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GOVERNMENT OF INDIA

MINISTRY OF WATER RESOURCES

GROUNDWATER INFORMATION BOOKLET

South Andaman District, A&N ISLANDS

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South Andaman District at a Glance

Sl. NO	Items	Statistics
1	**GENERAL INFORMATION**	
	i) Geographical area(Sq.Km.)	3106
	ii) Administrative Divisions (as on 31.03.2013)	
	• No. of Zilla Parishad	1
	• No. of Subdivisions	1
	• No. of Blocks/Tehsils	3
	• No. of Municipalities	1
	• No. of Gram panchayats	29
	• No. of revenue villages	99
	• No. of census villages	167
	• Inhabited villages	160
	• Un-inhabited villages	7
	• Urban area	26.34 Sq.Km
	• Rural area	3079.66 Sq.Km
	• Total number of islands in the district	99
	• Number of inhabited islands	11
	• Biggest inhabited islands	South Andaman
	• Smallest inhabited islands	Flat Bay
	• Southernmost island	Little Andaman
	• Northern most Island	South Andaman
	• Highest Peak	Mount Harriet
	iii) Population (as per 2011 census with population density per sq. km.)	2,37,586(80 per sq.km.),Male-1,26,804; Female-1,10,782; Tribal population-2600
	iv) Normal annual rainfall(in mm)	3180
	v) Actual Rainfall (in mm) as in 2012	3116.6 in Port Blair & ,2779.2 in Little Andaman
2	**GEOMORPHOLOGY**	
	Major physiographic units	1. Low to moderately high steep hills 2. Intermontane narrow valleys. 3. Gently sloping narrow to moderately wide coastal plain(0.02-0.8 km) Overall altitude of the islands varies from sea level to 465m.

Sl.No	Items	Statistics
3	**MAJOR DRAINAGES**	Dhanikhari,Mithakhari, Burmanala, Pemanala,Prothrapur nala in South Andaman and Chandan Nala in Little Andaman
4	**LAND USE(SQ.KM) as on 2012**	
	a. Forest area(Sq.Km)	3106.00
	b. Reporting Area for land utilization(Sq.Km)	2814.32
	c. Area under cultivation(Sq.Km)	2672.94.
	d. Not available for Cultivation(Sq.Km)	2729.48
	e. Other uncultivated land excluding fallow land(Sq.Km)	2840.98
	f. Current fallow(Sq.Km))	3.43
	g. Fallow lands other than current fallows(Sq.Km)	13.21
	h. Net area sown(Sq.Km)	69.03
	i. Area sown more than once(Sq.Km)	2.47
	j. Area submerged after tsunami(Sq.Km)	12.79
5	**MAZOR SOIL TYPES**	Entisols,Inceptisols and alfisols
6	**AREA UNDER PRINCIPAL CROPS(as on 2012)**	Paddy, pulses, oilseeds, vegetables, coconut, arecanut, fruits, sugar cane, root crops
7	**IRRIGATION BY DIFFERENT SOURCES(No. of structures & area in Sq.Km. as on 2012)**	
	Dugwells- 734 nos	7.34 Sq.Km.
	Borewells- 130 nos	3.25 Sq.Km
	Check Dams - 80 nos	5.62 Sq.Km
	Ponds/Tanks - 499 nos.	4.99 Sq.Km
	Actual area irrigated by ground water	10.59 Sq.Km
	Actual area irrigated by surface water	10.61 Sq.Km
	Total irrigated area	21.20 Sq.Km
8	**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB(As on 2012)**	Formerly it was 65 (till 2012 April). Numbers increased up to 85 nos. during December,2012
	No. of Dugwells	83

	No. of Piezometers	2
9	**PREDOMINANT GEOLOGICAL FORMATIONS**	Marine Sedimentary formations(Mithakhari & Flysch) comprising Fine grained sandstone, siltsone, shale, conglomerate;Ignoeous ophiolite suite comprising Acid- & Intermediate lava, Pillow basalt, Ultramafic rocks; chalk, mudstone, coralline limestone of Archipelago Group
10	**HYDROGEOLOGY**	
	Major water bearing formation	Ground water in Marine sedimentary formation occurs under unconfined condition in weathered residuum. Preponderance of clayey mineral render groundwater development possibility very low. Yield of dugwell(5-6m dia,6m depth)in Marine sedimentary group varies from 4000-5000 litres/day. Ground water in Ophiolites occurs under unconfined to semiconfined condition in weathered residuum while in fractured hard rock in deeper horizon in confined condition.Yield of dugwell(5-6m dia,6m depth)in Marine sedimentary group varies from 40,000-50000 litres/day.In case of borewell(6// dia,80m deep) yield varies from 80,000-1,00,000 litres per day. In Coralline limestone in archipelago group yield of dugwell(5-6m dia,6m depth)varies from 80,000-1,00,000 litres/day. Springs are profuse in all the geological formations. However, springs are sustainable in ophiolites and archipelago group.
	Premonsoon depth to water level during 2012	3-8m below ground level
	Postmonsoon depth to water level during 2012	1.5-5m below ground level
	Long term water level trend in 10 years(2002-2012) in m/yr	The water level trend has been analysed for all measurements and found that there is a rising trend varying from 0.021 to 1.196m/yr

11	**GROUND WATER EXPLORATION BY CGWB(as on 31.3.2012)**	
	No. of wells drilled	18 nos.
	Depth range	15.50m-128.60m
	Discharge	Negligible-45m^3/hr
	Storativity(S)	6.19x10-^{4}-9.65x10-^{4}
	Transmissivity(T)	112.3-211.1m^2/day
12	**GROUND WATER QUALITY**	
	Presence of Chemical constituents more than the permissible limit	High Iron in pockets and brackishness in dugwells close to the coastal tracts
	Type of water	Ca-Mg-HCo_3-Na- HCo_3
13	**DYNAMIC GROUNDWATER RESOURCES (As on 2008-2009) in** Hectare metre	
	Annual net Groundwater resources available	14846.41 Hectare metre
	Gross Groundwater draft for all uses	793.57 Hectare metre
	For irrigational use	51.27 Hectare metre
	For domestic & industrial use	742.30 Hectare metre
	Projected demand for domestic & industrial use up to 2025	458.85
	Stage of Groundwater development	2.58%
14	**AWARENESS AND TRAINING ACTIVITY**	
	Number of mass awareness programme organized	1(one)
	Number of Water management training programme organized	Two Under IEC(One),Under RGI(One)
15	**EFFORTS OF ARTIFICIAL RECHARGE AND RAINWATER HARVESTING**	
	Projects completed by CGWB (Nos. and amount spent)	Three. Executing agency was PHED, APWD, A&N Administration. Total amount spent-16.29 lakhs of which 12.92 Lakhs was provided by MOWR through CGWB while the rest 3.37 lakhs was spent from A&N Administration funds.
	Projects completed under technical guidance of CGWB (Nos.)	
16	**GROUNDWATER CONTROL AND REGULATION**	

	No. of over-exploited blocks	Nil
	No. of critical blocks	Nil
	No. of blocks notified	Nil
17	**MAJOR GROUNDWATER RELATED PROBLEMS AND ISSUES**	High iron in groundwater in some pockets. Water scarcity in the islands. Optimum rainwater harvesting in the islands through needful structures. Qualitative problems (salinity) in Neil and Havelock islands due to increase in population & agricultural activities. Post-tsunami changes on quantity and Quality of groundwater resources. Intensive groundwater surveillance and monitoring system in Neil,Havelock and parts of South Andaman islands to adjudge overdevelopment.

1.0 INTRODUCTION

1.1 Location and Administrative details: South Andaman district is located almost in the central part of the Union Territory of A&N islands and it is separated from North-Middle Andaman district by Middle Strait and Nicobar district by 10^0 channel in Indian ocean. The district of South Andaman (Fig-1.1) is comprising one Subdivision, three blocks/ Tehsils and a Zila Parishad. Port Blair is the district and Subdivisional Headquarters of South Andaman. It is also the capital town of the union Territory of A&N Islands. Port Blair is well connected with the major cities of Indian mainland like Kolkata,Chennai and Visakhapattanam(Visag) by sea routes, while Chennai and Kolkata and New Delhi are connected to Port Blair by daily air services. Recently another direct air service from New Delhi to Port Blair via Bhubaneswar is introduced. Besides, the capital of the UT is connected to the other islands by inter island ships, Helicopter services maintained by Pawan Hans. Recenly Sea plane service is introduced which ply in the islands of Noth-Middle and South Andaman district.

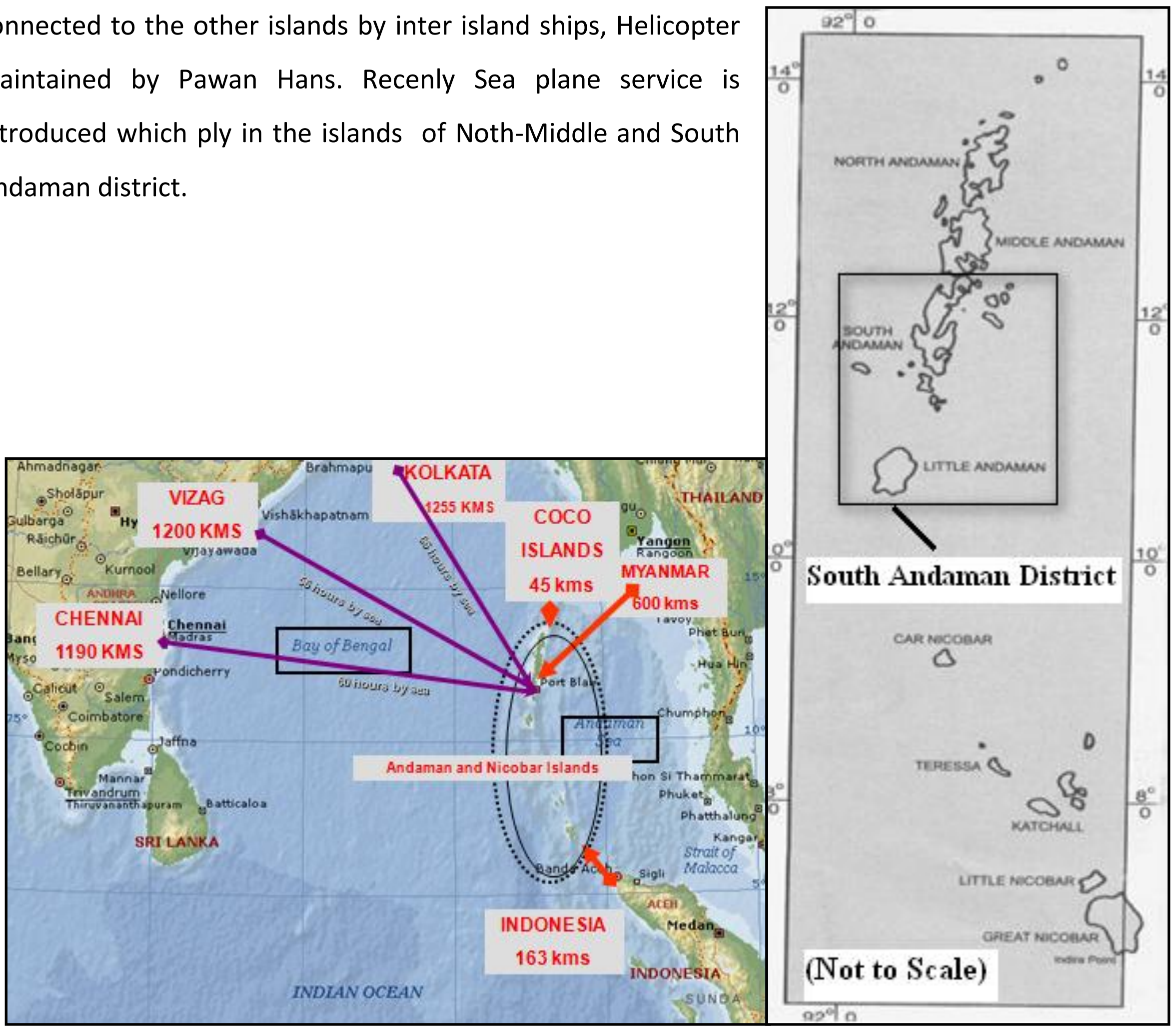


Fig-1.1 Location and Administrative Map of South Andaman district

1.2 Population: As per 2011 census,population of South Andaman district is 2,37,586, where Male population was 1,26,804 and Female 1,10,782. The population density is 80 per Sq. Km.. Total population of primitive Tribes in the district is 2600 which comprises Jarawa(in South Andaman Island), Ongi(in Little Andaman),Great Andamanese(in Strait island) and Sentinelese(in Sentinel island).

