The straight coastline suggests the major fault along the west coast. Associated with this fault a number of weak planes have developed. Western Ghat, which extends in NS to NNW – SSE direction 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. On account of various tectonic movements, the rocks have developed many fractured and joint zones up to 30 to 50 m bgl, as evident from borehole sections at Quepem. In Sacordem area in the district, NE – SW trending faults are exposed in Sacordem Iron Ore deposit along fold axis.

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, granite gneiss, metavolcanics and metasedimentaries. Hydrogeological map is illustrated in **Figure 2**.



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 m³/day/m. Promising ground water bearing areas are located near Kasapural area in Sanguem and Arelm area in Salcete taluk.

Alluvium

Alluvium constitutes good aquifers and is restricted to banks of rivers. 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 & 3.00 lps. Specific capacities vary between 27.10 & 200.78 m³/day/m and transmissivity varies from 25.44 – 177.50 m²/day.

Granite and Granite Gneiss

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 m³/day/m. Exploratory bore holes drilled in granite and granitic gneiss 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 m³/day/m and transmissivity from 0.87 to 34.60 m²/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 m³/day/m.

Exploratory 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 m³/day/m and transmissivity varied from 0.25 to 346.10 m²/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 m³/day/m.

5.1.2 Depth to water level

i) Pre-Monsoon of 2009:

The Depth to water level ranged from 1.49 to 14.90 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 less than 2 to 20 m bgl. Water level in the range of 10 to 20 m bgl is seen as small pockets in Salcete, Quepem, Canacona & Sanguem taluks.

i) Post-Monsoon of 2009:

The Depth to water level ranged from 0.74 to 14.50 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 5**. 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 Sanguem & Quepem taluks, 2 – 5 m bgl occur in major portions of Marmugao, Salcete, Quepem, Sanguem & Canacona taluks, 5 – 10 m bgl occur in Marmugao, Salcete, Sanguem & Canacona taluks. Water level in the range of 10 – 20 m bgl occurs as a small pocket in Canacona taluk.

5.1.3 Seasonal ground water level fluctuation

Water levels from 15 stations were compared to know the change in water level between pre-monsoon and post monsoon of 2009. While 14 stations recorded rise in water levels 1 station recorded fall in water level.

