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Central Ground Water Board

Department of Water Resources, River
Development and Ganga Rejuvenation,
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Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Noth and Middle Andaman District
Andaman and Nicobar Island

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN OF NORTH AND MIDDLE ANDAMAN DISTRICT, ANDAMAN AND NICOBAR ISLAND

By

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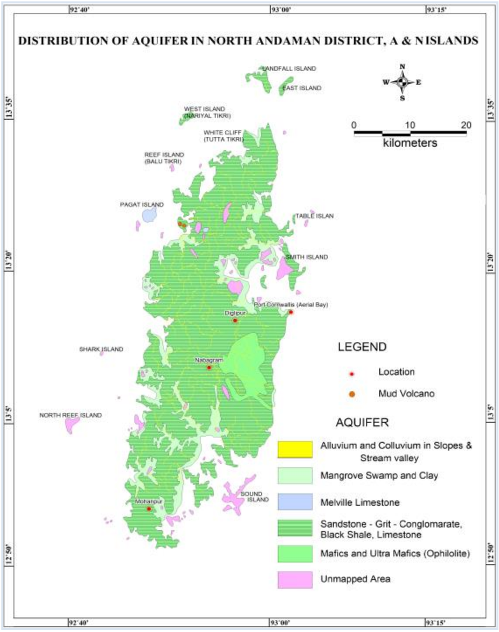

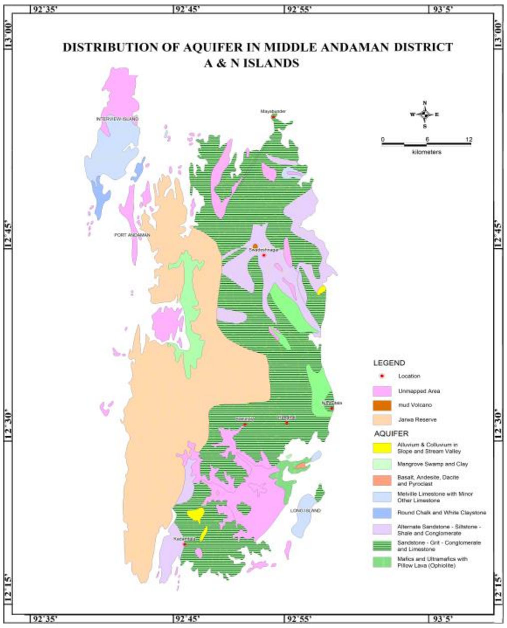

CENTRAL GROUND WATER BOARD

Eastern Region, Kolkata

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FOREWORD

To understand the nature and occurrences of groundwater, aquifer geometry, aquifer dispositions & characteristics and management of groundwater resource, National Aquifer Mapping & Management Programme (NAQUIM) has been taken up by CGWB under XIIth Plan. During the Annual Action Plan 2019-2020, Aquifer Mapping studies & Management plan was taken up in North & Middle Andaman District, Andaman and Nicobar Island.

The study under the aegis of NAQUIM includes four major components namely; Data generation, Data collection & compilation and preparation of Aquifer maps and Aquifer Management Plan.

This report is presented in two parts, where Part-I embodies general report & Data Gap Analysis of the study area, & Part-II include Tehsil wise Management Plans for the district. Relevant data in respect of the said subjects have been collected from different departments and their publications, viz. Andaman Public Work Department (APWD), ICAR Central Island Agricultural Institute (CIARI), Department of Agriculture, A & N Island, Directorate of Economics & Statistics, Land & Land Reforms Dept., A & N Islands, Data of Indian Meteorological Dept., National Bureau of Soil Survey & Land Use Planning, etc. of Govt. of India have also been used. Hydro-geological data is sourced from the scientific studies of CGWB pertaining to groundwater explorations, hydrogeological surveys, chemical analysis and outsourcing explorations being taken up for data generation.

Compilation of this report, evaluation of data and preparation of relevant maps present in report is the outcome of efforts given by ***Shri Awadhesh Kumar, Senior Technical Assistant (Hydrogeology)*** under the supervision of Mrs Sandhya Yadav, Scientist-E, Dr Indranil Roy, Scientist-D and Shri D. Bagchi, Sc 'B'. The section pertaining to Hydrochemistry has been prepared by Shri Atalanta Narayan Chowdhury, Assistant Chemist, Dr. Suparna Dutta Assistant Chemist and Shri Rinku Moni Burman, STA(Chemist) their contribution is thankfully acknowledged.

Effective method of dissemination of the existing technical information to different user agencies is an important aspect of NAQUIM, which plays a very vital role in the safe and optimal development of groundwater resources in our country. In this regard, Central Ground Water Board has taken up a great initiative in incorporating NAQUIM project since 2012, to fulfill this directive. It is much anticipated that, this report will become an important tool not only for various user agencies, Engineers, Scientists, Administrators, Planners and others involved in groundwater planning, development and management, but also to the common public to make them aware of local groundwater issues and its sustainable management.

(Dr. Anadi Gayen)
Scientist –E & Head of Office

EXECUTIVE SUMMARY

The study area falls under North and Middle Andaman district, which is located almost in the central part of the Union Territory of Andaman and Nicobar islands, and it is separated from South Andaman district by Middle Strait. The district of North and Middle Andaman comprises two Subdivisions, and three blocks/Tehsils. Mayabunder is the district head quarter, and Rangat & Diglipur are two Sub divisional headquarters of the district. Physiographically the study area comprises of:, i) Narrow, elongated hill ranges, ii) Sub-intermontane valleys, restricted in area, and iii) fringing gently sloping coastal tract and iv) tidal inlets and the adjoining swamps. Present area is underlain mainly by the argillaceous – arenaceous – calcareous sequence of sedimentary formations representing geosynclinal deposition and classified Mithakhari Group (Palaeocene to Oligocene age). Ultramafic exposed in the hills of Panchawati is a part of 'Ophiolite suit' of igneous rocks of Late Cretaceous age. Besides, Quaternary coastal beach sand and valley fill alluvium are found in discontinuous patches.

The clastic sedimentaries are generally finer grained and as a result their ground water potentiality is moderate to low; but the semi–consolidated formations and the consolidated ultramafics are highly fractured in nature owing to successive tectonic activities suffered by this area. These fractures serve as the main conduits for ground water flow beneath the surface. On the other hand, the unconsolidated formations, i.e. the beach sands, thin alluvial cover in valleys, colluvial deposits in Main River bed e.g. Rangat River, though restricted in occurrence, sometimes make good repository for ground water occurrence.

Ground water occurs in the weathered surficial mantle and the adjacent fractured zones in consolidated and semi-consolidated formations, and the primary porosities of unconsolidated formation under phreatic condition; thickness of this overburden ranges up to 6m. (Maximum saturated thickness of the water table aquifer of the study area is about 5.0 m in summer months and 6.5 m in rainy season.) In these islands, coastal fringe area generally shows the disposition of fresh water ground water laying over the landward-progressing saline water front. Because of the highly undulating topography, the phreatic aquifer, which is moderately potential, drains out ground water due to high natural hydraulic gradient. Water level is generally shallow all over the area; but in summer month from February onwards, water level more than 5 m have been encountered at a number of places, e.g. Uttara corner, Rajibnagar, Sabari, Kausalyanagar (part),

Tikadera, and Nimbutala. Yield of wells is moderately good in intermontane valley fills; though it becomes relatively low in summer months. After pumping dug wells in higher ground once, recuperation of ground water in these structures have been found extremely slow in summer; (Specific capacity of these wells ranges up to a maximum of 25-21 lpm/m drawdown in valleys.) Transmissivity (T) of phreatic aquifer ranges up to a maximum of 141.84 m^2/day. There are no bore wells in the area and that is why study of deeper aquifer is very much restricted.

In the study area, springs are sparsely distributed and these springs are utilized for pipe water supply in habitations of both North & Middle Andaman Island. Maximum yield of these springs range up to more than 60 LPs (Panchawati spring, Middle Andaman Island), and 12 lps (Shankar Nallah, Baratang island). Total population of North & Middle Andaman is 105,597(2011 census). Population of 62,464 (2011 census) covering villages of Middle Andaman and 43,183 (2011 census) covering villages of the North Andaman Island have been provided with pipe water supply from the spring sources of the respective Islands.

Tsunami, which hit the A & N Islands severally on 26th November 2004, has affected habitations of Middle and North Andaman Island. Land has been affected by salinity ingress. Besides, crop loss has also been reported from this area.

Inundation by saline water through tidal inlets is a common phenomenon in the study area, especially during natural calamity. Studies have been carried out and sites have been proposed for a number of villages for construction of different structures across the tidal channels for checking salinity ingress, if any, as well as quality improvement of ground water, apart from increasing the quantum of ground water reserve.

Due to existing fragile geo environmental situations in the islands following recommendation have been made: i) Ground water exploration/ Extraction through dug wells should be restricted as it may result in sea water ingress, ii) decision has to be taken to construct artificial structures like check dams, ponds, etc. for checking salinity ingress as well as quality and quantity improvement of ground water, iii) large diameter dug wells in the river beds & adjoining areas may be contributed, iv) construction of infiltration galleries/ collector wells as secondary source beside the presently available source.

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PART-I

AQUIFER MAPPING IN PARTS OF NORTH AND MIDDLE ANDAMAN DISTRICT, ANDAMAN & NICOBAR ISLANDS

NORTH AND MIDDLE ANDAMAN DISTRICT AT A GLANCE

1. General Information

I. Geographical Area : 3483 km^2

II. Administrative Divisions

Number of Tehsils : Three

Number of Town: One (Mayabunder)

Number of Villages : 227 (Inhabited: 198, Uninhabited: 29)

(As per Census 2011)

III. Population (Census 2011) : 105597(Male: 54861, Female: 50736)

IV. Annual Rainfall (2020) : 3180 mm

2. Geomorphology

Major Physiographic Units:
1. Low to moderately high steep hills
2. Intermountain 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.

Major Drainages : South Creek, Jarawa Creek Nallah in Baratang, Saberi Nallah, Dasarathpur Nallah, Rangat Nallah, Betapur Nallah, Korang Nallah, Webi Nallah, Tugapur Nallah in Middle Andaman, Kalpang Nallah, Magar Nallah, Cherian Nallah in North Andaman

3. Land Use (Sq. Km.) Forest area: 2955.68
Net area sown: 75.387
Total Cropped area: 90.07

4. Major Soil Types : Entisols, Inceptisols and alfisols

5. Area under Principal crops (km^2) : 139.53

6. Principal Crops : Paddy, Maize, Coconut, Areca Nut, Pulses,Oil Seeds, Sugarcane, Cashew Nut, Fruits, Spicesand Vegetables

6. Irrigation by different sources (km^2)

Tube wells/ Bore wells : Nil
Dug wells : 1.15
Ponds/Tanks : 0.02
Check Dam : 4.63

7. Number of Ground Water Monitoring Wells of CGWB (as on 31-3-2020): 37

8. Predominant Geological Formations : Marine sedimentary formation (Mithakhari Group and Andaman Flysch) comprising fine grained sandstone, siltstone, shale, conglomerate

Sedimentary rocks of Archipelago Group (Miocene) comprising chalk, white claystone, Melville limestone (coralline)

Ophiolite Group (Late Cretaceous) comprising ophiolite suite (acidic and intermediate lava, pillow basalt and ultramafic rocks), black shales with olistoliths

9. Hydrogeology of Principal Aquifers:

Ground water in marine sedimentary formation occurs under unconfined condition in weathered residuum. Presence of clay mineralsresults in very low possibility of groundwater development. In rocks of Mithakhari Group and Andaman Flysch, generally dug wells having diameter ranging from 5-6 m and depth of ~6 m have discharge varying from 4-5 m^3/day.

In the ophiolites, unconfined to semi-confined aquifers are developed in the fractured and weathered zone (depth range: 12.00 to 23.55 m) having discharge of 240-360 m^3/day. In the (Groundwater in Ophiolites occurs under unconfined to semi-confined condition in weathered residuum while in fractured hard rock in deeper horizon in confined condition. Based on in house groundwater exploration data, three exploratory wells at Amkunj, Chitrakut and Nimbutala (Middle Andaman district), were found to yield negligible discharge. Bore wells having typical diameter of 15 cm (6”) and drilled depth of ~80 m, constructed by state government are found to yield groundwater to the tune of 4-5 m^3/day. Dug wells located in Melville Limestone (coralline limestone) of Archipelago Group are found to have discharge varying from 80 to 100 m^3/day. Along the foot hill zones, perennial springs are quite common in locations like

Based on water level regime monitoring in North and Middle Andaman districts, the range of depth to water level in the ground water monitoring wells is given below:

Depth to water level (pre-monsoon 2019) **:** 1.0 to 5.0 mbgl

Depth to water level (post-monsoon 2019) **:** 1.0 to 2.0 mbgl

10. Ground Water Exploration by CGWB (as on 31-03-2020)

No.of wells drilled (North and Middle Andaman) : 13 Exploratory Wells (North Andaman: 2, Middle Andaman: 11)

Drilled Depth of Exploratory Wells (EW) : 23.55 m to 160.40 m

Discharge in EW :10 m^3/hr at Panchwati) to 25m^3/hr(Rangat)

Transmissivity (T) and Storage Co-efficient (S) : Not available

11. Groundwater Quality

Electrical Conductivity (EC) : Ranging from 157 µS/cm at Kishorinagar/ Parangara (Middle Andaman district) to 931 µS/cm at Milangram (North Andaman district)

Iron : High Iron (>1 mg/L) was recorded at Porlobjig 15 (2.6 mg/L), Tikadera (1.4 mg/L) and Mohanpur (1.1 mg/L)

Type of water **:** Ca-Mg-$HCO_3$and Na-HCO_3

12. Dynamic Ground Water Resources as on 31 March, 2020

Annual Extractable Ground Water Resources **:** 8805.16 ham
Net Ground Water Availability for Future Use **:** 8452.16 ham
Gross Annual Ground Water Extraction **:** 328.00ham
Stage of Ground Water Extraction **:** 3.72%

13. Ground Water Control and Regulation

Number of Over Exploited Blocks/Tehsils **:** 0
Number of Semi Critical Blocks/Tehsils **:** 0
Number of Critical Blocks/Tehsils **:** 0
Number of Safe Blocks/Tehsils**:** Three (Rangat, Mayabunder and Diglipur)
Number of Notified Blocks/Tehsils: Nil

14. Major Ground Water Problems and Issues **:** a) High iron (above Permissible Limit) in dug wells at few locations in Middle Andaman district

b) Water scarcity in summer season, as per the supply and projected demand (for 2030 and 2050) as documented by the State Government.

CHAPTER-1

1. INTRODUCTION

In XII five-yearPlan, National Aquifer Mapping (NAQUIM) was taken up by the Central Ground Water Board (CGWB) to carry out detailed hydrogeological investigation on toposheet scale of 1:50,000. The NAQUIM has been prioritised to study Over-exploited, Critical and Semi-Critical Talukas/Islands as well as the other stress areas recommended by the State Government. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The vagaries of rainfall, inherent heterogeneity & unsustainable nature of hard rock aquifers, over exploitation of once copious alluvial aquifers, lack of regulation mechanism has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "traditional groundwater development concept" to "modern groundwater management concept". Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. The proposed management plans will provide the "Road Map" for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus, the crux of NAQUIM is not merely mapping, but reaching the goalof ground water management through community participation. The aquifer maps and management plans in North and Middle Andaman district are proposed to be shared with the administration of Union Territory of Andaman and Nicobar Islandsfor implementation by the district administration.

1.1 Objective and Issues

The broad objective of the study is to establish geometry of the underlying aquifer systems in horizontal and vertical domain and characterize them, so as to work out the development potential and prepare aquifer wise management plan with respect to issues concerned viz. (i) Water scarcity in the Islands, (ii) Post-tsunami changes on quantity and Quality of groundwater resources, (iii) Salinity as well as Iron contaminations within the available limited aquifers, (iv)

Groundwater management under the influence of large scale tourism activities and (v) Rejuvenation of springs as the major source of groundwater.

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme being implemented by CGWB. There are four major components viz. (i) data collection/compilation (ii) data gap analysis (iii) data generation(iv)preparation of aquifer maps and management plan to achieve the primary objective. Data compilation included collection and procurement (wherever required) of maps from concernedagencies, such as the Survey of India, Geological Survey of India and state government departments like Andaman Public Works Department, computerization and analysis of acquired data and preparation of a knowledge base. Identification of data gap envisages requirement of further data generation in respect of hydrogeological, geophysical, chemical, hydrological, hydro-meteorological studies etc. Data generation includes those of hydrometeorology, chemical quality of groundwater, lithologs and determination of aquifer parameters through test pumping.

Generation of groundwater chemical quality data was accomplished by collection of water samples and their laboratory analyses for all major parameters, and some of the heavy metals. Additional data pertaining to sub-surface lithology and aquifer parameters were obtained through drilling of additional exploratory wells and slim holes, pumping tests at drilling sites.As per the revised annual action plan groundwater management studies in parts of North and Middle Andaman districts covering an area of 578 square kilometre was taken up by CGWB, ER, Kolkata. In this report the salient features of aquifer geometry, characteristics, ground water occurrences, availability, and resource vis-a-vis quality, development & management, scope of ground water have been covered.

1.3 Approach and methodology

A stepwise approach and methodology adopted to achieve the major objective have been shown below.

i) Compilation of existing data.
ii) Identification of data gap.
iii) Data generation based on data gap.
iv) Preparation of thematic maps on GIS platform.

v) Preparation of Rock-works based 2D/3D maps.

vi) Compilation of Island wise Aquifer Maps and Management Plan.

1.4 Location, Extent and Accessibility of the study area

The North & Middle Andaman; district possesses a geographical area of 3251.85 sq. kms, with three Tehsils*i.e.* Diglipur, Mayabunder and Rangat covering104 revenue villages. Mayabunder, a port town and isan old establishmentsince the British period. Diglipur is a new settlement area and the northern most town of North Andaman district located at a distance of 290 km from Port Blair. The tallest peak of the areais Saddle Peak (732 Metres) located near Diglipur. Kalpong is the only river of Andaman flows through Diglipur town.**(Figure-1.1& 1.2).**

Interconnection with Indian mainland in A & N Islands is only through Port Blair town. Port Blair is well connected with the major cities like Kolkata, Chennai and Visakhapattanam (Vizag) by sea routes, while Chennai, Bhubaneswar and Kolkata and New Delhi are connected by daily air services. Andaman Trank Road (ATR) is the main communication route in the main islands. Besides, Port Blair is also connected to the other islands by inter island ships and helicopter & sea plane services.

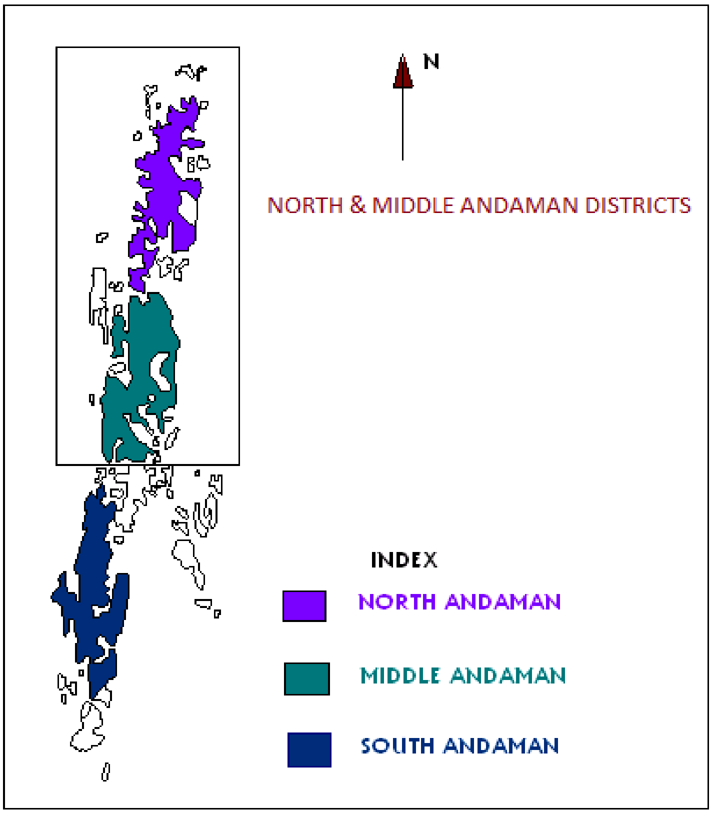


Fig. 1.1 Subdivisions of A & N Islands

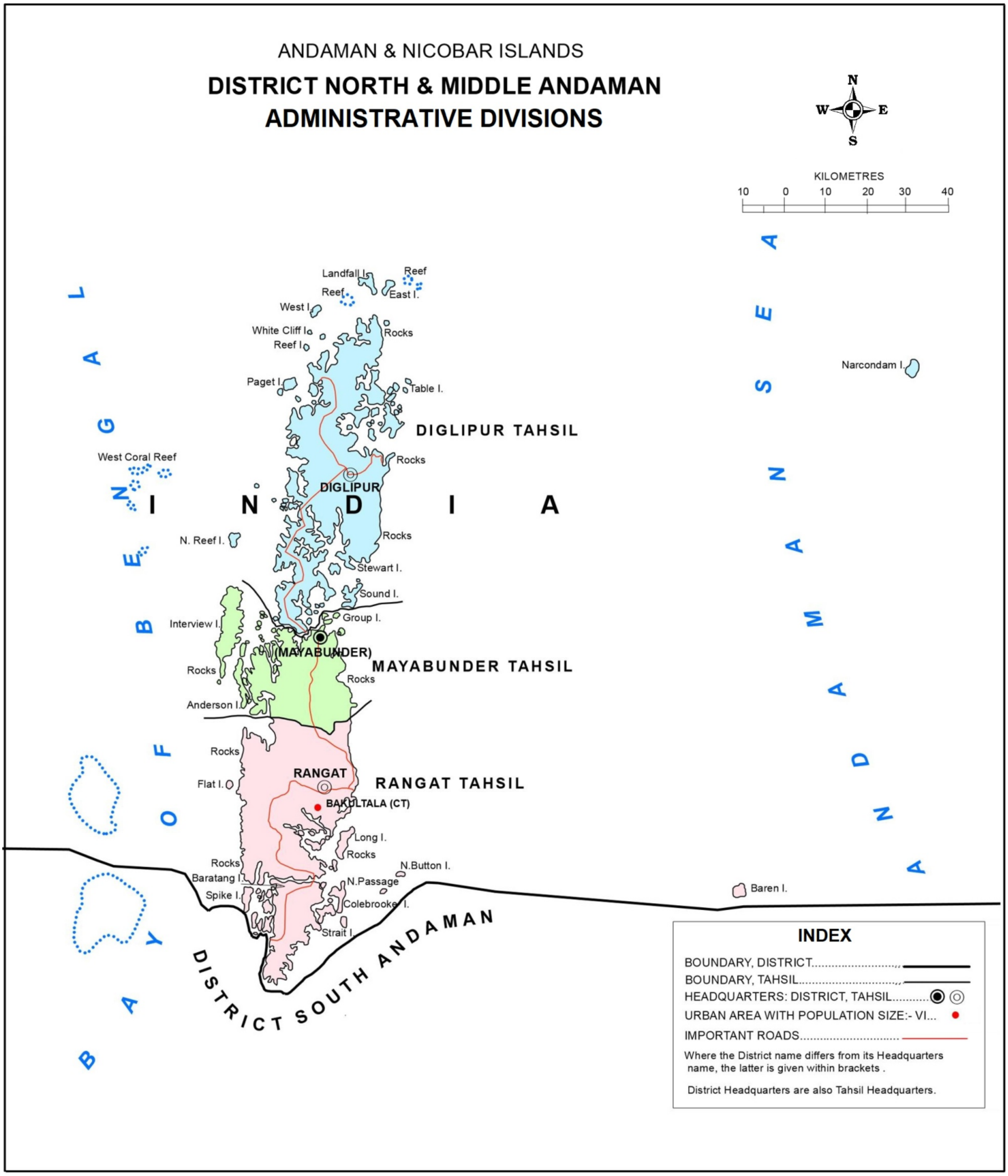


Fig. 1.2Location and Administrative Map of North & Middle district, Andaman & Nicobar Islands

1.5 Administrative divisions and population

As per 2011 census, population of N & M Andaman district is1, 05,597 (2011 census)in which male population is 54,861 and female population is 50,736. The population density is 28 per sq. km.literacy rate at 83.91%.The North & Middle Andaman district consists of three Tehsils viz., Diglipur, Mayabunder and Rangat. 104 revenue villages are represented by 198 habitations.

- **Diglipur Tehsil:** This tehsil consists of 72 inhabited and 9 uninhabited villages which are spread over in 7 inhabited islands viz., Narcondam, East, Land Fall, North Andaman, Smith, Curlew and Stewart Islands. This tehsil is located at the northern most part of this territory.

- **Mayabunder Tehsil:** Mayabunder tehsil comprising of 47 inhabited and 3 uninhabited villages is spread in three Islands viz., Middle Andaman Island (Part), Aves and Interview Island.

- **Rangat Tehsil:** This tehsil consists of 79 inhabited and 17 uninhabited villages spread over in 5 Islands viz., Middle Andaman (Part), Long, North Passage, Strait and Baratang Islands.

Inhabited Islands of North & Middle Andaman District: - There are 14 inhabited islands in North & Middle Andaman district which are as follows (1) East Island (Police post & Light house) (2) Narcondam Island (Police post) (3) Land Fall Island (Police post) (4) North Andaman Island (5) Smith Island (6) Curlew Island (7) Stewart Island (8) Interview Island (9) Aves Island (10) Middle Andaman Island (11) Long Island (12) North Passage Island (13) Strait Island (14) Baratang Island.

The Middle Andaman Island is the most populated island in the North & Middle Andaman district which is divided into two parts, represented by Mayabunder and Rangat Tehsils respectively. The Spike and Porlob Islands were inhabited in 2001 Census, turned uninhabited during the last decade, as no population was reported in 2011 Census. Inhabited Islands wise Population in North & Middle Andaman as follows in **Table no: 1.1.**

Table 1.1: Inhabited Islands wise Population in N & M Andaman (Census 2011)

District/ Sub districts	Total villages	Uninhabited villages	Inhabited villages	Population			Household	Scheduled Tribe	Tribe house hold	Inhabited Islands name	No of towns	Population		
				Total	Rural	Urban						Persons	Male	Female
District North & Middle Andaman	**227**	**29**	**198**	**105597**	**102856**	**2741**	**26199**	**758**	**212**		**01**	**105597**	**54861**	**50736**
Diglipur Tehsil	81	09	72	43183	43183	0	10702	125	47	North Andaman Island	0	42541	22230	20311
										Smith Island	0	600	328	272
										East Island (Police post &Lighthouse)	0	16	15	1
										Narcondam Island (Police Post)	0	16	16	0
										Curlew Island	0	2	2	0
										Stewart Island	0	2	2	0
										Land Fall Island (Police post)	0	6	6	0
										Aves Island (6	0	2	2	0
Mayabunder Tehsil	50	03	47	25788	25788	0	6316	189	43	Middle Andaman Island (Part)	0	25771	13312	12459
										Interview Island	0	15	15	0
Rangat Tehsil	96	17	79	36626	33885	2741	9181	444	122	Middle Andaman Island (Part)	0	29866	15456	14410
										Long Island	0	1032	529	503
										North Passage Island	0	3	3	0
										Strait Island	0	39	26	13
										Baratang Island	0	5686	2919	2767

*** **Source:** Directorates of Economics & Statistics Andaman & Nicobar Administration*

1.6 Land use, Irrigation and Cropping pattern

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 Jarwa creek in Baratang, the low-lying lands, mostly underutilization 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-1.2**).

Table 1.2Land use in North and Middle Andaman District

Item	Land use in Hectare
Total Geographical Area	330200
Reporting Area for land utilization	318153.96
Forest area	295568.00
Not available for Cultivation	4419.05
Other uncultivated land excluding fallow Land	7580.98
Current fallow	1818.57
Fallow lands other than current fallows	1228.66
Net area sown	7538.70
Area sown more than once	1468.30
Total Cropped area	9007.00

***Source: Department of Economics and Statistics, Andaman &Nicobar Administration.*

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 rain fed. In the North & Middle Andaman district, agriculture is pivoting on ground water irrigation especially in North& Middle 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. Major crops in N & M Andaman are presented in **Table-1.3**.

Table 1.3Major Crops in North & Middle Andaman District

Sl. No.	Type of Crop	Area(Hectares)	Production (MT)
1	Paddy	5222.85	16583.68
2	Maize	12.23	26.46
3	Coconut	1525.63	9.49
4	Arecanut	2297.49	6476.00
5	Cashewnut	4.16	6.58
6	Vegetables	2752.35	14376.80
7	fruits	1413.17	13759.35
8	Spices	345.18	1100.62
9	Pulses	281.00	50.20
10	Oil seeds & Sugarcane	98.53	388.73

***Source: Department of Economics and Statistics, Andaman & Nicobar Administration.*

1.7 Urban areas, Industries and Mining activities

Tehsils of North and Middle Andaman District consists of three tehsils viz., Mayabunder Rangat and Diglipur. Mining sites at Madhupur (Diglipur Tehsil), Shyamnagar (Diglipur Tehsil), Harinagar (Mayabunder Tehsil) and Panchawati (Rangat Tehsil) are identified mining area at North & Middle Andaman District.

- **Madhupur Area at Diglipur**

  An area 2.00 ha of hilly land at village Madhupur is identified for conduct of quarrying without the use of explosives. The proposed quarry consists of total 08 blocks with each block of area 0.25 ha.

- **Shyamnagar Area at Diglipur**

  An area 1.00 ha of hilly land at village Shyamnagar is identified for conduct of quarrying without the use of explosives. The proposed quarry consists of total 04 blocks with each block of area 0.25 ha.

- **Harinagar Area at Mayabunder**

  An area 2.00 ha of hilly land at village Harinagar is identified for conduct of quarrying without the use of explosives. The above proposed quarry consists of total 08 blocks with each block of area 0.25 ha.

- **Panchawati Area at Rangat**

  An area 1.50 ha of hilly land at village Panchawati village is identified for conduct of quarrying without the use of explosives. The above proposed quarry consists of total 06 blocks with each block of area 0.25 ha.

Altogether, in North & Middle Andaman Island 26quarry blocks have been identified. The selected area has limited spatial extent, recognizable through topographic expressions, small hillocks, mounds, ridges over shorter intervals having narrow depressions etc. The extraction from this area would be of minor minerals only *i.e.* earth and stone boulders.

Data gap Analysis-Existing Data Base

Because of small areal extent, data gap analysis as it is done in several districts of mainland, analysis cannot be followed in Island. However, depending upon the data availability the data adequacy and data inadequacy has been assorted.The major part of the Island >90% is covered by dense forest hence, the mappable area is inhabited by people and agricultural land are limited. Because of problem in transportation and non-availability of suitable drilling Rigs and vendors since beginning of ground water exploration both through construction of tube well& geophysical prospective was not carried out in Andaman & Nicobar Islands.

CHAPTER-2
CLIMATE

2.1Climate and Rainfall: 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. Monthly rainfall for last three years is tabulated in **Table 2.1**

Table2.1 Rainfall of Andaman & Nicobar Islands

ComparativeStatementshowingaverage(total)rainfall(mm)ofA&NIslandsoflastthre

Month	**201**		**201**		**201**		**% Variationin monthly Rainfallof 2019from2018**	**% Variationin cumulative Rainfallof 2019from 2018**
	Monthly	**Cumulative**	**Monthly**	**Cumulative**	**Monthly**	**Cumulative**		
January	279.02	279.02	170.67	170.67	174.85	174.85	2.45	2.45
February	9.05	288.07	50.20	220.87	11.97	186.82	-76.16	-15.42
March	33.28	321.35	19.80	240.67	19.50	206.32	-1.52	-14.27
April	101.42	422.77	114.47	355.14	39.28	245.60	-65.69	-30.84
May	276.05	698.82	359.18	714.32	231.95	477.55	-35.42	-33.15
June	320.85	1019.67	478.77	1193.09	611.52	1089.07	27.73	-8.72
July	364.61	1384.28	213.52	1406.61	213.82	1302.89	0.14	-7.37
August	386.00	1770.28	366.30	1772.91	766.03	2068.92	109.13	16.70
Septembe	354.85	2125.13	343.12	2116.03	546.53	2615.45	59.28	23.60
October	247.80	2372.93	296.22	2412.25	143.15	2758.6	-51.67	14.36
November	223.35	2596.28	229.73	2641.98	151.63	2910.23	-33.99	10.15
Decembe	**270.32**	**2866.60**	**317.8**	**2959.80**	**44.2**	**2954.43**	**-86.09**	**-0.18**

2.2 Temperature & Humidity:

Maximum and minimum temperatures in the islands fluctuate between 27 to 33˚C and 21 to 25˚C. The mean maximum temperature is 30.86˚C and means minimum temperature is 24.5˚C.The relative humidity varies from 77% to 80.83% and wind speed varies from 7 km/hr to 15 km/hr. The meanrelativehumidityis79%. 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 1500-1800 mm per annum.