1.3 Land use Forest covers a major part of the district. Since inception of the colonial British Raj, the forests in and around Port Blair and in parts of South Andaman island were cut to make room for establishments for Penal settlement and agriculture. After fifties there had been considerable loss of forestry for settlement of the refugees from East Pakistan now Bangladesh in South Andaman, Neil, Havelock and Little Andaman islands of the South Andaman district. Gradually the land use for settlement has been increased in the past few decades because of exodus of people from all over main land in search of livelihood. The low lying lands, mostly under utilisation for settlement and agriculture, were submerged under sea water due to the subsidence of many parts of South Andaman island after the mega earthquake(M=9.3) on 26.12.2004. The land use of South Andaman district is enumerated below(Table-1.4.1)

Table- 1.4.1 Land use in South Andaman District

Item	Land use in Sq.Km. (as in 2012)
Total Geographical Area	3106.00
Reporting Area for land utilization	2814.32
Forest area	2694.00
Not available for Cultivation	27.29
Other uncultivated land excluding follow Land	28.41
Current fallow	3.43
Fallow lands other than current fallows	13.21
Net area sown	69.03
Area sown more than once	2.47
Area submerged after Post-tsunami	12.79

Source: Dept. of Economics and Statistics,A&N Admn. , Andaman District

1.4 **Studies carried out by CGWB** Because of the absence of any groundwater surveys and investigation department in A&N Administration, all the ground water surveys and exploration in the islands are undertaken from time to time by CGWB and the erstwhile groundwater wing of Geological Survey of India . In 1967 the preliminary surveys and investigation for water supply in few habitations of Havelock & South Andaman Island was carried out by Shri D.P.Ghosh,Sr.Geologist of Geological Survey of India. In 1978-79 session Md.K.M.Najeeb, Jr.Hydrogeologist of CGWB had undertaken systematic hydrogeological surveys in Neil Island and in parts of South Andaman island. Systematic hydro-geological surveys and geophysical surveys coupled with groundwater exploration were taken up in South Andaman Island under the leadership of Shri I.Banerjee, Sr.Hydrogeologist, Eastern Region which continued from 1984 to 1990. Groundwater monitoring in the district although continued since 1990 or so but its systematic data has been kept recorded since 2000. The artificial recharge and conservation of rainwater and groundwater was initiated in 1998 by Sh. S.Bhattacharya, Scientist-B of CGWB, E.Region, and Kolkata. However, from 2000 onwards extensive studies on artificial recharge and rainwater harvesting were carried out by Shri A.Kar, Scientist-D. 50 sites were advocated for augmentation of water supply to APWD, PRI and defence of which 25 sites were executed. Very good promising results were obtained. Besides, CGWB (Kar, 2003&2005) has put forward the plan for optimum harvesting of surplus run-off, soil conservation through check dams in streams, construction of ponds, dug wells and bore wells for augmentation of irrigated agriculture. CGWB (Kar & Adhikari, 2005) has carried out impact assessment study of tsunami and earthquake on groundwater resources. In this connection CGWB has undertaken extensive surveys in the Post tsunami in all the inhabited islands including South Andaman while Geophysical surveys were also undertaken in South Andaman Island. In 2006-07 Reappraisal hydro geological surveys in Neil, Havelock and Little Andaman Island were undertaken under the supervision of Sh.A.Kar, Scientist-D. During 2008-10&2010-12 FPARP (Farmers participatory action research project) was carried out by Central Agricultural Research Institute (CARI), ICAR under the technical guidance of CGWB, E.Region, Kolkata.

1.5 Groundwater basin : There is no typical river occur which drains as also receives the entire run-off occur in the district as happens in mainland. More over the islands are discrete and separated by sea .However the major streams in the various islands fall in the district are described in the following chapter.

2.1 **Rainfall** The rainfall is received through South - West and North - East monsoons spans for the period from May to December. Average annual rainfall in these Islands is about 3000 mm while the normal annual rainfall at Port Blair is 3180 mm.

2.2 **Climate :** The islands in South Andaman district enjoy tropical humid climate because of their location in the equatorial zone surrounded by the Andaman Sea. The islands have only two seasons viz. Rainy Season and Summer Season Winter is virtually absent. The mean relative humidity is 79%.The mean maximum temperature is 30.2^{o}C and means minimum temperature is 23.8°C. The relative humidity varies from 79% to 89% and wind speed varies from 7 km/hr to 10km/hr. The maximum and minimum temperatures in the islands fluctuate between 27 to 33^{0}c and 21 to 25^{0}c. Daily evaporation rate in the island is fairly high which cumulatively ranges from 1500-1800 mm. per annum. The geographical localization is responsible for high average evaporation rate to the tune of 1500-1800mm per annum. Climatic aberration is highly effective for the availability of surface water and ground water in the islands. In few years in the past decade i.e in 2002 and 2007 the situation was so worsened that the Andaman and Nicobar Administration had to curtail the water supply in Port Blair and it was supplied only once in a week. The Dhanikhari Dam, the backbone of water supply to Port Blair was almost dried up during the years of rainfall aberration. In water scarce 2002, at the behest of Hon'ble Lt. Governor of A&N Islands, an urgent survey in the contiguous Rutland Island was carried out by CGWB(Kar,2002). Based upon the recommendation of CGWB, the project of Inter Island transfer Island of spring water was approved in 2009. To mitigate the water supply problem in Port Blair town, as a short term measure, the water supply through barges was started in 2002 itself. The intensive study revealed that nearly 36,54,722 Gallons of water per day may be available from Spring sources as also through tapping of base flow which can be obtained from the Rutland Island which is flowing to the sea .The water is currently catered to the Ships by Port Management Board. The work of interisland transfer of water is underway. In addition to this project, raising of Dhanikari dam by 5m is also approved by the A&N administration. The work is nearing completion. On completion, this will also facilitate the water supply sustainability to Port Blair town.

3.0 GEOMORPHOLOGY AND SOIL

3.1 Geomorphology: The size, shape and height ofa islands control the occurrence and movement of both surface and ground water resources to a considerable extent. Either or both types of water resources are likely to be available in larger quantities in wider and larger islands when compared to smaller and narrower islands. The width of a small island has major influence on the occurrence of ground water in basal aquifers.

Figure 4.1: Moderately high & Steep Hillock

Figure 4.2: An intermontane Valley

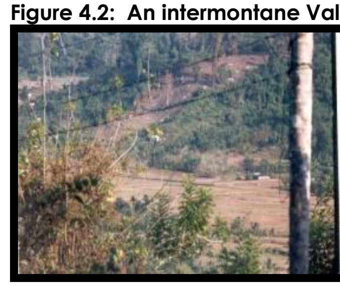


Figure 4.3: Gently Sloping Coastal Tract,

The islands in South Andaman District have varied topographical features. In general, barring a few small Islands, all the others have undulating terrain with main ridges running North-South. There are also spurs running East – West in between the main ridges. Deep inlets and creeks are formed by the submerged valleys. Flat lands are few. Coral reefs surround most of the Islands.

The islands generally feature a mountainous terrain with long ranges of hills and narrow valleys. The maximum altitude of these islands is at Mount Kavab, which is 460m above mean sea level. Mount Ford (435m, amsl) of Rutland island, and Mount Harriet(365m, amsl) are some of the high peaks in South Andaman The peaks i.e Mount Kavab and Mount Harriet ,are formed of marine sedimentary rocks . While Mount Ford is made of ophiolites(igneous). Geomorphology of South Andaman District is controlled by the geology and weathering characteristics of the rock types underlain.

Geomorphologically, theSouth Andaman District can be divided into the following five broad units.

1. Moderate to steep hill ranges having low to moderate heights. This type of geomorphology could be seen in the islands underlain by Marine Sedimentary group of rocks and Igneousophiolite rocks (Fig. 4.1). Examples are South Andaman,Rutland etc. Because of low infiltration capacity of Marine sedimentary rocks, many streams are generated in the tracts underlain by such rocks. While drainage density is high in such areas, ground water potential is low and springs although preponderant lose perenniality in lean periods cause water scarcity in rural areas of South Andaman with recession of monsoon. The islands with Ophiolites i.e. Rutland on the other hand have good ground water potential with perennial springs and drainage.

2. Narrow intermontane valleys (Fig. 4.2). This type of landform is formed in between the hills and could be seen in the afore said islands as mentioned under Sl. No. 1. In general the valleys are formed in the structurally weak planes i.e along the lineaments and may be termed as structural valleys

3. Narrow,gently sloping coastal tracts including swamps (Fig.4.3). These type of coastal landform could be seen in the islands underlain by Marine Sedimentaries contain mostly fine sand ,silt and clays. Since the length of the streams from hill to sea is less, the fluvial action on the rocks and sediments in their courses becomes less powerful. Consequently, owing to both the reasons larger clastics(sands,gravels and boulders) are not brought to the coast. Hence, in majority of the cases the beaches in such islands remain swampy and slender with low ground water potential in the lowlying areas. However, in cases where coral reefs are luxuriant around such islands, wide sandy beaches also could be seen. Example the Mahuadera(North Wadoo)r beach in the western coast of South Andaman Island etc.

4. Islands basically made of Coralline material (atoll) or having Clay-mudstone-chalk stone sequence in higher elevations with preponderance of coralline deposit in the low lying areas with very gentle slope and relatively wide coast encircling the islands. The uplifted atolls form low lying islands. Since the coral reefs are being denudated constantly in the shallower part of the sea because of wave action, huge quantity of coral lime sands are produced. They give rise to the formation of wider beaches. Examples of such islands areNeil, Jolly buoy, Havelock etc. In the higher elevations good springs are generated in Chalk stone which gives rise to few perennial streams as could be seen in Krishnanagar,Radhanagar and Vijoy Nagar on the way to Kalapathar village in Havelock island.The Coralline limestone in the lowlying areas form good repositories of ground water.

5. Rugged coast devoid of beaches . This type of coastal landform is visible in the islands or parts of the islands which are underlain by Ophioliticigneous rocks. Examples are Cinque Island,RutlandIsland,Barren(active) and Norcondom (dead) Volcanic islands, parts of South Andaman in between Chidiyatapu to Brookshabad. As the Ophiolites are highly fractured having good potential 7aof ground water, highly perennial as also potential springs are generated in such rocks which finally gives rise to many perennial streams like Burma Nala,Chiriyatapunala,LalmittyNala at Beadnabad,streams of Rutland etc.

3.2 Springs: The characteristic geological and geomorphologic conditions of the island have facilitated the origin of numerous springs in all the three major geological formations (i.e. Marine sedimentary group of rocks, volcanic and other igneous rocks and coralline limestone). The rural water supply in the entire district except Neil Island (Water supply in Neil is done from the wells) is maintained either directly from the springs or spring or spring fed perennial streams. These springs are, in general, formed in high altitudes because of good fracturing in the rocks. For this they also may be termed as fracture springs. However, the springs are highly yielding and sustainable in, igneous rocks and limestone as seen in Rutland (Kalapahar) and Cinque island underlain by igneous rocks and in Little Andaman and Havelock islands, underlain by limestone.

3.3 Soil

Soils in South Andaman, Rutland, Cinque, North Sentinel, Viper, Flat Bay etc Islands are mainly derived from sedimentary and igneous rocks like Sandstone, Silt stone, Shale Limestone and Mudstone and Igneous Ophiolite suite of rocks comprising Pillow lava,acid and intermediate volcanics, gabbro, Peridotite, Herzbergite etc. The soils in the islands are comprising alluvial soil,Sandy soil, Valley soil and Hilly soil. These soils are mostly deep to very deep, moderately to poorly drained ,clay to clayey loam with angular blocky to sub angular blocky structure. Granular structure could be seen in A&B horizons. Most of the alluvial soil is seen in valleys and used for Paddy in Kharif season, vegetables, pulses and oil seeds in Rabi season. Most of the plantation crop like coconut, arecanut are mostly cultivated in coastal plain and hilly land where slope is less than 10%. The valley land in South Andaman is most fertile as it is enriched in organic matter coming from the hillslope.

The soils of the other islands of South Andaman District like Havelock, Neil, Little Andaman, Strait islands are derived from the sedimentary rocks like Limestone, Coral sand, Mud stone etc. These soils are well drained with rapid permeability and are texturally classified as sandy,loamy sand,sandy loam. Plantation crops like, Coconut, arecanut, guava, mango, banana, sapota etc. are very well grown in such soils. Due to coarse soil structure there is no chance of water logging even during rainy season while high permeability also assures good moisture during dry spells and facilitate luxuriant growth of coconut, arecanut and root crops along the coastal stretches.

4.0 Agriculture and Irrigation:

4.1 Agriculture Agriculture is the mainstay of people in the district although the islands are not self dependent in matters of production of food grains. For this reason, the needful commodities are imported from the mainland. Tsunami and earthquake made a colossal impact on agriculture. Ministry of Agriculture, Govt. of India had taken up Rajiv Gandhi Rehabilitation project for agriculture for helping the affected people and rejuvenation of their agricultural practice. Agriculture is mostly rainfed. In the South Andaman district, agriculture is pivoting on ground water irrigation especially in Neil, Havelock and Little Andaman islands. In these islands vegetables are extensively grown. However, in the current decade irrigation facilities are created tapping groundwater and surface water sources. This has enabled the production of vegetables as also other crops in good quantity. Island wise cropping pattern is presented in the following table (Table-4.1).

4.2 Irrigation and Surface water resources : South Andaman district is endowed with sufficient rainfall. However, perennial springs and base flow are facilitating the perennial flow in some of the streams which is in the low key. In many of the streams even in summer. In many islands, surface runoff occurs rapidly after rainfall and recedes to little or no flow within hours. On low islands (i.e. Neil), surface water resources, if at all present, are likely to be in the form of shallow lakes. In South

Andaman district, drainage density is high, while in Havelock, Neil and Little Andaman Islands drainage systems are either absent or poor. However, potential springs are developed in such islands because of cavernous condition in Limestone. At places copious emanation from springs also give rise to potential drainage in Little Andaman Island.