Fig-3

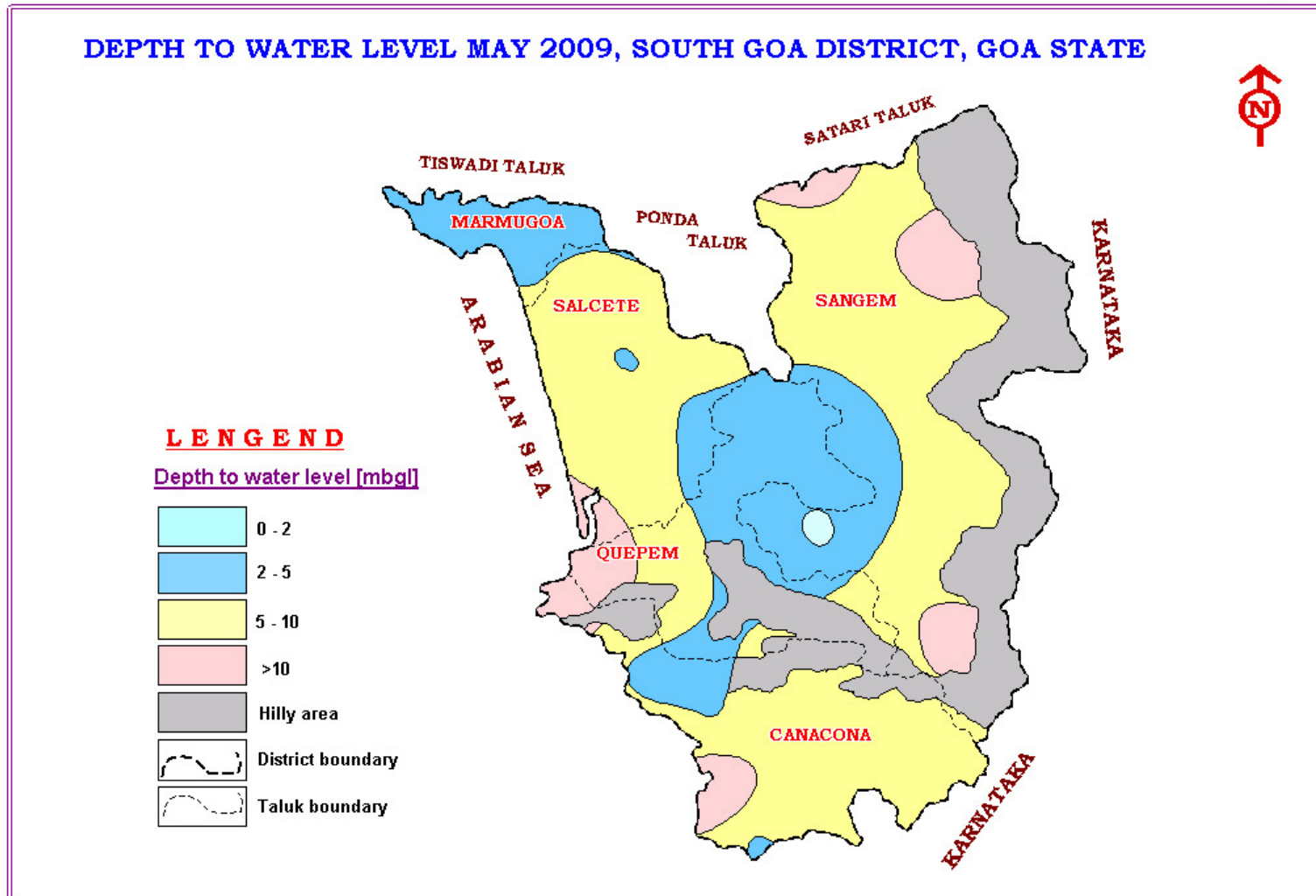
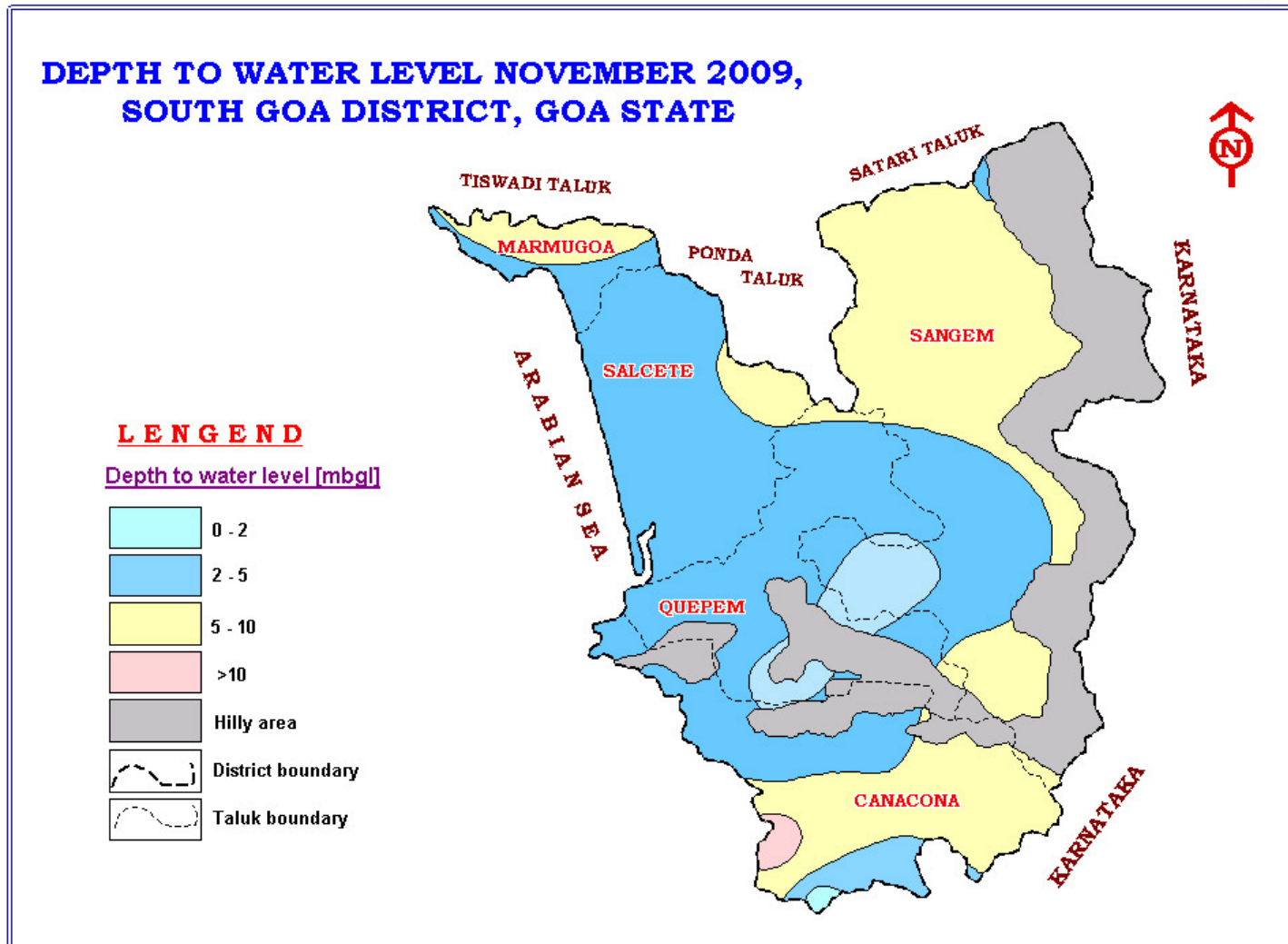