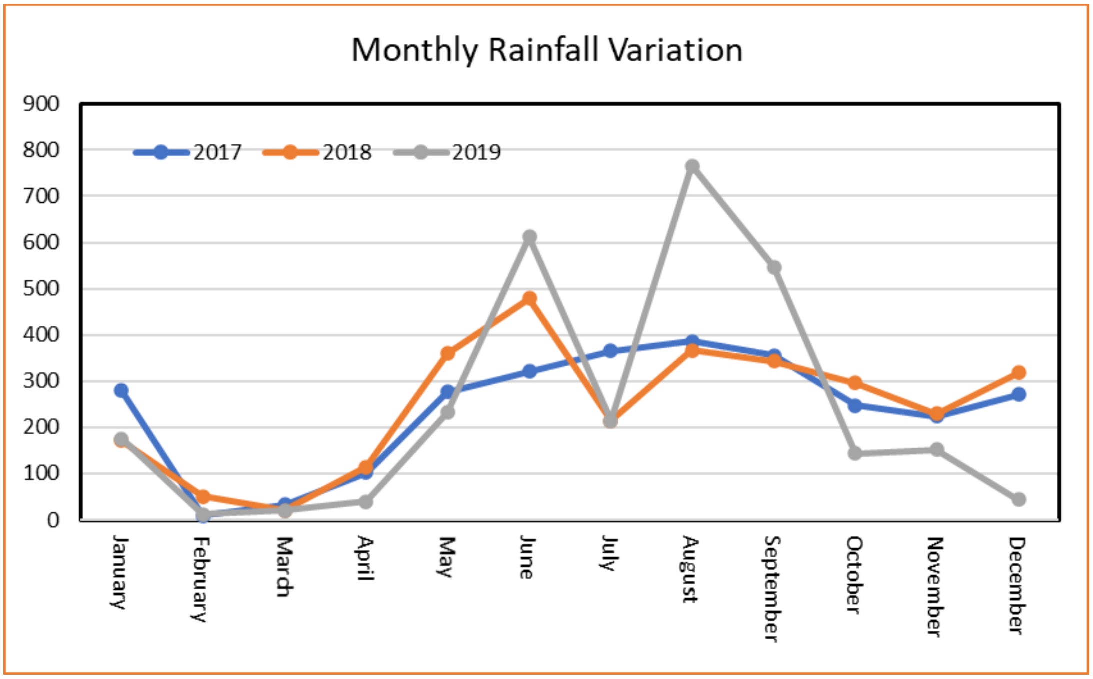


Fig. 2.1 Monthly Rainfall in Andaman & Nicobar Islands during 2017, 2018 and 2019

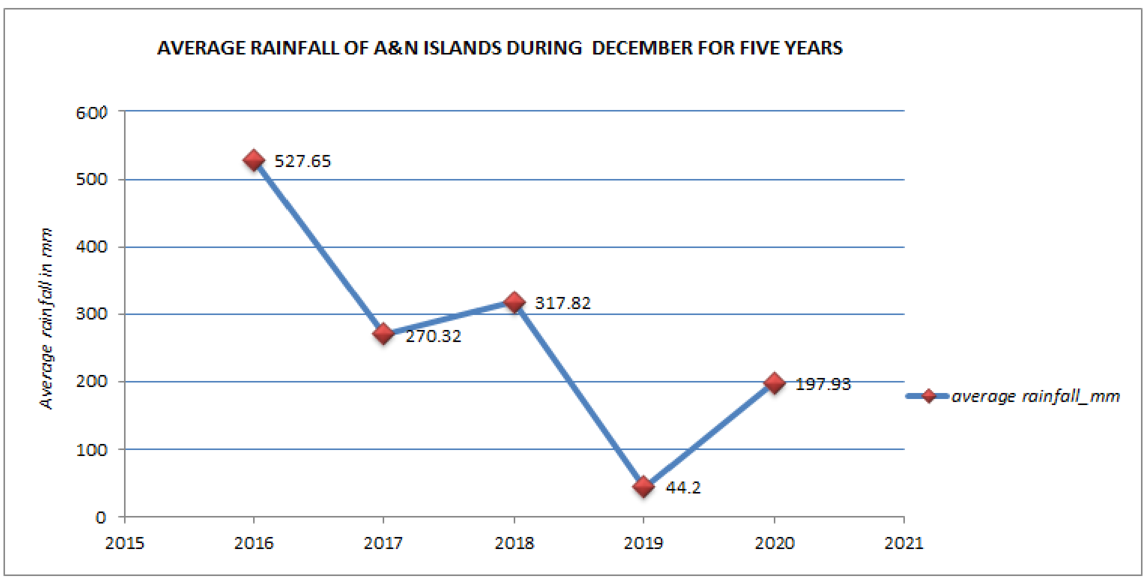


Fig. 2.2Average Rainfall in Andaman & Nicobar Islands
(From December 2016 to December2020)

**Source: Department of Economics and Statistics, Andaman & Nicobar Administration

Table2.2 Climatic Data of Port Blair(Temperature & Humidity)

Month/Year	**Mean Temperature (˚C)**								**Humidity (%)**							
	Maximum				**Minimum**				**08:30 hrs**				**17:30 hrs**			
	2017	**2018**	**2019**	**2020**	**2017**	**2018**	**2019**	**2020**	**2017**	**2018**	**2019**	**2020**	**2017**	**2018**	**2019**	**2020**
January	30.1	30.0	30.0	30.3	24.0	24.0	24.0	24.0	77	78	75	70	81	80	77	73
February	31.0	30.5	31.1	30.7	24.0	24.0	24.0	24.0	69	75	71	71	71	75	74	72
March	32.2	31.6	31.9	31.6	24.0	24.0	23.0	24.0	66	70	68	65	72	73	72	71
April	32.5	32.4	33.2	32.8	26.0	26.0	25.0	26.0	74	69	67	69	78	76	73	75
May	32.3	32.1	32.4	32.3	26.0	25.0	26.0	26.0	78	78	80	76	84	85	82	84
June	30.4	29.4	30.1	30.3	25.0	25.0	24.0	25.0	86	87	89	84	87	89	89	88
July	29.9	29.8	30.9	30.2	25.0	25.0	25.0	25.0	91	85	84	85	92	86	84	87
August	29.9	29.0	28.7	30.5	25.0	25.0	24.0	25.0	87	88	90	83	90	90	92	85
September	30.3	30.1	29.2	30.1	25.0	24.0	24.0	25.0	83	83	88	86	87	88	90	89
October	30.7	30.6	31.7	30.0	25.0	25.0	25.0	24.0	81	80	74	88	86	86	83	93
November	31.1	30.6	31.0	30.7	25.0	25.0	25.0	26.0	76	76	73	75	84	82	82	82
December	30.1	30.2	30.3	29.8	25.0	24.0	25.0	25.0	75	78	69	76	79	83	72	81
Average	**30.9**	**30.5**	**30.87**	**30.77**	**24.9**	**24.7**	**24.5**	**24.92**	**79**	**79**	**77.25**	**77.33**	**83**	**83**	**80.83**	**81.67**

**Source: Department of Economics and Statistics, Andaman & Nicobar Administration

CHAPTER-3

PHYSIOGRAPHY

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 465mamsl.

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 DEM of North & Middle Andaman district is shown in **Fig. 3.1A a**nd **Fig. 3.1B,** respectively.

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

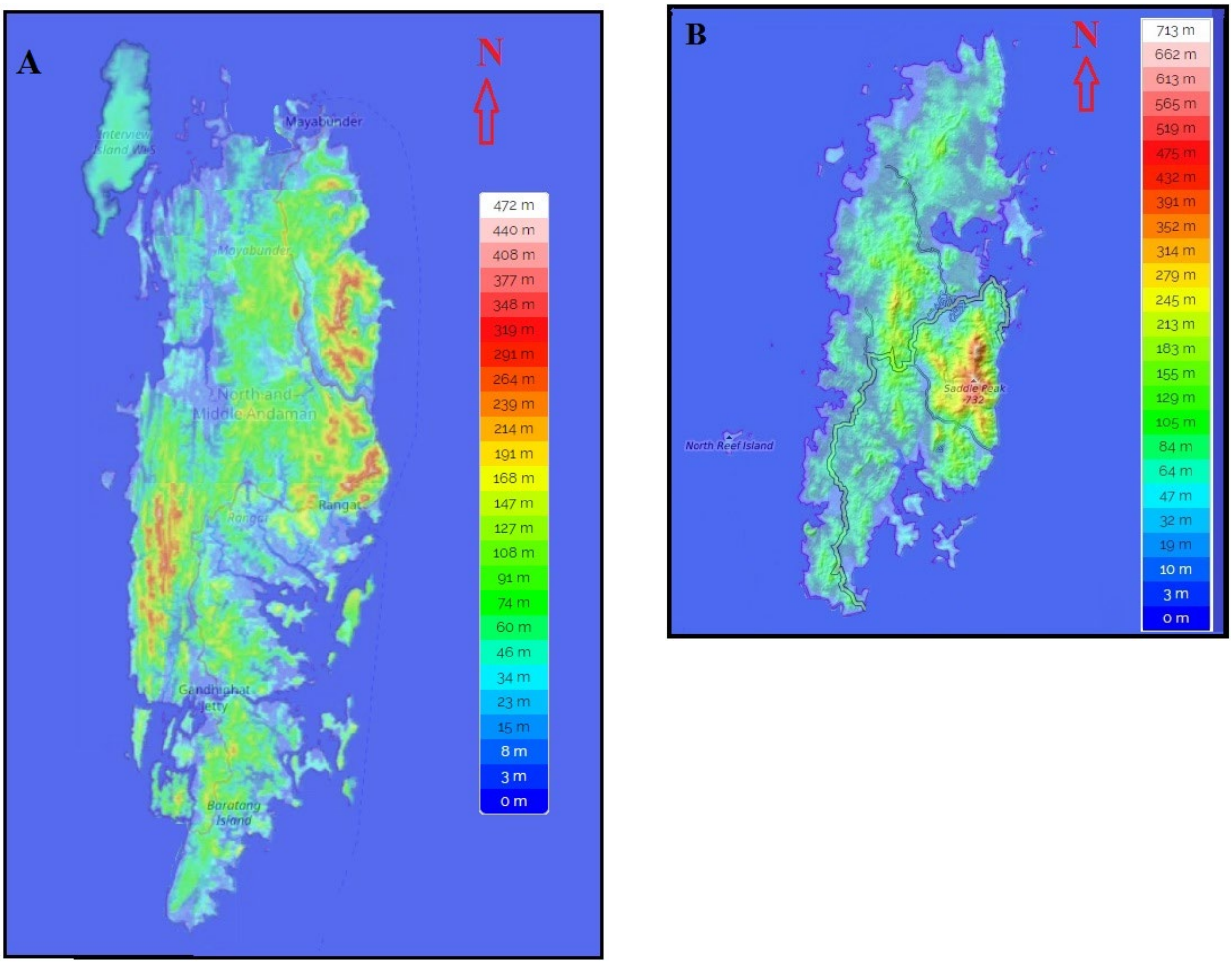


Figure:3.1Digital Elevation Model showing variations in topography in A) Middle Andaman district, B) North Andaman district.

3.2 Springs:

Geological and geomorphologic conditions of the islands have facilitated the origin of numerous springs (Fig-3.2.1.) 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 is maintained either directly from the springs 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 Panchawati Hills in Middle Andaman near Rangat and in Saddle Peak in North Andaman Island and in Narcondam Island (extinct volcano in North Andaman) underlain by igneous rocks.However, good perennial springs can also be seen in Limestone near Betapur, in Middle Andaman and in Long Island. Good yielding springs although could be seen in sedimentaries, their yield reduces in lean months and the discharge further dwindles with recession of monsoon.

Fig 3.2 Depression spring in marine sedimentary rock near Madhupur, Diglipur Subdivision

3.3 Drainage:

In comparison to South Andaman district, many perennial streams occur in North and Middle Andaman district. Amongst them important streams are South creek Nallah, Saber Nallah, Dasarathpur Nallah, Rangat Nallah Korang Nallah, Betapur Nallah, Thoratang Nallah, Kundu Nallah, Tugapur Nallah, Webi Nallah, Karmatang Nallah, , Cherian Nallah, Laxmipur Nallah, Swarajgram Nallah, Kalpong Nallah 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 Nallah 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 Nallah meets 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 Jarwa Creek of Baratang Island. The drainage map Shown in Fig 3.3 & 3.4.

3.4 Soil Characteristics:

Soils in North Andaman, Middle Andaman, Interview Island, East Island and Baratang Island are mainly derived from sedimentary and igneous rocks like sandstone, Siltstone, Shale Limestone and Mudstone and Igneous Ophiolite suite of rocks comprising Pillow lava, acid and intermediate volcanics, gabbro, Peridotite, Harzburgites etc. The soils in the islands comprise alluvial soil, Sandy soil, Valley soil and Hilly soil. These soils are mostly deep to very deep.

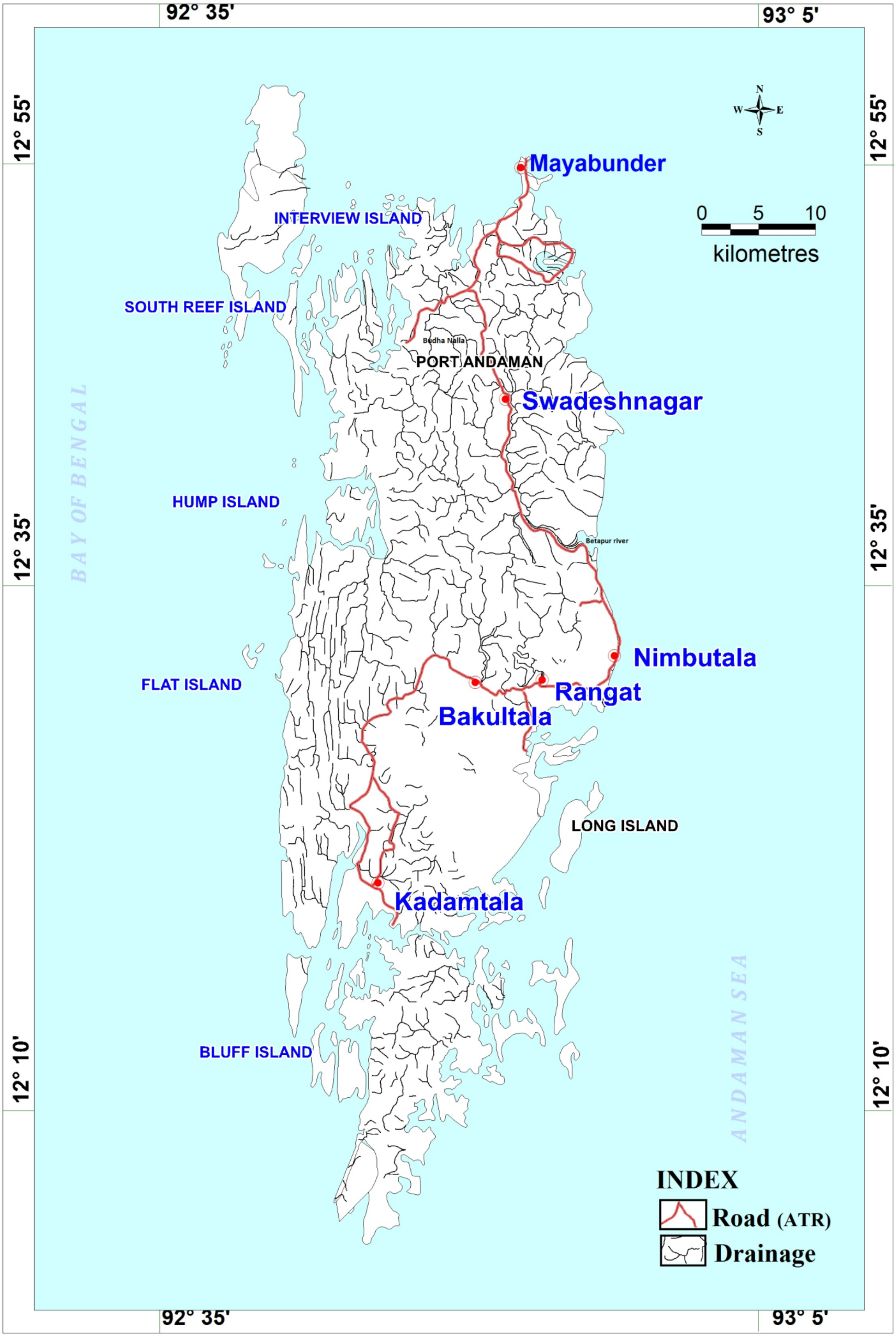


Fig: 3.3 Drainage map of Middle Andaman District

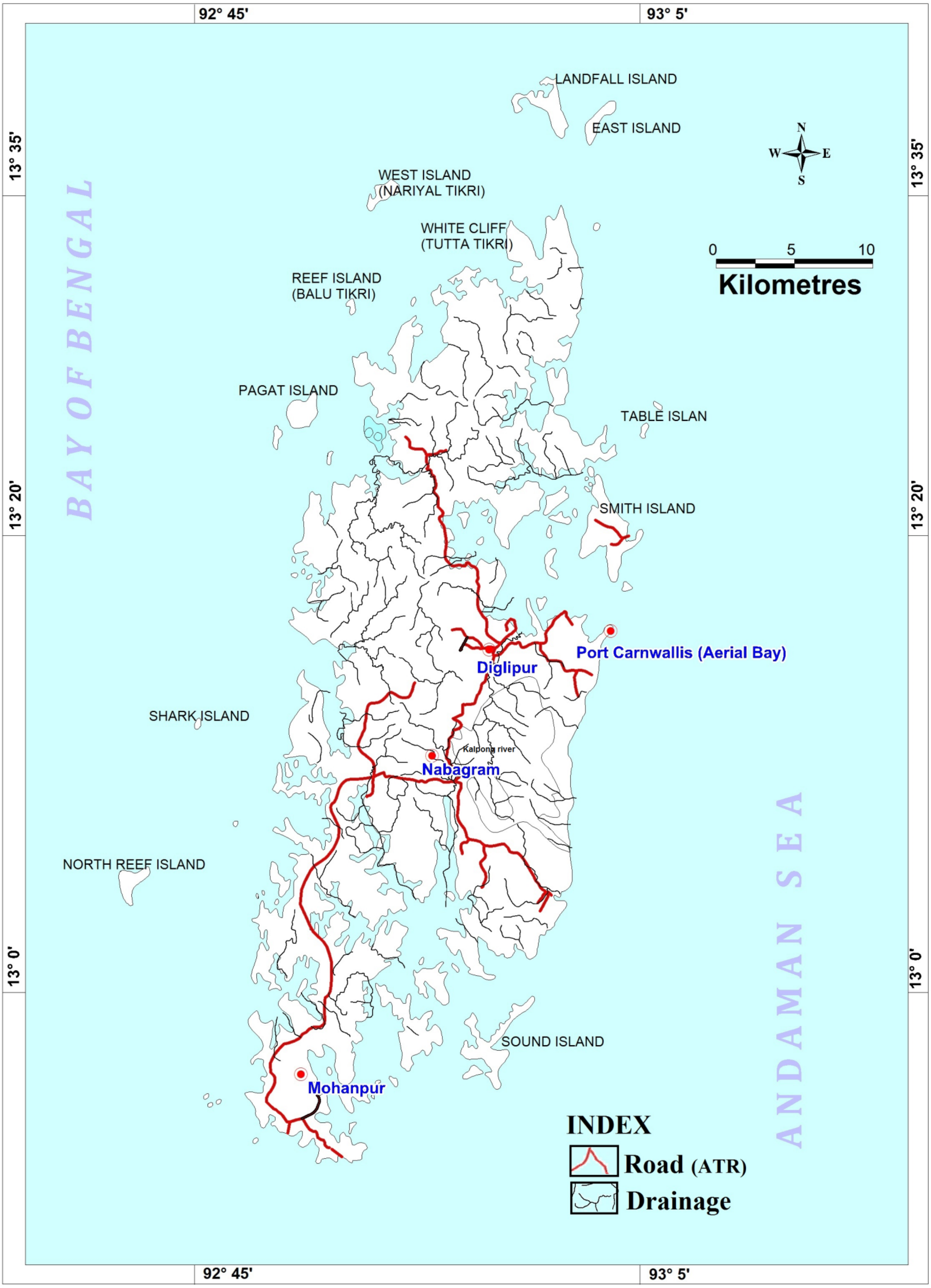


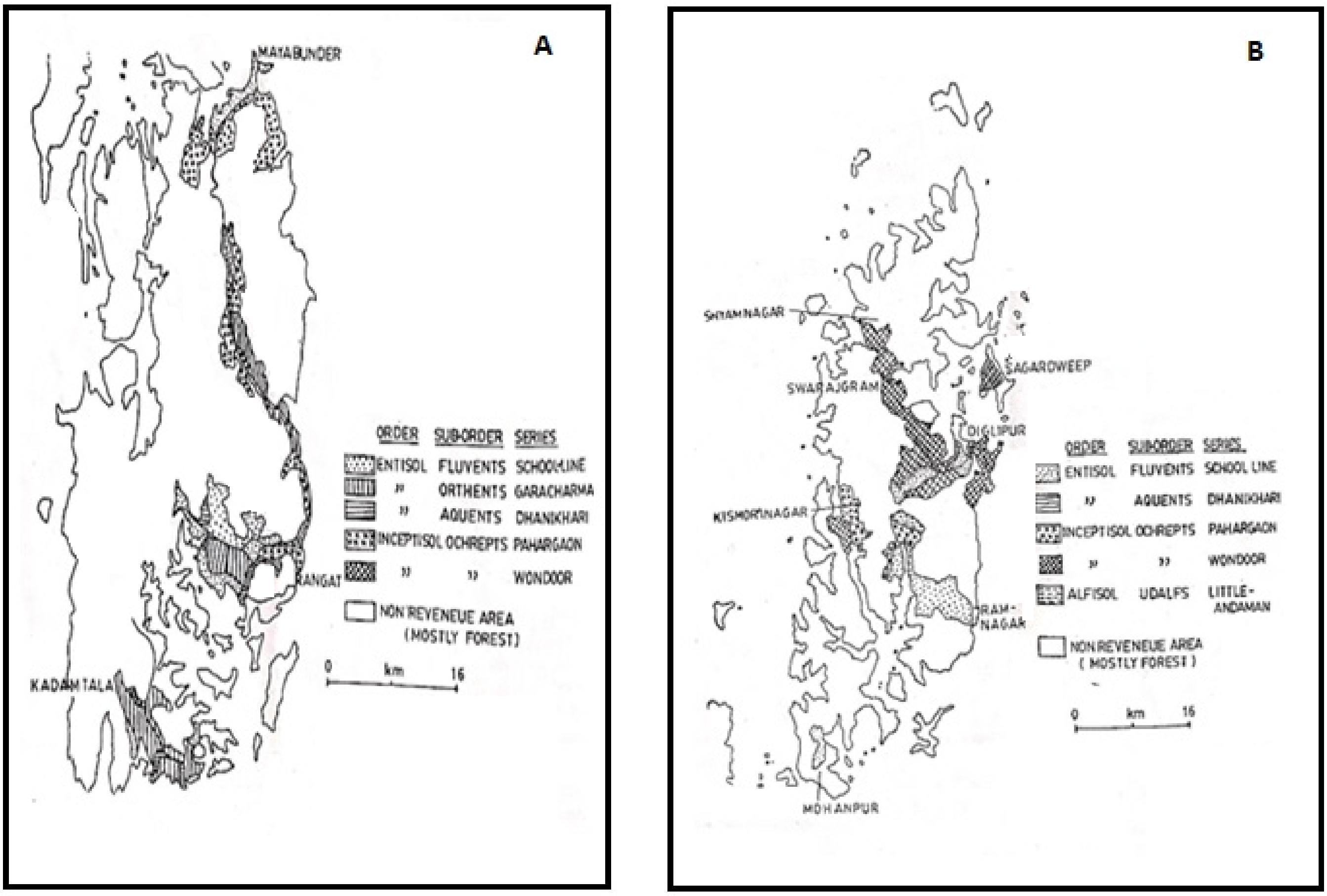
Fig: 3.4 Drainage map of North Andaman District

moderately to poorly drained, clay to clayey loam with angular blocky to sub angular blocky structure Most of the alluvial soil is seen in valley sand used for Paddy in Kharif season, vegetables, pulses and oil seeds in Rabi season. Most of the plants at ion 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 is lands of North and Middle Andaman District like Ross and Smith Island, Long Island are derived from the sedimentary rocks like Limestone, Coralines and, Mudstone 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 facilitates luxuriant growth of coconut, Arecanut and root crops along the coastal stretches.

Table3.1 Major Soil type of N & M Andaman District

District	Major soil type	Area (ha) including Forest soil	Percent %) of total	Depth of Soil
North & Middle Andaman	Entisols Orthrents)	11497	29.37	The soils on tableland and hills are moderately deep (50-100 cm). The slopes and foothills are deeply eroded and are shallow (25-50 cm) or very shallow (<25 cm).
	Entisols (Fluvents)	7546	19.28	
	Inceptisols Ochrepts)	7790	19.90	
	Entisols (Aquents)	747	1.91	
	Alfisols (Ustalfs)	450	1.15	
	Inceptisols Orthrents)	1196	26.40	The coastal plains and some of the hills have deep soils more than 100 cm depth.

***Source: Agriculture Contingency Plan for Andaman & Nicobar Islands, 2015)*



***Source Singh, N.T., Mongia, A.D., Ganeshamurthy, A.N. (1988) Soils of Andaman & Nicobar Islands. CARI Bulletin, A&N Islands, pp 64*

Figure: 3.5 A&B Soil Classification A) Middle Andaman B) North Andaman Islands

CHAPTER-4

GEOLOGY

4.1General geology:

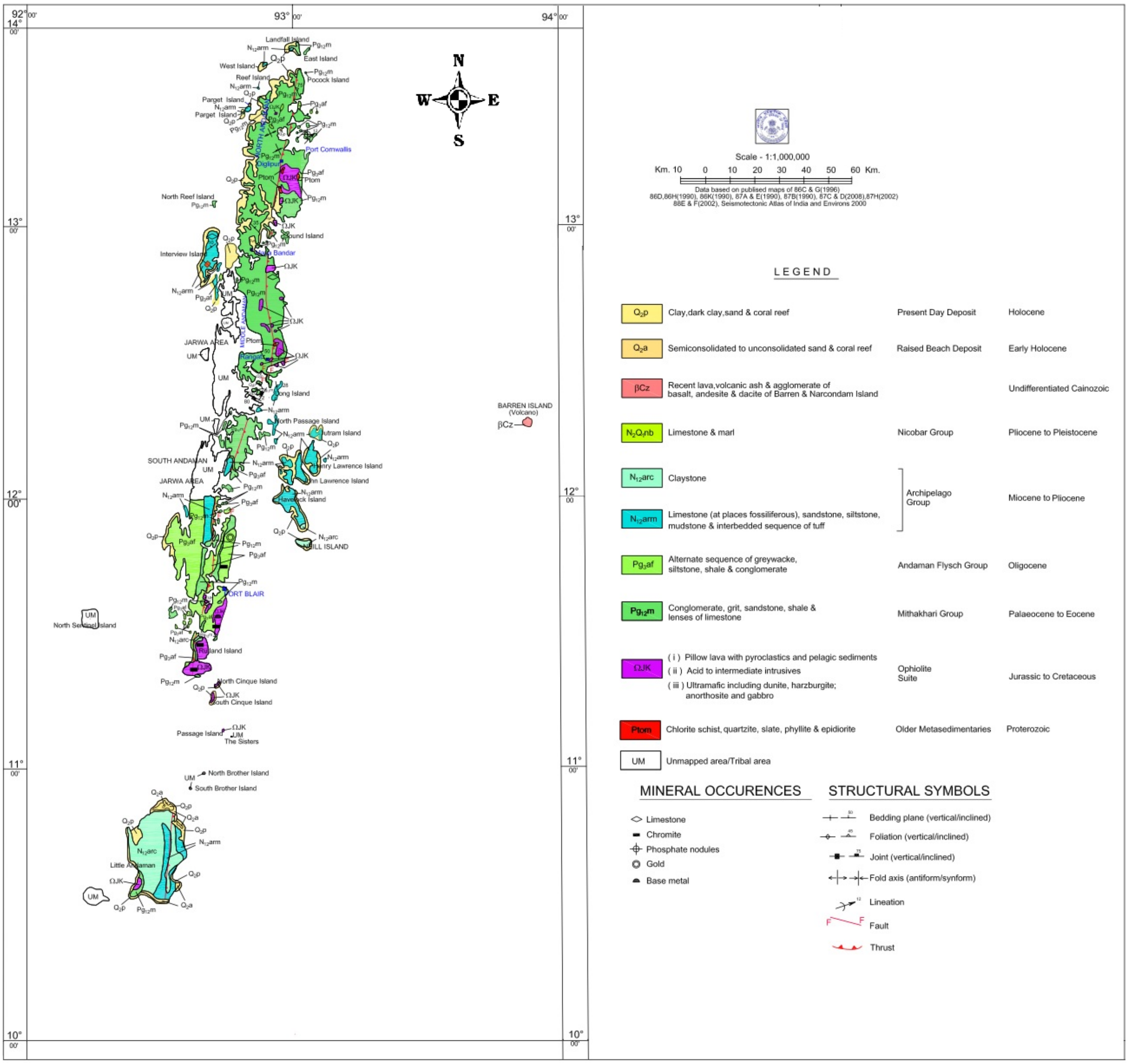
The Islands in the North-Middle Andaman district are composed mainly of thick Eocene sediments deposited on Pre-Tertiary sandstone, silt stone and shale with intrusions of basic and ultrabasic igneous rocks (Ophiolites). In the geologically Younger Richie's archipelago, calcareous sand stones are more 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 4.1**.

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 (volcanic 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 rock's 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.Geology of the South, North & Middle Andaman district shown in **Fig. 4.1**.

Table 4.1 Generalized Geological Succession of Andaman & Nicobar Islands

Age	Group	Formation
Recent to sub-Recent	Quaternary Holocene Group	Beach sand, Mangrove Clay, Alluvium, Coral Rags and Shale, Limestone, loosely consolidated pebbles bed.
----------------------------------	**----Unconformity---**	---------------------------------------
Pleistocene to Late Pliocene	Nicobar Group	Shell limestone, Sandstone, Claystone etc.
Miocene	Archipelago Group (Upper)	White Claystone, Melville Limestone Thinly bedded alternations of Sandstones and siltstones, grit, Conglomerate, Limestone, and Black Shales with olistoliths.
----------------------------------	**----Unconformity-----**	
Oligocene to Paleocene	Andaman Flysh, Mithakhari Group	
----------------------------------	**----Unconformity------**	---
Late Cretaceous	Ophiolite Group	Dyke Swarms, acidic suit, pillow lava with radiolarian chert and ultra-mafic suit.