In want of irrigation facility, the agriculture in the district was mainly rainfed. However, based upon the recommendation of CGWB(Kar,2003;Kar,2006) large scale rainwater harvesting through check dam was encouraged by the A&N Admn. and the practice was further accelerated in the Post tsunami under the Rajiv Gandhi Rehabilitation project for agriculture(Table-4.2).

Table- 4.1 Island wise cropping pattern in South Andaman District

Sl. No	Island	Crops Grown
1	Flat Bay	Vegetables,coconut,arecanut,spices
2	Havelock	Paddy,pulses,oilseeds,vegetables,coconut,arecanut,fruits,root crops
3	John Lawrence	Nil
4	Little Andaman	Paddy,Red oil palm,vegetables,coconut,arecanut,fruits
5	Neil	Paddy,pulses,oilseeds,vegetables,coconut,arecanut,fruits,spices
6	North Sentinnel	Nil
7	Rutland	Paddy,vegetables,coconut,arecanut,ginger,sugarcane
8	South Andaman	Paddy,vegetables,coconut,arecanut,fruits,spices,sugarcane
9	Strait	Vegetables,coconut,fruits
10	Viper	Coconut
11	Cinque	Nil

Source: Dept. of Economics and Statistics,A&N Admn.

Because of relatively less areal extent and paucity of catchments, the islands of South Andaman district are devoid of river systems. However, a few perennial streams such as Mithakhari Protheropore nala*,* Burma nala*,* Pema nala*,* Dhanikhari*,* Chandan nala etc. drain the South Andaman district. All the *nalas* meet the sea in Bays. The general drainage pattern of the islands varies from dendritic to sub-dendritic. However, land subsidence in the Post-tsunami have facilitated the tidal ingress along the streams of South Andaman island.

Table -4.2 : Source wise Irrigation and potential created in South Andaman

Sl No	Name of the Island	Source of Irrigation								Total irrigation potential created (Ha)
		Pond		Check dam		Dug well		Bore well		
		Total Pond constructd in various period	Irrigation Potential Created (Ha)	Dam constru-cted in various period	Irr. Pot. Created (Ha.)	Total Well constr-ucted in various period	Irr. Pot. Created (Ha.)	Total Bore well	Irr.potential created (Ha)	
1	South Andaman	403	435.97	74	520.14	358	358.0	130	325.0	1639.11
2	Little Andaman	43	31.53	Nil	Nil	138	138.0	nil	nil	169.53
3	Havelock	40	24.0	6	42.17	118	118.0	nil	Nil	184.17
4	Neil	13	7.8	Nil	Nil	120	120.0	nil	Nil	127.80

Source: RGRPA,Dept. of Agriculture,A&N Admn.

5.0 GROUND WATER SCENARIO

5.1 Geology

The Islands in the South Andaman district are composed mainly of thick Eocene sediments deposited on Pre-Tertiary sandstone, silt stone and shale with intrusions of basic and ultrabasic igneous rocks (Ophiolites). In the geologically Younger Richie's archipelago, calcareous sand stones are more common. The available geological evidence leads us to assume the possibility of a geological period when the Andaman and Nicobar Islands formed a range between Burma and Sumatra. The Andaman and Nicobar Islands with Preparis and Cocos formed a continuous hill connecting this with Burma (Myanmar) through Cape Negrais. The Tertiary sediments classified as the Mithakhari and Andaman Flysh Group comprises thinly bedded alternations of sandstones and siltstones, grit, conglomerate, limestones, shales, etc., are of Upper Cretaceous to Upper Eocene age. The Tertiary Group is overlain successively by the Archipelago Group, Nicobar Group and the Quaternary Holocene Group, intervening with unconformity. The generalized geological succession is given in **Table. 5.1**.

Marine inorganic sedimentary group of rocks comprising shale, sandstone, grit and conglomerate (Flysch and Mithakhari Groups) and organic sedimentaries like Coralline atolls and limestone and extrusive ad intrusive igneous rocks (volcanics and ultramafics) occupy the entire geographical area. Amongst these, the former (inorganic) Sedimentary group is most pervasive and occupy nearly 70% of the entire area of the islands while the Igneous group covers nearly 15% while the rest 15% goes to the coralline and limestone formations .All these rock formations are brought under tectonism because of their alignment in a tectonically active zone, evident from the occurrence of shallow and deep focus earthquakes in the islands. The last earthquake and devastation by tsunami were also the effect of tectonic setting of this archipelago in a converging plate margin. Because of tectonism, the igneous and Sedimentary groups of rocks are highly fractured and fissured. The fracturing in hard rocks form conduits for movement of ground water in the deeper horizon. The geology of the islands is highly varied and even changes within a small distance.

Table 5.1 Generalized Geological Succession of Andaman & Nicobar Islands

Age	Group	Formation
Recent to sub-Recent	Quaternary Holocene Group	Beach sands, Mangrove clay, Alluvium, Coral rags and Shell limestone, loosely consolidated pebble beds
--	**Unconformity**	--
Pleistocene to Late Pliocene	Nicobar Group	Shell limestone, Sandstone, Claystone, etc.
Miocene	Archipelago Group (Upper)	White claystone, Melville Limestone
--	**Unconformity**	--
Oligocene to Paleocene	Andaman Flysh , Mithakhari Group	Thinly bedded alternations of Sandstones and siltstones, grit, conglomerate, Limestones, black Shales with olistiliths.
--	**Unconformity**	--
Late Cretaceous	Ophiolite Group	Dyke swarms, acidic suite,Pillow lava with radiolarian chert and ultramafic suite.

5.2 Hydro geological framework

5.2.1 Pre-Tsunami

Hydrogeologically (Fig-5.2.1), the sedimentary rocks are very poor water yielder both in shallow and deeper horizons because of preponderance of clayey materials in them. As mentioned earlier although the sedimentary rocks possess fractures developed in them but these are highly clogged by the clayey residue. Hence in majority of the cases the exploratory boreholes drilled by CGWB in sedimentary formations did not yield water. The weathered horizon of such rock formations where dug wells are constructed also yield ground water in meagre quantity. A dug well having 5m diameter and 6m depth constructed in valley areas may yield maximum 4000-5000 litres/day.

The Igneous suite of rocks (Ophiolites) sustain good amount of water both in shallow and deeper horizons. Bore wells were being successfully constructed in these formations. A dug well 5m diameter and 6m depth used to yield to the tune of 15,000 to 30,000 liters/day , while a bore well 60m deep and 6" diameter yields 50,000 to 80,000 litres/day.

Amongst all these rock formations the Coralline formations and Limestones of Archipelago Group are the most potential and yield very high amount of water because of good porosity and permeability. In such terrains dug wells were constructed (Example - Little Andaman Island, Havelock and Neil island etc.). One dug well with the specification of 5m diameter and 6m depth may even yield to the tune of 50,000-1,50,000 litres /day .

Geology and topography facilitated origin of springs abundantly in all the three major geological formations (i.e Marine sedimentary group of rocks, volcanics and other igneous rocks and coralline limestone). The rural water supply in the entire South Andaman District barring Neil Island (Water supply is done in this Island only from the wells) is maintained either directly from the springs or spring or spring fed perennial streams along with dug wells with subsurface dyke and check dams. These springs are generally formed in high altitudes because of good fracturing in the rocks . For this they also may be termed as fracture springs. However, the springs are highly yielding and sustainable in, igneous rocks and limestone as seen in Rutland (Kalapahar), and in Little Andaman and Havelock islands (limestone).

5.2.2 Salient observations from the Hydro geological studies

- Geology of the islands is highly varied and complex. Each Island is having separate geological characteristics, which may vary with the contiguous Islands and even within the same island.
- Except in the areas underlain by the valley fill deposits and the pockets under lain by the igneous rocks and Coralline formation, the prospect of ground water development is bleak.
- Major parts of the islands are covered by unproductive sedimentary rocks.
- Out of 18 exploratory tubewells/borewells in South Andaman District only two were highly successful (one at Beadonabad and other at Calicut)
- In the light of the above facts CGWB contemplated to carry out artificial recharge and conservation studies of ground water utilizing the rainfall in A & N islands in general and South Andaman district in particular. The basic geological and hydrogeological factors favouring such type of studies in the islands are :
  - Islands receive copious rainfall
  - Areas are drained by numerous small, medium streams.
  - Even in the terrains underlain by sedimentary rocks, a good thickness of porous valley fill deposits could be seen in many areas which carry a huge quantity of base flow throughout the year.
  - Generally big boulders, gravels and porous pebbles are laid in the stream courses.
  - The base flow could be restricted by means of sub-surface dams and lot of surplus also for recharging the subsurface reservoir even in lean period.
  - From 2000 onwards as per the request of various Administration Depts. (APWD, Deptt. of Animal Husbandry, Deptt. of Forest, Home Deptt. Etc.), PRI and Central Govt. Deptts. Including Defence, 50 recommendations were given for augmentation of drinking water supply of which nearly 25 are already implemented in South Andaman District and promising results were obtained.
  - In 2003 as per the request of Agriculture Department , the minor irrigation development plan for the major parts of Andaman District was prepared by CGWB and 101 numbers of check dams were constructed out of which 63 were built in South Andaman district.

5.2.3 Salient observations from the Hydro geological studies

This plan envisages both development of ground water and combined water shed development rainwater harvesting through multiple check dams, subsurface dams, tidal bars and recharge-cum-production wells for drinking water supply, irrigation, provision of drinking water for cattle and soil human consumption and conservation. CGWB also recommended saline land reclamation for augmentation of agricultural land fresh ground water resources.

- Central Ground Water Board had funded APWD,A&N Admn. through Central Sector funds for three water supply schemes in South Andaman (at Birdline, Manjeri and at Lalpahar Nala) which have yielded very much encouraging results.
- With the available data CGWB had calculated the ground water resources of the island. (Pre-Tsunami) and it was reconciled it with the A & N Administration on 10.12.2004 for better utilization and management of ground water. The ground water resources in the changed geo environment after the Tsunami and earthquake has further been worked out in 2009 a for sustainable, cautious and scientific withdrawal of ground water in the islands.

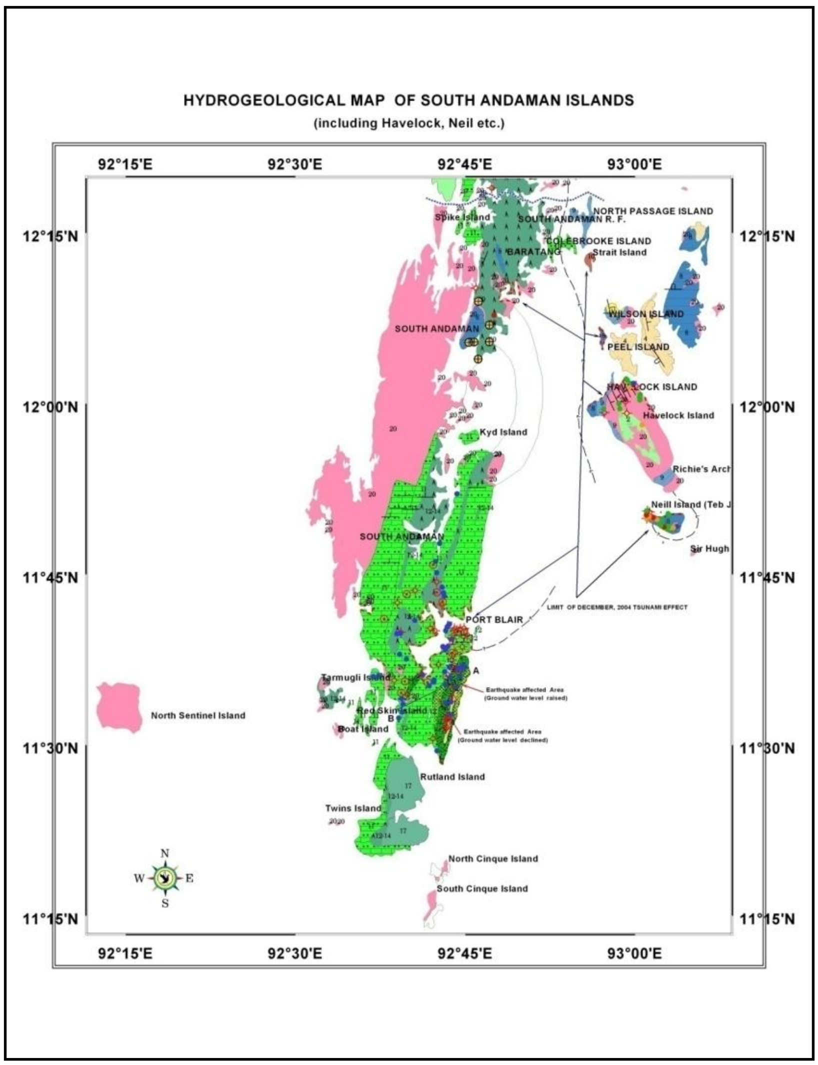
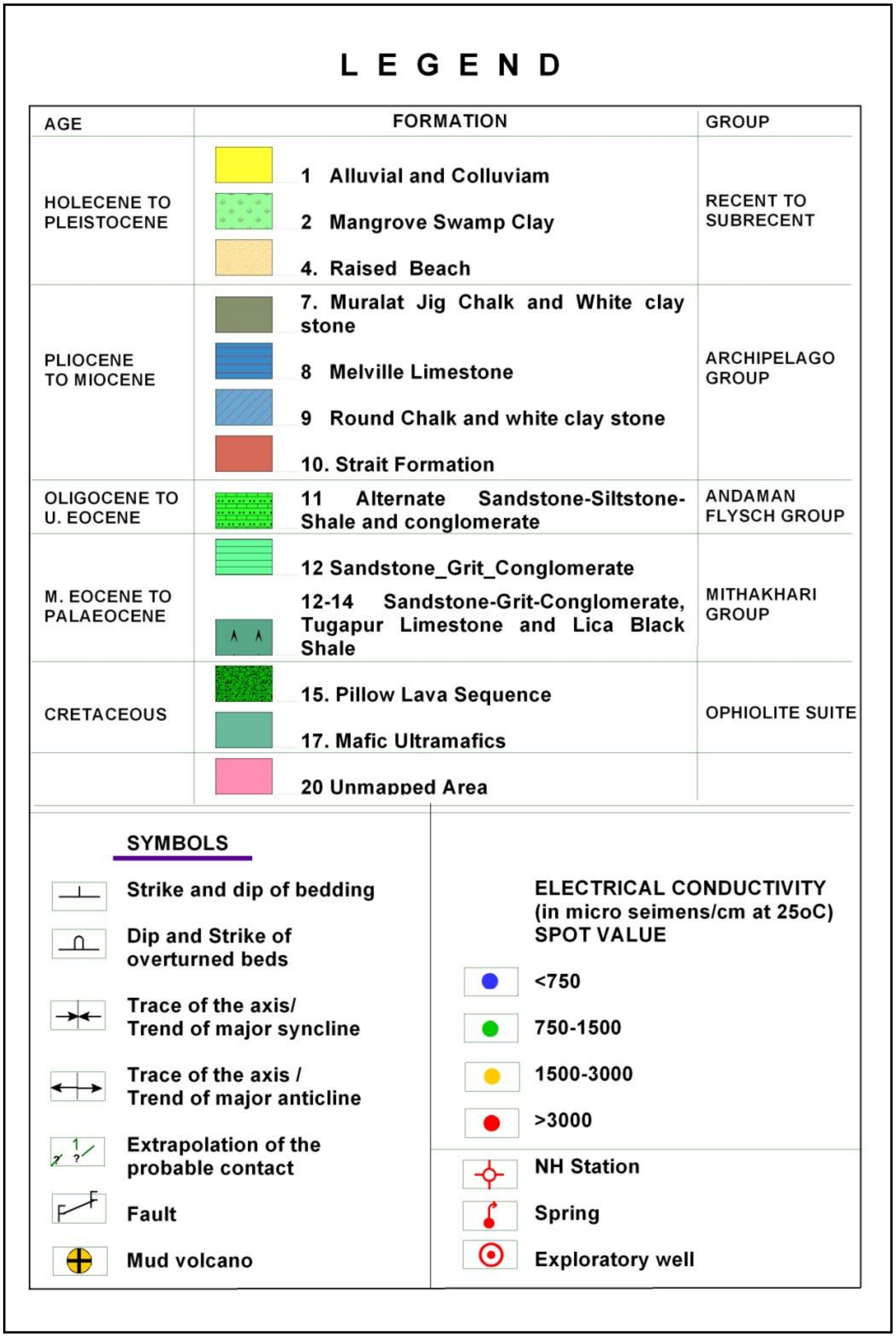


