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GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES

GROUND WATER INFORMATION BOOKLET
North-Middle Andaman District, A&N Islands

Dr. A. Gayen, Scientist 'C'
&
Amlanjyoti Kar, Scientist 'D'

Central Ground Water Board
Eastern Region, Kolkata

March, 2013

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CENTRAL GROUND WATER BOARD
Eastern Region, Kolkata

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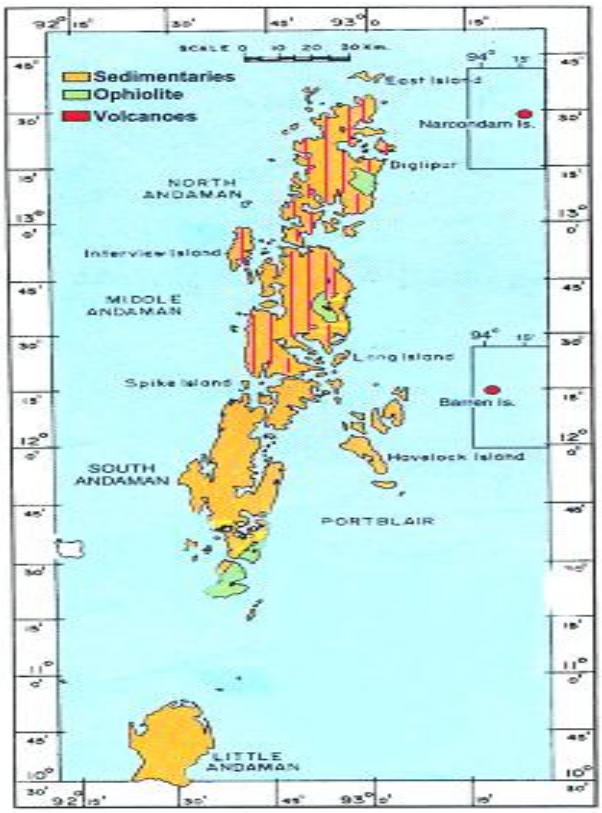


by
Dr. A. Gayen, Scientist 'C'
&
Amlanjyoti Kar, Scientist 'D'

Central Ground Water Board
Eastern Region, Kolkata

March, 2013

AT A GLANCE

North-Middle Andaman District

Sl. No.	Items	Statistics
1.	**GENERAL INFORMATION**	
	i) Geographical area (Sq.Km)	3251.85
	ii) Administrative Divisions (as on 31.03.2013)	
	• No. of Zilla Parishad	1
	• No. of Subdivisions	2
	• No. of Blocks/Tehsils	3
	• No. of Municipalities	Nil
	• No. of Gram panchayats	37
	• No. of revenue villages	98
	• No. of census villages	188
	• Inhabited	160
	• Un-inhabited	7
	• Urban area	Nil
	• Rural area	3251.85 Sq.Km
	• Total number of islands in the district	95
	• Number of inhabited islands	12
	• Biggest inhabited islands	Middle Andaman
	• Smallest inhabited islands	Aves Island
	• Southernmost island	Baratang
	• Northern most Island	East Island
	• Highest Peak	Saddle Peak
	iii) Population (as per 2011 census with population density per sq. km.)	105539 (32 per sq.km.),Male-54821; Female-50718
	iv) Normal annual rainfall(in mm)	3180
	v) Actual Rainfall (in mm) as in 2011	3888.7 in Port Blair & 3770.2 in Mayabunder & 3554.4 in Long Island
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
	Major Drainages	South Creek,Jarawa Creek Nala in Baratang,Saberi Nala,Dasarathpur Nala,Rangat Nala,Betapur Nala,Korang Nala,Webi Nala,Tugapur Nala in Middle Andaman,Kalpang Nala,Magar Nala,Cherian Nala in North Andaman
3.	**LAND USE (Sq.km.) (as on 2011)**	
	a. Forest area(Hectare)	308393.00
	b. Reporting Area for land utilization(Hectare)	281431.77
	c. Area under cultivation(Hectare)	19266.00
	d. Not available for Cultivation (Hectare.)	262165.00
	e. Other uncultivated land excluding fallow land(Hectare)	2840.98
	f. Current fallow (Hectare)	342.75
	g. Fallow lands other than current fallows(Hectare)	1321.06
	h. Net areasown(Hectare)	6903.50
	i. Area sown more than once(Hectare)	246.85
	j. Area submerged after tsunami(Hectare)	16
4.	**MAJOR SOIL TYPES**	Entisols,Inceptisols and alfisols
5.	**AREA UNDER PRINCIPAL CROPS (as in 2009-10)**	Paddy, pulses, oilseeds, vegetables, coconut, arecanut, fruits, sugar cane, root crops
6.	**IRRIGATION BY DIFFERENT SOURCES (Areas & No. of Structures) (as in 2009-10)**	
	Dugwells 115 nos.	115 hectares,
	Borewells	Nil
	Check Dams 66 nos	463.65 hectares
	Ponds/Tanks 204 nos.	204 hectares
7.	**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (as on 31.03.2013)**	26
8.	**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

9.	**HYDROGEOLOGY**	
	Major water bearing formation	Ground water in Marine sedimentary formation occurs under unconfined condition in weathered residuum. Preponderance of clayey mineral renders groundwater development possibility very low. Yield of dug well(5-6m dia,6m depth)in Marine sedimentary group varies from 4000-5000 litres/day. Ground water in Ophiolites occurs under unconfined to semi-confined condition in weathered residuum while in fractured hard rock in deeper horizon in confined condition. Yield of dug well(5-6m dia,6m depth)in Marine sedimentary group varies from 40,000-50000 litres/day. In case of bore well(6$^{//}$dia,80m deep) yield varies from 80,000-1,00,000 litres per day. In Coralline limestone in archipelago group yield of dug well(5-6m dia,4-5 m 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.
	Pre-monsoon depth to water level during 2012	0.36 -4.11 m below ground level
	Post-monsoon depth to water level during 2012	0.18 -2.70 below ground level
	Long term water level trend in 10 years(2002-2012) in m/yr	The water level trend has been analyzed for all measurements and found that there is a rising trend varying from 0.021 to 1.196m/yr.
10.	**GROUND WATER EXPLORATION BY CGWB (as on 31.3.2013)**	
	No. of wells drilled	13 nos.
	Depth range	30 m - 80.60m
	Discharge	Negligible: 45m^3/hr
	Transmissivity (T)	N.A
	Storativity (S)	N.A
11.	**GROUND WATER QUALITY**	
	Presence of Chemical constituents more than the permissible limit	High Iron in pockets and brackishness in dug wells close to the coastal tracts.

	Type of water	Ca-Mg-HCo_3 - Na- HCo_3
12.	**DYNAMIC GROUND WATER RESOURCES (2008-09)**	
	Net Groundwater availability	5549.08 ham
	Existing groundwater draft for irrigation purposes	11.75 ham
	Existing groundwater draft for all uses	294.67 ham
	Stage of Groundwater development	2.25%
13.	**AWARENESS AND TRAINING ACTIVITY**	
	Mass awareness programme organized (numbers)	Nil
	Water management training programme organized (numbers)	Nil
14.	**Efforts of artificial recharge and rainwater harvesting**	
	Projects completed under technical guidance of CGWB and funded by MOWR(Nos. and amount spent)	Nil
15.	**GROUND WATER CONTROL AND REGULATION**	
	No. of over-exploited blocks	Nil
	No. of Critical blocks	Nil
	No. of blocks notified	Nil
16.	**Major GROUND WATER 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.

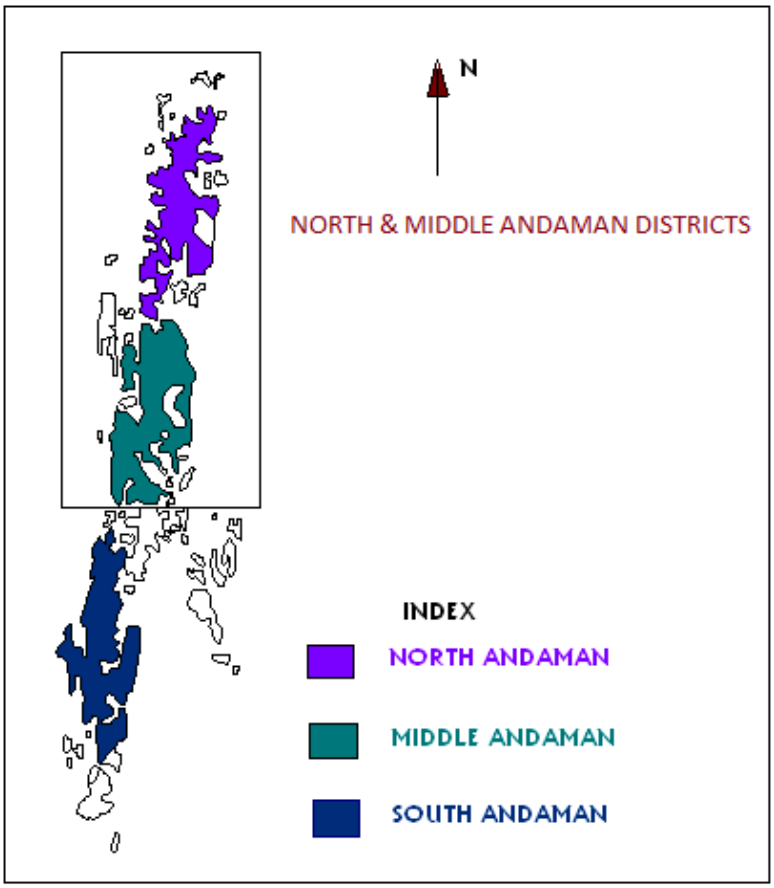
1.0 INTRODUCTION:

1.1 Location and Administrative Details

The North & Middle Andaman; district possesses a geographical area of 3251.85 sq kms., with 2 sub-divisions (Mayabunder and Diglipur), 3 tehsils i.e. Diglipur, Mayabunder and Rangat and 98 revenue villages. Mayabunder, a port town and having old establishments like Port Blair and its environs since the British period. Diglipur is a new settlement area and the largest and farthest town of North Andamans , located in the nortern extremity , at a distance

of 290 km from Port Blair. Main attractions around Diglipur are Ross & Smith Island, Saddle peak national park, Rampur beach and mud volcanos. The tallest peak of the islands called the Saddle Peak (732 Metres) is located in Diglipur. Kalpong, the only river of Andaman flows through Diglipur town.

Fig 1: Administrative Map of North & Middle Andaman district



Not to scale

1.2 Ground Water Basin

Rugged topography, steep slope, low infiltration capacity and close proximity of hill to sea disallow creation of potential groundwater reservoirs in major parts of the district.

1.3 Population

As per population census of 2011, total population of the district is 105539 of which Male- 54821 and Female-50718. Population density of the district is 32 per sq.km.

1.4 Land Use

Forest covers a major part of the district. Since inception of the colonial British Raj, the forests in and around Mayabunder were cut to make room for establishments for Penal settlement and agriculture. After sixties there had been considerable loss of forestry for settlement of the refugees from East Pakistan now Bangladesh in Middle and North Andaman, of the North-Middle 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. At places near Saberi and Dasarathpur in Middle Andaman and near Jarawa creek in Baratang, the low lying lands, mostly under utilisation agriculture, were submerged by sea water ingress due to the subsidence after the mega earthquake(M=9.3) on 26.12.2004. The land use of the district is enumerated below (Table-1).

Table-1: Land use in North-Middle Andaman District

Item	Land use in Hectare
Total Geographical Area	325185.00
Reporting Area for land utilization	281431.77
Forest area	308393.00
Not available for Cultivation	262165.00
Other uncultivated land excluding follow Land	2840.98
Current fallow	342.75
Fallow lands other than current fallows	1321.06
Net area sown	6903.50
Area sown more than once	246.85
Area submerged after Post-tsunami	16

1.5 Studies undertaken by Central ground water Board (CGWB)

The studies carried out by CGWB since 2000 has helped the A&N Administration to formulate and to start with water harvesting schemes tapping the surplus runoff through multiple check dams., subsurface dams/dykes, tidal bar for augmentation of both drinking water and irrigated agriculture. In North-Middle Andaman district, out of 281431.77 hectares of land under agriculture, 16 hectares was damaged by tsunami as well as by the permanent

saline water ingress due to land subsidence. Hence, strategies incorporating an integrated water Resources development plan through tapping ground water, rainwater harvesting and watershed development have been formulated by CGWB (Kar, 2005, 2006) in view of the post tsunami scenario in the islands. It is observed that after the 26.12.04 calamity if not qualitatively like South Andaman and Nicobar District, quantitatively there has been some change in the fresh ground water resources in North-Middle Andaman district.

Because of the absence of any groundwater surveys and investigation department in A&N Administration, all the ground water surveys 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 North Andaman Island was carried out by Shri D.P.Ghosh, Sr.Geologist of Geological Survey of India. In 1978-79 session.Dr.T.L.Chackraborty, Jr.Hydrogeologist of CGWB had undertaken systematic hydrogeological surveys in Middle Andaman Island during 1991. Groundwater monitoring in the district although continued since 1990 or so but its data has been kept systematically since 2000. The artificial recharge and conservation of rainwater and groundwater was initiated in 1998 in Long Island 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. 35 sites were advocated for augmentation of water supply to APWD, PRI and defence of which implementation of recommendation was executed in 10 sites. Very good promising results were obtained. Besides, CGWB (Kar, 2003&2006) 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 (Sarkar, 2000) has also carried out resistivity surveys in the district to select the sites for Artificial recharge of groundwater and rainwater harvesting. In 2006-07 Reappraisal hydro geological surveys in Middle Andaman and Baratang was undertaken by Dr.S.Brahma, Scientist-B under the supervision of Sh.A.Kar, Scientist-D. In 2009-10, Dr.A.Gayen,Scientist-C has carried out a special study to find out the alluvial patches in North-Middle Andaman. During 2010-12, FPARP (Farmers participatory action research project) was carried out in the district by Central Agricultural Research Institute (CARI), ICAR under the technical guidance of CGWB, E.Region, Kolkata.

2.0 RAINFALL & CLIMATE

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 North- Middle Andaman district enjoy tropical humid climate because of their location in the equatorial zone surrounded by the Andaman Sea. Winter is virtually absent and the islands have only two seasons viz. Rainy Season and Summer Season. 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.

2.3 Drainage

In comparison to South Andaman district, many perennial streams occur in North Middle Andaman district. Amongst them important streams are South creek Nala, Saber Nala,Dasarathpur Nala, Rangat Nala, Korang Nala, Betapur Nala, Thoratang Nala,Kundu Nala,Tugapur Nala,Webi Nala,Karmatang Nala, Magar Nala, Cherian Nala, Laxmipur Nala,Swarajgram Nala, Kalpong Nala are most important and drain the district along with many other small perennial and non-perennial streams. Many of these streams show substantial flow through out the year. Amongst all these streams, Kalpong nala is the largest and may be termed as a river. The stream is originated in Saddle peak and carries substantial flow all around the year. The lone hydel power project of A&N Islands is constructed on the stream near the village Nabagram in Diglipur subdivision. 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 has facilitated the tidal ingress along the streams of Middle Andaman island near Saberi and Dasarathpur and near Jarawa creek of Baratang Island.

3.0 GEOMORPHOLOGY AND SOIL

3.1 Geomorphology

The district is characterized by major physiographic units like i) Low to moderately high steep hills; ii) Intermontane narrow valleys; and iii) Gently sloping narrow to moderately wide coastal plain (0.02-0.8 km). Overall altitude of the islands varies from sea level to 465m.

North Andaman Island is covering a geographical area of nearly 2232.00 sq. km, and situated along a chain at a distance of nearly 150-200 km in the north of Port Blair town. The Diglipur zone (Tehsil) and Mayabunder zone (Tehsil) upto Billiground has been considered in North Andaman. This vast island is occupied by good arable land and it forms one of the good producers of vegetable in the Islands. Different types of vegetables are grown here. Crops are mainly rained. However, irrigation during the lean period is dependent on ground water. Dug wells, ponds and the perennial streams are the main sources of irrigation in the area. With the construction of multiple check dam by Agriculture department during 2003-2004 the double cropping is enhanced in the islands. Few shallow tub wells are constructed along the Kalpong river valley courses near D.B.Gram. Saline land reclamation is also successfully done in this island which has accentuated the land as well as ground water resources of the island.

Middle Andaman Island including Baratang is covering a geographical area of 1070 sq. km, where the share of Baratang Island is 297.60 sq km. The area is situated along a chain at a distance of nearly 65-150 km in the north of Port Blair town. The entire tract of Billiground upto Kadamtala is considered in Middle Andaman Island. This vast island is occupied by good arable landing Swadesh Nagar–Billiground and Parnashala–Kalsi sectors and it produces good quantity of vegetables for the Island. Different types of vegetables are grown in this tract, crops are mainly rainfed. However irrigation during the lean period is dependent on ground water. Dug wells, ponds and the perennial streams are the main sources of irrigation in the area. With the construction of multiple check dam by the Agriculture department during 2003-2004 the double cropping is enhanced in the islands.

Saline land reclamation is also successfully done in this island which has accentuated the land as well as ground water resources.

Physiographically the North & Middle Andaman group of islands can be subdivided into three main subdivisions.

1. Low lying coastal plains

2. Intermontane valleys

3. Moderate to high hills and forest.

The Andaman & Nicobar Islands have varied topographical features. The Andaman group of islands generally features a mountainous terrain with long ranges of hills and narrow valleys. The maximum altitude of these islands is at Saddle Peak, which is about 730 m above mean sea level. The peak is formed of sandstone, limestone and clay. There are no great elevations and the slopes are also moderate.