Fig.4



5.1.4 Long – term water level trend

i) Pre monsoon:

Water levels from 21 stations were compared to know the decadal change in water level during pre monsoon 2009. While 1 station recorded rise in water level 20 stations recorded fall in water level

ii) Post monsoon:

Water levels from 17 stations were compared to know the decadal change in water level during post monsoon 2009. While 10 stations recorded rise in water levels 7 stations recorded fall in water level

5.2 Aquifer system encountered in the district

Under ground water exploration programme of CGWB, in South 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 3.

Table 3: Formation wise aquifer parameters in South Goa district

Formation/Aquifers	Yield (lps)	Drawdown (m)	Sp. Capacity (m ³ /d/m)	Transmissivity (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 2004) is mentioned in Table 4.

Table 4: Taluk wise ground water resource potential of South 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 2004				
								SAFE AREA (%)	SEMI-CRITICAL AREA (%)	CRITICAL AREA (%)	OE AREA (%)	
Sanguem	1625.21	354.43	155.34	509.77	203.91	1066.87	31	SAFE				
Canacona	1161.43	327.96	106.65	434.62	140.00	693.46	37	SAFE				
Quepem	2637.75	180.01	179.47	359.47	235.58	2222.16	14	SAFE				
Salcete	1946.90	56.81	635.20	692.01	833.82	1056.27	36	SAFE				
Marmugao	1986.63	107.26	351.37	458.63	461.24	1418.14	23	SAFE				
TOTAL	9357.91	1026.47	1428.02	2454.49	1874.55	6456.89	26	SAFE				

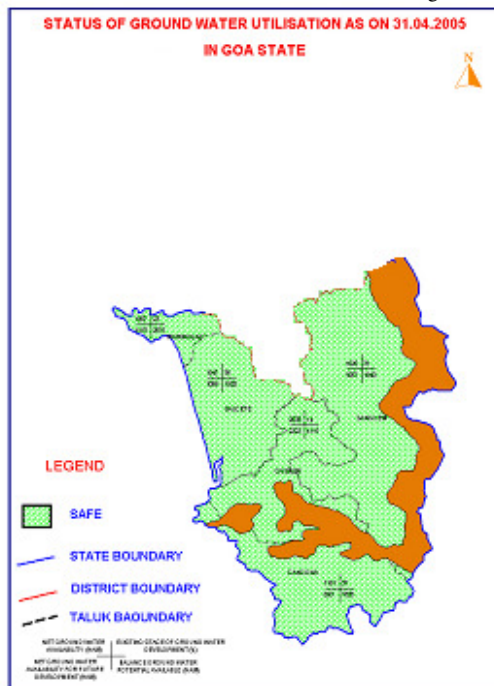
As illustrated in Table 4 and Map (**Figure 5**), there is good scope of ground water exploitation in all the 5 taluks of South Goa district. All the 5 taluks are 100% SAFE for ground water exploitation. However, there are pockets of declining water level in Quepem taluk of South Goa district. On the basis of long term water level trend (1995 – 2005) considered for computation of ground water resource, pre – monsoon trend of 11% of the observation wells in Sanguem, 14% in Canacona and 16% in Quepem taluks have recorded declining trend. Hence, ground water development may be regulated in such pockets.