Fig- 5.2.1 Hydrogeological map of South Andaman , Rutland,Havelock,Neil,Strait Islands South Andaman district and Baratang Island of N-Middle Andaman District(See legend and Hydrogeological potential presented separately)



HYDROGEOLOGY, GROUNDWATER POTENTIAL AND DEVELOPMENT PROSPECT:

(1) - Occur in the narrow intermontane valleys and stream valleys overlying Flysch/Mithakhari Formations and Ophiolite. Highly porous. Thickness varies from 0.5m to 17m . Baseflow occurs throughout the year. Subsurface dam/dyke highly feasible.. Yield of tubewell may be as high as 1,28,000 Gallons per day .Dugwell (5-6m dia. And 6m deep) with subsurface dyke may yield 50 thousand to 2 lakh litres per day.

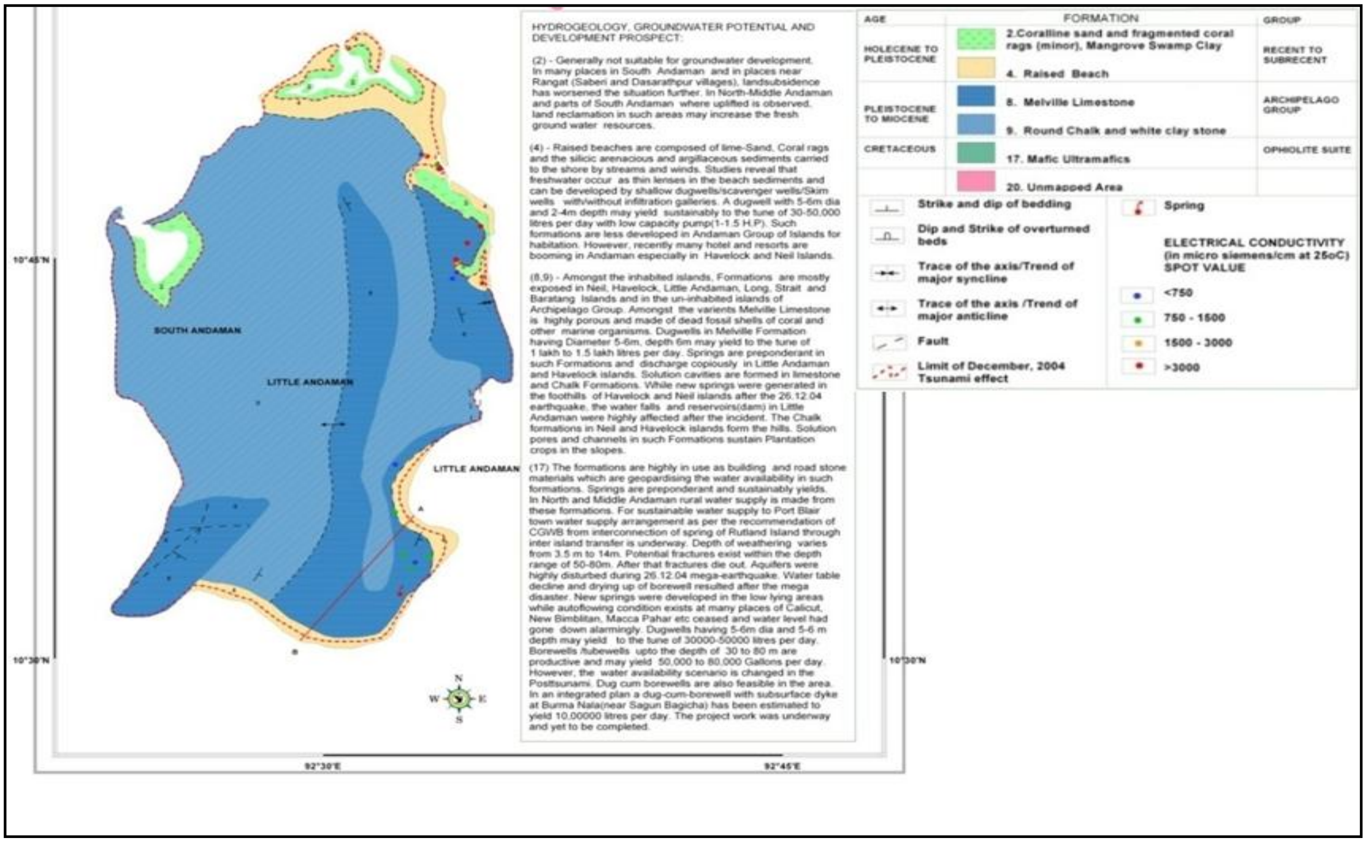
(2) - Generally not suitable for groundwater development. In many places in South Andaman and in places near Rangat (Saberi and Dasarathpur villages), landsubsidence has worsened the situation further. In North-Middle Andaman and parts of South Andaman where uplifted is observed, land reclamation in such areas may increase the fresh ground water resources.

(3) - Raised beaches are composed of lime-Sand, Coral rags and the silicic arenacious and argillacous sediments carried to the shore by streams and winds. Studies reveal that freshwater occur as thin lenses in the beach sediments and can be developed by shallow dugwells/scavenger wells/Skim wells with/without infiltration galleries. A dugwell with 5-6m dia and 2-4m depth may yield sustainably to the tune of 30-50,000 litres per day with low capacity pump(1-1.5 H.P). Such formations are less developed in Andaman Group of Islands for Habitation. However, recently many hotel and resorts are booming in Andaman especially in Havelock and Neil Islands.

(7,8,9) - Amongst the inhabited islands, Formations are mostly exposed in Neil, Havelock, Little Andaman,Long ,Strait and Baratang Islands and in the un-inhabited islands of Archipelago Group Amongst the varients Melville Limestone is highly porous and made of dead fossil shells of coral and other marine organisms. Dugwells in Melville Formation having Diameter 5-6m, depth 6m may yield to the tune of 1 lakh to 1.5 lakh litres per day. Springs are preponderant in such Formations and discharge copiously in Little Andaman and Havelock islands. Solution cavities are formed in lime-stone and Chalk Formations. While new springs were generated in the foothills of Havelock and Neil islands after the 26.12.04 earthquake, the water falls and reservoirs(dam) in Little Andaman were highly affected after the incident. The Chalk formations in Neil and Havelock islands form the hills. Solution pores and channels in such Formations sustain Plantation crops in the slopes.

(11,12,12-14) -The formations contain fine grained sandstone and shale intercalations which also gove-rns formations of a very impervious residue in the weathered profile. Springs are preponderant but yields dwindle with recession of monsoon. In Tugapur Limestone however, sustainable springs exist. Dugwells having 5-6m dia and 2-4m depth may yield meagre quantity of groundwater to the tune of 4000-5000 litres per day. Borewells /tubewells upto the depth of 121 m ard unproductive and unfit for development through tubewell/borewell. Shallow overlying alluvium in the stream valleys are the sole solution of sustainable water supply in the areas underlain by such formations . At places shallow tubewells of 30-40m depth may rarely yield unsustainably to the tune of 20000-30000 litres per day At Prothrapur Junction brackish water(EC=5910 Micromho/cm) was encountered with a discharge of 30200 Gallon per day.

(15) - The formations are highly in use as building and road stone materials which are geopardising the water availability in such formations. Springs are preponderant and sustainably yields. In North and Middle Andaman rural water supply is made from these formations. For sustainable water supply to PortBlair town water supply arrangement as per the recommendation of CGWB from interconnection of spring of Rutland Island through inter island transfer is underway. Depth of weathering varies from 3.5 m to 14m. Potential fractures exist within the depth range of 50-80m. After that fractures die out Aquifers were highly disturbed during 26.12.04 mega-earthquake. Water table decline and drying up of borewell resulted after the mega disaster. New springs were developed in the low lying areas while autoflowing condition exists at many places of Calicut, New Bimblitan,Macca Pahar etc ceased and water level had gone down alarmingly. Dugwells having 5-6m dia and 5-6 m depth may yield to the tune of 30000-50000 litres per day. Borewells /tubewells upto the depth of 30 to 80 m are productive and may yield 50,000 to 80,000 Gallons per day. However, the water availability scenario is changed in the Posttsunami. Dug cum borewells are also feasible in the area. In an integrated plan a dug-cum-borewell with subsurface dyke at Burma Nala(near Sagun Bagicha) has been estimated to yield 10,00000 litres per day. The project work was underway and yet to be completed.



5.2.2 Hydrogeological Map of Little Andaman Island

5.2.4 Post tsunami Hydro geological situation

Various geographical changes occurred in A&N Islands due to the plate collision. The impulse generated by the plate movement caused earthquake and tsunami in the Indian Ocean, had claimed record number of lives and emphatically devastated many countries including the A&N Islands. Besides, destruction of civil structures , the water resources in general and groundwater resources in particular were significantly affected by the colossal disaster(Fig.5.2.4.1-5.2.4.8) . In the following map(5.2.4.9), the impact of the tsunami and earthquake in different parts of South Andaman District is shown and the changes are briefly narrated in the following paragraphs.

- In high altitude terrains springs, check dams, ponds borewell(in South Andaman) are either dried up or discharges, are declined .

Fig-5.2.4.1 Fig-.5.2.4.2

Pond and check Dam dried up at high altitude near Calicut S. Andaman (Post Tsunami

Fig-5.2.4.3 Fig-.5.2.4.4

Check dam affected by Tsunami at Chouldari, S. Andaman. And Well dried up at high altitude, R.K. Pur, Little Andaman

Fig- 5.2.4.5 Water level rise in well at low altitude near Gandhi Bhawan, Portblair

In lower topographic terrains especially in South Andaman the discharge of streams, springs, and water level in wells are increased. In other places either the discharge is showings some rise or showing little decline or no change. However, in few cases the discharge ceased.

It Havelock Island at Vijoynagar in the foothill region one good discharging spring generated. Pond was seen over flowing on 02.03.2005. Sudden rise in discharge of spring at low altitude near Brookshabad, Portblair and pond dried up at Macca Pahar,S. Andaman.