Major drainages are South Creek, Jarawa Creek Nala in Baratang,Saberi Nala,Dasarathpur Nala,Rangat Nala,Betapur Nala,Korang Nala,Webi Nala,Tugapur Nala in Middle Andaman,Kalpang Nala,Magar Nala,Cherian Nala in North Andaman.

3.2 Soil

Soils in North Andaman, Middle Andaman, ,Interview island, , East Island, Baratang Island 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 comprise 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. 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 crops 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 hill slope. The soils of the other islands of North- Middle Andaman District like Ross and Smith Island Long Island, 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 Practices

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 North-Middle Andaman district, agricultural activities are boosted through augmentation of irrigation facilities since 2003 with the construction of check dams. In North and Middle Andaman islands vegetables are extensively grown besides Paddy..Island wise cropping pattern is presented in the following table (Table-2).

Table- 2: Island wise cropping pattern in North-Middle Andaman District

Sl. No	Island	Crops Grown
1	Aves	Paddy,vegetables,coconut,horticultural crops, spices
2	Baratang	Coconut
3	Porlob	Coconut
4	Curlew	Nil
5	East	Coconut, arecanut
6	Interview	Coonut, arecanut
7	Long	Paddy, vegetables, coconut, arecanut
8	Middle Andaman	Paddy, pulses, oilseeds, vegetables, coconut, arecanut, fruits
9	Narcondom	Coconut
10	North Andaman	Paddy,vegetables,coconut,arecanut,fruits,root crops
11	North Passage	Coconut, arecanut
12	Smith	Paddy,coconut,arecanut,fruits

4.2 Irrigation Practices

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. However, there has been a significant impact of boxing day (i.e.26.12.2004) mega earthquake (M=9.3) on water resources in general and groundwater resources in particular. The impact was varied in sedimentary and igneous formations and it affected qualitatively and quantitatively the water resources. Many of the effects are obliterated while some are permanent and still continuing.The impact of tsunami and earthquake on water resources is enumerated in the following chapters. Source wise irrigation details are presented in the table (Table-3).

Table-3: Area Irrigated by different Sources in the District of North& Middle Andaman

Sl. No.	Name of the Island	Source of Irrigation								Total irrigation potential created (Ha)
		Pond		Check dam		Dug well		Bore well		
		Total Pond constructed in various period	Irrigation Potential Created (Ha)	Dam constructed in various period	Irrigation potential created (Ha)	Total Well constructed in various period	Irrigation potential created (Ha)	Total Bore well	Irrigation potential created (Ha)	
1	Baratang	10	435.97	-	-	-	358.0	NIL	NIL	**1639.11**
2	Middle Andaman	98	31.53	38	54	112	138.0	NIL	NIL	**169.53**
3	North Andaman	96	24.0	34	42.17	3	118.0	NIL	NIL	**184.17**

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

5.0 GROUND WATER SCENARIO

5.1 Geology

The Islands in the North-Middle 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-4.

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 20% while the rest 10% 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 - 4: 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 Hydrogeology

Pre-Tsunami:

Hydrogeologically 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 may yield 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 formations dug wells are constructed (Example – Ross and Smith Island, Long island and the coastal tract of all inhabited islands).One dug well with the specification of 5m diameter and 4-5 m depth may even yield to the tune of 50,000-1,00,000 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).

Salient observations from the Hydro geological studies:

- Geology of the islands is highly varied and complex. Each Island is having complex and varied geological characteristics, which may change 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 11 exploratory tube wells/bore wells in Middle Andaman and 2 in North Andaman only 4 were successful. Amongst these three were drilled in Ophiolites(igneous rocks) while the rest .was drilled in valley fill near Rangat. The latter yielded substantially (@25m^3/hr) although the water was brackish (EC-3001 Microsiemens/Cm).
- 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 North-Middle 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, Dept. of Forest, Home Deptt. Etc.), PRI and Central Govt. Depts. Including Defence, 30 recommendations were given for augmentation of drinking water supply of which 10 are already implemented in North-Middle 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 38 were built in North-Middle Andaman district.
- 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.

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.

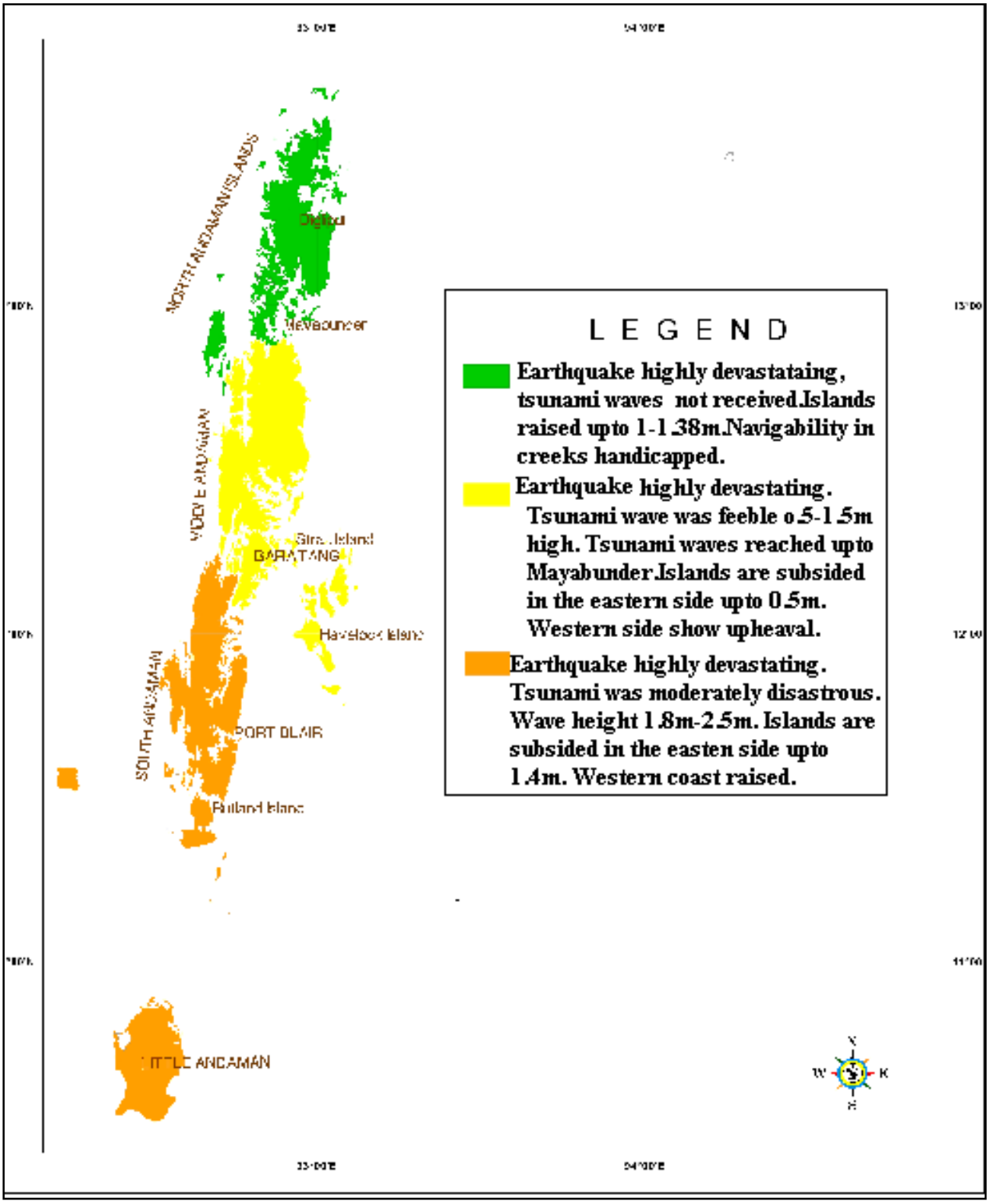
Post-Tsunami:

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 land resources and water resources in general and groundwater resources in particular were significantly affected by the colossal disaster. In the following map, the impact of the tsunami and

earthquake in different parts of North-Middle Andaman District is shown and the changes are briefly narrated in the following paragraphs.

- In high altitude terrains springs, ponds and wells were either dried up or discharges, were declined. In lower topographic terrains especially in the discharge of streams, springs, and water level in wells are increased. In other places either the discharge was showings some rise or was showing little bit decline or no change. However, in few cases the discharge was ceased.

Fig-2: 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 many places of North and Middle Andaman including Baratang island. The important places were Swadesh Nagar, M.Andaman,Laxmipur in N. Andaman island.