GEOLOGICAL MAP OF ANDAMAN AND NICOBAR ISLANDS



**Source *GEOLOGICAL SURVEY OF INDIA Miscellaneous Publication No. 30, Part XX ANDAMAN & NICOBAR ISLANDS*

Fig. 4.1 Geological Map of Andaman and Nicobar Islands

CHAPTER-5

GEOPHYSICAL STUDIES

5.1 Vertical Electrical Sounding (VES)

Geophysical investigations were carried out in North Andaman district for identification of sites for artificialrechargeand water conservation (like sub-surface dykes) and also for identification of feasible sites for exploratory drilling. In North Andaman district, 25 Vertical Electrical Sounding (VES) were completed in 15 selected locations by Central Ground Water Board, Eastern Region, Kolkata. The layer-wise resistivity and interpreted layer thickness are given in **Table 5.1.**

Table 5.1: VES Details in North and Middle Andaman District

Sl No	Location	Resistivity (ohm-m)					Layer Thickness (m)				
		P_1	P_2	P_3	P_4	P_5	h_1	h_2	h_3	h_4	h_5
1	Tughapur 7 No. N& M Andaman	7.2	2.88	4.35	--	--	0.8	12	--	--	--
2	Tughapur 8 No. N & M Andaman	26	5.2	11.6	--	--	7	56	--	--	--
3	Tughapur 7 No. A, N & M Andaman	100	4.5	--	--	--	2.5	37.5	--	--	--
4	Rest Camp, N & M Andaman	38	11.4	4.8	--	--	1	11	--	--	--
5	Tughapur 8 No. A, N & M Andaman	70	21	3.15	--	--	0.84	15.96	--	--	--
6	Webi Nallah 1, N & M Andaman	270	40.5	6.6	--	--	0.8	6.08	--	--	--

7	Webi Nallah 2, N & M Andaman	88	8.8	4.2	--	--	0.8	6.08	--	--	--
8	Austen Creek, N & M Andaman	76	12.92	80	14	--	7.8	46.8	23.4	--	--
9	Karmatang No. 10, N & M Andaman	76	72.92	59.5	17.55	--	6.7	40.2	32	--	--
10	Billi Ground, N & M Andaman	50	100	14	--	--	1.3	4.55	--	--	--
11	Swadesh Nagar I, N & M Andaman	250	25	12.5	--	--	2.2	11	--	--	--
12	Shanti Nagar, N & M Andaman	700	35	--	--	--	1	8	--	--	--
13	Swadesh Nagar 2, N & M Andaman	240	48	12	--	--	2.9	8.7	--	--	--
14	Basantipur, N & M Andaman	90	18	9	--	--	2.2	22	--	--	--
15	Basantipur, N & M Andaman	33	6.6	3.3	--	--	2.4	12	--	--	-

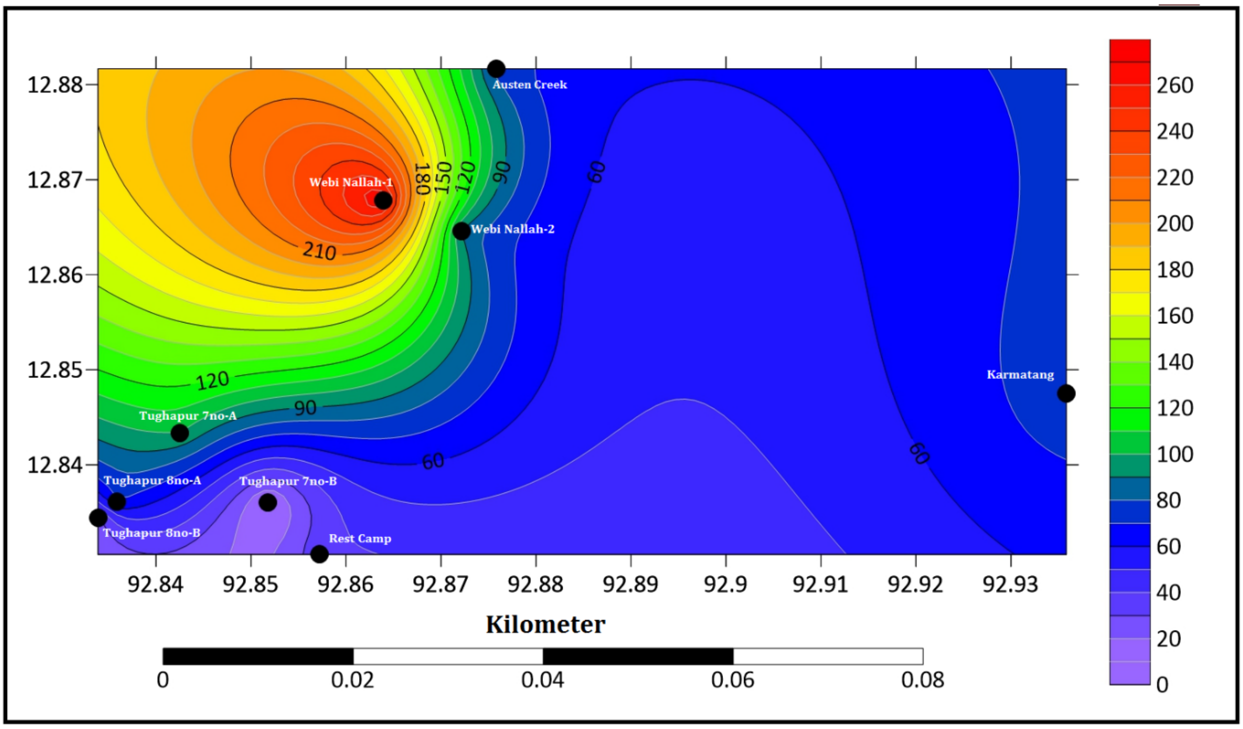


Fig. 5.1 True Resistivity Contour Map of First Layer of Northern Part of Middle Andaman district

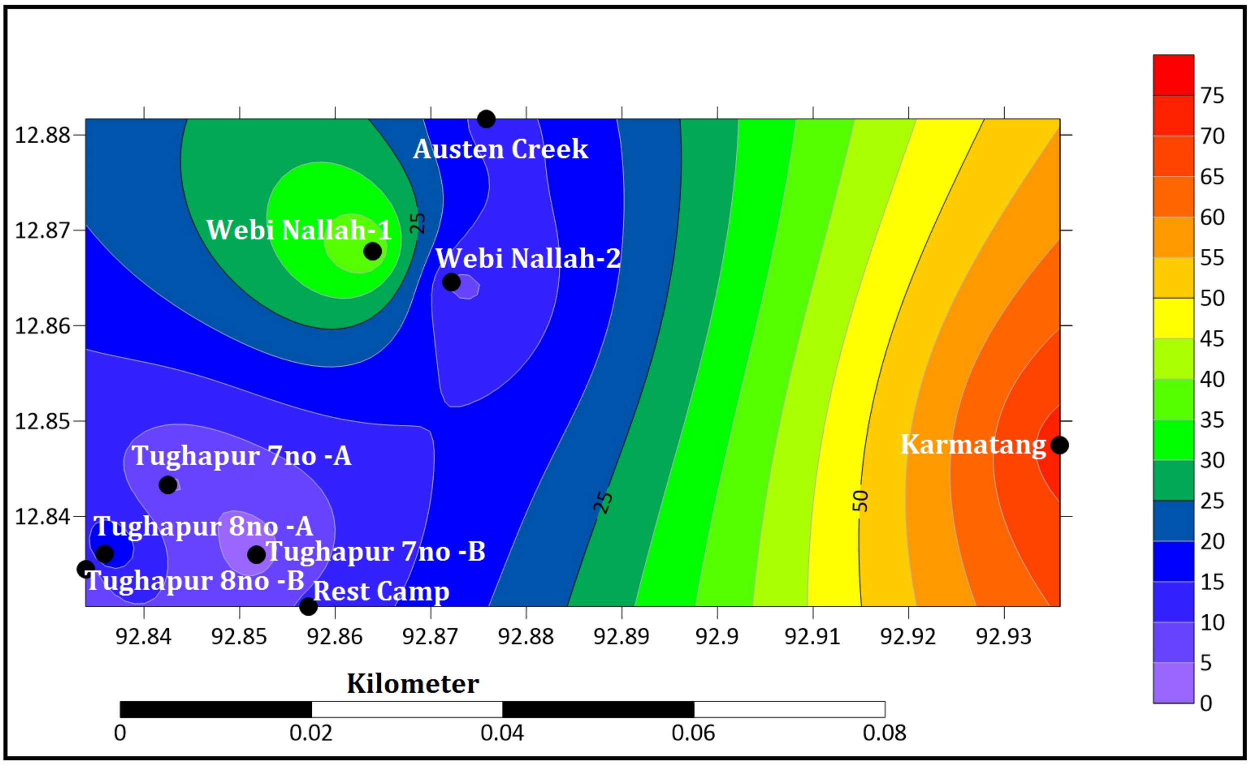


Fig. 5.2 True Resistivity Contour Map of Second layer, Northern Part of Middle Andaman district

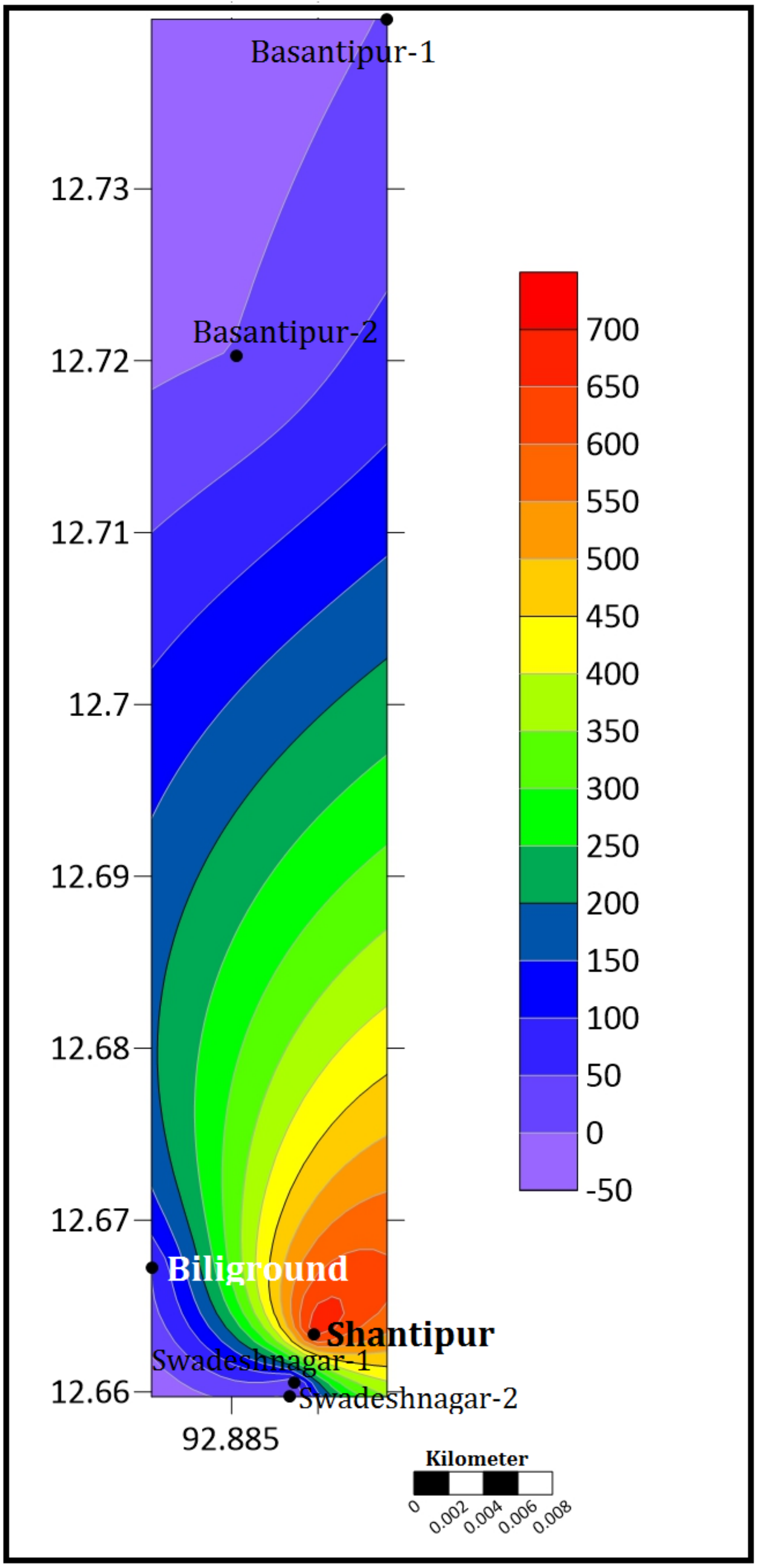


Fig. 5.3 True Resistivity Contour Map of First Layer, Southern Part of Middle Andaman district

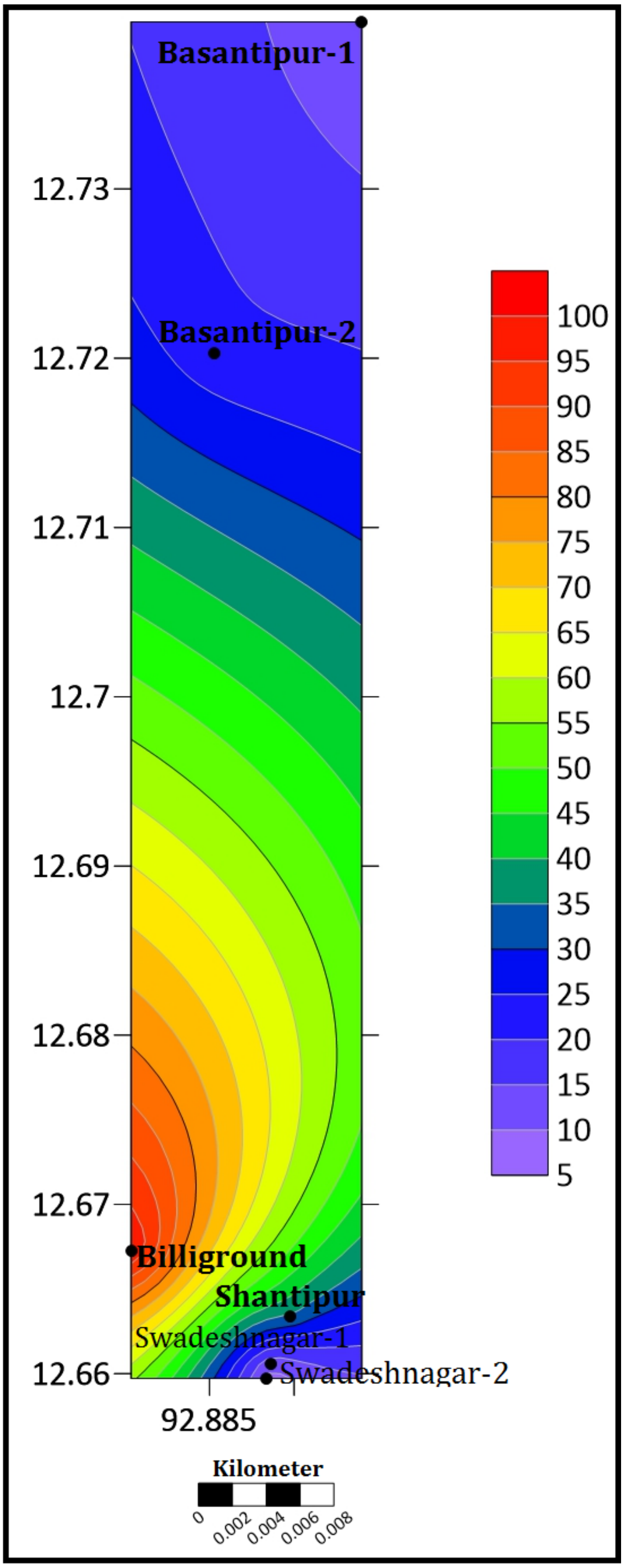


Fig. 5.4 True Resistivity Contour Map of Second layer, Southern Part of Middle Andaman district

Table 5.2 VES Details in Northern Part of Middle Andaman district

Sl no	Location	latitude	longitude	Layer_1	Layer_2	Layer_3	Layer_4	h1	h2	h3
1	Tughapur 7 No A	12.83601	92.85177	7.2	2.88	4.35	0	0.8	12	0
2	Tughapur 8 No A	12.83444	92.83388889	26	5.2	11.6	0	7	56	0
3	Tughapur 7 No B	12.84333	92.8425	100	4.5	0	0	2.5	37.5	0
4	Rest Camp	12.83056	92.85722222	38	11.4	4.8	0	1	11	0
5	Tughapur 8 No B	12.83611	92.83583333	70	21	3.15	0	0.84	15.96	0
6	Webi Nallah 1	12.86778	92.86388889	270	40.5	6.6	0	0.8	6.08	0
7	Webi Nallah 2	12.86455	92.872174	88	8.8	4.2	0	0.8	6.08	0
8	Austen Creek	12.88167	92.87583333	76	12.92	80	14	7.8	46.8	23.4
9	Karmatang No. 10	12.8475	92.93583333	76	72.9	59.5	17.55	6.7	40.2	32

Table 5.3 VES Details in Southern Part of Middle Andaman district

Sl no	Location	latitude	longitude	Layer_1	Layer_2	h1	H2	H
1	Billi Ground	12.66724	92.88037	50	100	14	1.3	4.55
2	Swadesh Nagar -1	12.66056	92.88861	2.2	11			
3	Swadesh Nagar 2	12.65972	92.88833	2.9	8.7			
4	Basantipur-1	12.72028	92.88528	2.2	22			
5	Basantipur-2	12.73986	92.894	2.4	12			
6	Shantipur	12.66338	92.88973	700	35	1	8	

From the **Fig. 5.1** it is concluded that Eastern part of the area, the top soil varying from clay to fine sand to coarse sand characteristics, North-western part of the area is showing gravel formation.

From the **Fig 5.2** it is concluded that western part of the area is characterised by Brackish formation, mainly in Tugapur and Rest Camp area (except some patches like Webi Nallah area), and eastern apart of the area are indicating the medium coarse sand to coarse sand formation saturated with fresh water.

From the **Fig 5.3** it is concluded that northern part of the Basantipur-1 area is mainly in clayey character. Central part of the area is sandy nature and southern part of the area is gravelly nature.

From the **Fig 5.4** it is concluded that northern part of the area like Basantipur -1 is brackish nature and southern part is medium coarse to coarse formation saturated with fresh water.

Based on the VES survey, six locations for artificial recharge to the shallow aquifer have been selected. The location and type of feasible artificial recharge structures are summarized in **Table 5.4.**

Table 5.4 Location-wise Feasible Artificial Recharge Structures, Based on Geophysical Survey

Sl. No.	Location	Feasible Artificial Recharge Structures
1	Tugapur No. 8	Sub-surface Dyke (SSD) and RCC well (dia. 6 m) in upstream side of the dyke with Weep Holes
2	Webi Nallah	Sub-surface Dyke & RCC Well
3	Karmatang Nallah	Sub-surface Dyke & RCC Well
4	Kundu Nallah, Shantinagar	Sub-surface Dyke & RCC Well
5	Swadesh Nagar	One well with Infiltration Gallery (dia. 8-10 m)
6	Badam Nallah, Basantipur	Sub-surface Dyke & RCC Well

CHAPTER-6

HYDROGEOLOGY

On the basis of conventional hydrogeological survey in mappable areas of Middle Andaman and North Andaman district, three distinct hydrogeological units have been identified. The formations are consolidated (crystalline hard rocks), semi-consolidated (sedimentaries) and unconsolidated (alluvial, colluvial and beach sands). Regional hydrogeological units mentioned above are: a) ultramafic rocks(ophiolites) characterized by secondary porosity, b) marine sedimentary rocks, in the form of an assemblage of sandstone-shale-conglomerate-limestone and c) quaternary beach sand, valley fills and unsorted colluvium, mainly exposed adjacent to river courses. Due to fine-grained sedimentary rocks having substantial clay content, groundwater potential of semi-consolidated formations is generally low. However, at Rangat in Middle Andaman district, in house exploratory drilling by Central Ground Water Board, Eastern Region has revealed discharge of 25 m^3/hr (6.94 lps) within the tapped zone ranging from 29.8 to 32.0 m. In this drilling site, porous alluvium (sand and gravel) was found to overlain by an ultrabasic (ophiolitic?) rock having a drilled depth of 151.4 m.

Regional hydrogeological scenario of the area is depicted by occurrence of unconsolidated mantle (alluvial cover) over the semi-consolidated and consolidated formations like sedimentary rocks and hard rocks, respectively. The alluvium is conspicuous in the intermontane valley fills, beach sands in coastal fringes and colluvium along parts of the river beds. The average thickness of saturated overburden (weathered zone), which has been characterized as the shallowest aquifer (Aquifer-I), was found to be varying from 5.0 m during the pre-monsoon period (summer season) to 6.5 m during the monsoon period. In the islands of North and Middle Andaman districts namely Long Island, Smith Island (Sagar Dweep), Baratang Island and Aves Island, groundwater generally occurs as fresh water lens over the invading saline water front.

As a part of the aquifer mapping study in North and Middle Andaman districts, separate thematic maps showing depth to groundwater level and groundwater level fluctuation are prepared for each of these districts.

6.1 HYDROGEOLOGICAL CONDITION IN NORTH ANDAMAN DISTRICT

The most potential hydrogeological unit in North Andaman district comprises Quaternary formations like beach sand, corals rags and thin alluvial cover, which is restricted as narrow linear tracts along the coast. Apart from this, colluvium in the intermontane valleys constitutes a shallow aquifer occurring under unconfined condition. This aquifer group has been named as Aquifer-I. Marine sedimentary rocks comprising the Andaman Flysch and the Mithakhari Group are the semi-consolidated to consolidated formations. Rocks belonging to the Ophiolite Group of Late Cretaceous age, characterized by pillow lavas, dyke swarms and ultramafic suite constitute the fissured rocks having conspicuous fracture (secondary) porosity. Interconnected fractures in the fissured rocks are conducive for formation of unconfined aquifers (Aquifer-I) in the area. The weathered mantle of ultramafic rocks often constitutes aquifers of low to moderately high groundwater potential in the depth range of ~10 to ~25 m. Dug wells are constructed in the weathered zone for meeting the domestic, Agri-irrigational and drinking water requirement.

During the aquifer mapping and management study in North Andaman district (AAP: 2019-2020), regional hydrogeological survey by conventional method was taken up in and around Diglipur, Laxmanpur, Vidyasagar Palli and Shibpur. During the systematic survey, hydrogeological information on 16 wells tapping the shallow, unconfined aquifer (Aquifer-I) was utilized to decipher the behaviour of groundwater table. As previously discussed, groundwater was utilized extensively for agri-irrigational, domestic and drinking purpose by the local populace. However, due to limited thickness of the weathered mantle (generally ~3 to ~5 m) and relatively impermeable nature of aquifer material (greywacke, siltstone and shale), majority of the wells have limited groundwater potential and generally low discharge. A dug well having depth of ~5 m and diameter of 2 m was reported to yield about 9 m^3/day in the post-monsoon period. However, the discharge gets substantially reduced during the pre-monsoon period in the summer season (CGWB 2009). The riverine sands and gravels of Kalpong River have relatively good potential for water resources development in the area. The water supply of Diglipur, the district headquarters, is dependent on a large diameter dug well on the northern bank of Kalpong River. Groundwater supply to the east of Diglipur, at Durgapur and Shibpur village is met through alluvial sands of Holocene age.

In North Andaman district, depth to water level (DTW) in majority (80%) of the monitoring wells was ranging from 0.12 to 1.50 m bgl, whereas deeper water level ranging from 1.5 to 4.5 m bgl was recorded in ~20% of the monitoring wells during the pre-monsoon period. The minimum DTW was 0.12 m at Laxmipur, whereas deepest water level of 4.56 m bgl was recorded at Debipur. The shallowest zone of DTW ranging from 0 to 1 m was recorded near Milangram, Laxminagar area in Diglipur (Subashgram) and southern part of Kishorinagar along the north eastern coast of the district. In the southern part of the district, in and around Haribay, Mohanpur and Debipur, pre-monsoon DTW was found to be ranging from 2.55 to 4.56 m bgl. During post-monsoon period (January 2020), DTW ranging from 0-2 m was observed at Subhasgram, Milangram, Laxmipur areas (coastal tract) and at Sitanagar in the central part of the district. Deeper water level condition (DTW: 2-4 m bgl) was found at Keralapuram. A perusal of seasonal water level fluctuation data shows minimum seasonal fluctuation of 0.09 m at Haribay, whereas the maximum fluctuation was 3.69 m at Debipur village.

Regional hydrogeological map showing locations of ground water monitoring wells in North Andaman district is shown in **Fig. 6.1** whereas the pre-monsoon depth to water level map is shown in **Fig. 6.2**. The post-monsoon depth to water level map (January 2020) in North Andaman district is given in **Fig. 6.3**. The map showing seasonal fluctuation in groundwater level in North Andaman district is given in **Fig. 6.4.**

A perusal of **Fig. 6.2** indicates that the groundwater level in North Andaman district during pre-monsoon 2019 was very shallow, as no well has recorded water level deeper than 3 mbgl, except at Debipur, where depth to water level of 4.56 mbgl has been recorded. During post-monsoon period (January 2020), the depth to groundwater level was even shallower, having the general depth range of 0-2 mbgl, except at Basantipur (3.11 mbgl) and at Keralapuram (4.21 mbgl). The regional depth to water level scenario is depicted clearly in **Fig. 6.3.** The seasonal fluctuation in groundwater level (June 2019 versus January 2020) in North Andaman district is depicted in **Fig. 6.4.** Visual analysis of the map reveals that seasonal decline in the range of 0-2 m was restricted to a small area in the southernmost part of the district.