Fig-5.2.4.6 Sudden rise in discharge of spring at low altitude near Brookshabad, Portblair

Fig-5.2.4**.7** Pre-Tsunami

Fig-5.2.4**.8** Post Tsunami

Change in discharge in spring fed water fall at high altitude in little Andaman

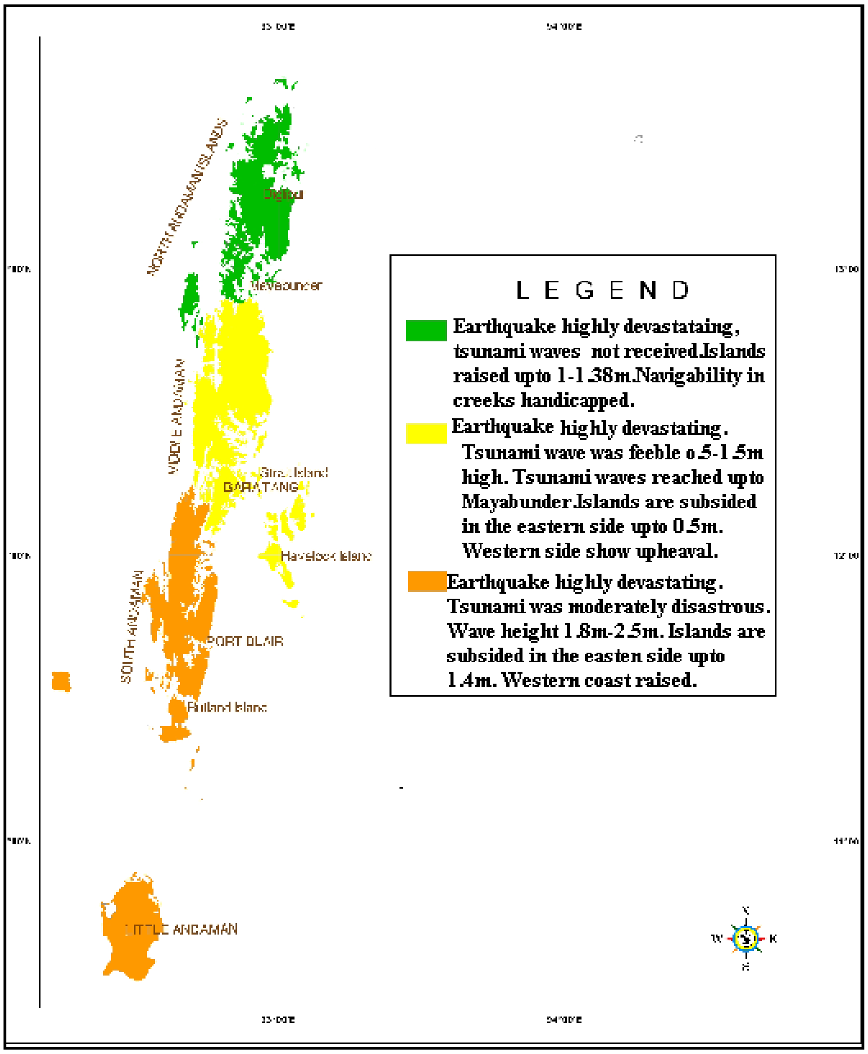


Fig-5.2.4.9 Map showing the severity of Tsunami and Earthquake in Andaman group of Islands

On 26.12.2004 during the earthquake free flow on the ground surface was observed in Little Andaman, Neil, Havelock and in many places all along in South Andaman.

- Saline Water was ejected (Fig-5.2.4.11)at several places as in R. K. Pur, Ravindranagar in Little Andaman, near Pema Junction Calicut, South Andaman
- Two earthen medium dams at R.K.Pur(Fig-5.2.4.10) and Ravindranagar were highly damaged during the earthquake and water was seeped through cracks and fissures developed on the dam bed.
- Cracks were generated in the aquifers which are cropping our in the surface..
- In S.Andaman district the arable lands and ponds are highly damaged during earthquake (especially in hard rock areas near New Bimblitan,Macca Pahar etc.) causing decline in soil moisture of the agricultural land and water holding capacity of the ponds
- . Field studies by various land survey Departments as also the field observations reveal that the Sippighat Hamphreygunj, Chidiyatapu, Mithakhari, Saitankhari,

Wimberliegunj,Namunaghar,Bambooflat,Wandoor,Manpur,Herbertabad etc. areas from the land shows some subsidence evident from permanent saline water ingress.

- 

Fig-5.2.4.10 State of R.K.Pur Dam, Little Andaman after 26.12.04 Earth Quake

Fig-.5.2.4.11Trail of high mineralized water flown at high land near Rabindra Nagar, Little Andaman.

- The reported range in subsidence vary from 0.5 to 1.5 meter
- Similarly there has been a reported upliftment Andaman , evident from lowering of creek water level during low and high tides.
- The low lying areas in the South Andaman District were inundated by Tsunami waves whose height varied from 1.0 to nearly 3.5 meters.
- These waves contaminated the ponds, wells and all fresh water bodies along the Coast.
- After Tsunami at various places in the affected islands, the contaminated wells were pumped out. At many places pumping was done cyclically. Following observations **were** noted.
  - ❖ In many areas during the first phase the wells showed positive result (i.e gradual decrease in salinity). However, after wards it started showing increase in salinity.
  - ❖ In many places the salinity did not change at all even after evacuation or repeated pumping.
  - ❖ At places the wells become naturally flushed without pumping.
  - ❖ At places they are still low brackish.
  - ❖ From the above observation the continuous monitoring should be undertaken by CGWB to reveal the actual cause of increase in salinity. Regular geohydrological monitoring would be highly necessary in the islands for successful construction, proper design and site selection of the water development structures.
  - ❖ Depending upon the hydrogeological, situation and terrain and aquifer condition the following structures in different Islands may be taken up.The various types of structures which are required in A & N Islands to conserve recharge and exploitation of ground water and rain water are :

1. Ponds 2. Check dams, 3. Sub surface dams, 4. Recharge shaft, 5. Intake wells 6. Collector wells with infiltration gallery, 7. Lift irrigation points , 8. Roof top rain water harvesting and recharge 9. Dykes along the coast to stop salinity ingress and land reclamation

From the extensive studies carried out by CGWB from 2000-2004(Pre-Tsunami) as also in Post Tsunami in the entire Andaman and Nicobar Islands in general and South Andaman district in particular had been extensively utilised for rain water harvesting, conservation of surplus run-off and other watershed management practices with the structures as mentioned below.

In Pre-Tsunami period (during 2003-04) 101 check dams were constructed in North, Middle and South Andamans of which lion's share were in South Andaman . For Agricultural rejuvenation in the PostTsunami, a big rehabilitation project named Rajiv Gandhi Agricultural Rehabilitation package for Agriculture had been envisaged where provision for irrigation water supply through suitable structures was a prime component. For implementation of the same, CGWB was considered by the Ministry of Agriculture as the expert Deptt and in this regard the following sources were recommended for construction(Table-5.2.4.1).

Table-5.2.4.1 Creation of Water Bodies and related structures in the Post-Tsunami

Sl.No.	Island Name/Zone	Check Dam(nos)	Ponds/Wells(nos)	Construction of dyke to stop salinity ingress(Km)
1	South Andaman	100	500	3.93
2.	Little Andaman Zone	5	46	-

5.2.5 Ground Water Monitoring

In order to study the behaviour of ground water regime with time and space in South Andaman district, 28 ground monitoring stations were established, and periodic water level measurements are being taken 2 times in the year, for pre-monsoon period during May and for the post-monsoon period during December. Depth to water level in majority of the monitoring stations ranges between 2- 5 m bgl (66%) and within 2 m bgl (25%) in rest of the stations during May. The minimum water level 1.01 m bgl was recorded during May at Gandhi Bhawan(Light House) well at Port Blair and maximum 10.55 m bgl at Calicut piezometer(borewell), in South Andaman. The water level trend has been analyzed for all measurements which shows that there is a rising trend of water level in majority of the wells during 1998 to 2007 to the tune of 0.021 to 1.19 m/yr. However during the same period the pre monsoon trend shows falling trend in most of the wells. Earth quake and tsunami on 26.12.04 had a potential influence on both quality and quantity of groundwater and surface water resources in a significant part of the district. The changes have also been noticed during the extensive hydrogeological islands by CGWB both in the Pre and Post-Tsunami. The quantitative changes are already discussed in Chapter 8.2 and further discussed in separate chapters dedicated to important inhabited islands of the South Andaman district, along with qualitative changes.

5.2.6 Ground Water Resources

As per the GEC 1997 norm the watershed or administrative unit could not be applied here since the islands are generally separated. There are 11 Islands in South Andaman district which are inhabited; hence the water resources of these Islands are taken into consideration. During computation the intermontane valleys and relatively flat topographical areas were considered as recharge areas. The hilly areas having slope more than 20% are deducted from the geographical area available in the inhabited islands. The water level data of all 36 islands are not available. Hence the rainfall Infiltration method was adopted for resource estimation. Base flow of ground water through streams as also the outflow from springs were also noticed, and the discharges were computed and added to ground water draft. The estimated resources of the A&N Islands as calculated in 2008-09 are presented in the following table(Table-5.2.6.2). The groundwater resources of South Andaman district is not shown separately. The ground water resources South Andaman islands has been observed to be reduced in the Post tsunami(2008-09) in comparison to the Pre-tsunami data(2004). The reasons are enumerated below:

5.2.6.1 Comparison with the earlier ground water resources estimate and reasons for significant departure from earlier estimate.

The loss in surface area in some of the highly earthquake and tsunami devastated islands have made possible changes in freshwater volume in the islands. In 11 (Eleven) inhabited islands of South Andaman district and in the total 38 inhabited islands of A&N Archipelago , parts of their area have been submerged due to effect of plate colloision(Table-5.2.6.1). This has been reflected in the ground water assessment. It's important to note that parts of the Andaman group of islands and the entire Nicobar group of islands were subsided during the plate collision and submerged. Hence net availability of fresh ground water resources have been decreased in comparison to the values obtained in previous ground water resource estimation in the islands in 2004 during Pre-tsunami. Domestic draft includes spring discharge and withdrawal from dugwells.

Table-5.2.6.1 : Island wise Damaged Area Due To Tsunami/ Earthquake

Island	Paddy and other field crops (in ha.)			Plantation crops (in ha.)			No. of affected Farmers
	Submerged Area	**Reclaimable area**	**Total Damaged Area**	**Submerged Area**	**Reclaimable area**	**Total Damaged Area**	
S/Andaman	1148.00	319.18	1467.00	131.00	69.00	200.00	1448
L/Andaman	00	43.00	43.00	00	74.00	74.00	48
Total	**1375.3**	**802.58**	**2177.70**	**2831.34**	**3059.67**	**5891.01**	**6324**

Source: Rajiv Gandhi Rehabilitaion Project for Agriculture,A&N Admn.,Portblair

Table – 5.2.6.2: Groundwater resources estimated in 2008-09

Comparative Criteria	*Resource Assessment 2008-09(In ham)*
Annual net Groundwater resources available	14846.41 Hectare metre
Gross Groundwater draft for all uses	793.57 Hectare metre
For irrigational use	51.27 Hectare metre
For domestic & industrial use	742.30 Hectare metre
Projected demand for domestic & industrial use up to 2025	458.85
Stage of Groundwater development	2.58%
Categorization for future ground water development	**Safe**

5.2.7 Ground Water Exploration

During the exploration programme of CGWB in the period of 1985-94, 47 boreholes were drilled in the entire A& N Islands. Amongst these wells 18 were drilled in South Andaman, It was observed that the boreholes drilled upto a depth range of 160m in Sedimentary formations did not yield except one site near Prothrapur Jail Junction, which yielded brackish water (EC – 5500 microsiemens /cm) to the tune of 9000 litres/hr. However, the valley fill deposits in the islands were seen to yield copiously . The productive aquifers occur within 60 m bgl in fractured volcanic and 30 m bgl in valley fill deposits with discharge varying from 10 to 45 m3/hr.. The well drilled by CGWB at Beadonabad is the main supply source in parts of South Andaman adjoining Beadonabad-Rangachang-Burmanala sector. The yield of the well was as high as 44,000 litres/hr. The Igneous rocks yield moderate to good. Upto 60m depth potential fractures were noticed. The yield range of the boreholes in these formations were found to vary from 10,000 to 25,000 litres/hr. There was no exploration in the Coralline and limestone formation. The following table (Table-5.2.7.1) shows the salient details of the productive wells drilled in A&N Islands.