Declining long-term post – monsoon trend has been observed in 40% of observation wells falling in Quepem taluk of South Goa. However, rest of the wells has shown rising trend.

5.4 Ground water quality

Ground water of the district is free from fluoride, nitrate and alkali hazards. In general the quality is good and potable. However, water table aquifers around Marmugao, especially locations close to and in the vicinity of creeks shows high electrical conductivity & chloride indicating brackish to saline nature of ground water. This can be attributed to seawater ingress in inland water table aquifers. In addition to this in areas confined to the vicinity of creeks of Sal River, ground water is brackish and unsuitable for drinking. The spatial distribution of saline water is given in **Figure 6**.

Figure-5



5.5 Status of groundwater development

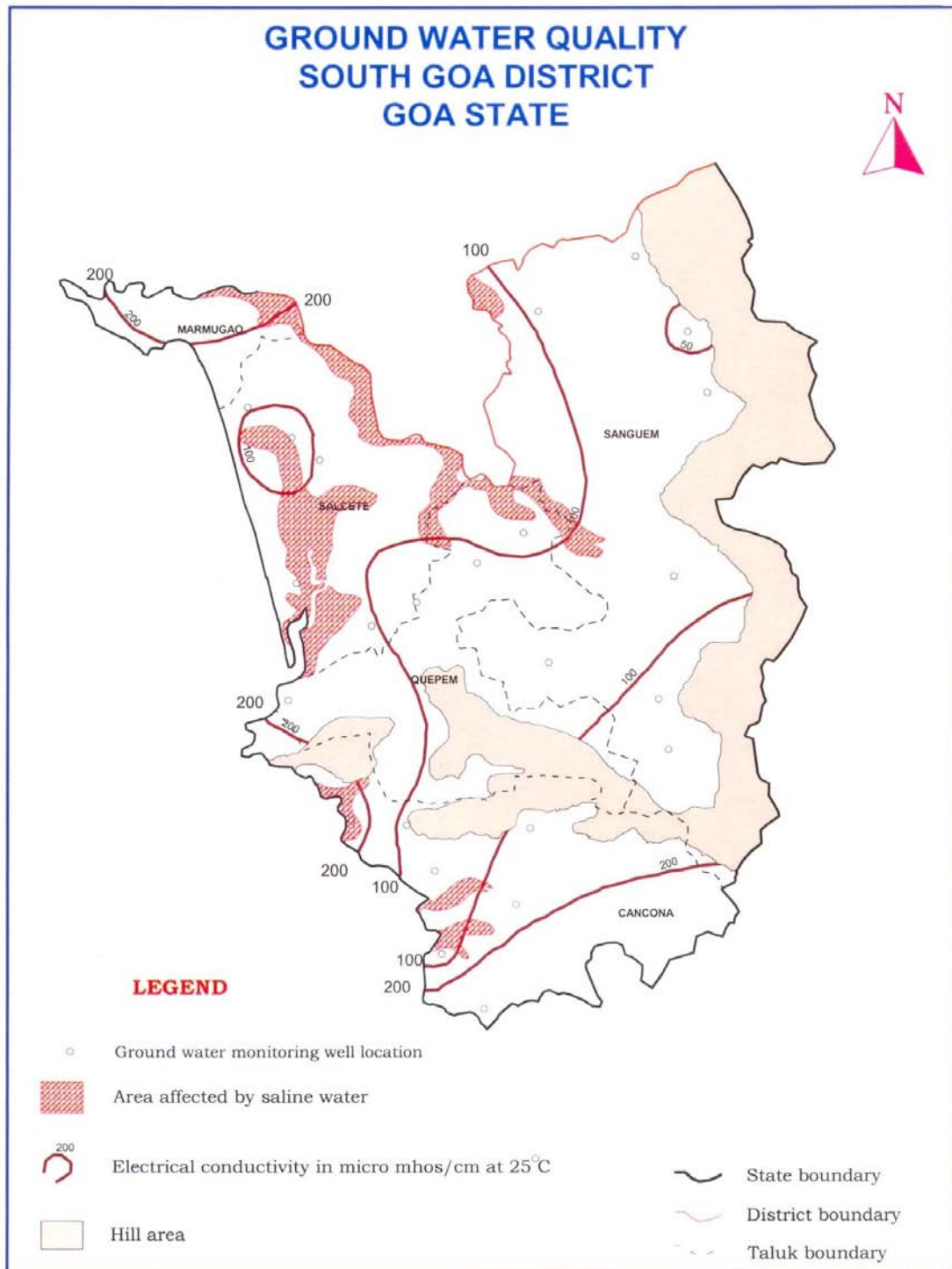
Dug wells are mainly the ground water abstraction structure in use for irrigation purposes in all the taluks. Shallow and deep tube wells are not much in use for irrigation purposes. Surface water irrigation is extensively prevalent in all the taluks of the district. Lift irrigation schemes are also being executed extensively in Sanguem and Quepem taluks. The details of ground water abstraction structures constructed under various minor irrigation schemes in South Goa district are mentioned in **Table 5**.