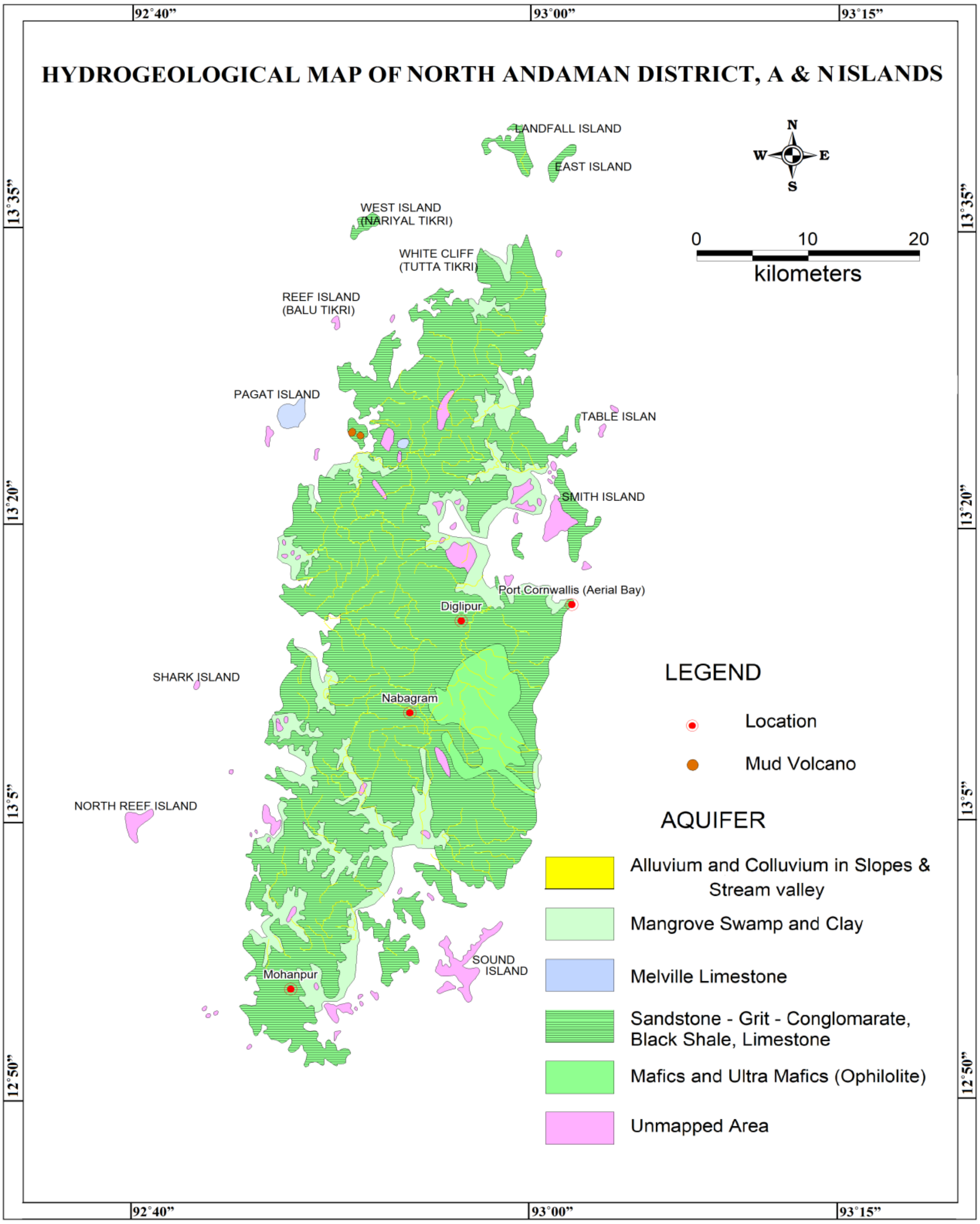


Fig. 6.1: Hydrogeological map, North Andaman District

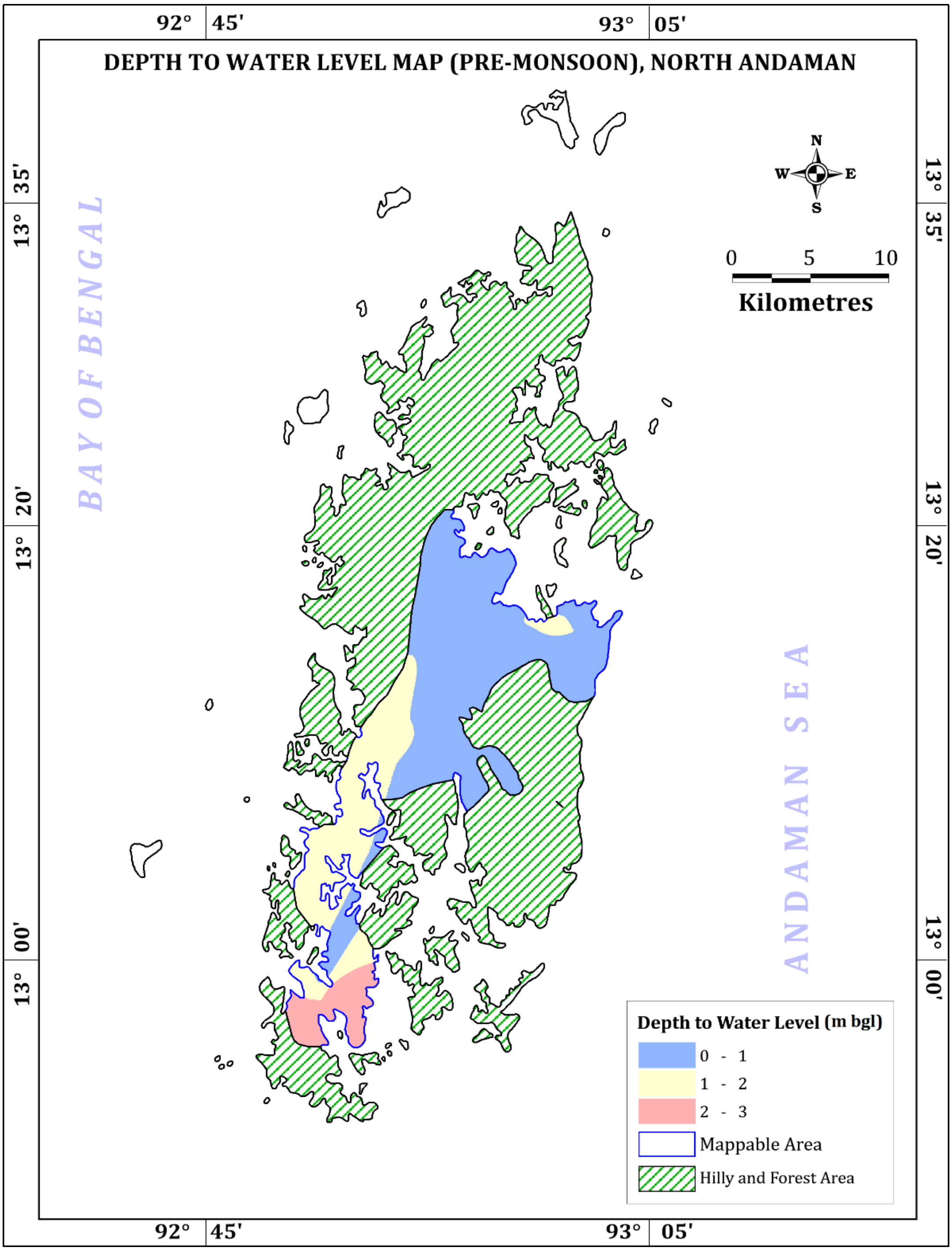


Fig. 6.2 Depth to water level map (pre-monsoon 2019), North Andaman district

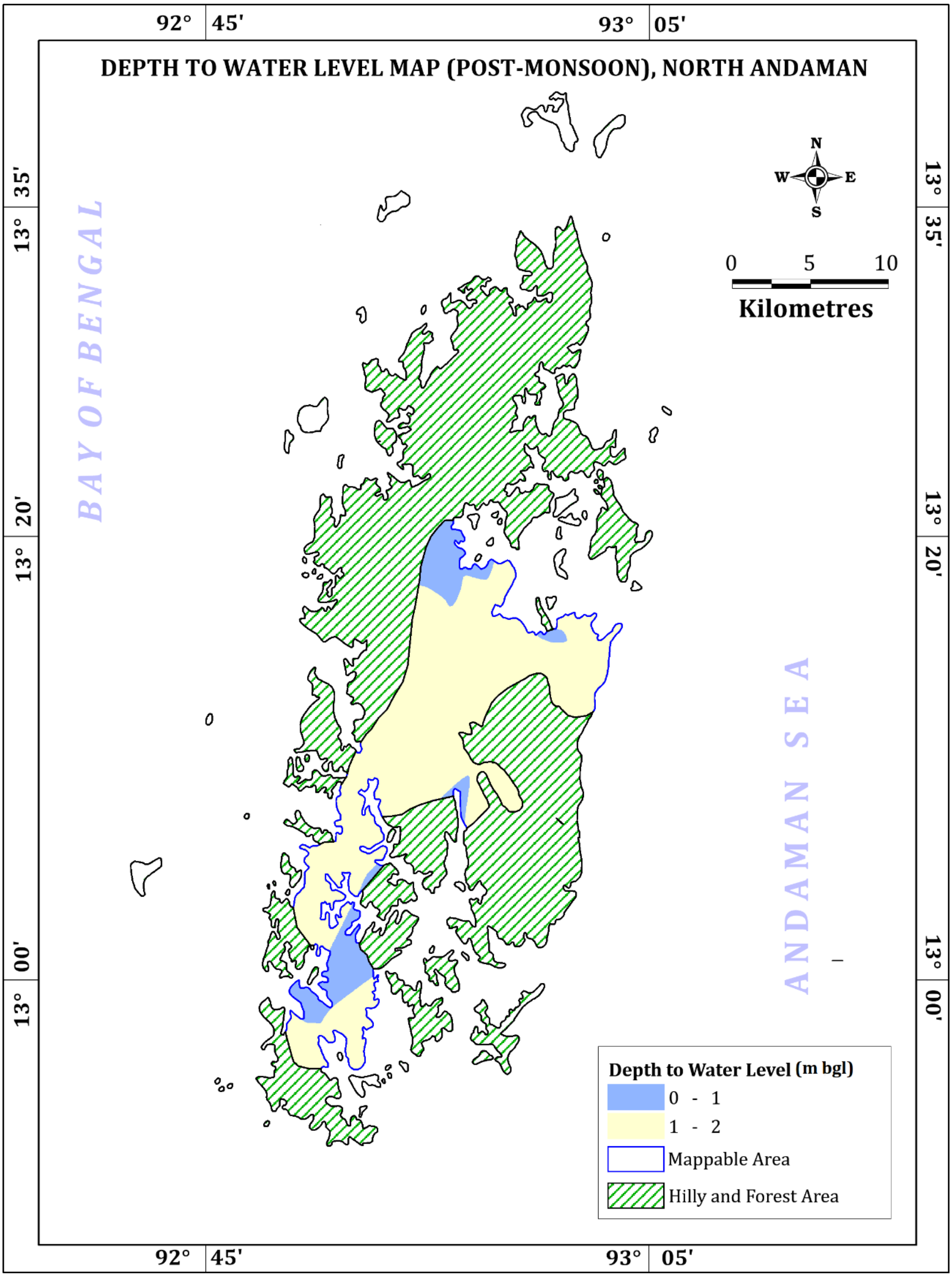


Fig. 6.3 Depth to water level map (January 2020), North Andaman District

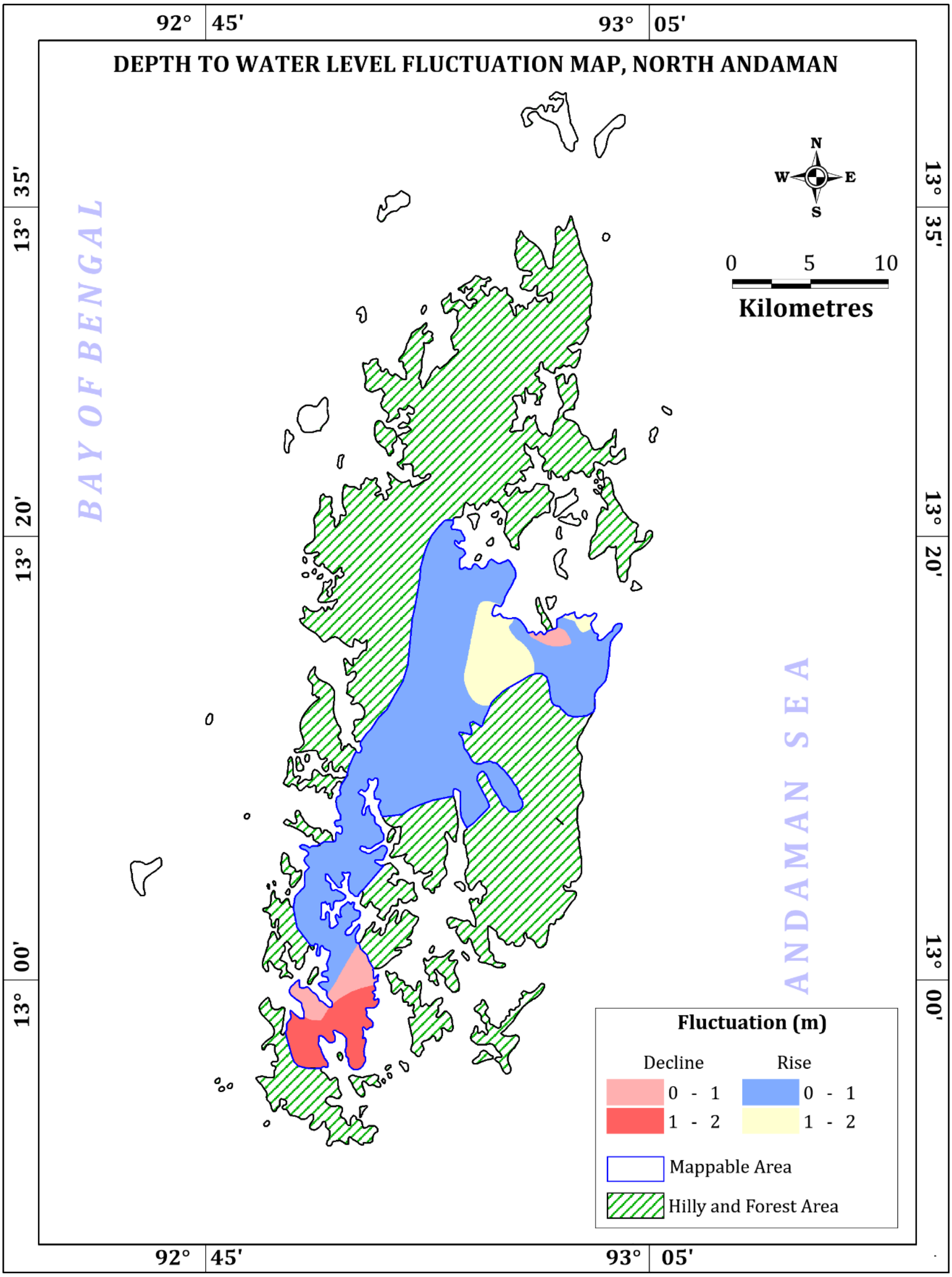


Fig. 6.4 Seasonal water level fluctuation map, North Andaman District

6.2 HYDROGEOLOGICAL CONDITION IN MIDDLE ANDAMAN DISTRICT

The regional hydrogeological scenario of Middle Andaman district is very similar to that of North Andaman district. The North and Middle Andaman districts constitute a continuous landmass of the main archipelago. Aquifers in Middle Andaman district occurs at shallow depth and under unconfined condition. The beach sands, relatively thin alluvial cover along the valley fill deposits and the colluvial deposits along perennial river beds are the most promising hydrogeological units of Holocene age. Fine to medium grained sand and silty sand constitute the clastic sedimentary rocks in the area. Due to relatively low porosity and permeability of the clastics, groundwater potential of the weathered mantle is very less, varying from 4 to 5 m^3/hr (96 to 120 m^3/day). Nonetheless, active tectonic (seismic) activity in the region results in fracturing of the country rocks and subsequent increase in the secondary porosity at places. It has been reported that fractured sedimentary rocks of Middle Andaman district have moderately high groundwater potential (CGWB 2009). Based on the depth to groundwater level data of 21 ground water monitoring wells, the thematic maps on depth to water levels for pre-monsoon (June 2019), post-monsoon (January 2020) and seasonal fluctuation map (June 2019 versus January 2020) are prepared. The regional hydrogeological map of Middle Andaman district with locations of ground water monitoring wells is shown in **Fig. 6.5.** Using the depth to water level data of pre-monsoon period (June 2019), a pre-monsoon depth to water level map has been prepared, which is shown in **Fig. 6.6.** Visual analysis of the map indicates that except for a very small area in the northernmost part of Middle Andaman district, depth to water level was found to vary from 0-2 m bgl. At Swadeshnagar, the depth to water level was 0.17 m agl, which indicates water logging condition in the area. Depth to water level was found to vary from 0.04 m bgl at Parnasala to a maximum of 2.17 m at Tikadera.

Depth to water level scenario in post-monsoon period (January 2020) was similar to that of the pre-monsoon. The depth to water level map for post-monsoon period is shown in **Fig. 6.7.** A perusal of the map indicates that relatively deeper water level condition (>3 mbgl) was seen in the north central and east central part of the district. As the map has been generated using data interpolation technique using dedicated software (MapInfo Professional), the deepest water level conditions are observed in the northernmost part, which was similar to the situation observed in pre-monsoon 2019. The deeper water level condition in post-monsoon period as compared to pre-monsoon is attributed to increased irrigational use through the large diameter dug wells tapping the shallow, unconfined aquifer. Seasonal water level fluctuation map of Middle Andaman district is shown in **Fig. 6.8.** A study of the map reveals that except for a small area in the south-central part, seasonal rise ranging from 0 to 3 m was recorded throughout the district. In the south-central part, seasonal decline in the range from 0 to 1 m was recorded.

In Middle Andaman district, the pre-monsoon depth to water level (DTW) ranging from 0 to 2 m bgl was observed at Tikadera, Kaushlyanagar and Uttara in the southern coastal tract. In most of the monitoring wells, the DTW in pre-monsoon (June 2019) was found to vary from 1 to 2 m bgl. During post-monsoon period (January 2020), most of the monitoring wells have recorded DTW ranging from 1-2 m bgl, except at Pahalgaon (2.41 m bgl), Porlobjig 15 (2.08 m bgl), Tikadera (2.56 m bgl), Long Island (2.22 m bgl and 2.74 m bgl) and Padmanabhapuram (4.00 m bgl). Seasonal water level fluctuation data indicates fluctuation ranging from 0 to 2 m was recorded in all the 21 monitoring wells.

Table 6.1 Depth to water Level Data in North & Middle Andaman District (2019)

Sl No	Well No.	District/ Island	Village	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Fluctuation	Latitude	Longitude
1	AN021	Middle	Rangat	0.50	0.85	0.35	12.50611	92.90861
2	AN022	Middle	Bakultala	0.21	1.01	0.45	12.50417	92.85833
3	AN023	Middle	Nimbutala	0.47	1.81	1.34	12.49444	92.95417
4	AN024	Middle	Kausalyanagar	0.67	0.54	0.64	12.52833	92.81833
5	AN025	Middle	Padmanavpuram	1.59	4.00	2.41	12.60667	92.94917
6	AN029	Middle	Baratang (Nilambur)	0.49	0.69	0.20	12.16833	92.76694
7	AN030	Middle	Uttara	0.21	1.05	0.84	12.32806	92.79
8	AN031	Middle	Kadamtala	1.48	1.88	0.4	12.34917	92.77417
9	AN032	Middle	Porlobjig-15	1.56	2.08	0.52	12.49556	92.78111
10	AN033	Middle	Tikadera	2.17	2.56	0.39	12.52278	92.81389
11	AN044	Middle	Parnashala	-0.22	1.13	1.35	12.52056	92.90333
12	AN050	Long	Long Island	0.54	1.88	1.34	12.36444	92.92333
13	AN051	Long	Long Island (forest Area)	0.53	2.22	1.69	12.36639	92.92333

14	AN052	Long	Long Island (secondary school)	1.12	2.74	1.62	12.36583	92.92028
15	AN058	Middle	Swadeshnagar	-0.33	1.61	1.94	12.65083	92.89111
16	AN095	Middle	South Creek (Sundergarh)	0.58	1.56	0.98	12.18667	92.79167
17	AN096	Middle	Phooltala Basti	1.75	1.50	-0.25	12.41167	92.76222
18	AN097	Middle	Kishorinagar (Parangara)	1.31	1.96	0.65	13.165	92.88167
19	AN102	Middle	Pahalgaon	1.43	2.41	0.98	12.83944	92.85333
20	AN103	Middle	Joypur	0.88	0.97	0.09	12.69944	92.88139
21	AN104	Middle	Betapur	0.18	1.27	1.09	12.62583	92.92111
22	AN026	North	Rest Camp	0.28	2.14	1.86	12.8281	92.857778
23	AN027	North	Dhobidera (Mayabunder)	0.47	1.62	1.15	12.91	92.899167
24	AN034	North	Mohanpur	2.55	1.09	-1.46	12.9542	92.835556
25	AN035	North	Srinagar	1.24	1.69	0.45	13.1394	92.868056
26	AN036	North	Nabagram	0.22	1.00	0.78	13.1547	92.948333
27	AN037	North	Sitanagar	0.32	1.17	0.85	13.2269	92.936111
28	AN038	North	Durgapur	0.24	1.31	1.07	13.2733	93.031944
29	AN039	North	Laxmipur	0.49	1.7	1.21	13.2758	92.966667
30	AN040	North	Subhasgram	0.15	1.87	1.72	13.2522	92.974167
31	AN041	North	Haribay	0.05	0.58	0.53	13.0022	92.843889
32	AN042	North	Tugapur No. 8	0.12	2.15	2.03	12.82	92.8225
33	AN043	North	Basantipur	0.16	3.11	2.95	12.7575	92.8725
34	AN098	North	Milangram	0.71	0.94	0.23	13.3142	92.941111
35	AN099	North	Shibpur	0.54	1.38	0.84	13.2428	93.043889
36	AN100	North	Kerlapuram	1.52	0.87	-0.65	13.26	93.013333
37	AN101	North	Webi (Debipur)	4.56	4.26	-0.30	12.8669	92.871944

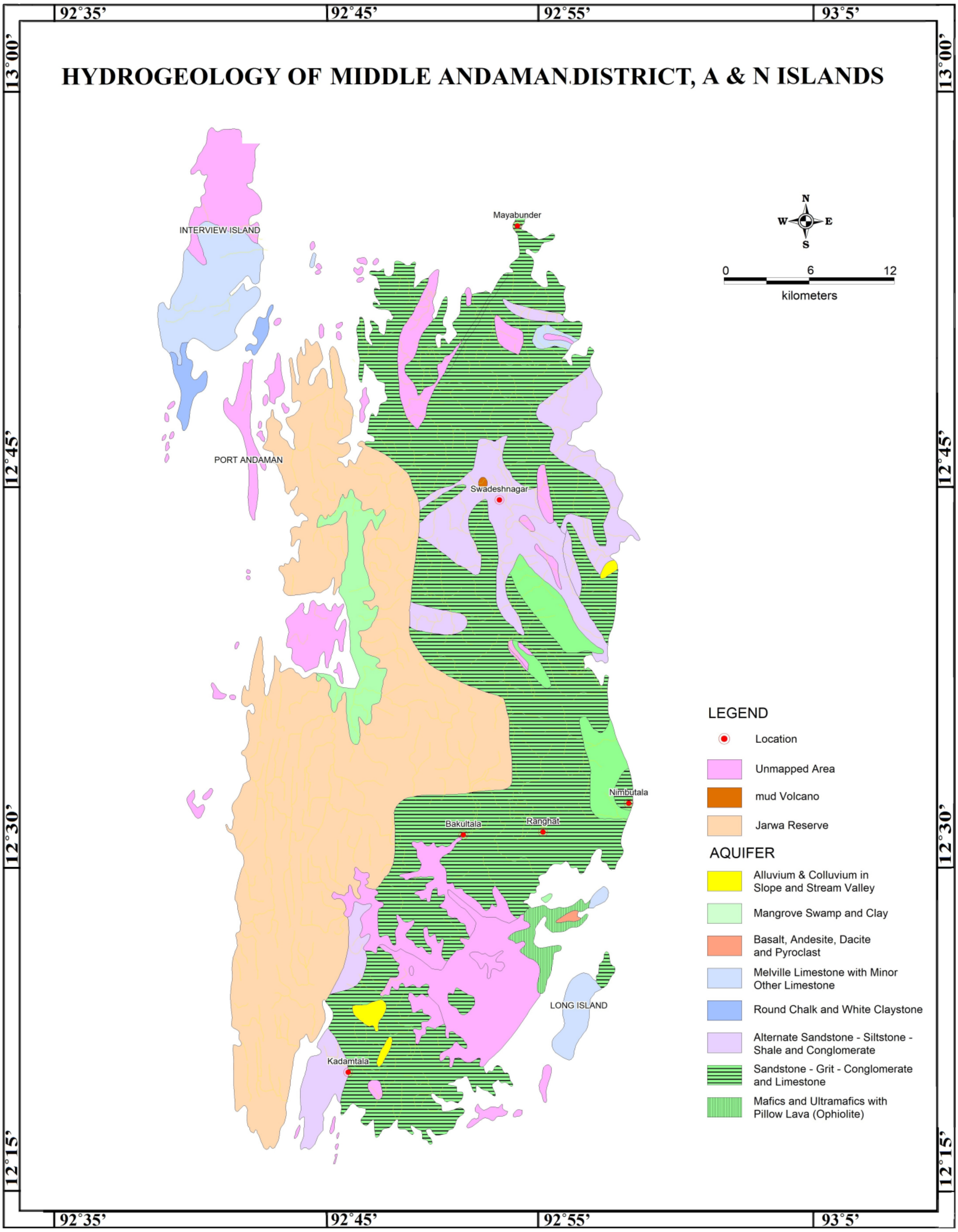


Fig. 6.5: Hydrogeological map, Middle Andaman District

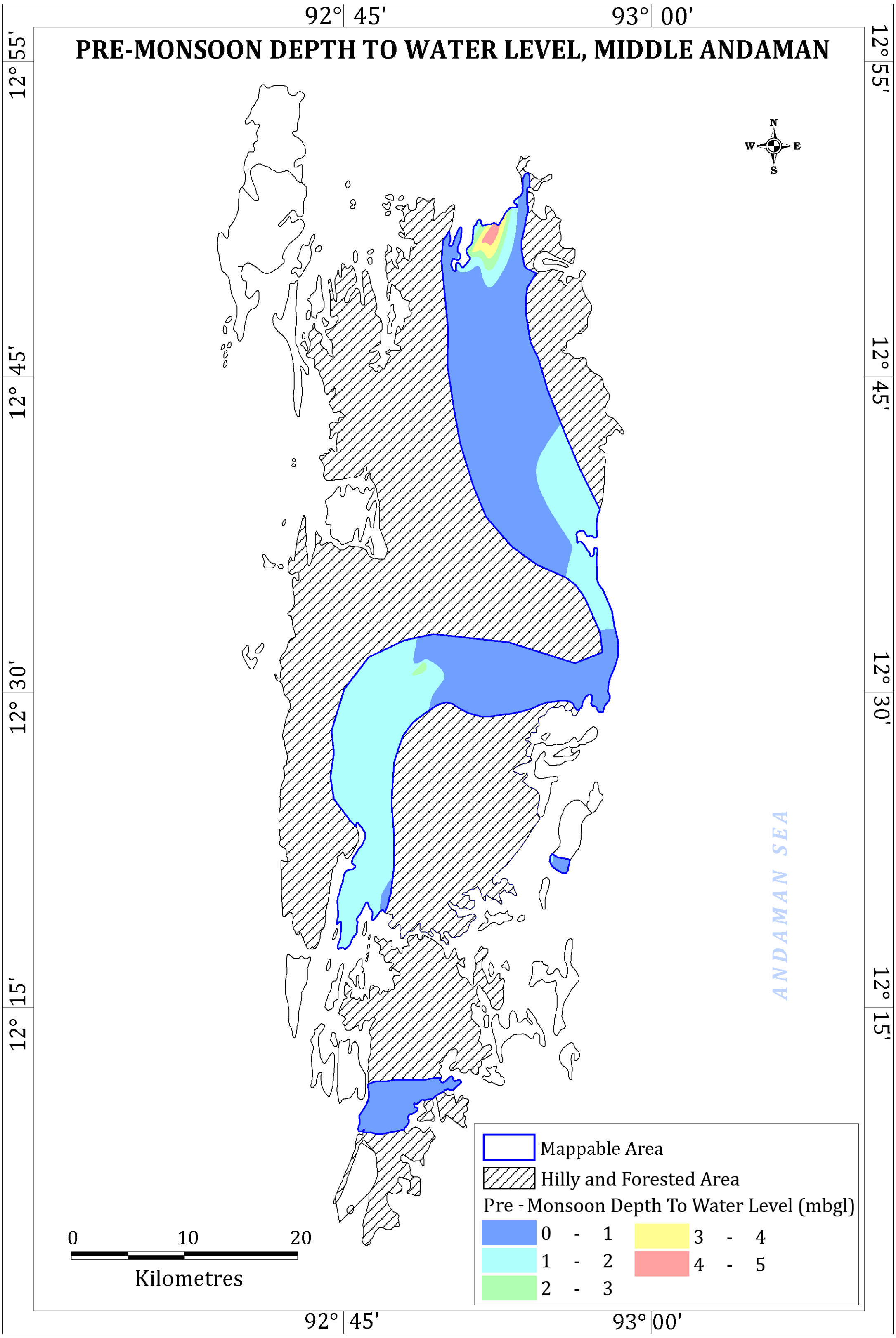


Fig. 6.6 Depth to water level map (June 2019), Middle Andaman District

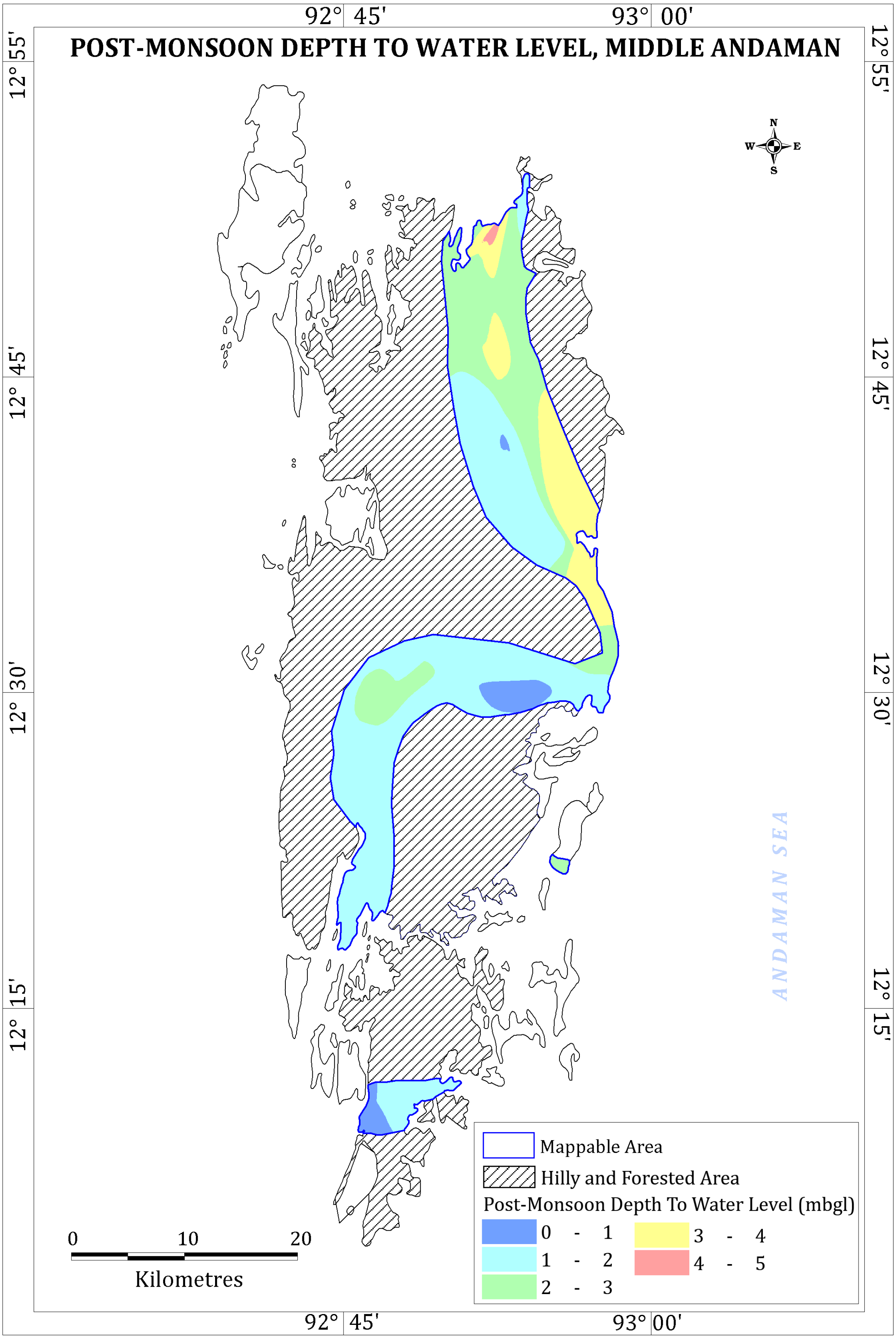


Fig. 6.7 Depth to water level map (January 2020), Middle Andaman District

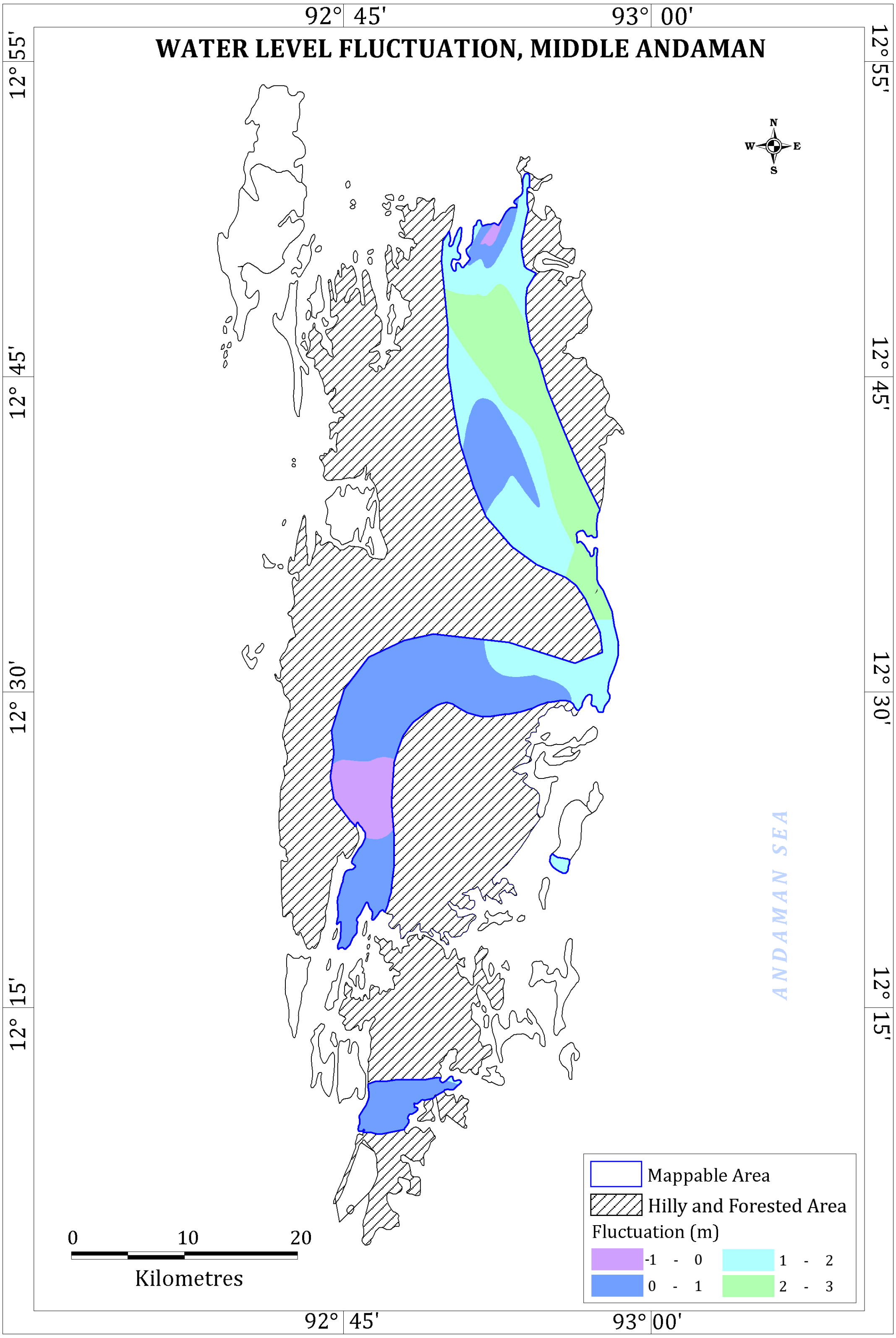


Fig. 6.8 Seasonal water level fluctuation map, Middle Andaman District

Available data of CGWB shows that the yield of dug wells is generally moderately good. A dugwell in intermontane valleys with 2m diameter and 5 m depth has a potential to yield ~9 m^3/hr (CGWB 2009). But in pre-monsoon period, the potential becomes lower as rainfall recharge is the predominant factor for replenishing the shallow, unconfined aquifer (Aquifer-I). In the volcanic suite of rocks, the potential fracture zones occur in the depth range 12.00-23.55 m, 22.0-30.0 m and 45.0-52.0 m in the area around Panchwati and Morisdera (CGWB 1990). It has been reported that after pumping of large diameter dug wells in the up-slope areas around Panchwati Hills, the recovery was full but slow. Typical recovery period varies from 3 to 5 day. In the valley fill areas, Specific Capacity of a dug well has been measured at 25.21 lpm/m, whereas Transmissivity of Aquifer-I was 131.84m^2/day (CGWB 2009). Large diameter dug wells are extensively used for agri-irigation during the summer months (April to June) and they are typically fitted with 1HP suction type centrifugal pumps.

Although the weathered and fractured igneous rocks form potential aquifers, the hard rock aquifers, sometimes occurring at deeper levels (>25 m), are not developed for water supply due to accessibility problem. In Middle Andaman district, generally the springs are sparsely distributed. Few perennial springs are extensively used for piped water supply in habitations like Rampur, Chitrakoot, Santibasti and Kadamtala. Spring discharge was found to vary from 12 lps (1036.80 m^3/day) at Shankar Nallah in Baratang Island to a maximum of 60lps(5184.0 m^3/day) at Panchwati. The Panchwati Hills is host to several perennial springs, which cater to water supply at locations like Nimbutala, Kaushalyanagar, Kalsi, Bakultala, Shyamkund, Shaktigarh, Panchawati and Rangat.

Springs at Shankar Nallah, Panchwati, Chitrakoot and Rampur are perennial in nature while those at Sabari Nallah, Tikadera, Nandidera and Joseb Nallah are ephemeral. The genetic classification of the springs has been attempted during the present study. Accordingly, springs at Shankar Nallah and Rampur are classified as fracture springs; those at Tikadera, Chitrakoot and Joseb Nallah are classified as seepage spring while the spring at Sabari Ward No. 2 has been classified as a depression spring. Analysis of spring discharge during the pre-monsoon/monsoon and post-monsoon periods reveals a substantial seasonal fluctuation, except at Panchwati (to the north of Panchwati Hills on the way to Sivapuram). At Nandidera, spring discharge was found to vary from 172.8 m^3/day in post-monsoon to 1296.0 m^3/day during monsoon period. At Tikadera, post-monsoon discharge (43.2 m^3/day) was only 10% of the monsoon discharge (432.0 m^3/day). At Chitrakoot, the pre-monsoon discharge (432.0

m³/day) was 50% of the monsoon discharge (864.0 m³/day), while at Joseb Nallah (ephemeral spring), monsoon discharge (302.4 m³/day) was seven times the discharge during post-monsoon (43.2 m³/day).

6.3 GROUNDWATER EXPLORATION

During the in-house groundwater exploration programme of CGWB (from the year 1985 to 1994), total 47 exploratory wells (EW) were drilled in entire Andaman and Nicobar Islands. Amongst these, 11 EW were drilled in Middle Andaman district and 2 EW were drilled in North Andaman district. It was observed that the boreholes drilled up to a depth range of 150 m in sedimentary formations generally are unproductive with negligible discharge. Nonetheless, the EW at Hawamahal near Rangat, having drilled depth of 151.40 m, was found to have a discharge of 25 m³/hr tapping a gravelly aquifer in the depth range of 29.8 to 32.0 m. At Panchwati, the EW with drilled depth of 90.97 m was found to have a discharge of 10 m³/hr tapping a fractured volcanic aquifer in the depth range of 13.10 to 14.72 m (CGWB 1990). 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 m³/hr. No groundwater exploration was carried out in Tertiary coralline limestone of Archipelago Group. The details of successful Exploratory Wells drilled in Middle Andaman district is given in **Table 6.1** (CGWB 1990).