Table-5.2.7.1 Salients of the groundwater exploration yielded groundwater in South Andaman District

Sl.No	Name of the Island	Place Name	Aquifer	Depth Drilled/Depth of the well(m)	Productive Aquifer zones tapped/Fracture zone(m)	Discharge (m^3/hr)	T(m^2/day)	S	Quality of water(EC in MS/CM)
1	**South Andaman**	**Calicut**	**Weathered and Fractured Pillow lava**	80.2/80.2	14.6-20.6 45.0-54.6	45	112.3	9.65 $\times 10^{-4}$	470 Fresh
2	**-do-**	**Beadnabad**	**Porous collovium overlying Pillow lava**	105.8/16.6	7-16.6	72	211.1	6.19 $\times 10^{-4}$	600 Fresh
3	**-do-**	**Brichganj**	**Weathered and Fractured Pillow lava**	128.6/128.6	13-14.6	1.8	-	-	512 Fresh
4	**-do-**	**Rangachang**	**Weathered and fractured Intermediate and ultrabasics**	71.2/71.2	Upto 30m	3	-	-	359 Fresh
5	**-do-**	**Homphreygunj**	**Highly weathered Pillow lava**						
6	**-do-**	**Prothrapore Junction**	**Fractured Sandstone with shale intercalation**	60.6/60.6	25-27 30-32 59-60	17	-	-	5910 Brackish
7	**-do-**	**Dilthaman Tank**	**Fractured Sandstone with shale intercalation**	121.0/30.0	Upto 30m	2.2	-	-	1693 Brackish

***** All the other 34 explorations drilled in sedimentary formations in S.Andaman,M.Andaman,Great Nicobar islands as also in Nancowry,Katchal and North Andaman Island were dry.**

5.2.8 Water table behaviour

Groundwater level always depicts the situation of topography, recharge from rainfall via-a-vis ground water development as also the potentiality of the aquifer in an area.In general the aquifers are water table in nature. However, in Ophiolite autoflowing condition exists. The autoflowing condition in Calicut-Macca Pahar-Bimblitan-Teylerabad area was highly affected by the earthquake of 26.12.04 and it is presented in the conjectural diagram (Fig-7.5.1.3 & Fig-7.5.1.4). The water table aquifer in Sedimentary Formations also met with a significant change after the Mega earthquake. At lower topography the water table had shown rise. The changes are still persisting at many places where as at places it is ceased.

Since major part of the district incorporating the Port Blair town is underlain by impervious Sedimentary rocks, the aquifers are not strained through pumping because of non availability of adequate water. Hence the water level in the town replicates the topography of the area falling in the town's jurisdiction. In the lower topographic horizons it is close to ground level where as in higher topographic locales it is more(Table-5.2.8.1). The water table in the district is monitored twice in a year from the established Hydrograph Network Stations. Average long term water level trend shows rise in water level. Select network stations spread in and around the town are presented below(Table-5.2.8.2).

Table-5.2.8.1 Depth to water level (mbgl) in Hydrograph stations of Port Blair Town,South Andaman (2012)

Well No	Well Type	Block / Mandal	Locality	M.P.	Depth	Dia	Water Level	
							May-12	Dec-12
AN001	Dug Well	South Andaman	Portblair(Sampat Lodge)	0.67	10.56	3.17	3.92	1.88
AN002	Dug Well	South Andaman	South Point(port Blair)	0.49	5.85	1.03	0.2	0.51
AN003	Dug Well	South Andaman	Corbyn's Cove(port Blair)	0.68	4.40	2.46	2	2.65
AN008	Dug Well	South Andaman	Shadipur(port Blair)	0.60	7.57	1.85	1.35	1.52
AN013	Dug Well	South Andaman	Brookshabad (Port Blair)	0.40	2.60	2.70	1.13	0.17
AN020	Dug Well	South Andaman	Junglighat (V I P Road)	0.00	4.50	1.50	0.56	8.44
AN045	Dug Well	South Andaman	Marina Park	0.56	3.30	1.06	0.73	0.67
AN057	Dug Well	South Andaman	Port Blair (Dobhi Well)	0.61	3.85	2.34	1.78	1.51
AN059	Dug Well	South Andaman	Light House	0.25	4.74	3.17	0.92	0.79

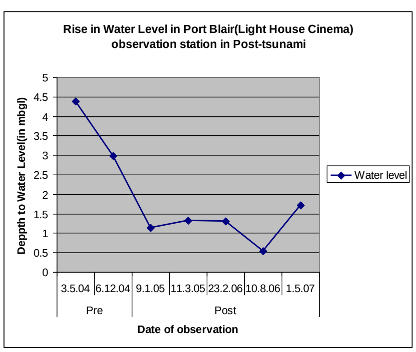
Table-5.2.8.2 Water level trend from the Hydrograph Stations in Select wells in Port Blair, South Andaman (1999-2012)

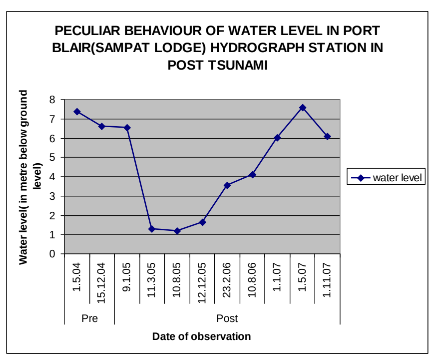
Well No	Location	N	Rise (m/yr)	Fall (m/yr)	Intercept (01-Apr-2000)
AN005	Austinabad(port Blair)	17	-	0.010	1.59
AN013	Brookshabad (Port Blair)	20	0.155	-	2.61
AN003	Corbyn's Cove(port Blair)	19	0.076	-	2.32
AN020	Junglighat (V I P Road)	16	-	0.225	-0.38
AN059	Light Hosuse	12	0.378	-	4.64
AN045	Marina Park	13	0.193	-	2.79
AN057	Port Blair (Dobhi Well)	12	0.182	-	3.36
AN001	Portblair	17	-	0.118	2.43
AN008	Shadipur(port Blair)	18	0.126	-	2.86
AN002	South Point(port Blair)	17	0.177	-	3.12

After the Mega Earthquake (M=9.3) and tsunami on 26.12.04, ground water resources in the district were affected significantly and it was clearly observed through the changes in water level in the observation wells located in and around the Port Blair town (Fig-5.2.8.1). The surface water sources in the low lying areas were contaminated by the sea wave having a height of nearly 1.2-1.5m in and around the town (Fig-5.2.8.2-5.2.8.4).Due to plate collision, the urban area was also subsided for a depth of 1.0 to 1.2m which facilitate regular ingress of sea water in the town and its periphery through the creeks, sewer drains and the valley areas. To stop the ingress, the strategic areas were immediately raised through earth and rock fills by the A&N Administration and Port Blair Municipal Council(PBMC) and currently the inundation problem is stopped.

Fig- 5.2.8.1 Tsunami wave ingresses in Port Blair town
On 26.12.04 morning. Picture taken from Marina Park area

The potential earthquake had influenced the ground water table and their movement. Ground Water level in higher topographical areas was declined while new springs were generated in the lower topographical locales (Fig-5.2.8.2-5.2.8.5) and water level in the wells in the valleys and coasts were increased.A rise in water level was observed near Light House Cinema , Port Blair. Here the water level is still remaining in elevated condition. New fractures also had changed the aquifer characteristics .However, at many places the water level situation has been bounced back to the pre-tsunami condition while at places the change is still persistent. Both the qualitative and quantitative changes in the Post-tsunami was monitored continuously by CGWB(Kar et. al,2005,2006).





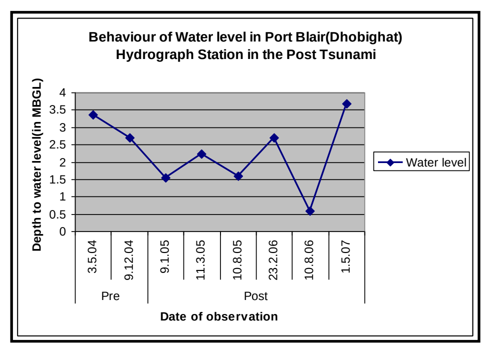


Fig-5.2.8.2- 5.2.8.4) Behaviour of Water table in topographic lows in and around Port Blair ,South Andaman

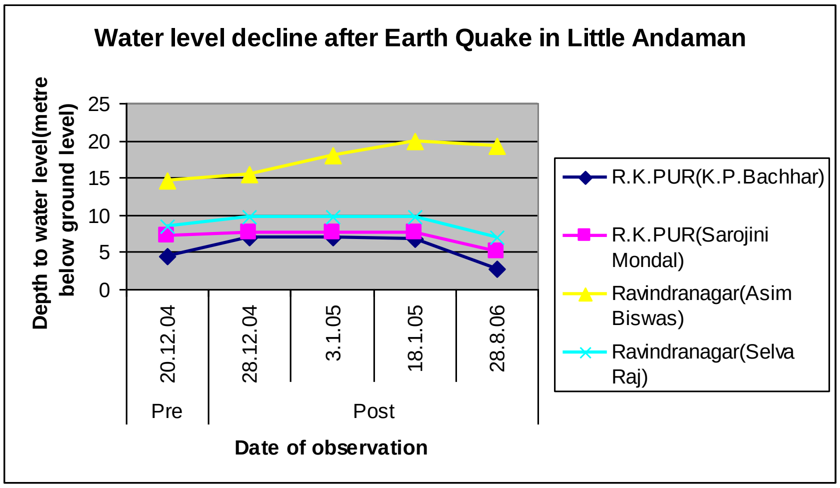


Fig- 5.2.8.5: Behaviour of Water level after 26.12.04 earth quake in Little Andaman Island

6.0 CHEMICAL QUALITY OF GROUND WATER

Analysis of ground water samples collected from the dugwells and exploratory borewells constructed in the area, were done in the chemical Laboratory of Central Ground water Board at Kolkata which revealed the following results..

The quality of ground water throughout the district of South Andaman is fresh and it is fit for all purposes barring few parts and it's varying from neutral to alkaline. Chemical analysis data of water samples(dug wells) from 63 hydrograph network stations and Pre-tsunami surveys and investigations reveal that the groundwater is generally calcium bicarbonate type, and the bicarbonate content varies from 91 to 427 ppm greatly predominates over the chloride content varying between 14 to 202 ppm. Computation of the chloride-bicarbonate ratio of groundwater from the islands show that the ratio varies between 0.1 to 0.2 . This indicates that there has been no large scale saline water intrusion in the island. It is worth mentioning in this regard that the network hydrograph stations are representing the pats of the Andaman group which did not suffer remarkable destruction by tsunami or land subsidence as it is happened elsewhere, which may cause qualitative deterioration due to sea water ingress. Detailed studies carried out by CGWB(Kar,2006,Kar et al,2008&2010) indicates that the there has been qualitative deterioration in the ground water quality in parts of the subsided and tsunami devastated islands of South Andaman district. The pre tsunami data also revealed that although presence of any toxic element is present still presence of high iron in the range of 0.6 to 7.65 ppm could be seen in deeper aquifers as seen in the analytical data of the exploratory wells as also in the dugwells at Light House(2.15),Annikat(2.59) and Namunaghar(1.36).The analysis of hydrograph network data also suggests that concentration of Ca,Mg and Na are within the permissible limit. Electrical conductivity of the water samples collected from the hydrograph stations in the Post-Tsunami are showing low mineralization value ranging from 292 to 1120 us/cm baring few places like Marina park,Corbyn's cove both in Port Blair, Saitankhari (South Andaman) and Havelock island. Post tsunami surveys in Nicobar island however shows higher mineral content in ground water. The salinity condition of wells in the post-tsunami are discussed in the following chapters dedicated to individual islands.

However, in view of plate collision and subsidence after the earthquake and Tsunami on 26.12.04, a qualitative change has been noticed in the groundwater samples collected from parts of the affected areas in the town. Figure-6.1 depicts the change in Salinity in the monitoring well at Corby'n cove area of Port Blair. The qualitative change is still persisting.Plots of chemical parameters in Piper diagram (Fig- 6.2-6.4) plots show increase in salinity in the Post tsunami in various islands of South Andaman district.

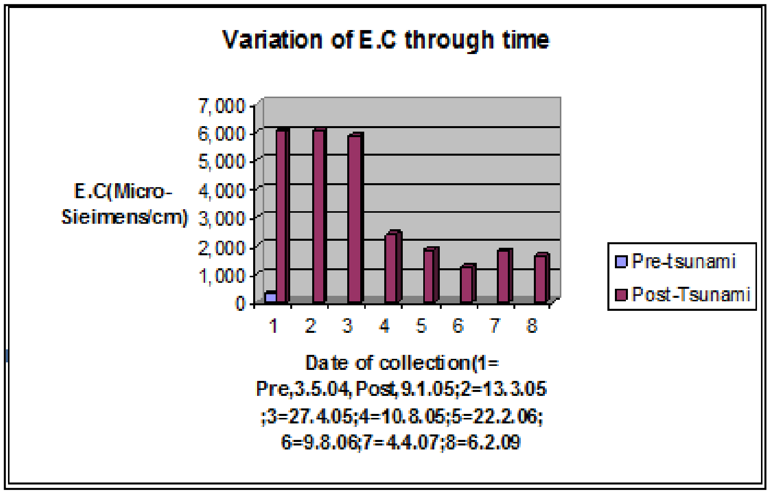
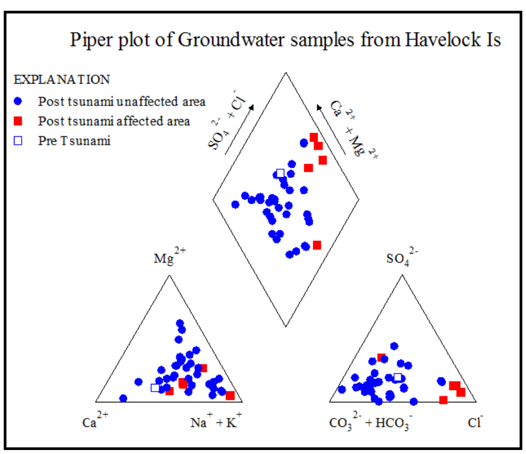