- Saline Water was ejected at several places in Baratang Island. The mud volcano in Baratang island which was erupted in 2003 was further erupted after the natural calamity. In one more new location in Baratang island, nearly 1.5 km south west of the existing mud volcano, large mud eruption took place.
- Cracks were generated in the aquifers which are cropping our in the surface.
- In North and Middle Andaman district the arable lands and ponds were highly damaged during earthquake (especially in Billiground area, Middle Andaman and devastation was highly precarious in Diglipur Subdivision, right from Mohanpur in the South to Hatilevel in the north) 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 Saberi,Dasarathpur area in Miidle Andaman island near Rangat and Jarawa creek area in Baratang island were subsided to the tune of 0.5-0.8m which had caused permanent saline water ingress.
- Although the entire landmass of North Andaman was severely rocked by the earthquake and several cracks were generated on the roads and cultivated land, civil structures subsided or displaced,there has been no damage in the hydel power dam in Nabagram on Saddle peak,North Andaman.
- The reported range in subsidence vary from 0.5 to 0.8 meter
- Similarly there has been a reported upliftment in North Andaman as also in the , western part of Middle Andaman to the tune of 1.2-1.5m, evident from lowering of creek water level during low and high tides.
- The low lying areas in the North-Middle Andaman district were inundated by Tsunami waves whose height varied from 0.5 to nearly 1 meter. The affected areas are Nilambur and Jarwa creek area,Baratang island; Saberi and Dasarathpur near Rangat, Rangat Bay area, Karmatang,Rampur area near Mayabunder all in Middle Andaman island and coastal area of Long island.

Inundation and devastation by tsunami wave was not reported from North Andaman island.

- 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.
    - ❖ At places the wells become naturally flushed without pumping.
    - ❖ The brackishness is obliterated in Rampur-Karmatang area and in Long Island. However,in the areas of land subsidence near Saberi and Dararathpur the brackishness in well water very close to the coast although declined, but it is continuing.
    - ❖ From the above observation the continuous monitoring should be undertaken by CGWB to adjudge the groundwater quality through time. 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.

Fig-3: Hydrogeological Map of North Andaman Island

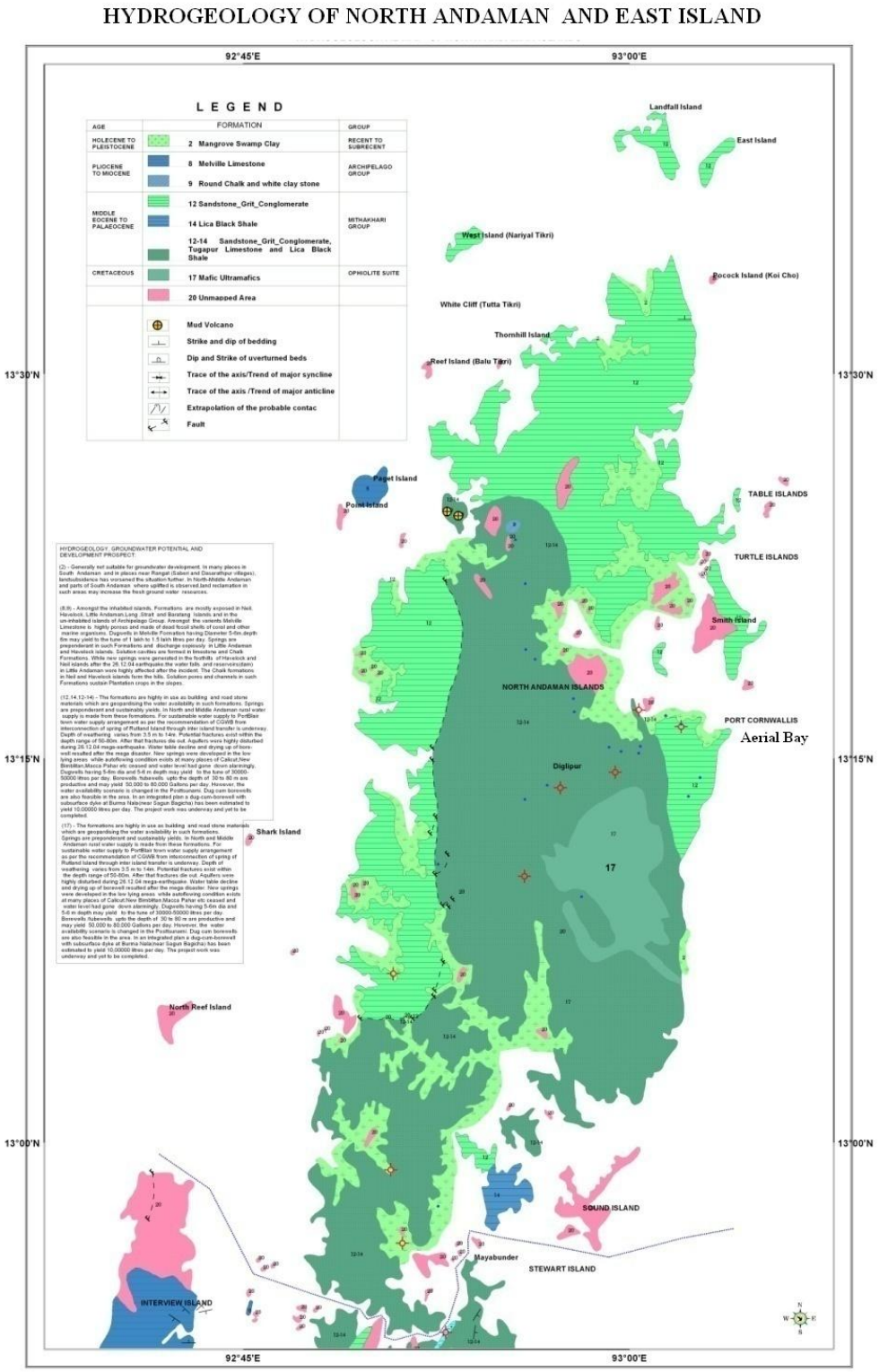
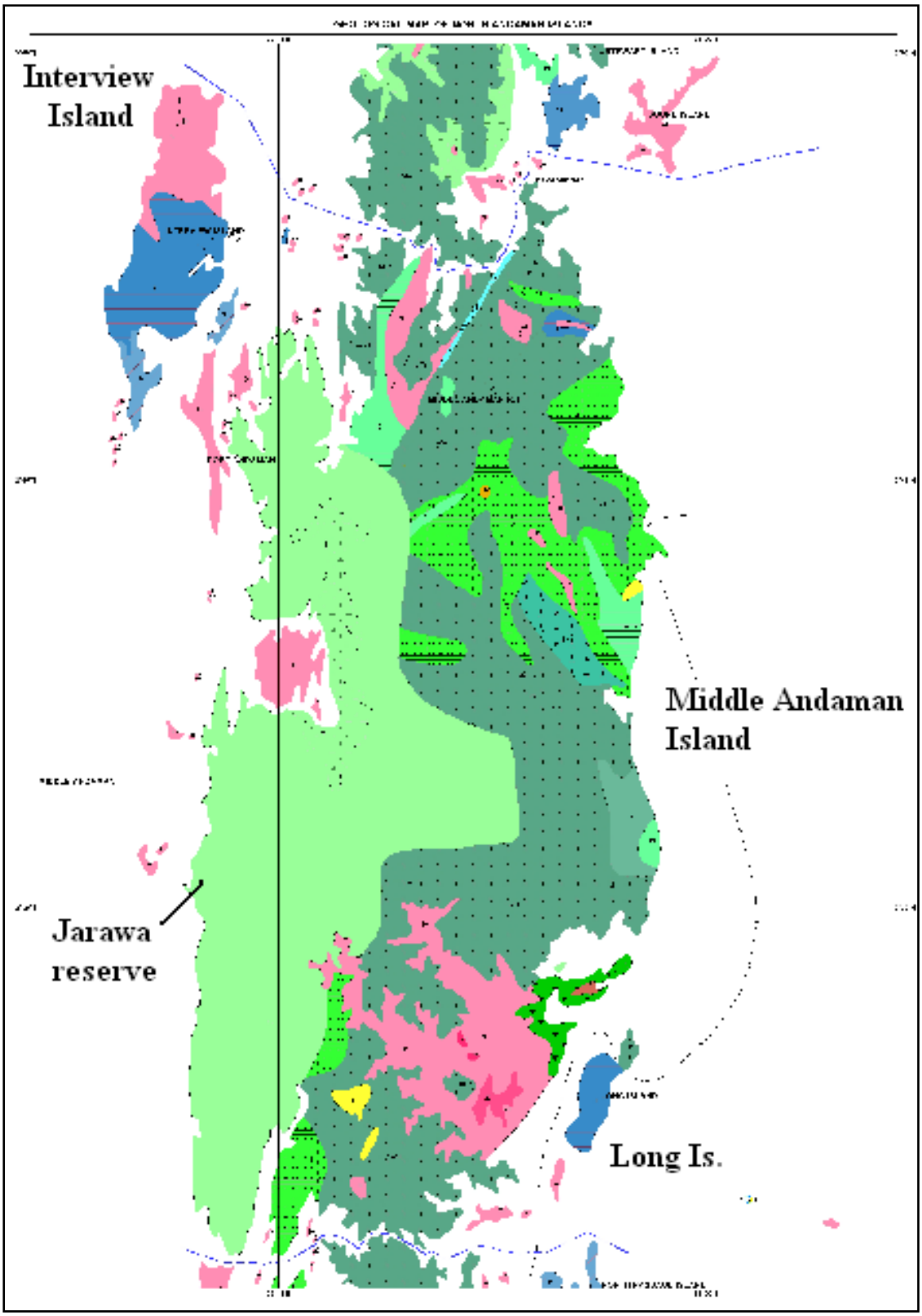