Table 6.2 Details of productive groundwater exploration in A&N Islands

Sl. No	Name of the Island	Place Name	Aquifer	Depth Drilled /Depth of Construction (m)	Productive Aquifer zones/ Fractured Zones tapped (m)	Discharge (m³/hr)	EC (µS/cm) and Quality of Groundwater
1	Middle Andaman	Rangat	Porous alluvium/colluvium overlie ultrabasic	151.4/35.0	29.8-32.0	25.0	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

Another nine Exploratory Wells drilled in sedimentary rocks in North and Middle Andaman districts were unsuccessful as the discharge in these wells was negligible.

6.4 DECADAL (LONG-TERM) FLUCTUATION

The decadal (long-term) fluctuation in groundwater level has been worked out based on data from the year 2010 to 2019. A perusal of the decadal data reveals that at Parnasala and Mayabunder, long-term decline in groundwater level was observed during pre-monsoon period. The average annual rate of decline in pre-monsoon period was 0.024 m/year at Parnashala and 0.025 m/year at Mayabunder. In the remaining 35 ground water monitoring wells (94.59 % of total), long-term rising trend was observed in pre-monsoon period.

During post-monsoon period, long-term rising trend was recorded in 9 out of 37 wells (24% of the total). During post-monsoon period, long-term rise was found to vary from 0.04 m/yr at Phulotala Basti to a maximum of 0.08 m/yr at Bakultala. The long-term declining rate was found to vary from 0.01m/yr at Kishorinagar to a maximum of 0.34 m/year at Kerlapuram. Details of the long-term (decadal) trend in depth to water level during the pre-monsoon and post-monsoon periods are summarized in **Table 6.2.**

Table 6.3 Decadal Trend in Depth to Water Level (2010-2019), North &Middle AndamanDistrict

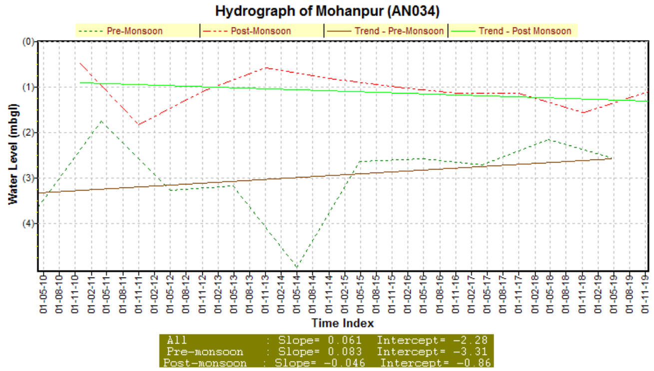
District/Island	**Location**	**Well No**	**Pre- Monsoon**		**Post- Monsoon**	
			Rise (m/yr)	**Decline(** m/yr)	**Rise** (m/yr)	**Decline** (m/yr)
Middle Andaman	Long Island	AN050	0.14	-	-	0.05
Middle Andaman	Long Island (Forest Area)	AN051	0.24	-	-	0.12
Middle Andaman	Long Island (Sec. School)	AN052	0.07	-	-	0.14
Middle Andaman	Bakultala	AN022	0.37	-	0.08	-
Middle Andaman	Baratang (Nilambur)	AN029	0.21	-	-	0.01
Middle Andaman	Betapur	AN104	0.14	-	0.07	-
Middle Andaman	Joypur	AN103	0.05	-	-	0.10
Middle Andaman	Kadamtala	AN031	0.07	-	-	0.08
Middle Andaman	Kausalyanagar	AN024	0.06	-	0.02	-
Middle Andaman	Kishorinagar (Parangara)	AN097	0.31	-	-	0.01
Middle Andaman	Nimbutala	AN023	0.04	-	-	0.09

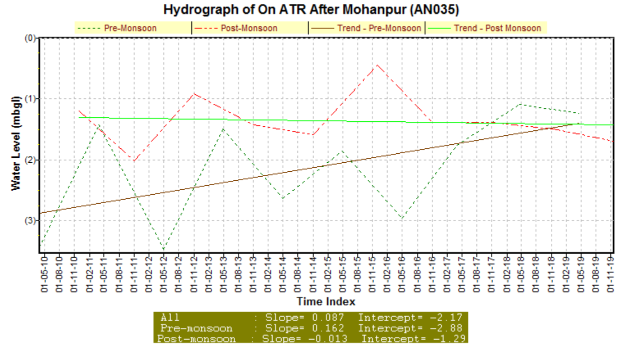
District/Island	Location	Well No	Pre- Monsoon Rise (m/yr)	Pre- Monsoon Decline(m/yr)	Post- Monsoon Rise (m/yr)	Post- Monsoon Decline (m/yr)
Middle Andaman	Padmanavapuram	AN025	0.05	-	-	0.16
Middle Andaman	Pahalgaon	AN102	0.09	-	-	0.12
Middle Andaman	Parnashala	AN044	-	0.02	0.01	-
Middle Andaman	Phooltala Basti	AN096	0.05	-	0.00	-
Middle Andaman	Porlobjig - 15	AN032	0.03	-	-	0.04
Middle Andaman	Rangat	AN021	0.20	-	0.07	-
Middle Andaman	South Creek (Sundergarh)	AN095	0.34	-	-	0.11
Middle Andaman	Swadeshnagar	AN058	0.25	-	-	0.08
Middle Andaman	Tikadera	AN033	0.09	-	-	0.06
Middle Andaman	Uttara	AN030	0.09	-	-	0.03
North Andaman	Basantipur	AN043	0.24	-	-	0.15
North Andaman	Durgapur	AN038	0.15	-	-	0.02
North Andaman	Haribay	AN041	0.17	-	-	0.01
North Andaman	Kerlapuram	AN100	0.19	-	-	0.34
North Andaman	Laxmipur	AN039	0.12	-	-	0.05
North Andaman	Mayabunder	AN027	-	0.03	-	0.12
North Andaman	Milangram	AN098	0.19	-	-	0.03
North Andaman	Mohanpur	AN034	0.08	-	-	0.03
North Andaman	Nabagram	AN036	0.19	-	0.04	-
North Andaman	Mohanpur	AN035	0.16	-	-	0.01
North Andaman	Rest Camp	AN026	0.27	-	-	0.06
North Andaman	Shibpur	AN099	0.22	-	0.01	-
North Andaman	Sitanagar	AN037	0.19	-	-	0.04
North Andaman	Subhasgram	AN040	0.18	-	-	0.01
North Andaman	Tugapur No. 8	AN042	0.31	-	-	0.02
North Andaman	Debipur	AN101	0.18	-	0.06	-

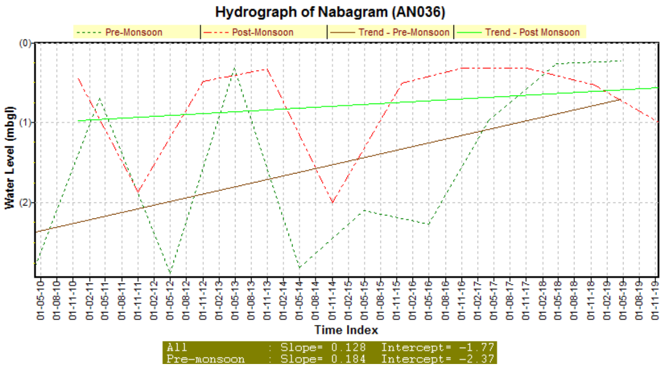
The long-term water level hydrographs of ground water monitoring wells are depicted under **Fig. 6.9.**

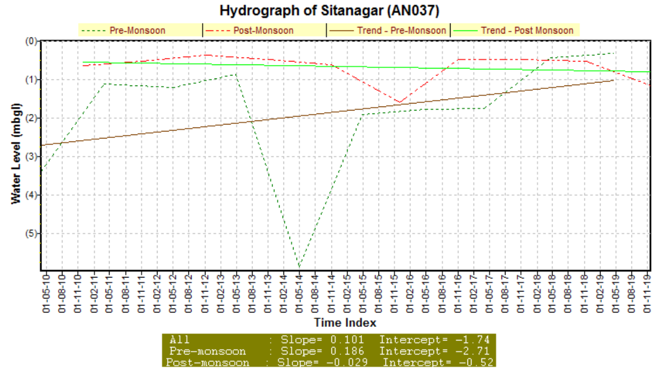
Fig. 6.9 Hydrographs of North and Middle Andaman District

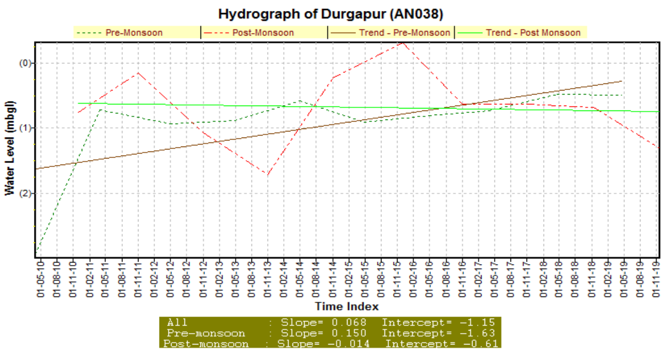
Hydrographs of North Andaman District

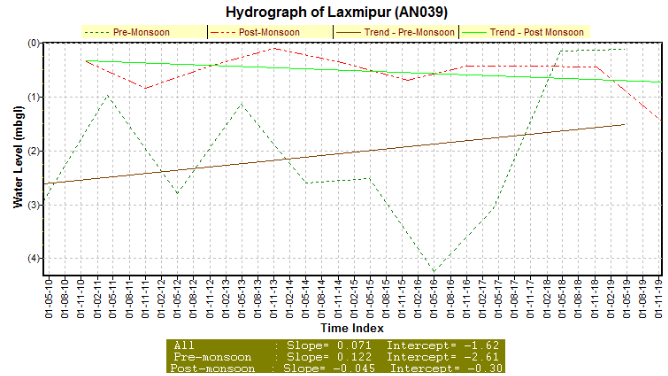


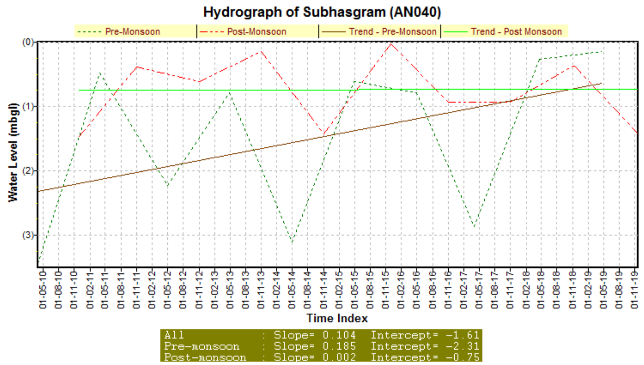


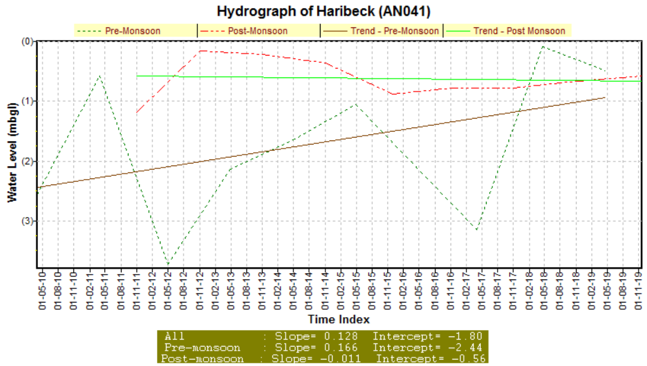


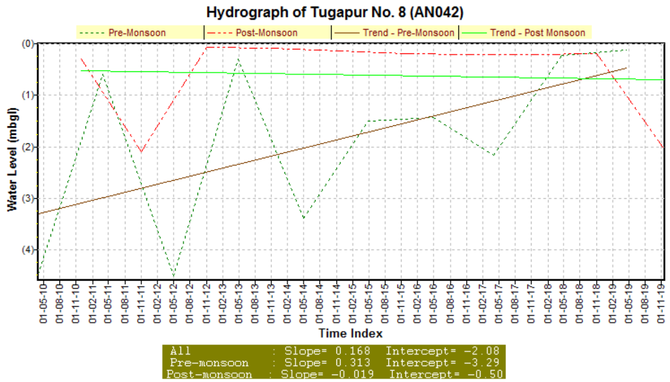


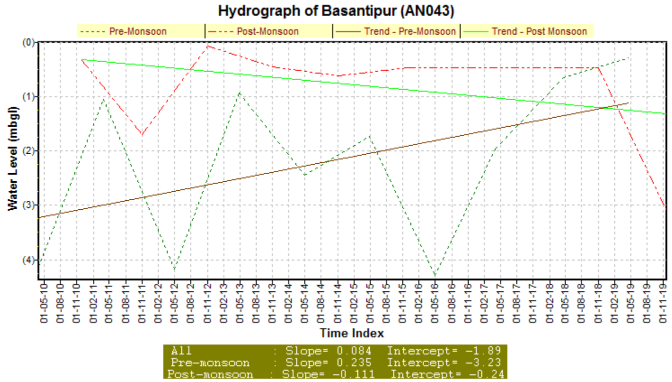


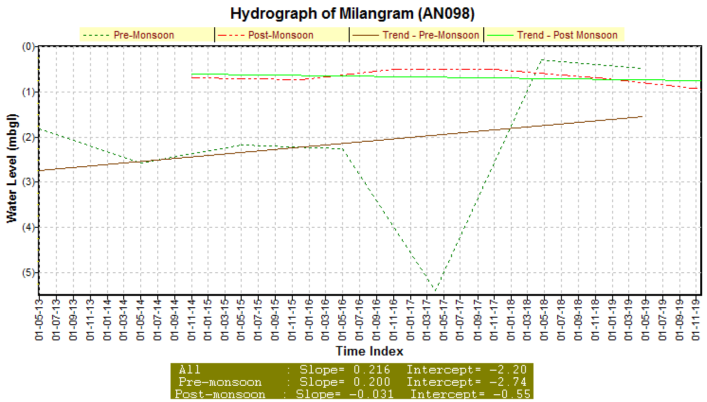


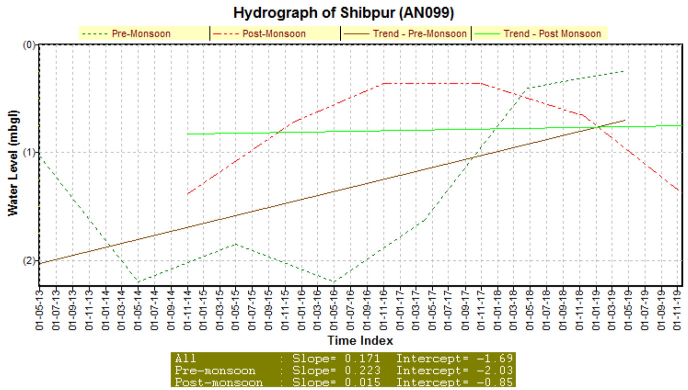

Hydrograph of Subhasgram (AN040)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.104 Intercept= -1.61
Pre-monsoon : Slope= 0.185 Intercept= -2.31
Post-monsoon : Slope= 0.002 Intercept= -0.75

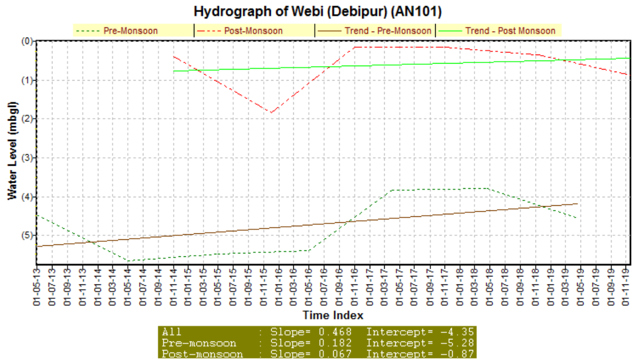

Hydrograph of Haribeck (AN041)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.128 Intercept= -1.80
Pre-monsoon : Slope= 0.166 Intercept= -2.44
Post-monsoon : Slope= -0.011 Intercept= -0.56

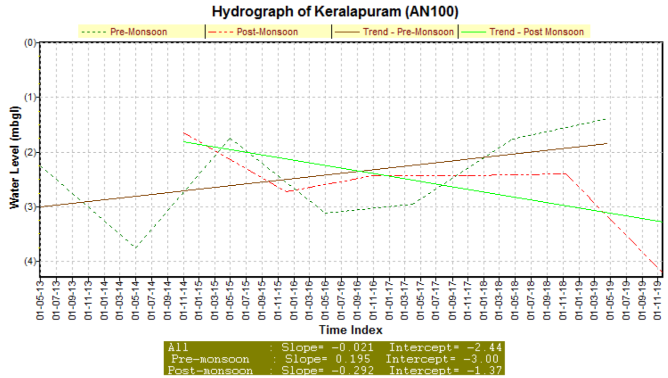

Hydrograph of Tugapur No. 8 (AN042)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.168 Intercept= -2.08
Pre-monsoon : Slope= 0.313 Intercept= -3.29
Post-monsoon : Slope= -0.019 Intercept= -0.50


Hydrograph of Basantipur (AN043)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.084 Intercept= -1.89
Pre-monsoon : Slope= 0.235 Intercept= -3.23
Post-monsoon : Slope= -0.111 Intercept= -0.24

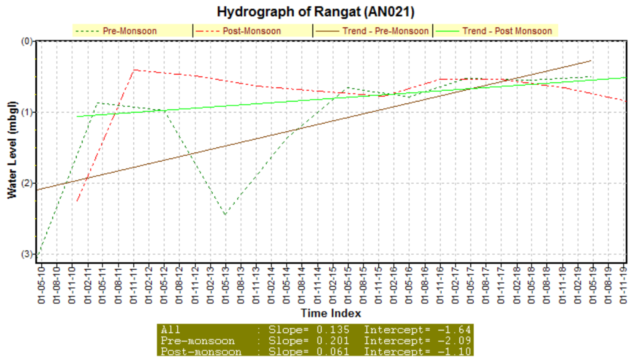

Hydrograph of Milangram (AN098)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.216 Intercept= -2.20
Pre-monsoon : Slope= 0.200 Intercept= -2.74
Post-monsoon : Slope= -0.031 Intercept= -0.55

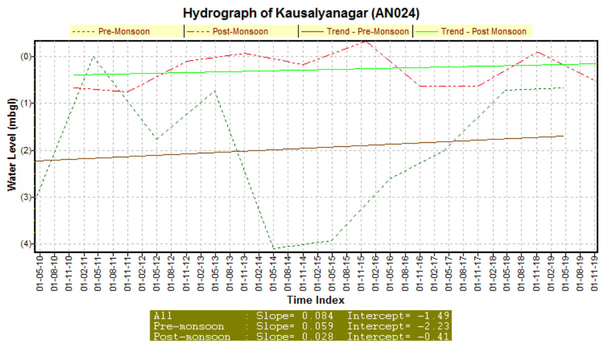

Hydrograph of Shibpur (AN099)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.171 Intercept= -1.69
Pre-monsoon : Slope= 0.223 Intercept= -2.03
Post-monsoon : Slope= 0.015 Intercept= -0.85

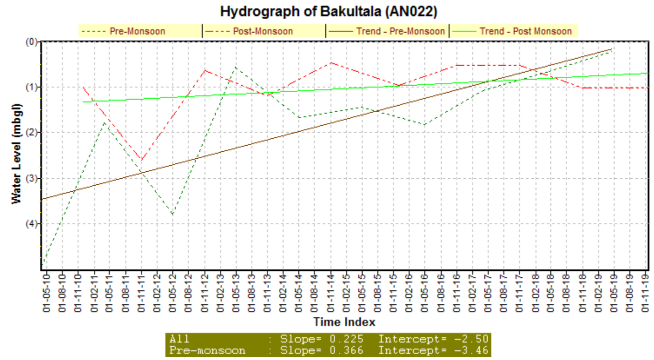


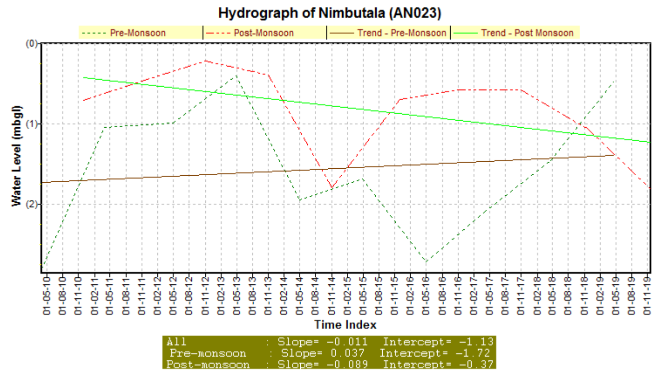


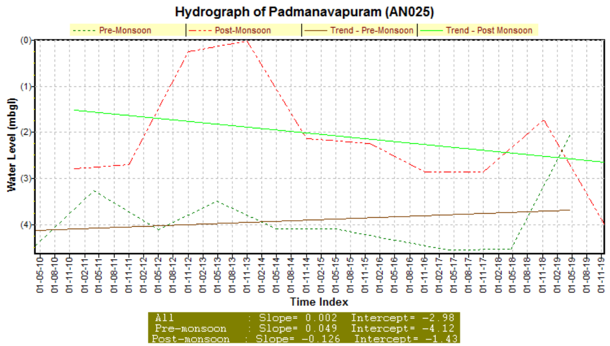
Hydrographs of Middle Andaman District

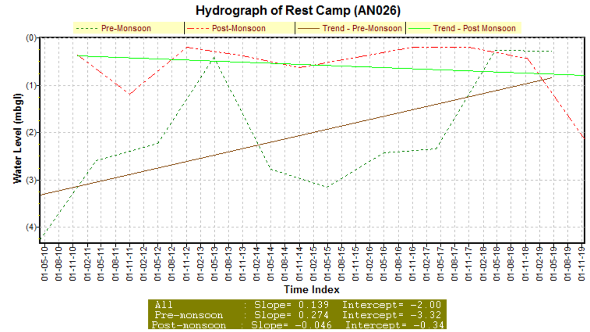


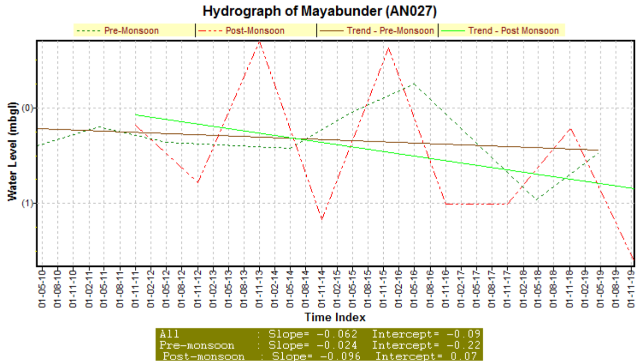


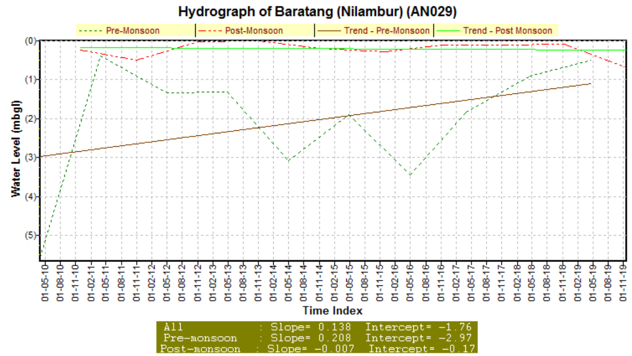


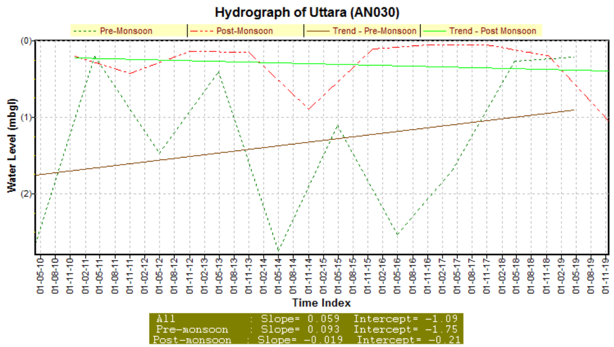


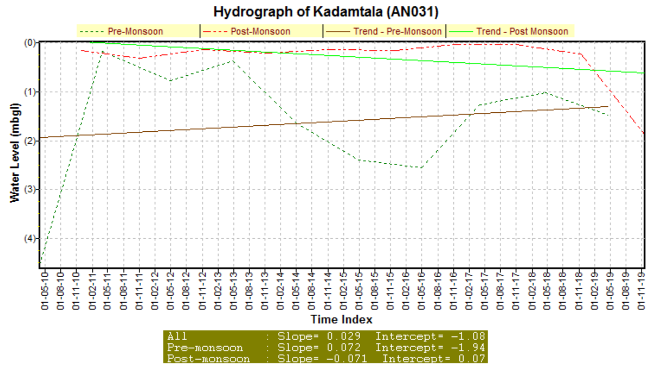

Hydrograph of Padmanavapuram (AN025)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.002 Intercept= -2.98
Pre-monsoon : Slope= 0.049 Intercept= -4.12
Post-monsoon : Slope= -0.126 Intercept= -1.43


Hydrograph of Rest Camp (AN026)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.139 Intercept= -2.00
Pre-monsoon : Slope= 0.274 Intercept= -3.32
Post-monsoon : Slope= -0.046 Intercept= -0.34

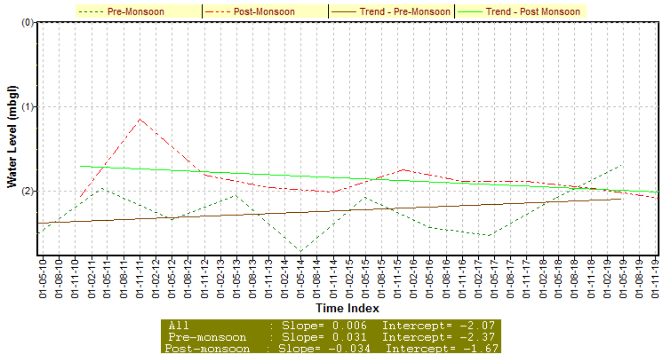

Hydrograph of Mayabunder (AN027)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= -0.062 Intercept= -0.09
Pre-monsoon : Slope= -0.024 Intercept= -0.22
Post-monsoon : Slope= -0.096 Intercept= 0.07


Hydrograph of Baratang (Nilambur) (AN029)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.138 Intercept= -1.76
Pre-monsoon : Slope= 0.208 Intercept= -2.97
Post-monsoon : Slope= -0.007 Intercept= -0.17

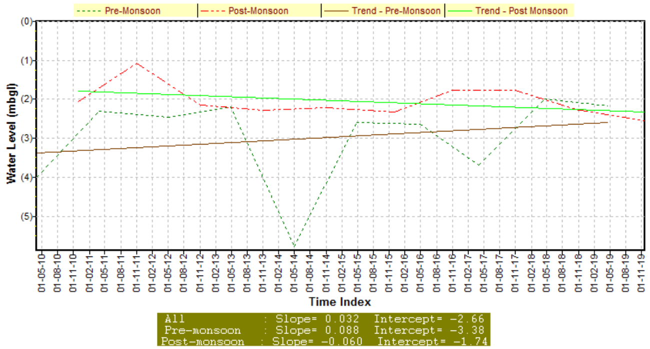

Hydrograph of Uttara (AN030)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.059 Intercept= -1.09
Pre-monsoon : Slope= 0.093 Intercept= -1.75
Post-monsoon : Slope= -0.019 Intercept= -0.21


Hydrograph of Kadamtala (AN031)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.029 Intercept= -1.08
Pre-monsoon : Slope= 0.072 Intercept= -1.94
Post-monsoon : Slope= -0.071 Intercept= 0.07

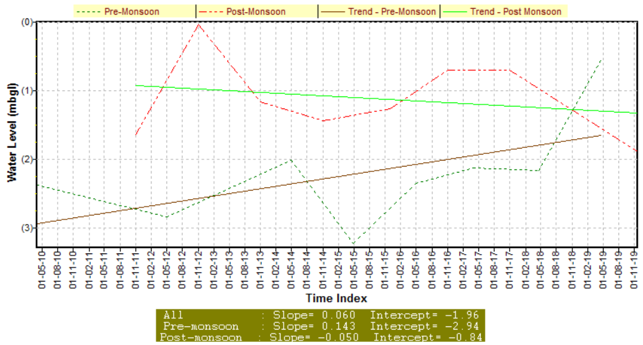
Hydrograph of Porlobjig - 15 (AN032)



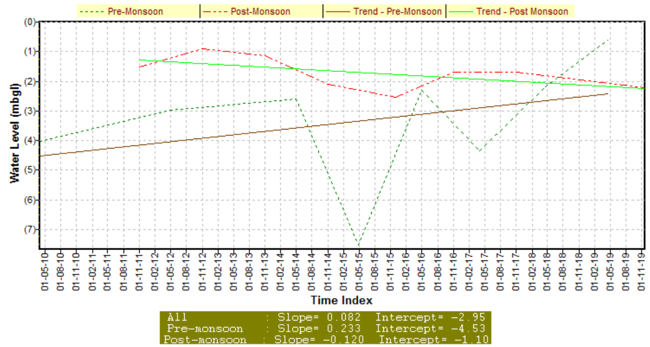
Hydrograph of Tikadera (AN033)



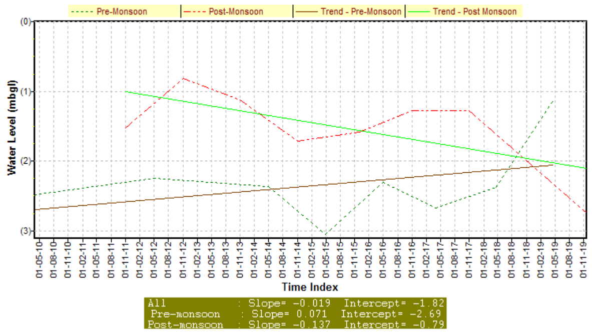
Hydrograph of Long Island (AN050)



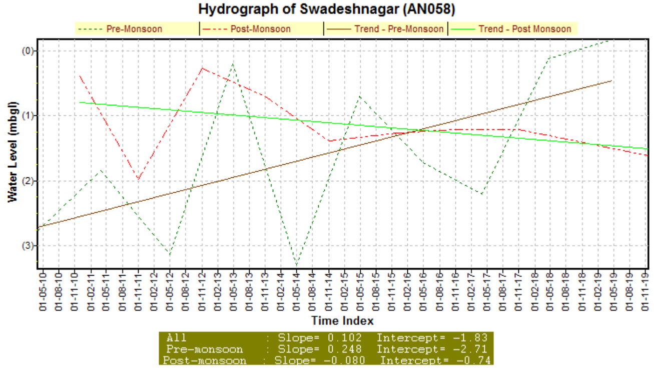
Hydrograph of Long Island (Forest Area) (AN051)

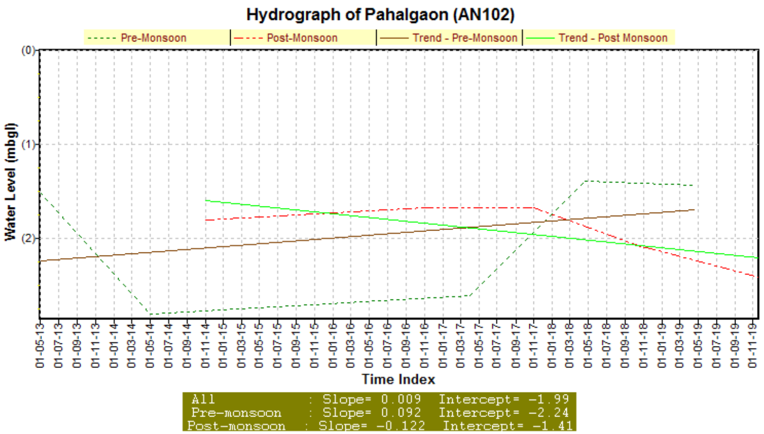


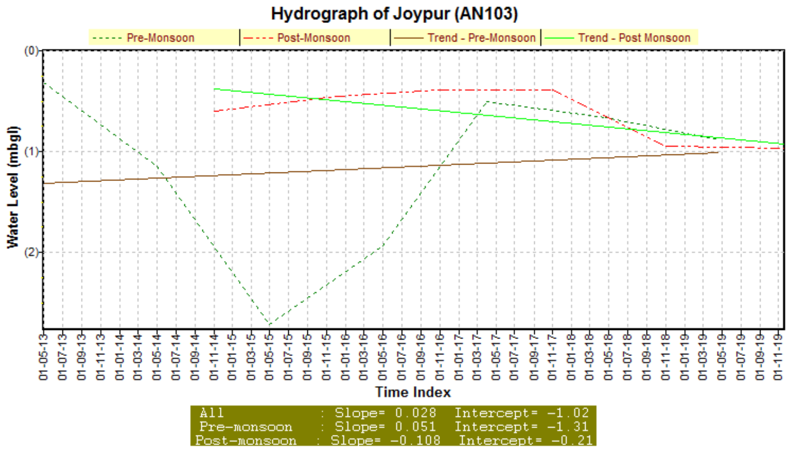
Hydrograph of Long Island (Sec. School) (AN052)

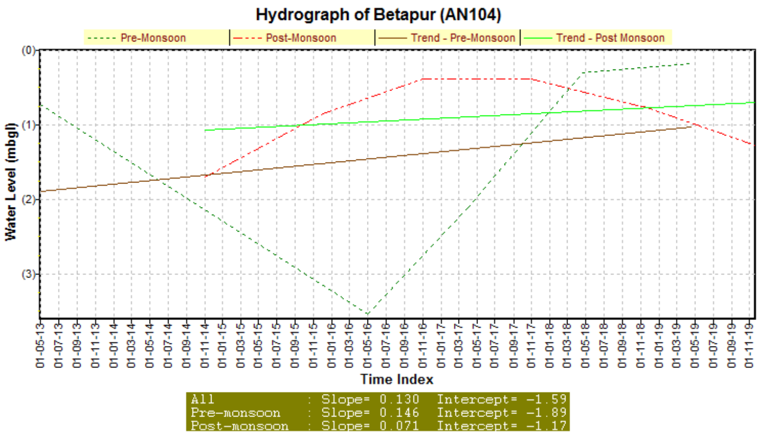


Hydrograph of Swadeshnagar (AN058)




Hydrograph of Pahalgaon (AN102)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.009 Intercept= -1.99
Pre-monsoon : Slope= 0.092 Intercept= -2.24
Post-monsoon : Slope= -0.122 Intercept= -1.41


Hydrograph of Joypur (AN103)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.028 Intercept= -1.02
Pre-monsoon : Slope= 0.051 Intercept= -1.31
Post-monsoon : Slope= -0.108 Intercept= -0.21


Hydrograph of Betapur (AN104)
Pre-Monsoon
Post-Monsoon
Trend - Pre-Monsoon
Trend - Post Monsoon
Water Level (mbgl)
Time Index
All : Slope= 0.130 Intercept= -1.59
Pre-monsoon : Slope= 0.146 Intercept= -1.89
Post-monsoon : Slope= 0.071 Intercept= -1.17

Chapter-7

DYNAMIC GROUND WATER RESOURCES ASSESSMENT

As per the Groundwater Estimation Committee (GEC)-2015methodology,thedesirable units for assessment like watershed oradministrative unit (blocks) could notbeutilized for estimation of dynamic ground water resources in North and Middle Andaman district. The main reason behind this constraint is that the individual islandsare geographically isolated from one another, although they form an archipelago. As only 13 islands out of total 95 are inhabited, ground water resources assessment was completed for these islands only, following the standard methodology recommended by the GEC-2015 committee. Duringthe computations, intermontanevalleysandareas with relativelyflattopography are considered asrecharge areas.Thehillyareas havingslopemore than20% areexcluded from the calculation. As depth to water level data in nine islands is not available due to absence of ground water monitoring wells, the water level fluctuation method could not be adopted for assessment of dynamic ground water resources. Instead, the empirical method for assessment using Rainfall Infiltration Factor (RIF) has been used for calculation. Contributions from perennial spring sources are also takeninto accountinthe ground water resource estimation.