Fig- 6.1 Bar Diagram showing change in Salinity(E.C)through time in the dugwell at Peerless Beach Resort, Cobyn's cove,Port Blair



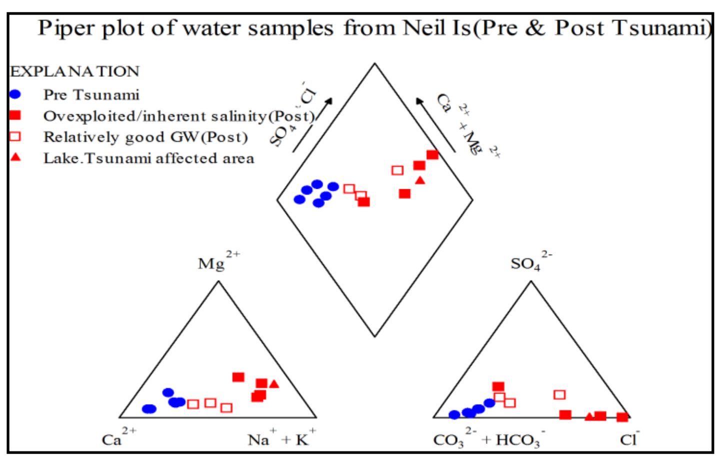


Fig- 6.2.2 **Fig- 6.2.3**

Piper plot of groundwater samples from Havelock and Neil Island

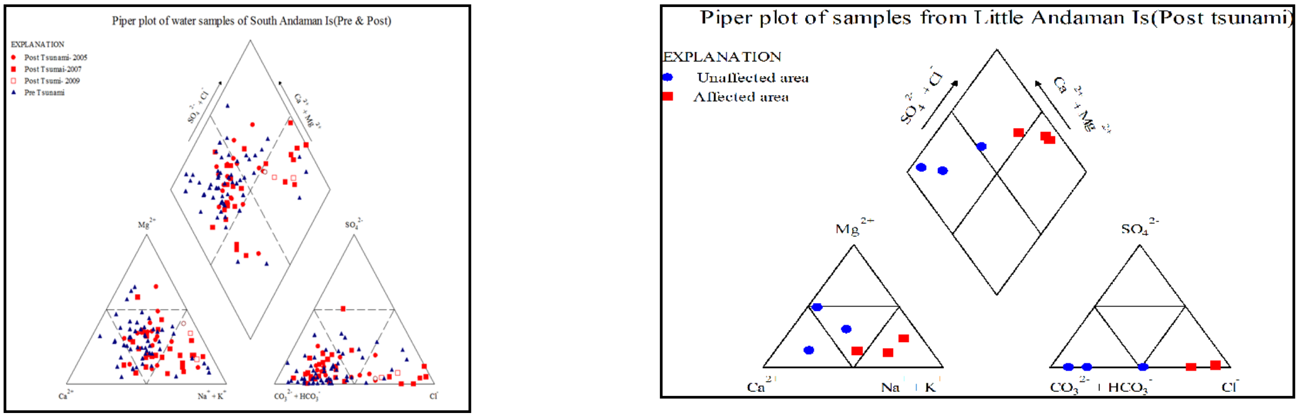


Fig-6.2.4 Piper plot of groundwater samples from South Andaman and Little Andaman Island

6.1 Water quality behaviour along and away from coast

Water quality in the aquifer was fresh in the pre-tsunami both along the coast and away from the coast. Because of the extreme impermeability as also water deficient condition of the sedimentary aquifer, formation of lens is not appears to be possible through out the island. However, where the aquifer is fractured and occurs in close juxtaposition to the sea, there is feasibility of occurrence of saline groundwater in the subsurface. Similarly at places occurrence of brackish connate water in the Marine sedimentary formation could be observed which were revealed during groundwater exploration as observed near Prothrapur Junction.

Detailed groundwater sampling from the hydro geological surveys, groundwater exploration as also sampling from network hydrograph stations are indicating the chemical behaviour of groundwater in the islands both in space and time. The previous figure(Fig-13.2.2-13.2.4), shows the plots of few important chemical parameter in Piper Diagram. The diagram depicts that the overall quality of groundwater through time has remain unchanged barring the areas close to the coasts which were affected by the tsunami. The figure also indicates that the salinity condition of the groundwater is changed in the post tsunami atleast in the coastal parts and the situated although it is a bit improved but still persistant and likely to be permanent due to the land subsidence.

6.2 Water quality behaviour with reference to rainfall

Ground water quality behaviour near by the coast always gets changed during rainy season. Especially in the shallow aquifer the change could be observed soon after the rainfall

7.0 GROUND WATER MANAGEMENT STRATEGY

7.1 Groundwater development strategy

a. During Pre- Tsunami

The overcome the shortage of water supply to the Port Blair town as also in view of severe water scarcity in 2002, the following short term, medium and long term options were adopted by APWD in the pre tsunami. The Short term options included A. Carrying water from Chain Nallah (Rutland Island) through barges for supply to the ships at Port Blair by Port Management Board. B. Taping the ground water sources (dug wells) and Ponds in Port Blair town advocated by CGWB.

Medium term options included A. Carrying water from Rutland through pipe lines. The project was studied initially by CGWB on request of APWD, A&N Administration in Feb,2002. B. Raising of Dhanikhari dam C. Chouldari project (completed and commissioned in 2003). C. Indranala project, South Andaman (An ongoing project, required input to be collected from APWD)

The only long term option which was planned in the Pre-tsunami was completion of Flat bay project. This project was designed for augmentation of water supply to the tune of 67 MLD, keeping in view of projected demand up to 2050. In this project there was a proposal to make an earthen dam in between Minnie Bay and Mithakhari village where Flat Bay is constricted. The project was abandoned after tsunami.

b. Projects under consideration in the Post-tsunami

It is already mentioned that the water scarcity in Port Blair town water supply was aggravated in the Post-tsunami. To tide over the crisis, various short, medium and long term options were adopted. The short term options included (i) To increase the water availability of Port Blair town from the Springs of Rutland through Barges. In this regard procurement of additional barges have been proposed.(ii) Urgent installation of Desalination plants in turn key basis to increase the immediate potable water availability at Port Blair and (iii) Dug well Sources.

Medium term options include (i) Fresh water lake Project near Sippi Ghat and augmentation from Pond sources, while the Long term options include A) Raising of Dhanikhari Dam B) Interisland transfer of Spring water from Rutland island and water supply from Indranala project .

Besides the following three time specific options, the following three options may also be considered for better management of water supply in the town

.(I) Water sources for catering raw water need in Port Blair town

In connection with the ongoing constructional work huge quantity of fresh raw water is daily required in Port Blair town. For this purpose the use of Dhanikhari water should be stopped if it is under utilization. For this purpose small reservoirs or sources may be created to cater for the said purpose. The Pond water also can be supplemented to the requirement.

(II)Large Scale Roof top rainwater harvesting in all houses and institutions

Rainwater harvesting in each house site and Government and Private institutions may be introduced. The rain water may be conserved in over surface or sub-surface cisterns and should be regularly utilized for household uses, gardening, car washing etc.

(iii)Waste Water Recycling

Waste water recycling is a technology now in practice worldwide what may also be practiced in Port Blair.

From the preceding chapters it is clear that a good amount of fresh water can be generated for sustainable water supply in Port Blair town. The options can augment a volume of 50.23 Million Litres of additional fresh water supply per day to the town. The approximate water availability from various sources are given below (Table-7.1.1).

Table-7.1.1 Augmentation of water supply to Port Blair town from Short, Medium and

Long term options in the Post- tsunami

Options	Name of the sources	Tentative water availability (lakh litres/day)	Remarks
Short term option	1. Water carriage from Rutland through barges.	0.5 mld	* Among the Long term option Flat Bay project was most important in the Pre-tsunami having a tentative yield of 67 MLD which is kept pending in view of land subsidence in the post-tsunami.
	2. From desalination Plant.	14 mld	
	3. New well sources in Port Blair.	0.39 mld	
Medium term option	1. Sippighat fresh water lake.	5.6 mld	
	2. Pond sources.	0.34 mld	
	3 Creation of new reservoirs in and around Port Blair.	2.9 mld	
Long term option (*)	1. Raising of Dhanikhari dam.	13.5 mld	
	1. Inter Island transfer at Rutland spring water.	12 mld	
	2. Indra Nallah Project.	1.0 mld	
Total water availability Million Lakh litres(MLD)		50.23 MLD	

Source: APWD,A&N Admn.

7.2 Ground water utilisation for drinking water supply and irrigation and rainwater harvesting

It is already discussed that inspite of copious rainfall received in the islands,availability of surface water is less while ground water is also available in the low tune because of various causal factors. Although in Port Blair the water supply is met from surface water source at Dhanikhari. Still in the entire rural areas of Andaman & Nicobar islands, the water supply for drinking is met from the Springs and dugwells. For augmentation of water supply to Port Blair tapping the Spring sources of contiguous Rutland island a suvey was carried out by CGWB in 2002 in the wake of extreme water crisis. The implementation work is underway.

Irrigation water requirements in few islands like Neil,Havelock and Little Andaman is met from groundwater.Utilisation of groundwater from borewells were highly popularised in parts of South Andaman which are underlain by hard rocks. However, aquifers in hard rocks in these areas suffered maximum stress during the 26.12.04 earth quake which facilitated multiple fractures in deeper and shallow aquifers. Because of this disaster many water loosing fractures were developed which had facilitated evacuation of ground water from the high lands and new springs were subsequently developed in low lying areas. This has caused drying up of many borewells and cessation of autoflowing condition as also lowering of water level. The discussion on the aspect is presented in the succeeding chapter.

Rainwater harvesting in the island was done for the first time during 1998-2000 by the A&N Admn. tapping the roof tops. Rainwater harvesting through ponds were initiated long back by the Agriculture Department for development of irrigation and fisheries. The activities were highly accentuated in the post-tsunami through the Rajiv Gandhi Rehabilitation project for Agriculture(Table-6.1). Similarly, under the technical guidance of CGWB,Dept. of Agriculture,A&N Administration had constructed 63 check dams during 2003-04 in South Andaman district. More check dams are further required to be constructed in the islands to harvest huge quantity of rainwater as also for ground water recharge.

7.3 Impact of demographic changes on water supply

Demographic pattern in the entire A&N Islands in general and in South Andaman encircling the city of Port Blair has witnessed a rapid demographic changes in the last few decades.

7.4 Artificial recharge practices adopted in the island with success stories

Extensive hydrogeological studies by CGWB have paved the way for successful implementation of artificial recharge practices in the South Andaman Island.The success stories of some of the projects are presented below.

7.4.1 Success stories

In the following table(Table-7.4.1.1) the success stories of important select artificial recharge projects are presented**.**

Table: 7.4.1.1 Select Drinking Water supply projects in South Andaman utilizing artificial Recharge technique during Pre-tsunami

Sl no.	Location	Structures proposed	Remarks
1	**Nayagaon(**Portblair Municipality)near airport boundary	**Check dam**-three, Subsurface dyke and one large dia(6.0m) well	**Geology**-weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 30,000 Litres per day. **Yield post construction**- 35000 Litres per day
2	Austinabad (Portblair Municipality)near Mariamma Temple	Subsurface dyke and one large dia(6.0m) well	**Geology**-weathered & fractured pillow lava. **Completed project. Pre-project estimated yield**- 35,000 Litres per day. **Yield post construction**- 50,000 Litres per day
3	Prorthrapur Nala behind Zail, Portblair Tehsil,S.Andaman	**Check dam-**Four,**Recharge shafts**-12 to 15 nos, Subsurface dyke and one large dia(6.0m) well	**Geology**-weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 30,000 Litres per day. **Yield post construction**- 35000 Litres per day
4	Panighat nala, Ferrarganj Tehsil, S.Andaman	**Check dam**-Four**, Recharge shafts**-12 to 15 nos, Subsurface dyke and one large dia (6.0m) well	**Geology**-weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 30,000 Litres per day. **Yield post construction-** 40,000 Litres per day

5	Stewartganj. Inside the village	**Check dam**-Four, **Recharge shafts**-12 to 15 nos, Subsurface dyke and one large dia (6.0m) well	**Geology-**weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 30,000 Litres per day. **Yield post construction-** 40,000 Litres per day
6	Guptapara, S.Andaman, Ferrarganj Tehsil **(Fig-18)**	Subsurface dam, one large dia (6.0m) well	**Geology**-weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 70,000 Litres per day. **Yield post construction-** 78,000 Litres per day
7	Atom Pahar, South Andaman	**Check dam-**one, Subsurface dyke and one large dia (6.0m) well	**Geology**-weathered & massive Impervious Sedimentary rocks. **Completed project. Pre-project estimated yield-** 5,000 Litres per day. **Yield post construction**- 15,000 Litres per day

7.5 Vulnerability of the Island with reference to Disaster

Although a major part of South Andaman island is occupied by high hills the coastal parts having relief upto 10m are susceptible to Tsunami devastation. Although there is no previous record of high tsunami wave more than 5m in the Island, still considering the probability a Digital Terrain model is generated and it is presented in Chapter 10.0. From the model it is very much easy to demarcate the total area vulnerable for tsunami wave of any particular height. However, land subsidence to the tune of 1.2-1.5m in considerable part of South Andaman was responsible for a natural sea water ingress. Beside tsunami, the South Andaman island is also vulnerable for earthquake because of its localisation in a highly tectonically active zone(Zone-V). Sea waves generated from cyclonic storm may invade the island any time. However,there is no record of devastating cyclone or sea wave of any kind hitting the island.