Fig-4: Hydrogeological Map of Middle Andaman Island



L E G E N D

AGE	FORMATION	GROUP
HOLECENE TO PLEISTOCENE	1 Alluvial and Colluviam 2 Mangrove Swamp Clay 4. Raised Beach	RECENT TO SUBRECENT
PLIOCENE TO MIOCENE	7. Muralat Jig Chalk and White clay stone 8 Melville Limestone 9 Round Chalk and white clay stone 10. Strait Formation	ARCHIPELAGO GROUP
OLIGOCENE TO U. EOCENE	11 Alternate Sandstone-Siltstone-Shale and conglomerate	ANDAMAN FLYSCH GROUP
M. EOCENE TO PALAEOCENE	12 Sandstone_Grit_Conglomerate 12-14 Sandstone-Grit-Conglomerate, Tugapur Limestone and Lica Black Shale	MITHAKHARI GROUP
CRETACEOUS	15. Pillow Lava Sequence 17. Mafic Ultramafics	OPHIOLITE SUITE
	20 Unmapped Area	

SYMBOLS

- Strike and dip of bedding
- Dip and Strike of overturned beds
- Trace of the axis/ Trend of major syncline
- Trace of the axis / Trend of major anticline
- Extrapolation of the probable contact
- Fault
- Mud volcano

ELECTRICAL CONDUCTIVITY (in micro seimens/cm at 25oC) SPOT VALUE

- <750
- 750-1500
- 1500-3000
- >3000

- NH Station
- Spring
- Exploratory well

5.3 Depth to Ground Water Level

In order to study the behavior of ground water regime with time and space in Andaman group of islands 63 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. Almost all the monitoring stations are dug wells except few bore wells. Depth to water level in majority of the monitoring stations ranges in between 2-5 m bgl (66%) and within 2 m bgl (25%) in rest of the stations during May. The minimum depth to water level 0.9 m bgl was recorded during May at Mayabunder in North Andaman.

5.4 Aquifer Parameters

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 11 were drilled in Middle Andaman and 2 were drilled in North Andaman island. It was observed that the boreholes drilled upto a depth range of 150 m in Sedimentary formations did not yield groundwater. However, the valley fill deposits in the islands were seen to yield copiously as seen near Rangat. The productive aquifers occur between 23-90m below ground level in fractured Ophiolites(Mafics and Ultramafics) and 29-32 m bgl in valley fill deposits with discharge varying from 10 to 25 m^3/hr.. The well drilled by CGWB at Hawamahal near Rangat in valley fill yields 25 m^3/hr. There was no exploration in the Coralline and limestone formation. The following table (Table-5) shows the salient details of the productive wells drilled in N-M Andaman district.

Table-5:Ground water exploration along with Aquifer Parameters in the 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	Middle Andaman	Rangat	Porous alluvium/colluvium overlie ultrabasics	151.4/35.0	29.8-32.0	25	-	-	3001 Brackish
2	-do-	Culvert no 64/65	Fractured ultrabasics	60.2/60.2	22-30 45-52	10	-	-	829 Fresh
3	-do-	Panchawati	Fractured ultrabasics	90.97/90.97	13.1-14.72	10	-	-	852 Fresh
4	-do-	Culvert No 69	Fractured ultrabasics	23.55	12-23.55	12	-	-	901 Fresh

*** All the other 9 explorations drilled in sedimentary formations in N-M Andaman District were dry.

5.5 Long Term Water Level Trend

The long term water level trend has been analysed 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.

5.6 Ground Water Resources

As per the GEC-1997 methodology, the watershed or administrative unit could not be applied here since the islands are generally separated. There are 36 Islands 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; the Rainfall Infiltration Method has been adopted for ground water resource estimation. Perennial source like springs have also taken into account in the ground water resource estimation. Ground water resource estimation for the year 2008-09 by GEC-1997 methodology is shown in table-6. Comparison of Dynamic Ground Water Resources of A &N Islands during 2004 vs. 2010-11 has shown in table 6a.

Table –6:Total Ground Water Resources of Andaman and Nicobar islands (2008-2009)

Sl. No.	Assessment Unit/ District	Total Dynamic Resource (ham)	In-Storage Ground water resources (ham)	Total Ground Water Resources (ham)
1	North Andaman island	2740.11	289.23	3029.34
2	Middle Andaman	2127.14	215.24	2342.38

Table-6a: Comparison of Dynamic Ground Water Resources of A &N Islands during 2004 vs. 2010-11

Comparative Criteria	*Resource Assessment 2004 (ham)*	*Resource Assessment 2010-11 (ham)*
Total annual ground water recharge	**32673.00**	**33561.47**
Net annual ground water availability	**32598.50**	**31023.14**
Current Annual Gross Ground Water Draft for drinking purpose	**1197.36**	**1965.56**
Annual allocation of ground water for domestic and industrial water supply up to next 25 years	**790.67**	**1225.78**
Available ground water for future use	**31771.446**	**28822.54**
Stage of Ground Water development	**3.72%**	**4.54%**
Categorization for future ground water development	**Safe**	**Safe**

5.7 Ground Water Quality

Analysis of ground water samples collected from the dug wells and exploratory bore wells constructed in the area, revealed that the quality of water is fresh and fit for all purposes. However, in view of plate collision and subsidence after the earthquake and Tsunami on 26.12.04, qualitative change has been noticed in the groundwater samples collected from parts of the affected areas in the town. The qualitative change is still persisting. Plots of chemical parameters in Piper diagram plots show increase in salinity in the Post tsunami in various islands of South Andaman district.