Dynamic ground water resources for the inhabited islands of North and Middle Andaman district have been calculated based on GEC-2015 methodology, jointly by the CGWB, ER, Kolkata andthe Andaman Public Works Department (APWD) for the year 2020. The calculations are given in **Table7.1**.

Table7.1: Dynamic Ground Water ResourcesAssessment, North and Middle Andaman district (as on 31-3-2020)

Sl. No.	Assessment Unit	Net ground water availability (ham)	Gross ground water extraction (ham)	Stage of Extraction (%)	Category
1.	Aves Island	1.39	0	0	Safe
2.	Baratang Island	3918.52	17.65	0.45	Safe
3.	East Island	79.76	0.03	0.04	Safe
4.	Interview Island	243.27	0.03	0.01	Safe
5.	Long Island	421.27	3.21	0.76	Safe
6	Middle Andaman	1306.64	173.45	13.27	Safe
7	Narcondam	31.36	0.03	0.10	Safe

	Island				
8	North Andaman	2483.87	132.11	5.32	Safe
9	North Passage Island	87.4	0	0	Safe
10	Prolob Island	26.68	0	0	Safe
11	Smith Island	77.41	1.39	1.80	Safe
12	Stewart Island	31.54	0	0	Safe
13	Strait Island	96.05	0.09	0.09	Safe
	Total	**8805.16**	**327.99**	**3.73**	**Safe**

A perusal of **Table 7.1** indicates that the Stage of Extraction (SOE) in North and Middle Andaman district was 3.73% (as on 31-3-2020). A wide variation in the SOE was observed between the islands. SOE was 0% in the uninhabited islands like Aves Island, North Passage Island, Prolob Island and Stewart Island. SOE was found to vary from 0.01% at Narcondam Island to 13.27% in Middle Andaman Island. The very low SOE indicates that groundwater resources are underutilized and there is great scope for harnessing the unutilized groundwater resources within the zone of fluctuation. Accordingly, tube wells tapping the shallow and deeper aquifers without having salinity problem, needs to be constructed based on ground hydrogeological and geophysical surveys. The district administration has to adopt a proactive role in this direction with required technical inputs from the CGWB, ER, Kolkata and as per the recommendations by the State Ground Water Co-ordination Committee (SGWCC).

Chapter-8

HYDROCHEMISTRY

The North & Middle Andaman hydrochemistry as well as quality of the groundwater for drinking and irrigation purposes was assessed by analysing the groundwater collected from different parts of the Island. Sampling was deliberated in such a way, so as to get a general idea of the whole island. Hydrochemistry of the study area was assessed by using the piper diagram (**Fig 8.1).**

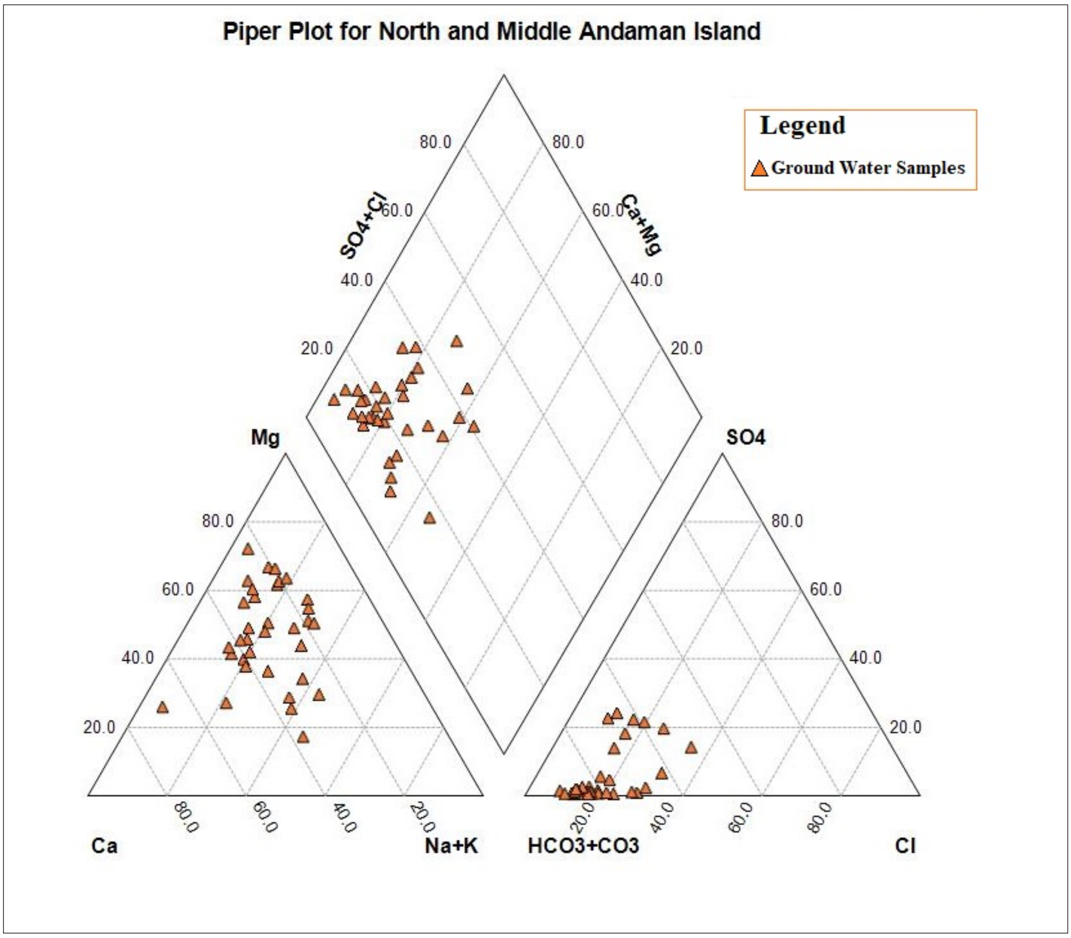


Fig. 8.1 Piper Plot of Groundwater Samples, North & Middle Andaman district

From the piper diagram it can be inferred that groundwater is dominated by the HCO_3^- + CO_3^{2-} anion with no dominant cation. Overall, the groundwater is magnesium bicarbonate type, which indicates the presence of calcite and dolomite mineral in the subsurface. During infiltration of rain water, the carbonate minerals get dissolved, resulting in dissolution of calcium, magnesium and bicarbonate to shallow groundwater.

8.1 Suitability for Drinking Purpose

The statistically summarized analysed groundwater data (pre-monsoon 2021) are presented in **Table 8.1** and detail analyse data in **table 8.4.** The data reveals that the pH of the area is within the BIS permissible range of 6.5-8.5. The average pH of the Island is 7.62 with a maximum of 8.07 and a minimum of 7.14. The mean conductance of the study area as evaluated was found to be 490.73 µS/cm at 25°C, the conductance varies from a minimum of 157 µS/cm at 25°C to a maximum of 931 µS/cm at 25°C with a standard deviation of 211.85 µS/cm at 25°C **(Fig 8.1).** The total alkalinity (TA), chloride, sulphate and nitrate concentrations were found to be much below the permissible limit prescribed by the BIS. The TA was found to vary from 50 to 420 mg/L, chloride from 14.18 to 113.44 mg/L, sulphate from 0.56 to 90.60 mg/L and nitrate from 0.54 to 13.10 mg/L.

Table 8.1 Chemical Analysis of Groundwater Samples (pre-monsoon 2021)

	Unit	Max	Min	Mean	STD	BIS Limit
pH		8.07	7.14	7.62	0.25	6.5-8.5
Electrical Conductance (EC)	µS/cm at 25°C	931.00	157.00	490.73	211.85	–
CO_3^{2-}	mg/L	–	–	–	–	–
HCO_3^-	mg/L	500.20	61.00	237.57	101.51	–
TA as $CaCO_3$	mg/L	420.00	50.00	195.14	84.29	600.00
Cl^-	mg/L	113.44	14.18	31.23	18.17	1000.00
SO_4^{2-}	mg/L	90.60	0.56	13.93	23.98	400.00
NO_3^-	mg/L	13.10	0.54	1.72	2.69	45.00
F^-	mg/L	0.83	0.15	0.46	0.18	1.50
TH as $CaCO_3$	mg/L	355.00	65.00	197.43	78.58	600.00
Ca^{2+} as Ca	mg/L	74.00	12.00	31.30	15.64	200.00
Mg^{2+} as Mg	mg/L	65.61	6.08	28.96	15.36	100.00
Na^+	mg/L	63.39	4.62	25.88	18.31	–
K^+	mg/L	11.04	0.51	2.43	2.28	–
TDS	mg/L	526.56	95.42	284.45	116.52	2000.00
Fe	mg/L	2.62	0.14	0.50	0.46	1.00
U	mg/L	6.39	0.10	1.27	1.65	60.00

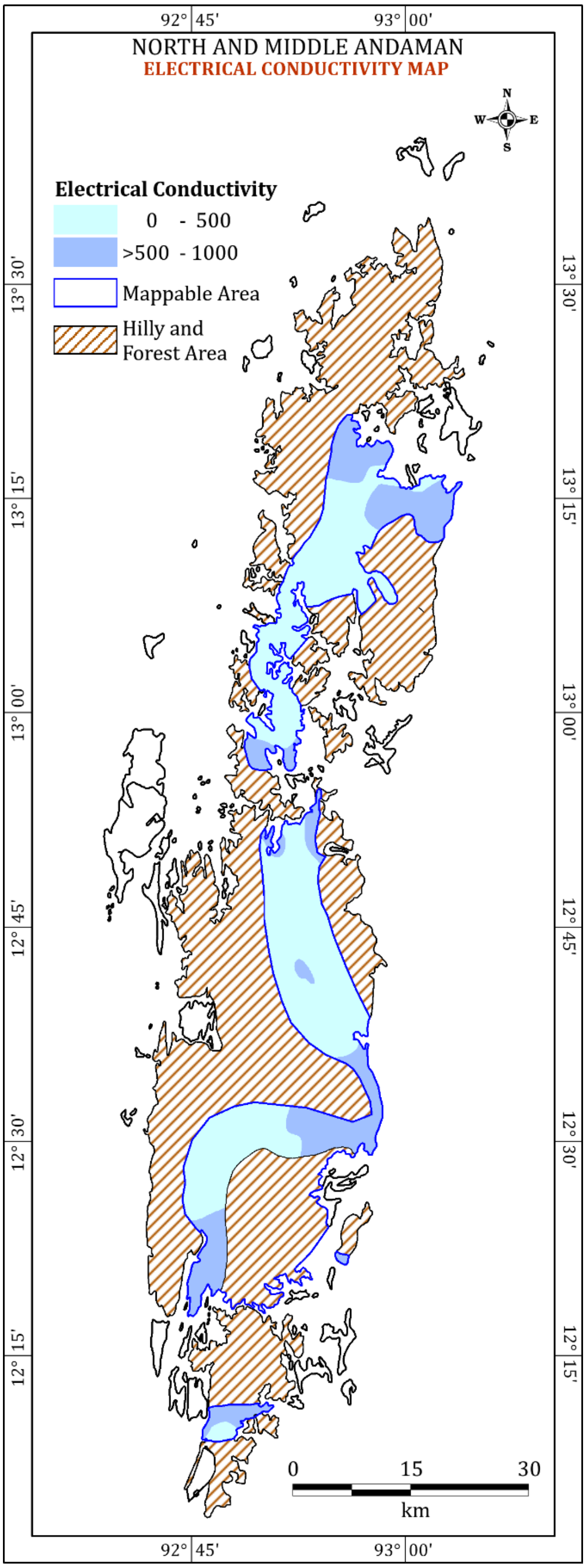


Fig. 8.2 Electrical Conductance map, North and Middle Andaman district

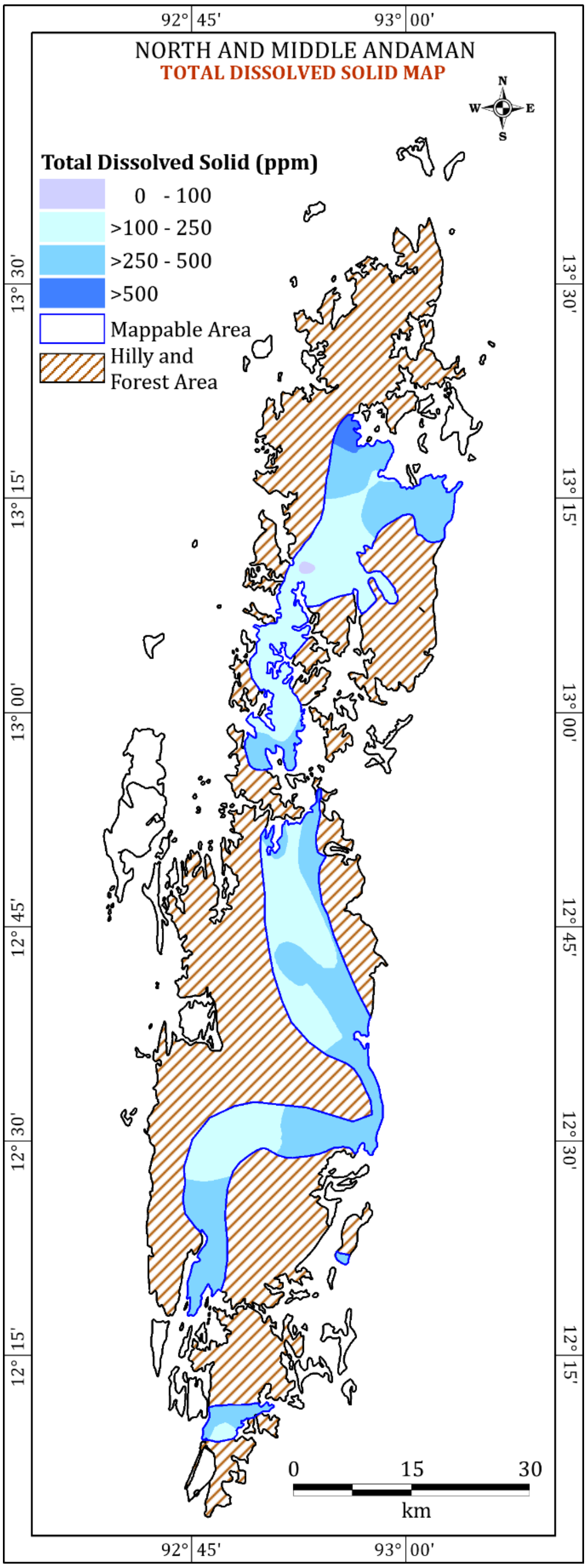


Fig. 8.3 Spatial Distribution map of TDS, North and Middle Andaman district

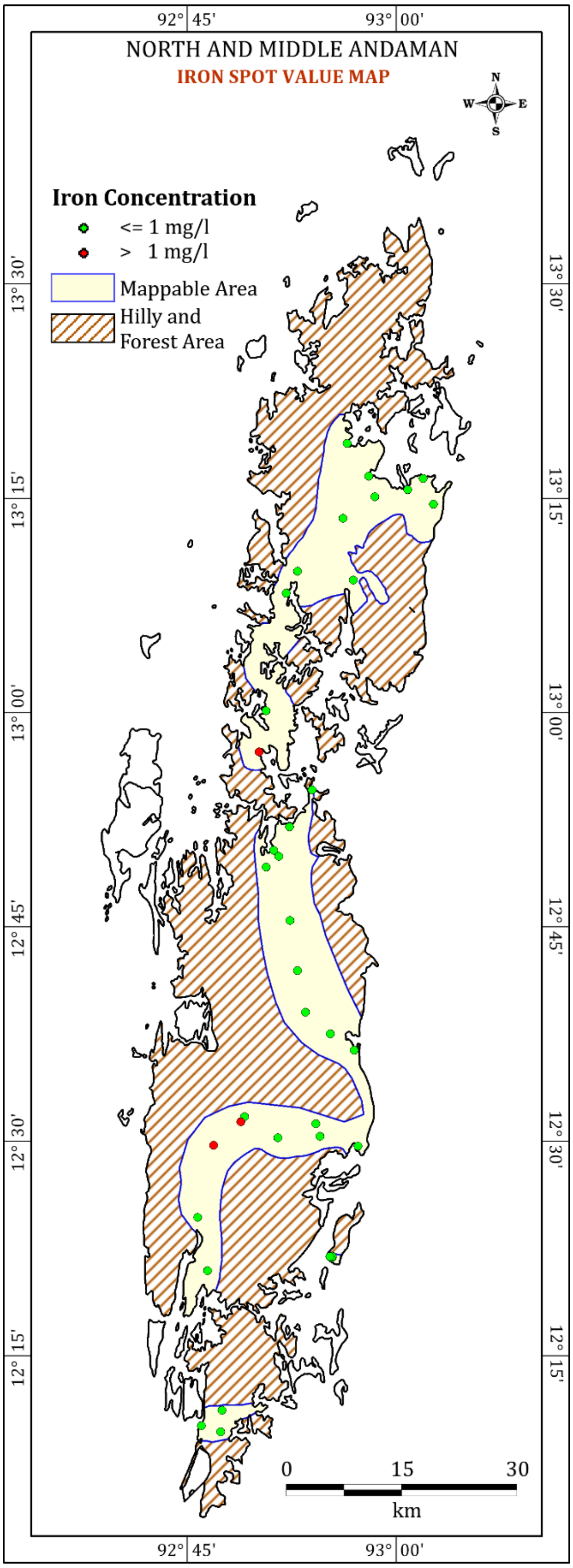


Fig. 8.4 Spatial Distribution Map of Iron, North and Middle Andaman district

Total Dissolved Solids (TDS) was mostly ranging from 200 mg/L to 400 mg/L with patches of the area showing TDS in the higher range of 400 mg/L to 600 mg/L **(Fig.8.3).** TDS exceeding 400 mg/L was observed at South Creek or Sundargarh (409 mg/L), Subhashgram (475 mg/L), Parnasala (485 mg/L), in the forest area of Long Islands (497 mg/L) and at Dhobidera in Mayabunder area (527 mg/L) in Middle Andaman district and at Shibpur (439 mg/L) and Milangram (515 mg/L) in North Andaman district. Mostly, the TDS values are within the Acceptable Limit of BIS as per the standard guidelines on drinking water. Except for high iron content in groundwater, remaining inorganic constituents are found to be within the Acceptable Limit as per the drinking water guidelines of BIS. Iron concentration in the monitoring wells was found to vary from 0.14 to 2.62 mg/L with an average of 0.50 mg/L and a standard deviation of 0.46 mg/L. High iron concentration in groundwater was detected in Mohanpur (1.1 mg/L), Tikadera (1.4 mg/L) and Porlobjig-15 (2.6 mg/L). Spot values of iron concentration in North and Middle Andaman district was shown in **Fig. 8.4.** A visual analysis of the map reveals that high iron in groundwater was restricted to the central and south-central parts of Middle Andaman district.

8.2. Suitability for Irrigation Purpose

The suitability of the groundwater for irrigation in the study area was assessed by employing Sodium Absorption Ratio (SAR), Permeability index (PI) and US Salinity Laboratory Diagram.

8.2.1: Sodium Absorption Ratio (SAR)

SAR index is used to assess the state of flocculation or dispersion of clay aggregates in soil. Sodium and potassium ions facilitate the dispersion of clay particles while calcium and magnesium promote their flocculation. The behaviour of clay aggregates influences the soil structure and affects the permeability of the soil which directly depends on the water infiltration rate. The SAR is calculated by employing the equation:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

The SAR value reveals that all the samples fall within the excellent category for irrigation. The SAR values are tabulated under **Table 8.2.**

Table 8.2 Irrigation Water Quality on the basis of Sodium Absorption Ratio (SAR)

Range	Suitability for Irrigation	Number of Samples
<10	Excellent	37
10-18	Good	0
18-26	Doubtful	0
>26	Unsuitable	0

8.2.2 Permeability Index (PI)

Permeability Index is based on the cation exchange reaction taking place in soil. The permeability of the soil is highly influence by continuous irrigation. It can be determined by using the equation:

$$PI = \frac{Na + \sqrt{HCO_3^-}}{Na + K + Ca + Mg}$$

The Permeability Index data reveals that 32 groundwater samples(86.49 % of total) are suitable for irrigation whereas only 5samples (13.51 % of total) are moderately suitable. No sample has been categorized as unsuitable for irrigational use. This indicates the overall suitability of groundwater in shallow aquifers of the area.

Range	Suitability for Irrigation	Number of Sample
Class I (>75%)	Good	32
Class II (25%-75%)	Moderate	5
Class III (<25%)	Unsuitable	-

8.2.3: U. S. Salinity Laboratory Diagram

A graphical classification of water which is given by the U.S. Salinity Laboratory is used for classification of irrigation water (Wilcox 1958, Richards 1954). The classification scheme is based on SAR and Electrical Conductivity (EC).

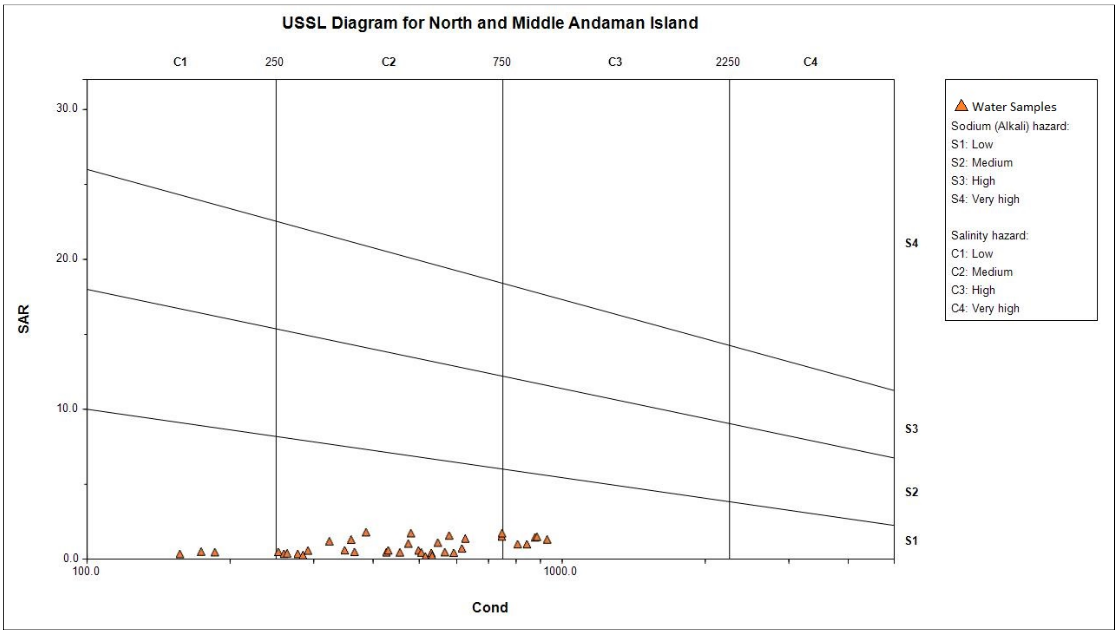


Fig. 8.5 USSL Diagram, North and Middle Andaman district

The USSL diagram reveals that all the samples fall in the low sodium hazard zone(S1 class) whereas most of the sample falls in the medium hazard zone (C2 class) in terms of the salinity hazard. The diagram also shows that four samples were falling in the high salinity hazard zone (C3 class). Overall, the quality of groundwater in thedistrict was found to be suitable for drinking, except in few locations whereslightly higher iron concentration (above Acceptable Limit of 1.0 mg/L) has been reported. In terms irrigation water quality, groundwater is very much suitable for irrigational use, except for slightly high Electrical Conductivity (>750 µS/cm) at few locations like Dhobidera (Mayabunder), Parnashala, Subhashgram, Long Island and Milangram. of the irrigation the quality of the water is found to be suitable, however the water could be utilised for irrigation after treatment of the water for salinity for better production of crops.

Table8.3 Indices for evaluation of groundwater for Irrigation

Location	SAR	PI (%)
Rangat	0.40	48.97
Bakultala	0.42	51.90
Nimbutala	0.38	52.51
Kausalyanagar	0.56	68.09
Padmanavpuram	0.43	55.66

Rest Camp	0.55	56.91
Dhobidera (Mayabunder)	1.47	58.38
Baratang (Nilambur)	1.06	66.88
Uttara	0.46	69.45
Kadamtala	1.35	64.40
Porlobjig-15	0.58	65.42
Tikadera	0.43	79.46
Mohanpur	1.55	66.18
Srinagar	1.79	86.22
Nabagram	0.33	63.04
Sitanagar	0.26	57.93
Durgapur	1.02	64.33
Laxmipur	1.25	73.03
Subhasgram	0.97	46.33
Haribay	0.45	78.61
Tugapur No. 8	1.15	72.56
Basantipur	0.46	60.09
Parnashala	0.96	45.32
Long Island	0.18	46.63
Long Island (forest Area)	1.42	63.25
Long Island (secondary school)	0.43	55.69
Swadeshnagar	0.33	62.08
South Creek (Sundergarh)	1.47	61.76
Phooltala Basti	0.56	53.10
Kishorinagar (Parangara)	0.34	79.24
Milangram	1.29	48.01
Shibpur	1.71	64.16
Kerlapuram	1.71	79.50
Webi (Debipur)	0.34	66.56
Pahalgaon	0.67	53.61
Joypur	0.13	48.38
Betapur	0.42	54.77

Table 8.4 Chemical Analysis of Groundwater Samples in North and Middle Andaman District

SN	Lab Code	District	Location	Well ID	Source	Latitude	Longitude	pH	EC µS/cm at 5°C	CO_3^{2-}*	HCO_3^-	TA as $CaCO_3$	Cl^-	SO_4^{2-}	NO_3^-	F^-	TH as $CaCO_3$	Ca^{2+} as Ca	Mg^{2+} as Mg	Na^+	K^+	TDS	Fe	U
										mg/L														µg/L
1	C - 932	N&M Andaman	Rangat	AN021	DW	12.5061	92.90861	7.92	592	0	317	260	35	1	BDL	0.32	265	34	44	15	2	325	0.3	2.3
2	C - 933	N&M Andaman	Bakultala	AN022	DW	12.5041	92.85833	7.78	456	0	226	185	21	5	2	0.60	205	38	27	14	7	251	0.3	0.3
3	C - 934	N&M Andaman	Nimbutala	AN023	DW	12.4944	92.95417	7.78	531	0	323	265	25	2	1	0.68	245	36	38	14	1	314	0.5	0.9
4	C - 935	N&M Andaman	Kaushalyanagar	AN024	DW	12.5288	92.81861	7.64	292	0	140	115	21	1	1	0.65	125	24	16	14	1	164	0.4	0.5
5	C - 936	N&M Andaman	Padmanavpuram	AN025	DW	12.6066	92.94917	7.29	506	0	275	225	32	BDL	BDL	0.66	215	32	33	14	1	280	0.2	BDL
6	C - 937	N&M Andaman	Rest Camp	AN026	DW	12.8327	92.85917	7.75	431	0	220	180	25	1	1	0.40	195	20	35	18	1	234	0.4	1.1
7	C - 938	N&M Andaman	Dhobidera (Mayabunder)	AN027	DW	12.9100	92.89917	7.74	886	0	500	410	57	5	1	0.57	340	32	63	62	1	527	0.3	0.6
8	C - 940	N&M Andaman	Baratang (Nilambur)	AN029	DW	12.1683	92.76694	7.83	548	0	293	240	28	1	1	0.49	200	26	33	35	1	303	0.5	0.5
9	C - 941	N&M Andaman	Uttara	AN030	DW	12.1613	92.79000	7.59	253	0	122	100	28	1	1	0.47	110	22	13	11	2	153	0.5	0.5
10	C - 942	N&M Andaman	Kadamtala	AN031	DW	12.3491	92.77417	7.90	626	0	342	280	28	1	1	0.38	240	26	43	48	1	356	0.3	0.1
11	C - 943	N&M Andaman	Porlobjig-15	AN032	DW	12.4955	92.78111	7.70	349	0	189	155	25	1	1	0.70	150	22	23	16	3	206	2.6	0.1
12	C - 944	N&M Andaman	Tikadera	AN033	DW	12.5227	92.81389	7.38	186	0	92	75	21	BDL	1	0.48	80	22	6	9	2	117	1.4	0.2
13	C - 945	N&M Andaman	Mohanpur	AN034	DW	12.9541	92.83556	7.61	579	0	238	195	60	6	8	0.34	195	36	26	50	7	338	1.1	BDL
14	C - 946	N&M Andaman	Srinagar	AN035	DW	13.1394	92.86806	7.38	387	0	195	160	21	2	1	0.31	115	32	9	44	3	231	0.2	BDL
15	C - 947	N&M Andaman	Nabagram	AN036	DW	13.1547	92.94833	7.31	278	0	177	145	21	1	3	0.43	145	14	27	9	1	185	0.9	0.8
16	C - 948	N&M Andaman	Sitanagar	AN037	DW	13.2269	92.93611	7.35	285	0	183	150	21	1	BDL	0.35	160	20	27	7	1	190	0.3	0.2
17	C - 949	N&M Andaman	Durgapur	AN038	DW	13.2733	93.03194	7.54	475	0	238	195	35	11	4	0.39	190	38	23	32	2	292	0.4	4.1

18	C - 950	N&M Andaman	Laxmipur	AN039	DW	13.2758	92.96667	7.29	360	0	134	110	21	38	2	0.54	120	28	12	32	5	221	0.3	0.7
19	C - 951	N&M Andaman	Subhasgram	AN040	DW	13.2522	92.97417	7.55	844	0	329	270	28	86	7	0.34	355	56	52	42	2	475	0.7	5.0
20	C - 952	N&M Andaman	Haribay	AN041	DW	13.0022	92.95417	7.36	174	0	98	80	21	1	1	0.33	85	22	7	10	1	123	0.4	0.3
21	C - 953	N&M Andaman	Tugapur No. 8	AN042	DW	12.8200	92.84389	7.38	324	0	104	85	28	29	6	0.38	110	24	12	28	2	193	0.6	0.6
22	C - 954	N&M Andaman	Basantipur	AN043	DW	12.7575	92.87250	7.69	366	0	220	180	18	2	BDL	0.57	175	36	21	14	2	227	0.4	6.4
23	C - 955	N&M Andaman	Parnashala	AN044	DW	12.5205	92.90333	7.68	807	0	311	255	32	91	13	0.41	355	74	41	42	3	485	0.6	2.3
24	C - 961	N&M Andaman	Long Island	AN050	DW	12.3644	92.92333	7.14	533	0	305	250	25	5	2	0.74	255	74	17	7	1	317	0.2	1.8
25	C - 962	N&M Andaman	Long Island (forest Area)	AN051	DW	12.3663	92.92333	7.34	878	0	494	420	32	2	BDL	0.68	280	40	44	55	11	497	0.2	0.7
26	C - 963	N&M Andaman	Long Island (secondary school)	AN052	DW	12.3658	92.92028	7.22	567	0	299	245	25	5	BDL	0.61	220	44	27	15	3	302	0.2	0.2
27	C - 969	N&M Andaman	Swadeshnagar	AN058	DW	12.6508	92.89111	7.60	260	0	146	120	18	8	BDL	0.15	135	18	22	9	1	165	0.2	2.5
28	C-1006	N&M Andaman	South Creek (Sundergarh)	AN095	DW	12.1866	92.79167	7.50	747	0	299	245	39	46	1	0.42	250	26	45	54	1	409	0.3	1.7
29	C - 1007	N&M Andaman	Phooltala Basti	AN096	DW	12.4116	92.76222	7.91	499	0	256	210	43	1	1	0.21	225	22	41	19	4	300	0.4	0.6
30	C - 1008	N&M Andaman	Kishorinagar (Parangara)	AN097	DW	13.1650	92.88167	7.38	157	0	61	50	18	5	1	0.32	65	12	9	6	1	95	0.3	0.5
31	C - 1009	N&M Andaman	Milangram	AN098	DW	13.3141	92.94111	7.91	931	0	281	230	113	61	3	0.83	345	30	66	55	7	515	0.3	0.1
32	C - 1010	N&M Andaman	Shibpur	AN099	DW	13.2430	93.04417	7.72	748	0	348	285	67	BDL	1	0.52	260	74	18	63	2	439	0.9	0.1
33	C - 1011	N&M Andaman	Keralapuram	AN100	DW	13.2600	93.01333	8.07	481	0	165	135	32	47	1	0.34	125	24	16	44	2	279	0.1	5.6
34	C - 1012	N&M Andaman	Webi (Debipur)	AN101	DW	12.8669	92.87194	7.86	264	0	140	115	18	2	2	0.18	120	20	17	9	3	163	0.2	0.8
35	C - 1013	N&M Andaman	Pahalgaon	AN102	DW	12.8394	92.85333	7.64	616	0	299	245	32	7	1	0.74	250	22	47	25	2	340	0.9	3.5
36	C - 1014	N&M Andaman	Joypur	AN103	DW	12.6994	92.88139	8.07	516	0	262	215	14	3	BDL	0.26	225	22	41	5	BDI	267	0.2	0.5
37	C - 1015	N&M Andaman	Betapur	AN104	DW	12.6258	92.92111	8.03	427	0	171	140	25	37	BDL	0.19	175	16	33	13	1	246	0.8	1.1

CHAPTER-9

AQUIFER MANAGEMENT PLAN

9.1 Supply Sideand Demand Side Aquifer Management

Supply side management of an Aquifer Management Plan focuses on increasing the volume of water available through ways like a) finding new sources, b) increasing storage capacity, c) diverting water to increase water supply at a particular location and d) using technology to create clean, potable water from a previously unutilized source. Demand side management, on the other hand, can be defined as reducing the volume of water that is being used by the stakeholders for specific purpose like household use, farming, municipal or industrial needs. The main objective is to increase the Water Use Efficiency throughout theyear.