7.5.1 Epidemics

Mosquito borne diseases like malaria, Chikengunia are very common in South Andaman. Due to the land subsidence, after the tsunami , the malarial fever broke out into the South Andaman island in the form of epidemics.

7.5.2 Tsunami

Beside,the devastating Indian Ocean tsunami of 26.12.04, past record reveals that atleast twice in the past tsunami was experienced in the A&N Islands. One was in 1941 and the other was in 1881. Both the tsunami was generated due to earthquake having epicentre in the deep sea.

7.5.3 Impact of tsunami and earthquake on the South Andaman island

The coastal tracts are highly affected after Tsunami and consequiently the arable lands underlain by such formation was affected by salinity ingress(Fig- **7.5.1.**1 & **7.5.1.**2**)**. The result of salinity indicated electrical conductivity in affected wells varies from 3390 to 13350 m Ms/cm during

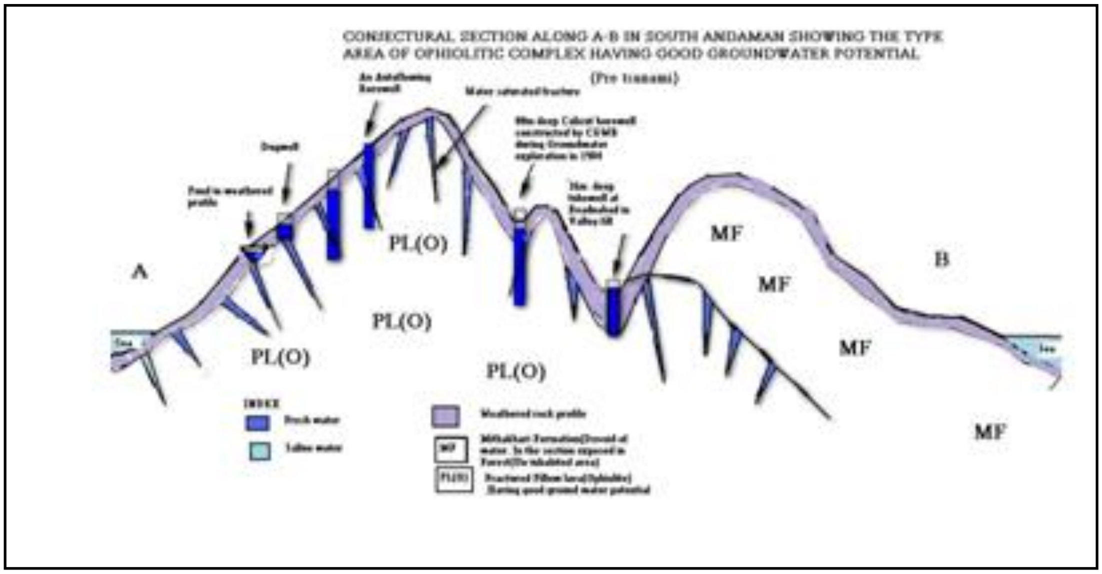
March’05 and 4000 to 6960 Ms/cm during May’05. The monitoring is still continuing. Continuation of salinity may be because of ingress of salinity in the sub surface. However, salinity is apparently low after the monsoons of 2010-11 in some areas. Although is low areas at many places ground water level has come up wards after the earthquake where as at high land water level has gone down. At places even the after shock had influenced the water level. The monitoring well behind Sampat lodge(Port Blair) had shown water level below 8.01 m on 2.1.2005 while on 9.3.2005 tha water level was at 1.28m below ground level. The volcanic rocks are forming potential groundwater reservoir and facilitate construction of ponds, borewell, dug well with subsurface dam, infiltration gallery, checkdam etc. the areas are highly effected after the earthquake. In south Andaman small strech of coralline formation is available near Marina Park and carbynscove area where ground water is under use. In both the places ground water was available in appreciable quantity which was affected due to tsunami. Depth to water level varies from 2.57 mbgl to 9.26 mbgl.and 2.94 mbgl to 9.14 mbgl respectively during pre and post monsoon times. Ponds,checkdams,dug wells and borewells in Maccapahar-Bimbliton-calicut tract were highly affected.In Ferrarganj area ponds were dried up.

Fig- 7.5.1.1

Fig- 7.5.1.2

Affected wells in the costal area at Marina Park, and Brookshabad, Portblair

At one place polythene sheets are utilized to wrap the fractured basement in the pond. Presently water is impounded after the monsoon which may not retain for a long period because of high evaporation rate. Based upon the studies carried out different conceptual models are devoloved. Following figures(Fig- 7.5.1.3 &Fig- 7.5.1.4) show various post tsunami changes in the hard rock areas of south Andaman.

Fig  –

7.5.1.3 Conjectural section along A-B in South Andaman (Pre-Tsunami)

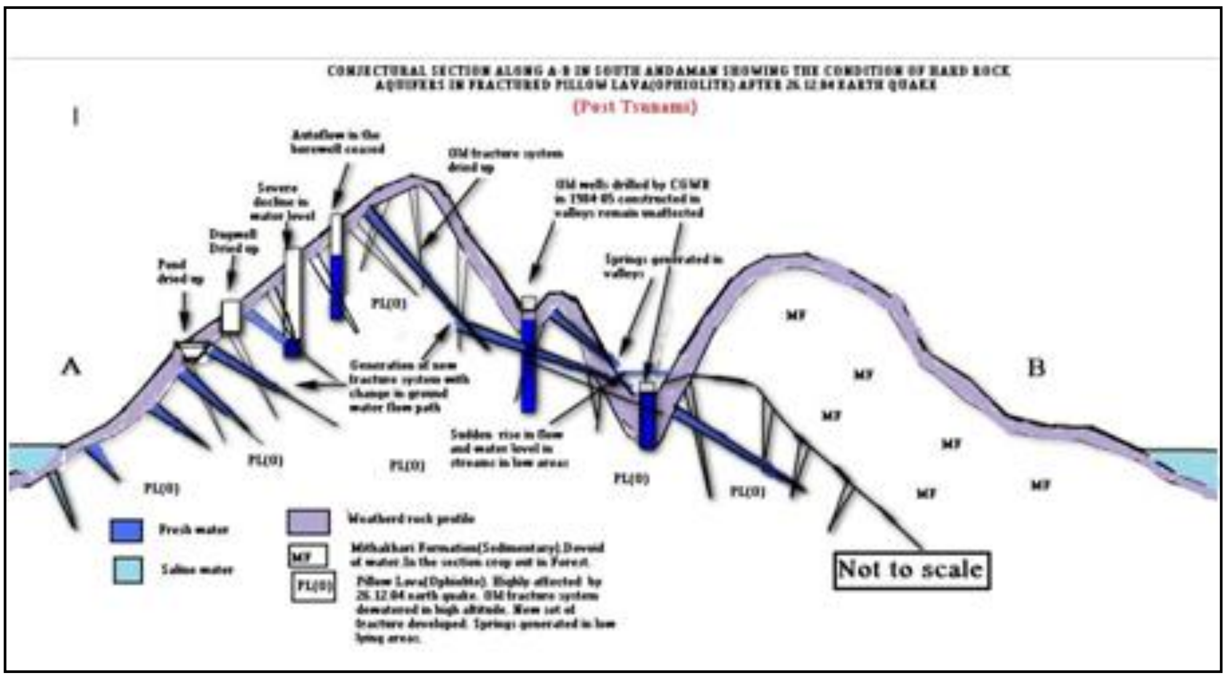


Fig. **7.5.1.4** Conjectural section along A-B in South Andaman (Post-Tsunami)

7.6 Major Groundwater related problem

It is already mentioned that the geologic formations in and around Port Blair town are highly varied and major parts are occupied by impervious sedimentary rocks where ground water development possibility is in the low key. These rocks are unfit for construction of borewells/tubewells. Dugwells are feasible in such formations but yield is restricted. A dug well of 2-3m diameter and 5m depth can only yield 2000-3000 litres per day. However in select locations especially near the drainage it may discharge in much higher tune. In Port Blair municipal area only in

Brookshabad the igneous rocks are available where bore wells can be drilled in specific areas. In a small patch near Corbin's Cove adjacent to Peerless Beach Resort where moderate quantity of water could be available from shallow and porous Coralline limestone Formations through dug wells, in the Pre tsunami where the quality of groundwater is slightly deteriorated in the post-tsunami.

7.7 Feasibility of Rainwater and artificial recharge

While the impervious sedimentary formations are unfit for groundwater development, these formations are highly suitable for construction of ponds especially feasible in the valleys and topographic lows where it get both ground water and act as a very good rainwater harvesting structure. Consequently the low-lying areas as opined by CGWB (Kar, 2003, 2005, 2006, 2007) can be developed for construction of ponds as also reservoirs. Artificial recharge techniques also could be applied (Fig-16) only in small pockets which were advocated by CGWB (Kar, 2001, 2003). Many of these recommendations are already implemented by PBMC (Port Blair Municipal Council) and APWD (Andaman Public Works Department).

8.0 Recommendations

There have been significant changes in groundwater resources of South Andaman district in the post-tsunami. Both the mega earthquake (M=9.3) and the Killer tsunami on 26.12.04 were responsible for many changes in the availability and quality of groundwater. The tsunami waves of height varying from 1.5m to 2.8/ 3.0 m had contaminated the water resources in the low-lying coastal areas of the affected islands. Subsidence of land in parts of the islands and destruction of landmass has been caused in the district. These had caused some reduction in the fresh water volume as conjectured by this study as also opined by the International Ground water resources assessment centre (IGRAC). In this regard the models developed .Study has revealed that the qualitative changes are not fully obliterated and it still persists at places. The expected depth wise reduction in freshwater has warranted cautious development of ground water resources in the district of South Andaman in the Post tsunami. Consequently with the expected rise in sea level, the coastal aquifers are being stressed and they are likely to be further endangered.

Large scale rainwater harvesting in the watersheds, more and more saline area reclamation and construction of subsurface dams and check dams in the estuarine streams would improve the scenario. Close qualitative monitoring should be continued for future management of groundwater resources in these disaster prone and ecologically fragile islands.

Owing to the above qualitative deteriorations in the aquifers, problems are being faced for development of ground water resources in the tsunami affected islands.

Fig- 8.1 Saline reclamation bund and drainage training works at Chouldari, These works are beneficial for land resources preservation and stopping salinity ingress in the subsurface, S.Andaman.

It is to be mentioned that after the 26.12.04 disaster there was considerable decrease in fresh ground water volume, where plenty of ground water was available from dug wells without any quality deterioration in the Pre tsunami. Particularly the depth criteria, maximum availability, and future sustainability are the main concern for them in the changed scenario. Especially in the islands like Neil, Havelock the changes in quality may have a future influence on groundwater sustainability especially in view of its accelerated groundwater uses for tourism in the post-tsunami. This is a clear threat to the environment in matters of future development of ground water in the islands for its optimum development for rebuilding of the islands after the colossal disaster. Now in view of the anticipated sea level rise, the coastal aquifers in the islands appear to be more vulnerable in the forthcoming period. Hence the water user Departments in the islands should go for: -

I. A cautious development in view of the future sustainability.

II. The ground water development surveillance system with quality monitoring for time-to-time detailed assessment should be built up forthwith by the A&N Administration in consultation with CGWB to monitor the situation.

III. To augment the fresh water resources as also to reduce the salinity ingress, large scale rainwater harvesting in the watershed, saline reclamation bunds, tidal bar in the estuarine streams with sub surface dyke would be highly beneficial as observed by the USGS in Atlantic coast (Barlow, 2000), which have been already advocated in the islands (Kar, 2003,2006c).

Soon after disaster at the behest of Govt. of India, the A&N administration had taken up Rajiv Gandhi Rehabilitation Project for Agriculture where ground water development and rainwater harvesting was a very important component. In this regard based upon the post-tsunami research studies carried out by CGWB (Kar,2006) in liaison with the agriculture dept. ,A&N administration and the post tsunami terrain condition, the modified target of implementation structures were formulated and the developmental activities were continued till 2010-11.

From the foregoing discussion it is clear that there have been some qualitative and quantitative changes taken place particularly in the ground water resources in the islands. field observation carried out by the author reveals that with the destruction of coast line by the tsunami, subsidence and progression of tidal line towards coast has caused sea water ingress both in the surface and subsurface . because of this problem it appears that the former thickness of fresh water resources has been reduced, which has caused the changes in quality as being observed in the monitoring wells spread all over the islands. the observations are spectacularly matching with the models and observations made by the International ground water resources management center(IGRAC,2006). For this reason a problem in development of the drinking water supply sources in the islands is being faced by APWD, A&N Administration. especially the depth criteria , availability and future sustainability is the main concern for them in the changed scenario. However, based upon detailed studies and prevailing hydro geological situation and terrain and aquifer conditions of the islands, the following structures are recommended in the post-tsunami to conserve, recharge and exploitation of ground water and rain water:

1. Ponds 2. Check dams, 3. Sub surface dams/dykes, 4. Recharge shaft/Pit/well, 5. Intake wells 6. Collector wells with infiltration gallery, 7. Lift irrigation points, 8. Roof top rain water harvesting and recharge 8. Saline area reclamation and construction of bunds/tidal bars,sluice gates and drainage channels(Fig-8.1).