Fig- 5: Piper plot of Pre& Post tsunami samples of Long Island

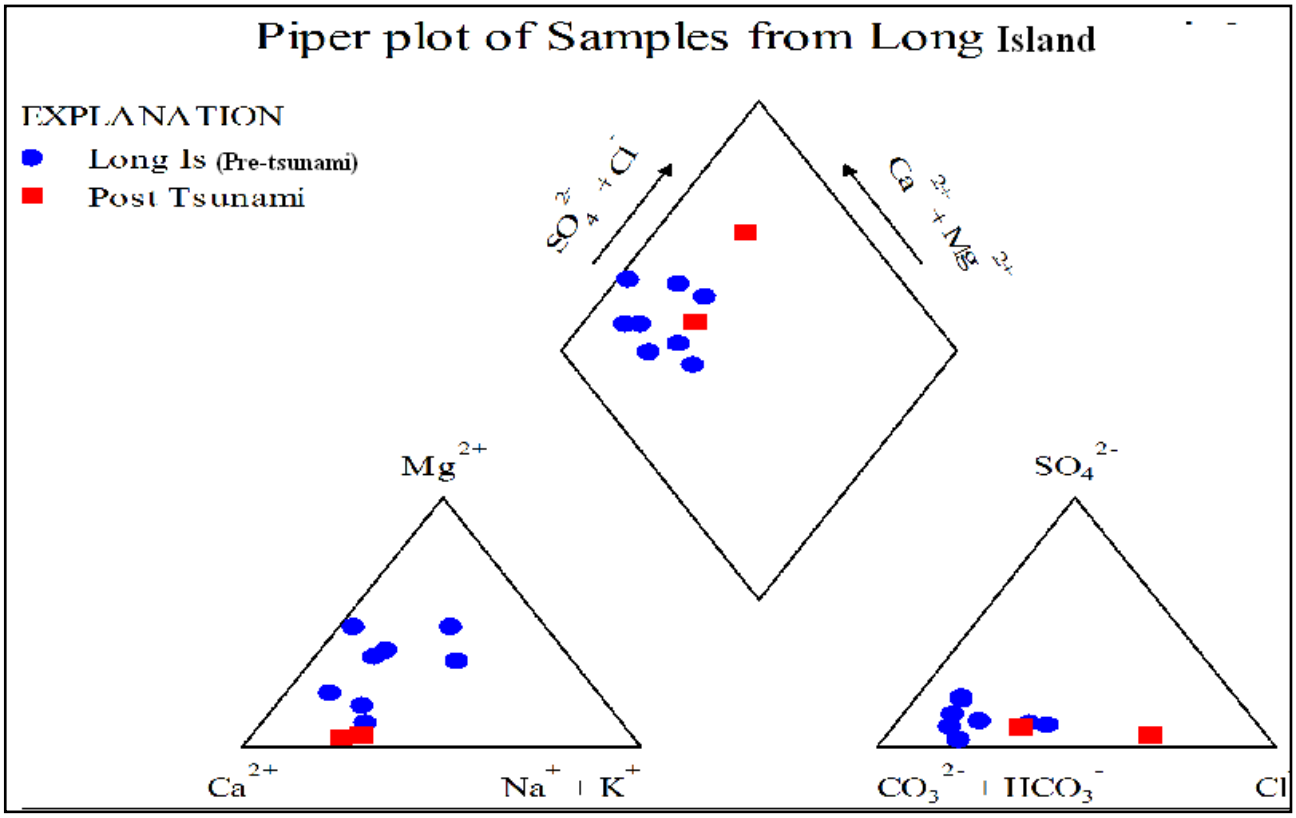


Fig- 6: Piper plot of Pre& Post tsunami samples of Middle Andaman Island

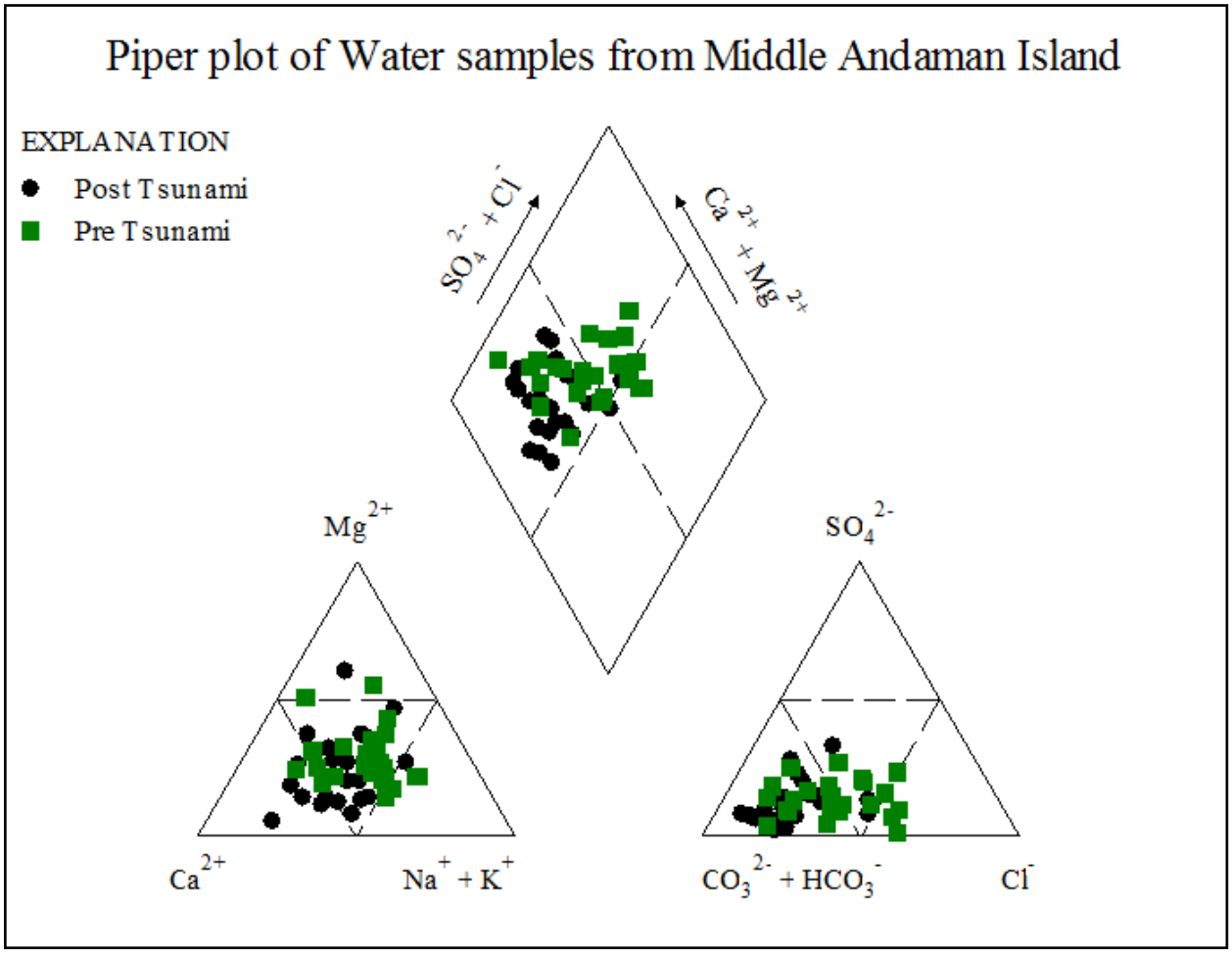
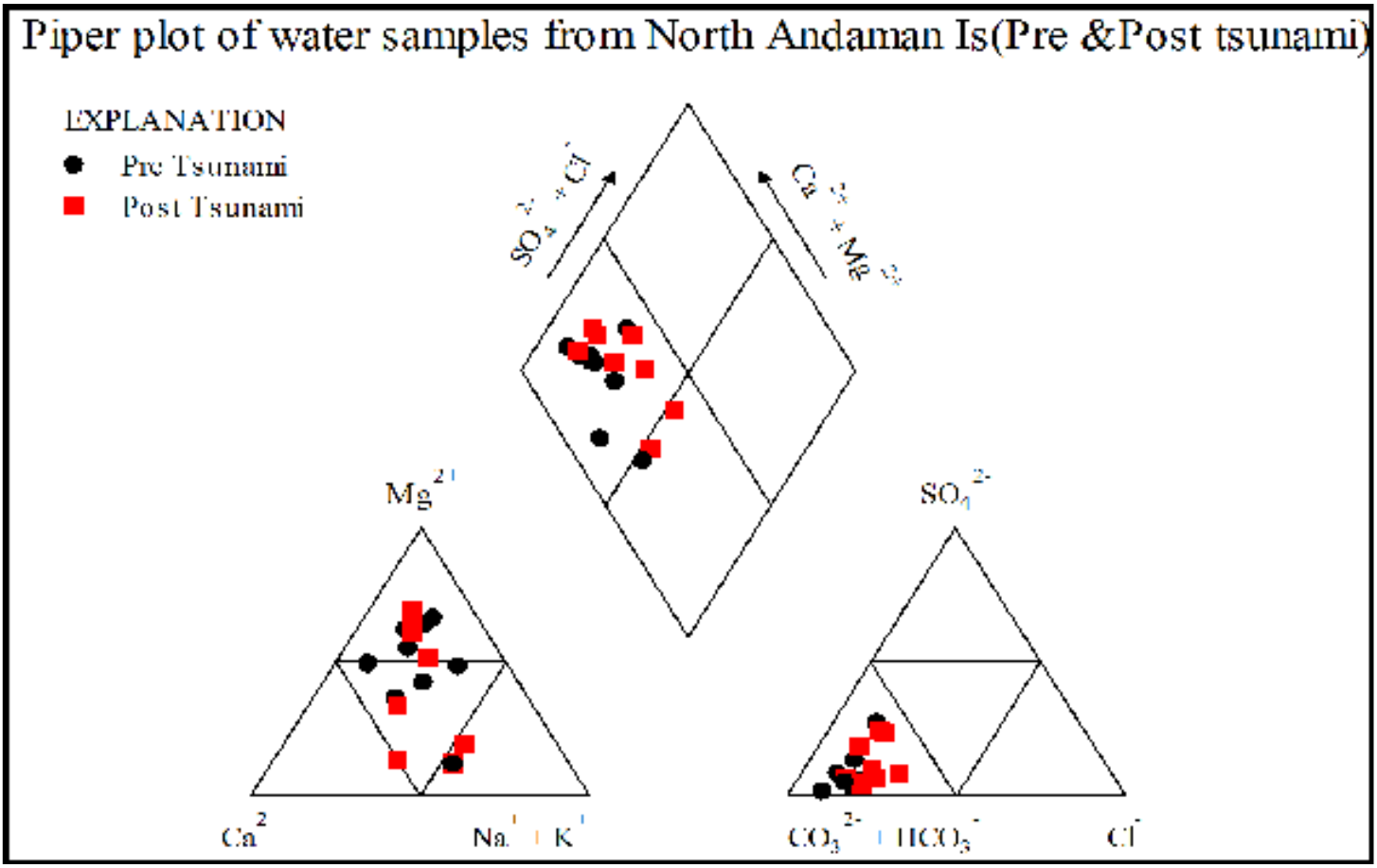

Piper plot of Water samples from Middle Andaman Island
EXPLANATION
Post Tsunami
Pre Tsunami
$SO_4^{2-} + Cl^-$
$Ca^{2+} + Mg^{2+}$
Mg^{2+}
Ca^{2+}
$Na^+ + K^+$
SO_4^{2-}
$CO_3^{2-} + HCO_3^-$
Cl^-

Fig- 7: Piper plot of Pre& Post tsunami samples of North Andaman Island



6.0 GROUND WATER MANAGEMENT STRATEGY

6.1 Ground Water Development

Central Ground Water Board carried out ground water exploration in Andaman and Nicobar islands from 1985 to 1994 during which 47 exploratory wells had been drilled. Of these, 18 wells have been constructed in South Andaman, **11 in Middle Andaman, 2 in North Andaman**, 9 in Nicobar, 3 in Nancowry and 4 in Katchal. It is concluded from the exploration data that, in general, productive aquifers exists down to a depth of 60 m bgl. The quality of water in deeper aquifer deteriorates, probably due to contamination with the saline water below. The productive aquifer occurs within 60 m bgl in fractured volcanic and 30 m bgl in valley fill deposits with discharge varying from 10 to 45m^3/hr. However, no productive granular zones were encountered down to the drilled depth of 160 m bgl in the semi-consolidated sedimentary formation. The valley fill deposits comprising of assorted pebbles, cobbles and gravels of volcanic, ultramafics and cherts in sand clay matrix in certain valleys are proved to be productive. Ground water quality in these shallow aquifers is suitable for drinking and domestic purposes. In Middle and South Andaman the discharges from the bore wells ranges from 10 to 25 m^3/hr and 0.2 to 44.67 m^3/hr respectively.