Due to extremely low stage of Ground Water Extraction (3.73 %), there is no justification to adopt demand side aquifer management interventions. Even supply side aquifer management may not also be taken up on priority as North and Middle Andaman district is bestowed with plentiful rainfall, having Average Annual Rainfall of 3180 mm. Nonetheless, site specific measures on water conservation and open area/roof top rain water harvesting schemes may be implemented as per specific requirement from the state government.

9.1.1 Urban and Rural Water Profile

The urban and rural population in North and Middle Andaman district is 2741 and 102856, respectively (Census 2011). The rural population constitutes ~97% of the total population, while the urban populationis only ~3%. As per Census 2011, entire urban population is concentrated in Rangat tehsil in Middle Andaman district. The Andaman Public Works Department (APWD) has installed public water supply connections in North and Middle Andaman district. As on 31-3-2020, 350 household connections(public water supply) have been provided to 26439 rural households (State Specific Action Plan 2020) in North and Middle Andaman district. Out of 114 habitations, 111 habitations (97.4 % of total) are under Fully Covered (FC) category, whereas only 3 habitations are Partially Covered and Water Quality affected (PC+QA) category (SSAP 2020). However even the fully covered habitations have typical water usage profile characterized by year-round water rationing (from summer season to monsoon season) ranging from few minutes in a day to few minutes in a week. The villages not connected by all-weather roads also do not enjoy the privilege of piped water supply.

9.1.2 Panchayat Wise Drinking Water Supply

The details of water demand, water supply, availability during normal and summer seasons, projections for the year 2030 AD and 2050 AD, supply versus demand gap and augmentation measures are summarized in **Table 9.1**to **Table 9.3.** For meeting the growing demand for drinking water, the supply needs to be augmented based on existing supply versus demand gap. This would require expeditious completion of the ongoing schemes and identification of new commercially viable schemes. Moreover, artificial ground water recharge schemes should be recommended by the Central Ground Water Board for long term sustainability. The policy may be undertaken to meet short term, medium-term and long-term water requirements of the urban areas by considering tourist population. The Andaman and Nicobar Public Works Department has a number of projects in the pipeline to help augmenting water supply.

Table 9.1 Existing Drinking Water Supply Sources(Source: SSAP 2020)

Sl. No.	Name of Panchayat	No. of Households	Source of water	Other sources			New Source
				No. of Ring Wells	No. of Check Dams	No. of MI Ponds	
Rangat Tehsil							
1	Nilambur (Baratang)	778	Tiger Nallah, APWD Water Tank	21	05	20	Perennial nallah at Wrafter Creek, KattaKari and Rajatgarh
2	Sundergarh (Baratang)	643	Shankar Nallah	12	02	15	Shankar nallah at Adazig, spring at Udaygarh, TikkaDera, Adazig, perennial nallah at South Creek near PHC, Baratang
3	Uttara	604	Kadamtala Dam	22	Nil	15	Nil
4	Kadamtala	815	Kadamtala Dam	50	04	Nil	Katla nallah situated in Reserve Forest
5	Kaushalya Nagar	569	Panchayawati Water Tanks	45	04	21	Nil

6	Urmilapur	528	Panchayawati Water Tanks	22	03	23	Laxmanpur village
7	Bakultala	441	Panchayawati Water Tanks	15	Nil	Nil	Nil
8	Sabari	291	Parnashala-II Nallah	15	02	Nil	Nil
9	Long Island	323	Check Weir at SigmanDera	30	Nil	03	Nil
10	Parnashala	619	Parnashala Check Dam	28	02	11	Nil
11	Rangat	940	Janakpur Check Dam, Amkuj Waterfall &Morrichdera	Nil	Nil	Nil	Nil
12	Dasarathpur	772	Panchayawati Water Tanks	22	Nil	37	Nil
13	Nimbutala	854	Janakpur Check Dam, Amkuj Waterfall &Morrichdera	07	Nil	Nil	Nil
14	Shivapuram	865	Panchayawati Water Tanks	05	Nil	Nil	Nil
Mayabunder Tehsil							
15	Swadeshnagar	937	Swadeshnagar Nallah Source (Collected from Ring Well)	Nil	Nil	Nil	Nil
16	Harinagar	863	Panchawati-I Nallah	15	Nil	Nil	Natural Nallah at Jaipur village 1.5 km from Billigroundbaazar.
17	Basantipur	611	Pareshnagar-I APWD Tanks and Prafullyanagar-I Ring well with Pipeline	18	02	58	Nil
18	Pahalgaon	1137	Lal Tikre	25	Nil	Nil	Water project at Tugapur W. No. 4 and Pahalgaon W. No. 2 & 3.
19	Chainpur	369	Chainpur	46	01	Nil	Nil
20	Rampur	880	Karmatang Nallah	09	08	Nil	Nil
21	Pokhadera	629	Karmatang Nallah	18	Nil	05	Nil
22	Mayabunder	805	Karmatang Nallah	04	Nil	Nil	Nil
Diglipur Tehsil							
23	Kishorinagar	624	Kishorinagar weir	84	02	105	Nil
24	Paschimsagar	439	Paschimsagar&Uttarpara weir	09	Nil	50	Paschimsagar at W. No. 01

25	Kalighat	569	Check weir on Nallah near Police Radio, PulinMondal house, FPDC Colony, Forest Colony	07	09	31	Nallah near Hari Mandir at W.No.4
26	Ramnagar	345	Nallah	17	01	32	Nil
27	Nabagram	569	Kalpong river Dam & tributaries	14	03	Nil	At W. No. 6 near Ramakrishna Roy house.
28	Sitanagar	686	Sitanagar Spring	27	02	Nil	Nil
29	Diglipur	893	Kalpong river	31	03	42	Nil
30	Subashgram	1237	Kalpong river	19	08	43	Water treatment plant at Subashgram Ward No. 7.
31	Madhupur	1161	Kalpong river	36	05	Nil	Natural source at Rabindrapally& DB Gram, dug well at Madhupur & DB Gram.
32	Laxmipur	658	Kalpong river (Khudirampur Treatment Plant)	25	Nil	31	Nil
33	R.K.Gram	966	Kalpong river	06	03	Nil	Nil
34	Keralapuram	832	Lamiyabay	29	03	12	Natural Nallah at V.S. Pally Ward No. 03 and Cherian Nallah.
35	Shibpur	742	Lamiyabay	19	08	45	03 Nos natural Nallah at Lamiya Bay near Sindhur Nallah, Dumoor Nallah and Chal Tikery Nallah
36	Gandhinagar	1076	Gandhi nagar Ring Well	13	Nil	69	Streams at Ganesh Nagar and Santi Nagar
37	Radhanagar	765	Raja Plot Weir	53	Nil	Nil	Nil

Table 9.2 Rural Population and Public Water Supply (as on 31-3-2020)

District	Tehsil	Villages	Rural Population	Total Rural Households	Household Connections with PWS
N&M	Diglipur	72	43183	10702	350
Andaman	Mayabunder	47	25788	6316	
	Rangat	79	36626	9181	
Total		**198**	**105597**	**26199**	**350**

**Source: Jal Jeevan Mission, Department of Drinking Water and Sanitation, Ministry of Jal Shakti, Department of Economics and Statistics, Andaman and Nicobar Administration

Note: PWS = Public Water Supply

Table 9.3 Water Supply With Fu lly Covered (FC), Partially Covered (PC)and Quality Affected (QA) Habitations (as on 31-3-2020)

District	Number of Habitation			Population (Lakhs)		
	Total	FC	PC+QA	Total	FC	PC+QA
North & Middle Andaman	114	111	3	0.95	0.93	0.02

Source: Jal Jeevan Mission, Department of Drinking Water & Sanitation, Ministry of Jal Shakti

Table 9.4 Water Supply, Demand, Projections and Augmentation Measures in Major Inhabited Islands in North and Middle Andaman District(Source: SSAP 2020)

Tehsil	Population (2011 Census)	Domestic water demand (MLD)	Water Supply		Water Available (MLD)		Excess/Shortage* (MLD) as per 2011 Census		Domestic Water Projection for 2030				Domestic Water Projection for 2050				Augmentation (Present/Future)	
			Source	Capacity (MLD)	Normal	Summer	Normal	Summer	Population	Demand (MLD)	Normal E/S* (MLD)	Summer E/S* (MLD)	Population	Demand (MLD)	Normal E/S* (MLD)	Summer E/S* (MLD)	New Source (No.)	Capacity Addition (MLD)
Diglipur	43183	1.73	Kalpong River	1.2	1.2	1.0	1.96	0.62	57002	2.28	1.41	0.07	75242	3.01	0.68	-0.66	i) Dam (1) ii) Well at Mohanpur (1) iii) Tanks (8)	1
			Lamia Bay Spring	1.04	1.04	0.67												
			Shyam Nagar Spring	0.11	0.11	0.05												
			Swaraj Gram Spring	0.09	0.09	0.025												
			Pachim Sagar Spring	0.13	0.13	0.13												
			Rajaplot	0.06	0.06	0.02												

			Spring			5												
			Milan Gram Spring	0.07	0.07	0												
			Kishorinagar Spring	0.05	0.05	0												
			Sri Nagar Spring	0.02	0.02	0												
			Naba Gram Spring	0.2	0.2	0.2												
			Madhyam Gram Spring	0.042	0.042	0.042												
			Nichiantapur Spring	0.01	0.01	0.01												
			Kalighat Spring	0.2	0.2	0.1												
			Jaganath Dera Spring	0.01	0	0												
			Ram Nagar Spring / Well	0.07	0.07	0												
			Hara Tikery Well	0.08	0	0												
			Mohanpur Spring & Well	0.08	0	0												
			Wells	0.61	0.3	0												
			Krishnapuri Spring	0.1	0.1	0.1												
			Sub Total	**4.17**	**3.69**	**2.35**												
Mayabunder	25788	1.03	Karmatang – I,II,III,IX, Burmadera & Garjan Nallah	2.4	2.4	0.9	4.52	0.61	34040	1.36	4.19	0.28	44933	1.80	3.75	-0.16	i) Tank (8) ii) RO Plant (1) iii) Source (1)	i) 8 ii) 3.0 KLPD iii) 0.4
			Tugapur, Lall Tikery & Camp No. 7	0.36	0.36	0.08												
			Bajota, Pudumadurai & Chainpur Spring	0.3	0.3	0												
			Upper Paresh Nagar Spring	0.7	0.7	0												
			Nimbudera	0.6	0.6	0.25												
			CFO Nallah, TV Kulam Spring	0.49	0.49	0.2												
			Betapur Spring & Thoratang Well	0.3	0.3	0.1												
			Wells	0.04	0.04	0.01												
			Jaipur-18	0.19	0.19	0.05												
			Lower Paresh Nagar	0.06	0.06	0												
			Korang Nallah	0.11	0.11	0.05												
			Sub Total	**5.55**	**5.55**	**1.64**												

Rangat	36626	1.47	Parnashala, Haren Nallah, Jarwa Nallah, Lall Tikrey & Panchawati - I	1.03	1.03	0.5	2.02	-0.15	48346	1.93	1.56	-0.61	63817	2.55	0.94	-1.23	i) Weir (1) ii) Tanks (8) iii) Well at Parnashala	i) 0.4 ii) 1 iii) 0.25
			Panchawati Mini, Janakpur-I & II, Chitrakut, Morishdera, Panchawati-II	1.03	1.03	0.4												
			Weir at Sigmadera/Wells	0.16	0.16	0.05												
			Camp-No. 7, Camp No. 15 Atterajig, Uttra East Cornor, Reservoir Camp No 3 & Reservoir Phooltala	0.36	0.36	0.1												
			Shankar Nallah, Wrafter creek, Kanchangrah, Well	0.91	0.91	0.27												
			Sub Total	**3.49**	**3.49**	**1.32**												

9.2 Aquifer Management Plan for Domestic and Drinking Purpose

- Rooftop rain water harvesting and storage structures:In North and Middle Andaman district, traditional rain water harvesting system is available in most of the houses. However, only small water tanks are used to store the rain water, mainly due to relatively high cost coupled with constraints in space.
- Minimal or zero loss of water in the piped water supply schemes: During the public water supply, harvested water was found to flow from the overhead tanks. This leads to substantial water loss in each house. To remedy the wastage, provision for installation of float valves need to be made mandatory by the district administration with periodic monitoring and vigilance by the Andaman Public Works Department.
- Creation of rain water storage structures free from seepage (Lined pond-larger size) at different location and linking it with water supply
- Making awareness on water scarcity, water saving, efficient and reuse of domestic water

- Promotion of household level rainwater harvesting through demonstration and technical support.
- Regular manual checking of pipes for any leakage.

9.3 Aquifer Management Plan for Irrigation

Water resource development in North and Middle Andaman district should be based on utilization of rainwater, either through surface storage or through enhanced groundwater recharge by adopting site specific schemes for managed aquifer recharge. Conservation of surface water resources is possible through construction of farm ponds, especially lined ponds in sandy sub-soil areas where rate of infiltration is relatively high. Check dams can be constructed in series along perennial streams and canals for recharge to the shallow aquifer (Aquifer-I) in the upstream areas of such natural or man-made channels. Considering the topographical variation in North and Middle Andaman district, different types of recharge and water conservation structures are feasible at different locations within a watershed. Various types of water conservation and managed recharge to Aquifer-I in North and Middle Andaman district are enumerated below:

9.3.1 Farm Ponds with Dug Wells

In gently sloping hilly tract, water resources development is feasible through construction of a series of recharge structures in the form of small ponds or check dams. Such structures may be constructed in the stream bad at suitable locations. It is estimated that storage potential for these structures would be ranging from ~1000 to ~5000 m^3(SSAP 2020). Besides water conservation and harvesting, these structures have potential to recharge the shallow aquifer in the depth range of ~10 to ~15 m. In the downstream side of the recharge structures, dug wells having diameter ranging from 4 to 5 m can be successfully utilized for water supply as the additional storage in Aquifer-I can be extracted through them. Pilot schemes in this direction are required to be implemented by the Andaman Public Works Department. Schematic diagram of the structure is shown in **Fig. 9.1.** Funds for implementation of pilot schemes (as in Garacharma, South Andaman district) may be arranged through District Development Funds or MLA Scheme, both for the rural and peri-urban areas (Srivastava and Ambast 2012). Integrated farming involving paddy and fish farming (pisciculture) could also be taken up in the agricultural farm ponds, depending upon requirement and village economy.

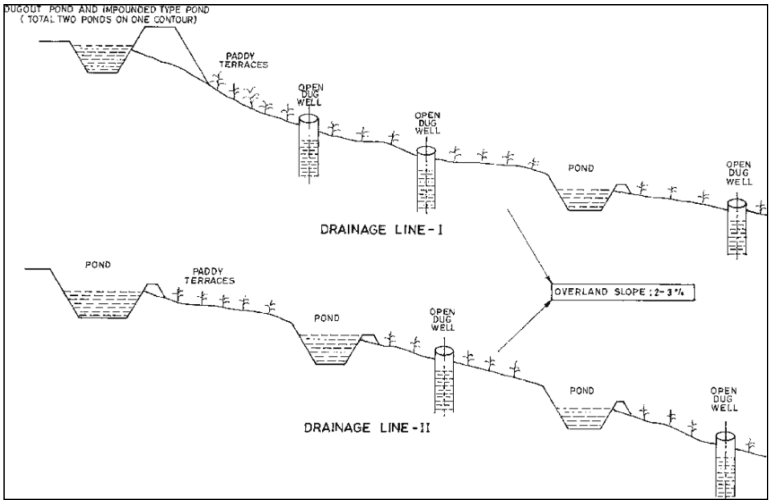


Fig. 9.1 Schematic diagram showing recharge ponds and large diameter dug wells in the gently sloping hilly area, North and Middle Andaman district

9.3.2 Rainwater Harvesting Through Check Dam

Check Dams could be constructed in natural depressions for assured irrigation to paddy crops and vegetables in various parts of Middle Andaman district like Rangat, Mayabunder and in rural areas of North Andaman district near Diglipur. The water harvesting potential through construction of a series of Check Dams in Port Blair (South Andaman district) by Central Island Agricultural Research Institute (CIARI) under the Indian Council for Agricultural Research (ICAR) has been well documented (SSAP 2020). Such schemes need to be implemented in North and Middle Andaman district by the district administration. Such programmes may also be dovetailed with the construction of 75 *Amrit Sarovars* as a part of the Jal Shakti Abhiyan – Catch the Rain 2022 (JSA-CTR 2022) programme of the Ministry of Jal Shakti, Government of India under technical guidance of the attached or subordinate offices of the Ministry.

9.3.3 Water Harvesting Through Lined Ponds

Lined ponds and tanks are one of the best options for harvesting of surface water at relatively cheaper cost in the hilly tracts with porous soil and sub-soil in the North and Middle Andaman district. For lining of the agri-irrigational ponds and tanks, the use of plastic films has been documented in various parts of South Andaman district and also in Car Nicobar district (SSAP 2020). The tough low-density polyethylene (LDPE) film tailor made for lining has been used in such areas by the CIARI, ICAR. The LDPE film acts as an impermeable material, which prevents infiltration and percolation of stored surface water. However, in areas underlain by rocks of

Andaman Group and Ophiolite Group, such structures are not feasible as only unconsolidated sandy formations are suitable for construction of such harvesting structures.

9.3.4 Permanently Raised Bed and Furrow System

During rainy season, low-lying coastal areas are either prone to water logging or actually water logged, as observed in Swadesnagar and Parnasala. For such areas, for sustainable cropping of paddy as well as diversification of cultivation along with fish farming, the concept of permanently Raised Beds and Furrow System (RBF) has evolved. The basic design of RBF system comprises four raised beds (4 m wide) and three furrows (6 m wide), which together forms a structure having a length of ~50 m. The structure is made by excavating the soil from either side of the bed and putting it in the bed area by cut and fill method. The excavated area is formed into a furrow of 6 m width having a depth of 1.5 m and a slope of 1:1. At the end of the furrow, an area of2 m x 2 m is deepened up to 2.5 m to collect water, which will act as fish shelter during the summer months. Each of the raised bed is converted into an inverted trapezium shape and stabilized by planting annual grasses on either side. The furrows are used for rainwater harvesting and the raised beds are used for vegetable cultivation. In RBF, the beds have also shown reduced salt built up problems, which aids in sustainable agriculture (SSAP 2020). Schematic diagram of a Raised Bed and Furrow System (RBF) is shown in **Fig. 9.2.** Cultivation of vegetables using the RBF System is illustrated in **Fig. 9.3.**

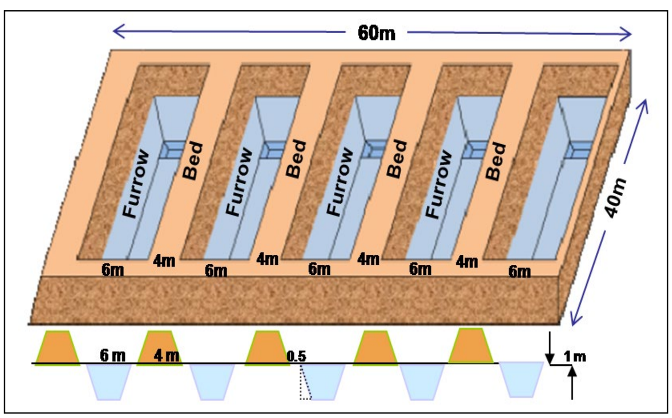


Fig. 9.2. Design (L) and field photo (R) of a Raised Bed and Furrow System

Fig. 9.3 Cultivation of Vegetables using RBF System (Source: SSAP 2020)

9.3.5 Contour Bunding and Contour Barriers

Contour Bunding is a technique that helps retain moisture and nutrients while preventing soil erosion. Contour Barriers are contour strips which intercept downslope flowing water and soil particles. These barriers slow down the water movement and reduce the erosive force of flowing water. Such structures also filter out and trap the suspended soil particles, keeping them from being washed out of the field. A long-term advantage of Contour Barriers is that soil growth is facilitated behind such barriers, which creates a terrace-like effect. Contour Barriers can be classified as live (strips of living plants), dead (rocks, crop residues) or mixed (a combination of both). In live Contour Barriers, plants like Glyricidia, *Leucaena* sp., pineapple and vetiver are used for arresting soil erosion.

9.3.6 Bench Terraces

Bench Terraces area soil and water conservation measure used on sloping land with relatively deep soils to retain water and control erosion. They are normally constructed by cutting and filling to produce a series of level steps or benches. This allows water to infiltrate slowly into the soil. The original bench terrace system consists of a series of flat shelf-like areas that convert a steep slope of 20 to 30 % to a series of level (or nearly level) benches. The technique consists of construction of series of platforms along contours cut into hill slope in a step like formation. The platforms are separated at regular intervals by vertical drop (or by steep sides) and protected by vegetation and sometimes packed by stone retaining walls. The terraces convert long un-interrupted slope into several small strips to make a protected platform, which facilitates moisture storage and minimises soil erosion. The Bench Terraces are highly recommended for coconut growing areas, totalling 1525.63 ha in North and Middle Andaman district.

9.3.7 Moisture Conservation Through Mulching

Mulching prevents direct evaporation of soil water, thus substantially reducing the crop water requirement. Mulching is usually practiced when cultivating commercially important crops, fruit trees, vegetables, flowers and nursery saplings. Paddy straw used to be the most common mulching materials for crops, which has been well documented (SSAP 2020). For North and Middle Andaman district, black polythene mulch and silver-black plastic mulch is found to be most suitable for conservation of soil moisture and increased water use efficiency. Photograph of plastic mulching is shown in **Fig. 9.4.**

Fig. 9.4 Silver-black Plastic Mulch

9.3.8 Water Harvesting from Springs and Streams

Spring sources, both perennial and seasonal, are an important source of water supply in North and Middle Andaman district. However, there should be adequate provision to minimize suspended particles due to heavy sand and silt content of spring run-off in monsoon period. Before using the seasonal spring-based source for water supply as a contingency plan (along with gravity based supply from perennial spring sources), suitable provision for filtration must be ensured by the APWD. For Agri-irrigational use, farm ponds lined with impermeable HDPE sheets are cost-effective structures for supply during lean periods. Few perennial streams (locally known as nallah) may also serve as potential source for augmentation of water resources in the area. During construction of artificial recharge structures at Hydrogeologically feasible areas, proper engineering design and architectural considerations (under the supervision of a team comprising professional hydrogeologists and civil engineers) need to be followed. Pioneering investigations in North and Middle Andaman district have been completed by CGWB (Kar 2006) wherein the following structures were recommended for formulation of a District Wise Water Conservation Plan:

North Andaman:

Diglipur Tehsil: Check Dams – 496, Recharge Wells (along stream) – 404, Recharge Wells (in the upland area) – 100, Subsurface Dykes – 100, Ponds – 75

Middle Andaman:

Mayabunder tehsil: Check Dams – 97, Recharge Wells (along stream) – 92, Recharge Wells (in the upland area) – 50, Subsurface Dykes – 19, Ponds – 30

Rangat tehsil: Check Dams – 309, Recharge Wells (along stream) – 283, Recharge Wells (in the upland area) – 100, Subsurface Dykes – 67, Ponds – 75

It has been reported that Saddle Peak in North Andaman Island and Panchawati Hills in the Middle Andaman Island are host to several perennial spring sources (Kar 2006). During the present study on aquifer mapping and management, few feasibility surveys were completed along selected spring sources, both in the North and Middle Andaman Islands. A brief account of site-specific recommendations on water conservation and artificial recharge is given below:

North Andaman Island

- **Cherian Nallah:** This perennial stream flows through Keralapuram village in Diglipur tehsil. During field survey, it was observed that severe bank erosion is taking place along this stream. For water conservation and artificial recharge, a series of check dams need to be constructed in the meandering part of the stream before the bank erosion takes place. Distance between two check dams may be kept between 100 to 150 m and feasible number of check dams is 20. There is also a feasibility to construct 20 recharge wells (~20 m deep, 4” dia.) in between the check dams. Moreover, to arrest the base flow, 5 sub-surface dykes may be constructed. Gabion structures or spurs may be constructed on the nallah bed to arrest surface flow and to reduce soil erosion. The water conservation and recharge scheme would benefit ~60 ha land through watershed development programmes.

- **V. S. Pally Stream:** Agriculture Department has constructed one check dam on this stream. There is feasibility of constructing additional 6 check dams within a mutual distance of ~50 m to ~75 m. Seven recharge wells (~25 m deep, 4” dia.) and 3 to 4 recharge shafts (~15 m deep, ~12” dia.) are feasible in between two check dams in this stream source. The estimated land area that would be benefited after implementation of the scheme is ~20 ha.
- **Shibpur Village Stream:** This stream flows through Shibpur village having a length of ~5 km and average width varying from 3 to 4 m. Feasibility survey in the area reveals 30 check dams having height varying from 0.75 to 1.20 m (excluding foundation height) and mutual distance varying from ~50 to ~75 m can be constructed. There is also feasibility for constructing a tidal bar near the exit point of the village. Moreover, 30 recharge wells and 5 subsurface dykes could be constructed in this stream source for implementation of artificial recharge scheme. It is estimated that ~26 ha land would be benefited in the form of assured and sustained water supply through construction of the proposed water conservation and artificial recharge structures.
- **Kalpong River:** This is by far the biggest stream in North and Middle Andaman district. Severe bank erosion has been observed along this river. This is further aggravated by indiscriminate river bank quarrying, which has been controlled to some extent post-2014 by the Andaman administration. Field survey in select stretches of the river indicates 50 check dams, 50 intake wells and 10 subsurface dykes are feasible, which would benefit ~505 ha area under assured irrigation as a part of integrated watershed development and management.
- **Laxmipur Village Stream:** The Laxmipur village is reported to be facing water scarcity during the summer season (SSAP 2020). For meeting the Agri-irrigational water use, adoption of open area rainwater harvesting is techno-economically feasible. However, necessary funding for community-based rainwater harvested supply is essential on the part of district administration. Tidal ingress up to 1.5 km has been observed in the Laxmipur stream, which is very conspicuous during the post-2004 tsunami. Along the Nallah, 25 check dams (height: 1.0 to 1.5 m, base width: ~25 to 30 m), 25 intake wells (depth ~15 m, dia. 4” to 6”) and 4 subsurface dykes (foundation depth: ~4 m from stream bed) are found to be feasible. It is estimated that ~130 ha land will be benefited through assured water supply in the catchment area of Laxmipur Nallah.

- **Sitanagar Village Stream:** Bank erosion is conspicuous long this stream, whose discharge is only second to the Kalpong River. Four check dams were reportedly constructed along the stream course by the agriculture department during the period 2011-2016. This stream, locally known as Sitanagar Nallah, is a tributary of Kalpong River. Therefore, construction of tidal bar is not recommended in this stream. After the feasibility survey, 30 check dams (base width: ~10 m to 12 m, height: 1.0 to 1.5 m excluding foundation height), 30 intake wells (dug wells having depth: ~10 to ~12 m, dia. 2 m to 3 m) and 4 subsurface dykes were found to be suitable along the stream course. Construction of these structures would benefit ~200 ha area under assured irrigation.

Middle Andaman Island

In Mayabunder and Rangat Tehsil, few stream sources were surveyed for feasibility of construction of check dams, intake wells (mainly large diameter dug wells), subsurface dykes and less commonly, tidal bar (artificial) to regulate the salinity ingress along the tidal creeks. A brief description of the site-specific recommendations on water resources conservation and augmentation is given below:

- **Webi Stream:** Webi village is reported to suffer from water scarcity during summer season. Saline water ingress is observed along New Debora – Saw Tomo section. A tidal bar may be constructed in this area to check the saline water ingress, which is adversely affecting irrigation. The catchment area of Webi stream is estimated at ~100 ha and 25 check dams (base width: ~15 to ~25 m, height excluding foundation height: 1.0 to 1.5 m) are feasible in this stream with spacing between two consecutive check dams ranging from ~75 m to ~100 m. Intake wells (depth: 10 to 15 m, dia. 2 to 3 m) may be constructed along the banks of the stream for supply of harvested water for growing paddy and vegetables throughout the year. Also, to arrest the base flow, 5 subsurface dykes may be constructed having height of ~1.5 to 2.0 m and foundation depth of ~5 to 6 m below the stream bed.
- **Karmatang Stream:** This stream has two minor streams (branching nallahs) having length of ~400 m and ~500 m respectively. In one of the branch streams, a check dam has been constructed by the Agriculture Department. Ground feasibility survey indicates that total 15 check dams (base width: ~6 to 7 m in branching nallahs and ~30 m in the main Karmatang Nallah) are feasible. Additionally, 15 intake wells (diameter: ~2 m to 4 m, depth: 15 m) and 2 subsurface dykes are feasible, which would benefit ~30 ha area for taking up assured irrigation within the watershed of the Karmatang stream source.