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

Sl. No.	Taluk	Dug wells	Shallow tube wells	Deep tube wells	Surface flow irrigation	Lift irrigation
1.	Sanguem	405	5	1	314	388
2.	Quepem	173	1	-	237	100
3.	Salcete	88	-	-	164	26
4.	Marmugao	109	-	-	73	1
5.	Canacona	486	10	2	194	24
	TOTAL	1261	16	3	982	539

Source: IIIrd Census of Minor Irrigation Schemes 2000 – 01

Fig-6



6.0 Ground water management strategy

6.1 Ground water development

Stage of ground water development in the district is 26% 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 200m dia may be drilled from 45 to 150m depths as per 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.

In this regard, Department of Water Resources, Govt. of Goa, has taken up various projects pertaining to inter linking of rivers in the district, post – monsoon water harvesting and canals.

7.0 Ground water related issues & problems

Water table aquifers around Marmugao, especially locations close to and in the vicinity of creeks shows high electrical conductivity & chloride indicating brackish to saline nature of ground water. This can be attributed to seawater ingress in

inland water table aquifers. In addition to this in areas confined to the vicinity of creeks of Sal River, ground water is brackish and unsuitable for drinking. Salinity is more pronounced during May when fresh water flow is minimum and maximum seawater ingress takes place.

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 Awareness Programme on “Hydrological Information System” under Hydrology Project - II, organized by Central Ground Water Board

Awareness Programme on “Hydrological Information System”, was organized under Hydrology Project – II, on 27.11.2008 at Madgaon, South Goa. The programme was attended by the representatives of State Govt. departments and members of Hydrology Project user group.

8.2 Training Programme on “Hydrological Information System” under Hydrology Project - II, organized by Central Ground Water Board

Training programme on “Hydrological Information System”, was organized under Hydrology Project – II, on 27.11.2008, at Madgaon, South 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 in South 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) 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.
- (iii) Bore wells of 150 to 200 mm diameter may be drilled from 45 to 150 m depth depending upon local hydrogeological conditions.
- (iv) Investigations have revealed that water table aquifers around Marmugao, especially locations close to and in the vicinity of creeks shows high electrical conductivity & chloride indicating brackish to saline nature of ground water. This can be attributed to seawater ingress in inland water table aquifers. In addition to this in areas confined to the vicinity of creeks of Sal River, ground water is brackish and unsuitable for drinking. Thus it is recommended that 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.