6.2 Tube Well Design

Top weathered formations are cased by assembly pipes and hard rock portion up to fracture zone remains uncased.

6.3 Water Conservation & Artificial Recharge

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.

Success stories:

In the following table (Table-7) the success stories of important select artificial recharge projects are presented.

Table-7: Select Drinking Water supply projects in North-Middle Andaman district utilizing Artificial Recharge technique during Pre-tsunami

Sl no.	Location	Structures proposed	Remarks
1	Karmatang,Near Mayabunder,North Middle District	**Subsurface dyke 40m long,6m deep and one large dia(8.0m) well**	**Geology-weathered & massive Impervious Sedimentary rocks Completed project. Pre-project estimated yield- 3,00000 Litres per day. Yield post construction- 4,00000 Litres per day. The project was taken up in view of severe water crisis post-tsunami**
2	Beatpur Nala,Swadessh Nagar, North Middle District	**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 lakkh Litres per day. The project is incomplete. May be commissioned in view of water crisis post-tsunami.**
3	Pahelgaon Nala,North Middle District	**Subsurface dyke and one large dia (6..0m) well**	**Geology- weathered & massive Impervious Sedimentary rocks Completed project. Pre-project estimated yield- 40,000 Litres per day. Yield post construction- 50,000 Litres per day. The project was constructed in post-tsunami. Commissioned in view of water crisis in post-tsunami.**
4	Tugapur-15 Nala, North Middle District	**Check dam-Five, Recharge shafts-12 to 15 nos, Subsurface dyke and one large dia(6.0m) well with a bore well 25m deep. Dug-cum-bore well**	**Geology- weathered & massive Impervious Sedimentary rocks Completed project. Pre-project estimated yield- 60,000 Litres per day. Yield post construction- 1,00000 Litres per day. The project was constructed in pre-tsunami. Commissioned in view of water crisis post-tsunami .**
5	Webi Nala, North Middle District	**Check dam-three, feeder wells with infiltration galleries - 6-8 nos, Subsurface dyke, one large dia(8-10 m) well with three to four bore wells 20-25m deep. Dug-cum-bore well**	**Geology- weathered & massive Impervious Sedimentary rocks ject work is incomplete. Pre-project estimated yield- 2,00000 Litres per day.The project is highly necessitated in the post-tsunami in view of severe water crisis in the area.**

7.0 GROUND WATER RELATED ISSUES AND PROBLEMS

It is already mentioned that the geologic formations in N-M Andaman district 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 bore wells/tube wells. Dug wells are feasible in such formations but yield is restricted. However in select locations especially near the drainage it may discharge in much higher tune. In the district appreciable quantity of water could be available from shallow and porous Coralline limestone Formations through dug wells. Island wise Damaged Area Due To Tsunami/ Earthquake in N&M Andaman Islands has shown in table-8.

Table-8: Island wise Damaged Area Due To Tsunami/ Earthquake in N&M Andaman Islands

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**	
Rangat	11.00	73.00	84.00	00	00	00	181
Mayabunder	5.00	39.00	44.00	7.00	7.00	14.00	19
Diglipur	00	27.20	27.20	00	00	00	47

Impact of Tsunami on North and Middle Andaman Islands

NORTH ANDAMAN ISLANDS

North Andaman Island is covering a geographical area of nearly 2232.00 sq. km and is situated along a chain at a distance of nearly 150-200 km in the north of Port Blair town. North Andaman island is consist of two tehsils-The Diglipur zone (Tehsil) and Mayabunder zone (Tahsil) upto Billiground. It is occupied by good arable land. North Andaman Island produces substantial amount of different vegetables. Crops are mainly produced in the rainy season. However, irrigation during the lean period is dependent on ground water. Dug wells, ponds and the perennial streams are the main sources of irrigation in the area. With the construction of multiple. Department of Agriculture has constructed many check dams during 2003-2004 which has helped to convert the monocropped land into double cropped land. Few shallow tube wells are constructed along the Kalpong river valley courses near D.B.Gram. Saline land reclamation is also successfully done in this island which has accentuated the land as well as ground water resources of the island.

North Andaman island is underlain by Marine Sedimentary group of rocks comprising fine grained sandstones, Shales, Connglomerate, grit etc. and Cretaceous Igneous volcanics and intrusives. Miocene limestones are available in high altitudes (i.e. nearby Tugapur), whereas recent to sub- recent organic coralline limestones are available in the coastal tracts and in small islands like Ross and Smith Island (near Diglipur). Good springs are available at higher altitudes in the Mayabunder, Webi, Karamatang, Pahelgaon, Chainpur areas in Mayabunder Tehsil and Mohanpur, Kishorinagar, Nabagram, Sitanagar Durgapur, Kalipur, Keralapuram, Swarajgram, Laxmanpur, Hatilevel areas in Diglipur Tehsil. The igneous rocks are available in the Saddle peak area in Diglipur.

Although the igneous rocks form potential aquifers, due to inaccessible hilly areas, it could not be developed. However, good emanating springs are available in Saddle peak. Depth to water level in the wells varies from 2.74m. to 5.35 mbgl and 1.06 mbgl.to 3.57 mbgl during pre and post monsoon seasons respectively. Villagers utilize dug well water for drinking and day to day use. However, the water supply in the area is done mainly from springs (as in Mayabunder and major part of Diglipur area), where as the supply at Diglipur is made form the intake well constructed in the river bed of Kalpong. The pipelines were damaged by the recent earthquake.

Impact of Tsunami in the North Andaman Island

Most fortunately this island was spared by the furious tsunami baring a small part of Rampur near Mayabunder. However, the island was severely affected by the earth quake which affected the water resources.

The study revealed that the coastal stretches for a width of only 50 to 100 meters in parts of the village of Rampur and Karmatang Nallah area were partially affected by the Tsunami. The waves which were relatively timid in nature and struck the coast with very less power. The height of the wave nearby the coast was nearly 0.5 to 1.0 m and it could penetrate the island only for a length of 50 to 100 meters (fig-8).

Fig.-8: Depletion of height of water level in the coastal area due to Tsunami

However, the saline wave could contaminate the wells in parts of Rampur area nearby the coast (range of EC 2000 to 2520 µs/cm). However, in no other areas in the island, salinity in wells by the invading Tsunami has been reported. The saline waves could not damage the agricultural land.

Fig.-9: Earthquake has made deep fractures in the surface and Water in the pond in many areas were leaked and disappeared due to Tsunami

However, earthquake has made deep fractures in the surface which ejected lot of fresh water (fig-9) and sand in many areas (as near Laxmipur and D.B.Gram near Diglipur). The water in the pond in many areas were leaked and disappeared after the earthquake and this was observed near Mohanpur, Kishorinagar as also throughout in Diglipur and in many areas near Tugapur, Pahelgaon etc near Mayabunder. In such areas water level in dug wells also declined after the earthquake. During the earthquake the arable lands have been severly affected which caused significant decline in soil moisture. This had also caused drying up of various standing crop as also plantation crops in various parts of Diglipur. The discharge in the springs of Karmatang, Tugapur and Restcamp has been lined causing some curtailment to the water supply in the area. However, in some occasions as near Srinagar, Haribay near Mohanpur the discharge of the springs and water level has been increased. In general in the

entire tract of North Andaman the land has been uplifted. This is conjectured from the dried up creek beds and extended beaches which were not observed before the earthquake. The navigation in the creek flowing near Kalighat of Diglipur has been handicapped after the earthquake. It is now only navigable during considerable rise during high tides. The Austin creek bridge has been damaged due to the vertical as well as horizontal movements during the earthquake and presently (till May, 2005) the road link between Diglipur and mayabunder is cut off. Simailrly, the metalled road near Mohanpur was severely damaged. One masonry house near Rampur was badly damaged (fig.-10).

Fig.- 10: Metalled road near Mohanpur was severely damaged.
One masonry house near Rampur was badly damaged.

The study revealed that the recent Tsunami could not damage the water resources in the island to a great extent. The contaminated wells were examined. The effect of natural flushing as also pumping was noticed. The wells are still showing slight brackish. The salinity condition of the wells may disappear after the earthquake reveals that in the ensuing future many parts of the Island is going to face a threat to cater fresh water for continuation of drinking water supply as also agriculture. To augment drinking water supply check dams are to be constructed along with subsurface dam and intake wells and the same will harvest good amount of water for supply. Similarly, in all steram valleys from hill to sea multiple check dams , subsurface dams and tidal bars as opined by CGWB is to be constructed. This will conserve huge fresh water (ground water and surplus rain water as run off) aand soil for sustainable development of agriculture in the area. Saline land reclamation work in the area should be encouraged along with construction of ponds in the catchments to enhance the land and fresh ground water resources in the area. Ponds are to be constructed on individual

or community basis taking the institutional subsides or through self financing to conserve more and more fresh water. However, under the aegis of Rajiv Gandhi Rehabilitation Package number of ponds may be constructed in the land holdings of the farmers. Besides irrigation, pisciculture, duck cultivation and other associated cattle and poultry farming would be highly beneficial from such water conservation structure. The present decline in yield in various structures like ponds, springs dug wells etc. are to be noticed even after the rainy season to recommend the further modes of development in the same area. The observation will indicate wehetr the same structure will be tenable or it is to be modified or abandoned. For immediate augmentation of drinking water supply in the tract the following recommendations are made.

Impact of Tsunami on Middle Andaman island including Baratang

Middle Andaman Island including Baratang is covering a geographical area of 1070 sq. km, where the share of Baratang Island is 297.60 sq km. The area is situated along a chain at a distance of nearly 65-150 km. In the north of Port Blair town. The entire tract of Billiground upto Kadamtala is considered in Middle Andaman Island. This vast island is occupied by good arable landing Swadesh Nagar – Billiground and Parnashala –Kalsi sectors and it produces good quantity of vegetables for the Island. Different types of vevetables are grown in this tract, crops are mainly rainfed. However irrigation during the lean period is dependent on ground water. Dug wells, ponds and the perennial streams are the main sources of irrigation in the area. With the construction of multiple check dam by the Agriculture department during 2003-2004 the double cropping is enhanced in the islands. Saline land reclamation is also successfully done in this island which has accentuated the land as wel as ground water resources.

The island is underlain by Marine sedimentary group of rocks comprising fine grained sandstones, shale's , conglomerate, grit etc and cretaceous Igneous volcanics and intrusive. Miocene limestone are available in the high altitudes (as near Betapur) and in Long Island and Strait Island (separately discussed) where as Recent to Sub Recent organic coralline lime stones are available in the coastal tracts and in small islands like Lalji Bay, Mark Bay (near Long island). Because of low porosity and permeability, the extensive Marine sedimentaries do not form potential aquifers. These type of rocks are available in Baratang island, Kadamtala, Prolobjig, Bakultala, Kausalyagar, Kalsi, Nimbutala, Swadesh Nagar etc.

However, good springs are available in such formations at higher altitudes. The igneous rocks are available in the Panchavati hill and near Janakpur hill in Rangat and near Billiground area. Although the igneous rocks form potential aquifers, still because fo existence of this rocks in the hills i.e.in the inaccessible areas, these hardrock aquifers could not be developed. However, good emanting springs are available in such formations at higher a;titudes. The igneous rocks are available in the Panchavati hill and near Janakpur hill in Rangat and near Billiground area. Although the igneous rocks form potential aquifers, still because of existence of these rocks in the hils i.e. in the inaccessible areas, these hardrock aquifers could not be developed. However, good emanting springs are available in Panchavati hill which forms the main supply source of drinking water to the entire Rangat and adjoining areas. Depth to water level in the wells varies from 2.88m to 5.35 mbgl and 0.93m to 3.36 mbgl during pre and post-monsoon seasons. Villagers utilize dug well water for drinking and day to day use. The water supply in this area is done mainly from springs, & as in Rangat, Kadamtala, Bakuktala, Baratang areas in many areas the pipe lines were damaged by the recent earth quake.

Most fortunately this island was spared by the furious tsunami baring a small part of Long Island and Strait Island, Nimbutala Jetty area and Dasarathpur, Sabari area near Rangat and Jarwa creek area in Baratang Island. However, these islands were disturbed by the earth quake which affected the water resources.

The study reveled that the coastal stretches for a width of only 50 to 100 meters in the extreme low lying parts near Nimbutala and villages of sabari and Dasarathpur and Jarawa creek area in Baratang Island were affected by the Tsunami waves which was relatively timid in nature and struck the coast with less power. The height of the wave nearby the coast was nearly 0.5 to 1.0 m. The land subsidence at Sabari & Dasarathpur area in Rangat and Jarawa creek area in Bartang has caused permanent saline water ingress. The saline wave could contaminate the ponds and wells in parts of Sabari, Dasarathpur and Nimbutala areas nearby the coast. However, in no other areas the salinity in wells by the invading tsunami has been reported. The saline waves could not damage the agricultural land except the areas near Sabari, a Dasarathpur and small tract near Bakultala and Kausalyanagar. The detailed account of saline affected arable land is collected and surveyed by Agriculture department.

The detailed account of saline affected arable land is collected and surveyed by Agriculture department. The devastating earthquake had made deep fractures in the surface which ejected, sand and mud (as near Swadeshnagar). Lot of saline water and mud was ejected in Jarawa creek area. Fresh mud was further ejected along the old volcano which was erupted in 2003. However, a new mud volcano has erupted in 1.5 km further south west of Rajatgarh mud volcano.

The water in the ponds in many areas were leaked and disappeared after the earth quake and this was observed near Swadeshnagar and Billiground. In such areas water level in dug wells were also declined after the earth quake. The discharge in the springs of Panchavati on ATR has been declined and dried up Fig.11).

Fig.- 11: Water in the ponds in many areas were leaked and disappeared after the earth quake near Swadeshnagar and Billiground. Water level in dug wells was declined after the earth quake. Discharge of the springs of Panchavati on ATR declined and dried up.

The study revealed that the recent Tsunami could not damage the water resources in the island to a great extent. The contaminated wells were examined. The effect of natural flushing as also pumping was noticed. The wells are still showing little brackishness. The salinity condition of the wells has decreased through dilution of rain water with saline water.

The study on overall ground water situation of the island as caused after the earthquake reveals that for continuation of drinking water supply as also agriculture check dams are to be constructed along with subsurface dam and intake wells and the same will harvest good amount of water for supply. Similarly in all stream valleys from hill to sea multiple check dams, subsurface dams and tidal bars as opined by CGWB are to be constructed. This will conserve huge fresh water (both ground water and surplus rain water as run off) and soil for sustainable development of agriculture in the area. Saline land reclamation work in the area should be encouraged along with construction of ponds in the catchments to enhance the land and fresh ground water resources in the area. Reservoir ponds can be constructed by individual one or community basis by availing the institutional subsidies or through self financing to conserve rain water. Besides irrigation, pisciculture, duck cultivation and other associated cattle and poultry farming would be highly beneficial from such water conservations. The present decline in yield in various structures like ponds, springs, dug wells etc. are to be noticed even after the rainy season to recommend the future modes of development in the same area. The observation will indicate whether the same structure will be tenable or it is to be modified of abandoned.

8.0 AWARENESS & TRAINING ACTIVITY

8.1 Mass awareness Programme (MAP)

Nil.

8.2 Ground Water Management Training Programme (WMTP)

One WMTP organized in Port Blair, wherein many Officers and research scholars from various organizations/Institutions like APWD,CARI,Dept. of Agriculture etc. participated as trainee.

8.3 Exhibition/Mela/Fair etc.

Nil.

8.4 Presentation and Lectures delivered by CGWB officers

One lecture delivered by Dr.A.Gayen, Sc‘C’ before farmers in a FPARP programme organized by Central Agricultural Research Institute (CARI), Port Blair.

9.0 AREA NOTIFICATION

Not Applicable.

10.0 RECOMMENDATIONS

There have been significant changes in groundwater resources of North-Middle 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 as also quality of groundwater at places. The tsunami waves of height varying from 0.5-0.8 m had contaminated the water resources in the low-lying coastal areas of some parts of the district. Upheaval of land in major part and subsidence in some parts of the islands were occurred during the natural calamity on 26.12.04. These had caused some changes 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 changes are not fully obliterated and it still persists at places. The expected depth wise reduction in fresh water has warranted cautious development of ground water resources in the North-Middle Andaman district of 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 rain water 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.

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 centre(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, 4. Recharge shaft, 5. Intake wells 6. Collector wells with infiltration gallery, 7. Lift irrigation points, 8. Roof top rain water harvesting and recharge.

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