➢ **Rampur Stream:** About 600 m length of the stream (Nallah) section was surveyed having average channel width of 4 m. One check dam has been constructed by the state government. However, another check dam (base width: 6 m, height: 1.5 m excluding height of foundation) may be constructed ~150 m downstream of the existing check dam. Two recharge shafts (depth: ~15 m, diameter: 2 to 3 m) having a distance of ~100 m between them may be constructed along with one subsurface dyke.

➢ **Rangat Nallah:** This perennial stream flows through Rangat, Mithila and Sitanagar. Saline water ingress was found ~3 km upstream of Dasarathpur. A series of check dams ~100 to 150 m apart, may be constructed having maximum base width of ~40 m and height of ~2 to 2.5 m (excluding foundation height). For checking saline water ingress, a tidal bar needs to be constructed at Dasarathpur. Feasibility survey along stretches of the stream indicates that 30 check dams, 30 intake wells and 5 subsurface dykes may be constructed to harness the full potential of water resources conservation and sustainable development. It is estimated that ~300 has land would be benefited through the proposed intervention in the catchment area of Rangat Nallah.

➢ **Kausalyanagar Nallah:** This perennial Nallah (stream) has a length of ~3 km, width varying from ~3 to 5 m and depth of channel bed varying from ~3 to 5 m, as reported by the state government. As tidal influence (saline water ingress) has been observed ~1.5 km upstream of Kausalyanagar Bridge, construction of a tidal bar will be helpful in checking the ingress. Feasibility survey along the Nallah reveals that 15 check dams, 15 large diameter wells (intake wells) and 5 subsurface dykes could be constructed by the state government. Three to four recharge shafts (depth: ~15 m, diameter: 2 to 3 m) are also feasible in between two check dams and the tidal bar.

➢ **Shaktigarh Nallah:** This Nallah (stream) is a tributary to Kausalyanagar Main Nallah. Along the Nallah section, limited ground survey could be done. There is a feasibility for construction of 3 check dams (base width: ~6 to 8 m, height: 1.0 to 1.5 m, excluding foundation height), 3 intake wells (depth: ~15 m, diameter: 2 to 3 m), 1 subsurface dyke (height: 2 to 3 m, depth of foundation: ~6 m below the stream bed) and 3 to 4 recharge shafts (depth: ~15 m, diameter: 1 to 2 m) in between two check dams. It is estimated that ~10 ha land would be benefited under assured irrigation in the catchment area of this Nallah.

➢ **Nimbutala Stream (Nallah):** A series of check dams with an interval varying from ~50 to 70 m may be constructed along this perennial stream source. Ten intake wells along both banks of the stream (depth: ~20 m, diameter: 3 m) and two subsurface dykes (base width: ~8 m, height: 2 m, foundation depth: ~6 m below the stream bed) could be constructed to harness the water resources potential in an area of ~45 ha in the catchment of the Nimbutala source.

- **Kadamtala Stream:** Drinking water scarcity during summer season is frequently seen in Kadamtala village and nearby habitations. As it is a tribal area, falling within the reserved forest and sparse tribal population of the Jarwa tribe, the ecological balance must be maintained, albeit with limited development of the water resources. This perennial stream source is also frequented by flash floods. Therefore, instead of building conventional cement concrete check dams, vegetative barriers and brush wood check dams need to be constructed with an interval of ~50 to 75 m. There is also a feasibility to construct 2 subsurface dykes having an interval of ~750 m to 1 km in the catchment area of Kadamtala stream. The suggested method of water resources harvesting and augmentation would help develop sustainable Agri-irrigation practices in an area of ~240 ha. Ten large diameter dug wells (intake wells) may be constructed along the right bank of Kadamtala stream for water supply to Kadamtala and Uttara village.
- **Adazig Nallah:** This Nallah is a perennial stream flowing along Adazig-Bijoygarh-Navsari section to the south of Kadamtala Sector. The area falls within Baratang Island and the Nallah is utilized for limited cultivation by the local populace. Feasibility survey along the left bank of this stream indicates 3 check dams, 3 intake wells and 1 subsurface dyke could be constructed, which is estimated to benefit ~12 ha land area under assured irrigation. Additionally, 3 to 4 recharge shafts (depth: ~20 m, diameter: 2 to 3 m) could be constructed to recharge the shallow, unconfined aquifer in the area.

In orderto assess the water supply versus demand (requirement) position during the years 2011, 2030 and 2050 AD, separate diagrams for Diglipur tehsil (North Andaman Island) and Mayabunder and Rangat Tehsil (Middle Andaman Island) are generated. The diagrams show the supply versus demand gap (positive for excess and negative for shortage) for the normal season (except the summer months) and for the peak summer season, when water scarcity problem is most acute. The diagrams are shown in **Fig. 9.5** to **Fig. 9.10.**

A perusal of the figures indicates that the supply versus demand gap is positive during the normal season (except the summer season) in all the three tehsils viz. Diglipur, Mayabunder and Rangat. However, during the peak summer season, water scarcity problem is manifested as the supply versus demand gap becomes negative. The calculations are based on projected population of 57002 in 2030 AD and 75242 in 2050 AD, as compared to the population of 43183 as per Census, 2011 data. Visual analysis of **Fig. 9.6** and **Fig. 9.8** reveals that water scarcity in summer is evident in Diglipur tehsil to the tune of ~0.75 MLD (million litre per day) and ~0.15 MLD in Mayabunder tehsil. The situation is alarming in Rangat tehsil, where water scarcity has been observed in 2011 AD and also projected in 2030 AD and 2050 AD. The water scarcity will be ~0.75 MLD in 2030 AD in Rangat, whereas it is projected to increase to ~1.25 MLD in 2050 AD. Therefore, water conservation and augmentation measures need to be focused with priority in Rangat tehsil. Another challenge is the rapidly increasing small and medium scale enterprises in and around Rangat town.

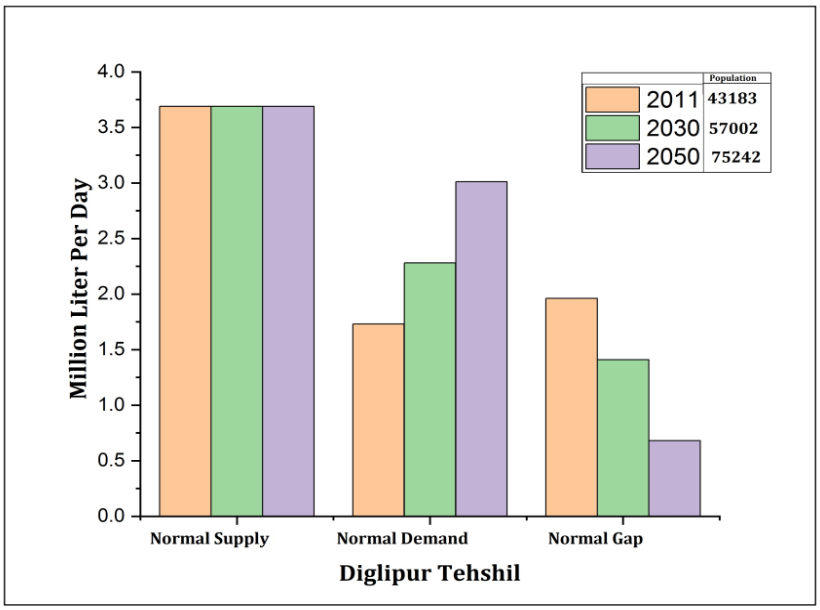


Fig. 9.5 Supply versus demand position (normal season) during the period 2011 AD to 2050 AD, Diglipur tehsil

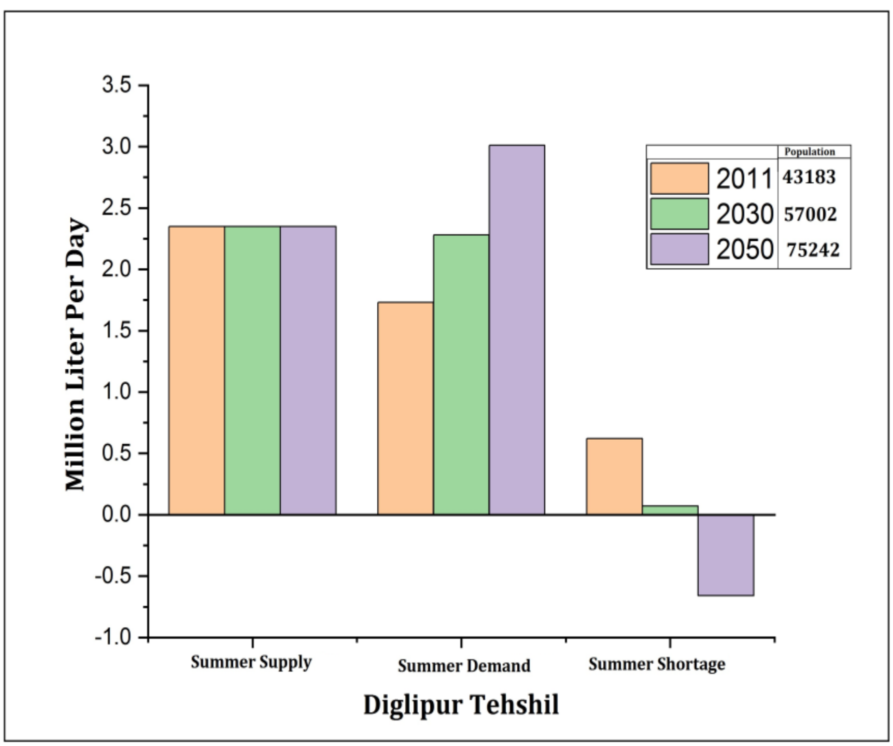


Fig. 9.6 Supply versus demand position (summer season) during the period 2011 AD to 2050 AD, Diglipur tehsil

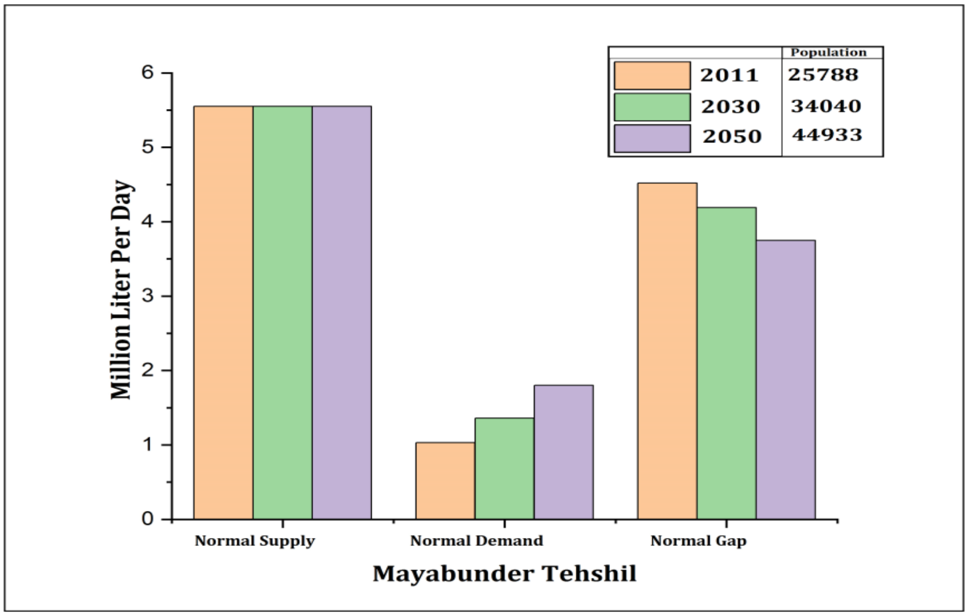


Fig. 9.7 Supply versus demand position (normal season) during the period 2011 AD to 2050 AD, Mayabunder tehsil

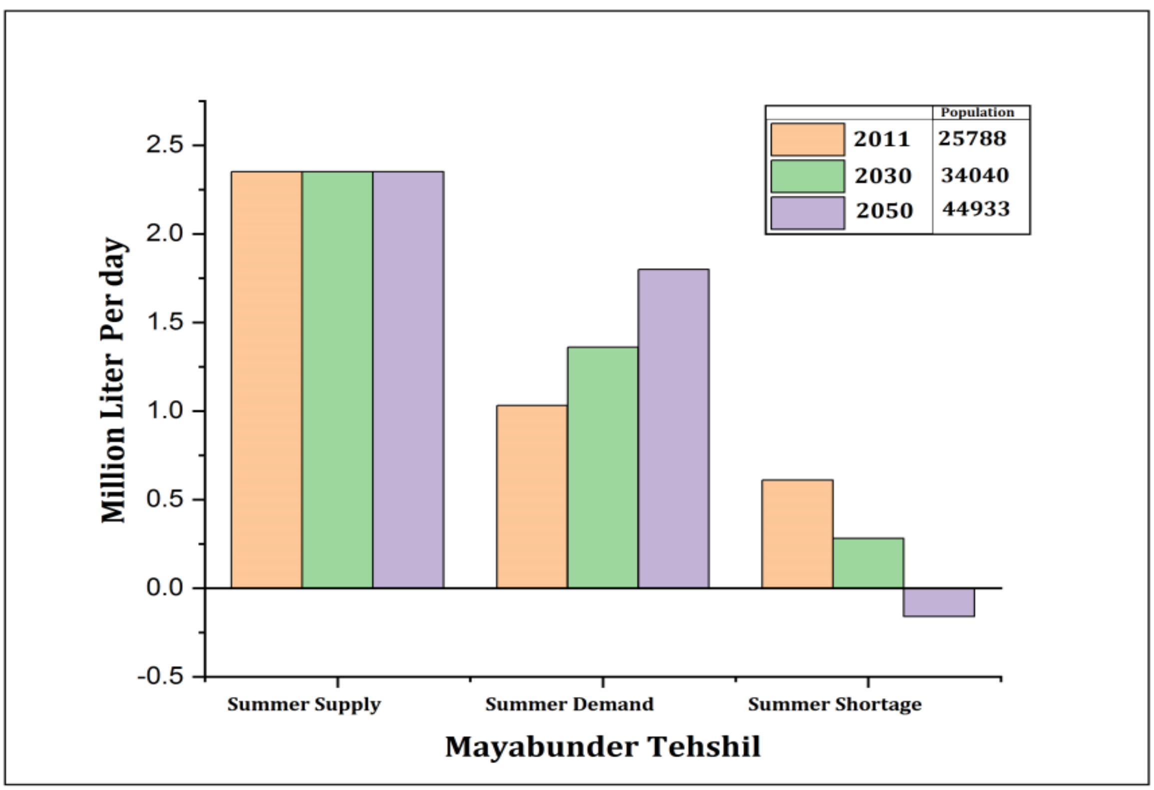


Fig. 9.8 Supply versus demand position (summer season) during the period 2011 AD to 2050 AD, Mayabunder tehsil

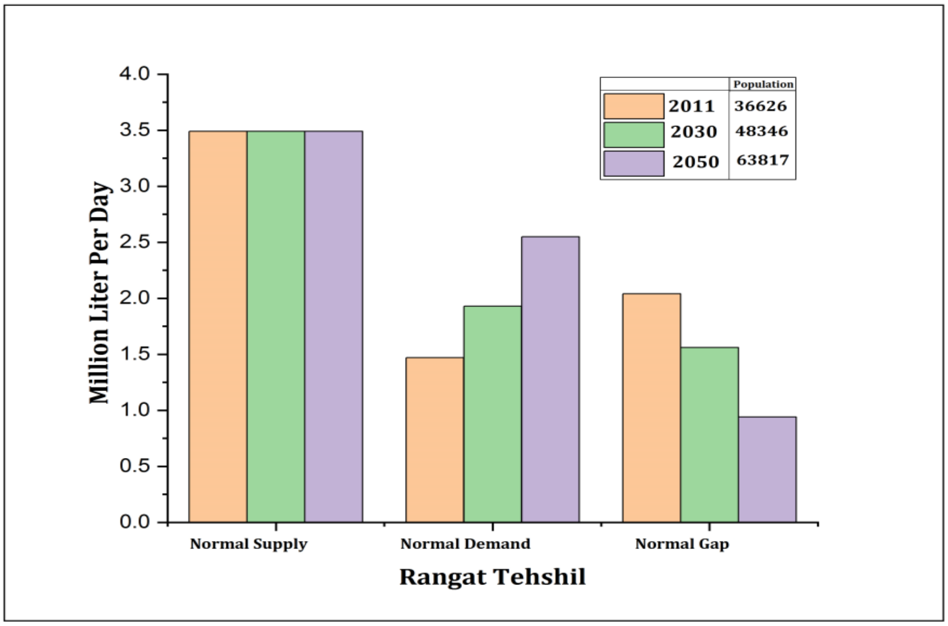


Fig. 9.9 Supply versus demand position (normal season) during the period 2011 AD to 2050 AD, Rangat tehsil

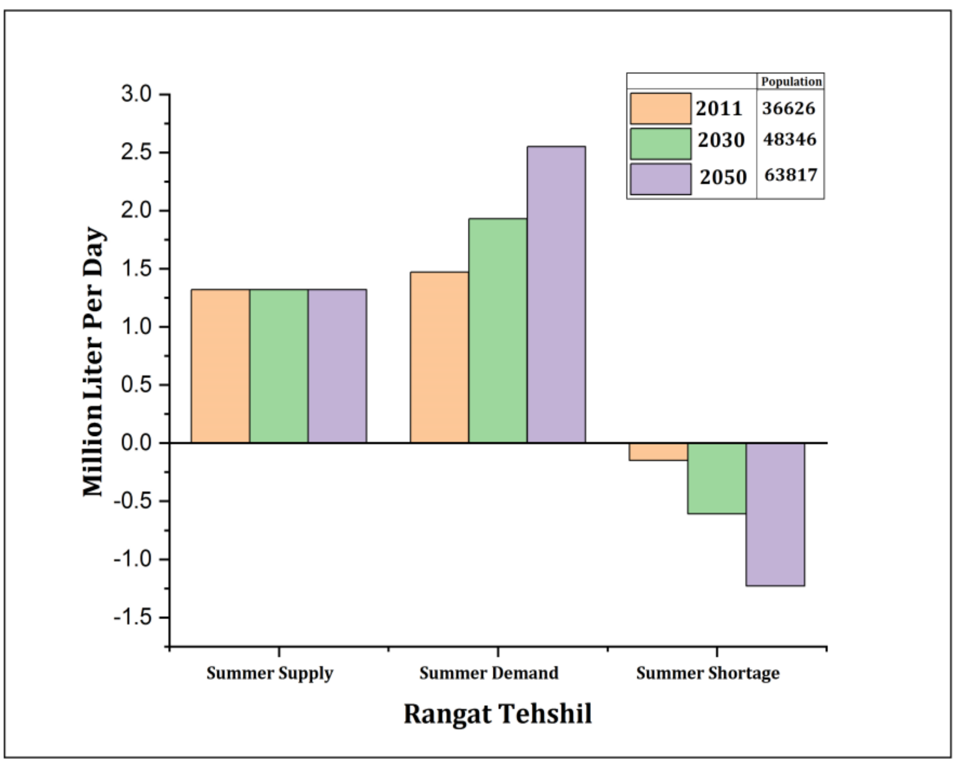


Fig. 9.10 Supply versus demand position (summer season) during the period 2011 AD to 2050 AD, Rangat tehsil

9.3.9 Change in Irrigation Pattern for Increased Water Use efficiency

Instead of the conventional system of flow and lift irrigation, the water use efficiency has to be increased by adopting sprinkler or drip irrigation technique. Though the islands receive more than 3000 mm of rainfall, the farmers face water scarcity during dry months due to lack of storage structures. Hence, the available water needs to be used most judiciously. The water use efficiency of drip irrigation technique is even more than that of sprinkler irrigation. However, depending on the existing socio-economic condition of the farmers, the drip irrigation can be adopted for growing high-value vegetables like cauliflower, tomato and pumpkin in dedicated polyhouses. Pilot projects on System Rice Intensification (SRI) and sprinkler and drip irrigation needs to be demonstrated in the farmer's field by ICA-CIARI as a part of their on-going projects.

9.4 Water Conservation for Industries and Infrastructure Projects

As per available data base of Micro, Small and Medium Enterprises (MSME) Department, Directorate of Industries, the total number of small and micro enterprises in North Andaman was 244, whereas for Middle Andaman, the number was 250 units (SSAP 2020). The major constraints on monitoring of industrial water use are lack of proper infrastructure, absence of dedicated department for regulation and monitoring, lack of centralized data base, lack of statutory guidelines and power to monitor and initiate action to reduce the fresh water use or release of waste water and lack of skilled manpower for measurement and monitoring. The following general guidelines are suggested, based on the existing scenario on water resources management by the district administration:

- Water harvesting, storing and multiple use of water at all industries and infrastructures through regulations or guidelines by administration.
- Fixing water meter and float value in overhead tanks in all buildings. In the first phase, selected government buildings may be taken up.
- Establishment of waste water treatment plant and gradual introduction to the concept of reuse of water for purposes other than drinking.
- Turning off all the water flow valves during shutdown of plants.

- Incentives to promote establishment of packaged drinking water industry in a phased manner, initially in and around major perennial stream-based sources like Kalpong River, Sitanagar Nallah and also through rejuvenation of perennial springs after site specific hydrogeological-geophysical-hadrochemical surveys.
- Cleaning the machinery, equipment and other facilities in the industrial units only, when necessary, thereby reducing wastage of water.
- Monitoring and regulation of indiscriminate construction of bore wells (privately owned) by the industries and infrastructure projects.
- Regulation by the Central Ground Water Authority till a separate State Ground Water Authority (SGWA) is not established by the Andaman and Nicobar Administration.
- Periodic field visits by CGWB officials to assess the changes in industrial and infrastructural water use and evaluation-based outcomes on the web portal, as applicable.

9.5 Scope of Artificial Recharge

North and Middle Andaman district comprise 95 large, medium and small islands, out of which 13 islandsare inhabited.The islands are spread over an area of 3483km^{2}area, out of which ~2956 km^{2}iscoveredbyforest. The average annualrainfall in the district is 3180 mm. In spite of copious rainfall, the islands face acute scarcity of freshwater, especially in the peak summer season in selected pockets. Sincetheislandsareunderlainpredominantlybyimpervious marine sedimentary rocks (turbidite), deeper infiltration of surface watercannot take place. This results in profuse base flow from the shallow aquifers, formed in numerousstream valleys. The untapped base flow forms a substantial submarine groundwater discharge. The weatheredmantle (down to a depth of ~15m) and shallow fractures contribute towards potable watersupplyinNorth and Middle Andaman district. Inmanyislandsof the district, perennialspringsaregeneratedalongthesurfaceopening offractures, sinkholes andtopographiclows. The springs are major source of drinking water supply to the ruralpopulation.Keepinginmind theimportanceof springs, spring sheddevelopment is required along with catchment areatreatment. Construction of water conservation and artificial recharge structures like check dams, intake wells, subsurface dykes, gabion structures are essential. Such structures need to be constructed in the upstream sides of discharge area of the spring sources. Details of the feasible structures for Diglipur, Mayabunder and Rangat tehsil are given under Section 9.3.8.

9.5.1 Identification of Recharge Area

In spite of copious rainfall and proximity to sea on all sides, the islands of North and Middle Andaman district face water scarcity during non-monsoon period. Continuous base flow to the seas also makes the sustainability of springs a major issue. Hence, it is proposed to identify areas where water conservation structures are feasible. The area feasible for artificial recharge, on a regional scale, is shown in **Fig. 9.11.** Relevant details are summarized in **Table 9.5.**

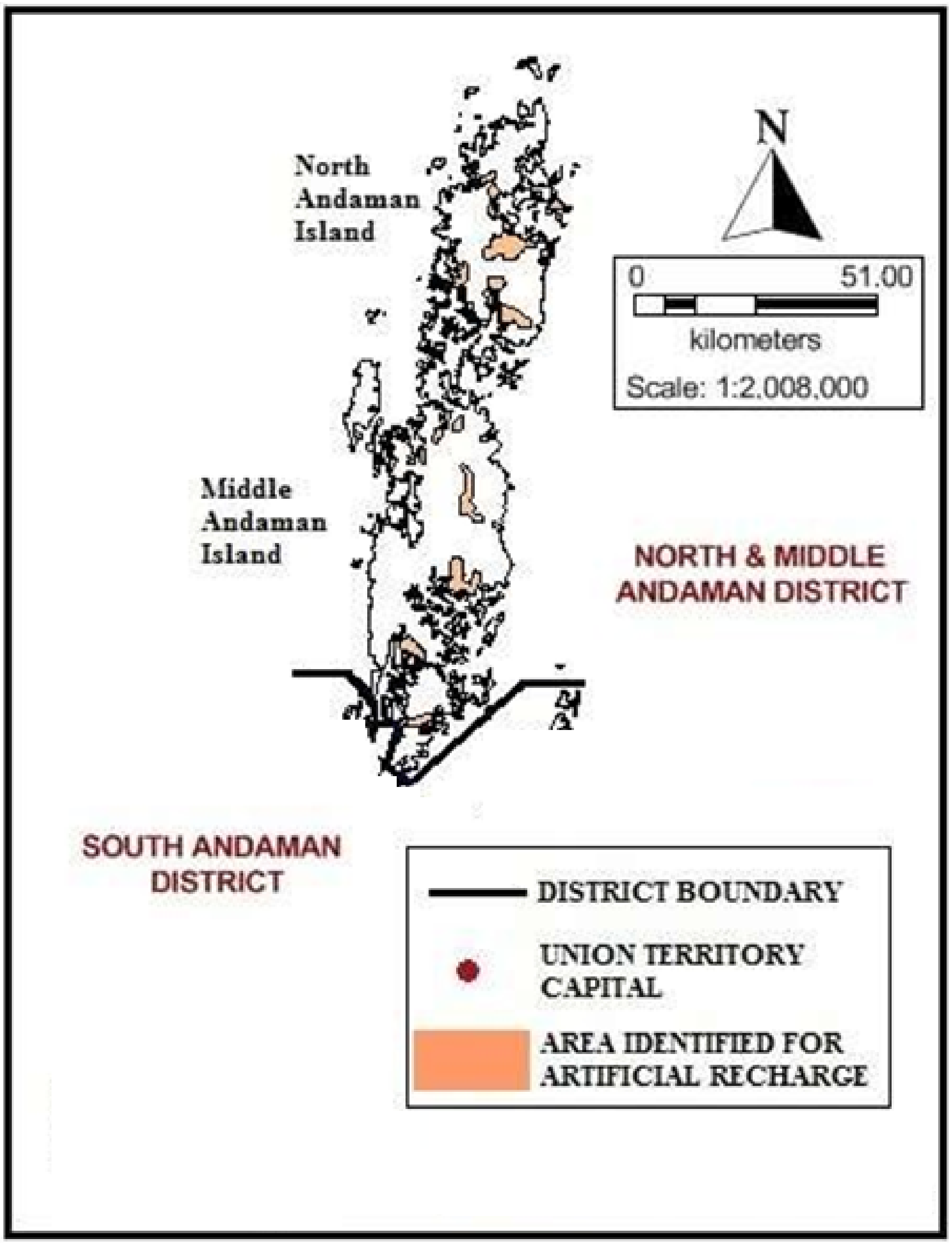


Fig.9.11AreaidentifiedforArtificialRecharge, North and Middle Andaman district

Table9.5 Scope of Artificial Recharge in North and Middle Andamandistrict

Area ofDistrict(km²)	AreaIdentifiedfor Artificial Recharge (km²)	Volume ofUnsaturatedZone (MCM)	AvailableSubsurfaceSpace forArtificial Recharge(MCM)	WaterRequiredforRecharge(MCM)	SurplusWater AvailableforRecharge(MCM)
3227.00	242.20	968.80	116.26	154.62	2053.11

**Source: Master Plan for Artificial Recharge (CGWB 2020)*

9.5.2 Types of Artificial Recharge Structure

In order to facilitate water storage in surface and also to augment shallow groundwater recharge, spring shed developmentwithcatchmentareatreatment,micro-watershedmanagement, roof top rain water harvesting and open area rain water harvesting, construction of check dams, intake wells, cement plugs, subsurface dykes and tidal bars (in selected area having salinity ingress problem) are proposed in the inhabited islands of North and Middle Andaman district. Detailed studies regarding feasibility for construction of water conservation, harvesting and artificial recharge along the perennial and seasonal streams in North and Middle Andaman district has been completed by workers from CGWB (Kar 2006, Brahma 2009). As per one detailed study, the total number of implementable water conservation and recharge structures is as follows:

- Diglipur Tehsil: Check Dam – 496, Intake Well – 404, Subsurface Dyke – 70
- Mayabunder Tehsil: Check Dam – 97, Intake Well – 92, Subsurface Dyke – 19
- Rangat Tehsil: Check Dam – 309, Intake Well – 283, Subsurface Dyke – 67
- Total for North and Middle Andaman district: Check Dam – 902, Intake Well – 779, Subsurface Dyke – 156

9.6 Rainwater Harvesting

North and Middle Andaman district is benefited by both the south-west monsoon and the north-east monsoon, the latter being received during the winter months. However, areas like

Laxmipur, Kadamtala and Sitanagar are facing water scarcity problem during the lean period, which starts from December and lasts until April. As the district is blessed with plentiful rainfall (>3000 mm), both roof top rain water harvesting (RTRWH) in urban and peri-urban areas and open area rain water harvesting (OARWH) in rural areas is essential to remedy the problem of water scarcity, both for drinking and domestic purpose. As per the building bye law adopted by the Port Blair Municipal Councildesigning the roofs in selected government building for RTRWH has been initiated, which has been documented by ICAR-CIARI (SSAP 2020).Due to problems of relative inaccessibility of the islands of Baratang, Middle Andaman and North Andaman from Port Blair, the desired thrust in this direction is yet to be observed by the district administration. It is suggested to take up pilot projects on rain water harvesting at Rangat, Diglipur and Mayabunder by institutes like ICAR-CIARI and also by the Andaman Public Works Department and agriculture department.

The latest initiative by the Andaman and Nicobar administration is the "Blue Pipe Project" undertaken by the Port Blair Municipal Council (PBMC) wherein connecting water wells through community roofs have been taken up. The initiative has been formulated as a part of a unique experiment on Urban Community Based Low Cost Rain Water Harvesting. The initiative has been widely circulated in the social media also. However, as the scheme has been launched very recently, the actual impact of water resources harvesting has to be analysed once the scheme is widely implemented in parts of North and Middle Andaman district. Preliminary survey during the present study has shown that roof top rain water harvesting could be taken up at Rangat and Diglipur in the first phase. This may be followed up by systematic coverage at Mayabunder and Durgapur areas. Both roof top and open area rain water harvesting could be implemented in the campus of Mahatma Gandhi Government College, Mayabunder. There are many popular tourist destinations in the district namely Ross and Smith Island, Kalipur, Ramnagar, Karmatang and Baratang, which could also be targeted for implementation of rain water harvesting for developing geo-tourism with funding from the MGNREGA scheme and or AMRUT and CAMPA schemes by the district administration.

9.7 Cost Component

Based on the number of feasible structures on water conservation and artificial recharge, the calculations for North and Middle Andaman district are summarized in **Table 9.6.** The data used in the table are based on previous thematic studies by officers of the latest available unit cost estimate for various types of structures is taken from published report by the ICAR-CIARI (SSAP 2020). A perusal of the table indicates that the total cost for implementation of rain water harvesting and artificial recharge in North and Middle Andaman district is 367.85 Crore Rupees (36,785 Lakh Rupees), as per the estimates for the year 2020 AD (SSAP 2020).

Table 9.6 Cost Estimate of Artificial Recharge and Rain Water Harvesting

Number of Structures				Cost of Structures (Lakh Rupees)				
Check Dam	**Intake Well**	**Sub-SurfaceDyke**	**RTRWH**	**Check Dam**	**Intake Well**	**Sub-SurfaceDyke**	**RTRWH**	**TotalCost**
902	779	156	2250	13530.00	7790.00	390.00	15075.00	36785.00

CHAPTER-10

CONCLUSION AND RECOMMENDATIONS

10.1 CONCLUSION

Based on the present study on aquifer mapping and management in North and Middle Andaman district, the following conclusion is drawn:

- Geology of study area is characterized by sedimentary rocks having relatively low groundwater potential. However, weathered and fractured rocks of Ophiolite Group and alluvium along the east and west coast have better groundwater potential.

- Valley fill deposits and weathered mantle of fractured, jointed and/or faulted igneous (mafic and ultramafic) rocks, coralline and foraminiferal limestones constitute a shallow aquifer (Aquifer-I) in the depth range of ~12 m to 32 m, as deciphered from groundwater exploration in Rangat and Panchawati in Middle Andaman Island.

- A deeper aquifer (depth range: 45 to 52 m) has been deciphered in fractured volcanic rocks. However, out of 13 Exploratory Wells drilled in North and Middle Andaman district, only four wells were found to be productive.

- Discharge in the Exploratory Wells was found to vary from 240 m^3/day at Panchawati to a maximum of 600 m^3/day at Rangat. The productive zones at Rangat site were found in the depth range of 29.8 m to 32.0 m in a gravelly aquifer (Aquifer-I).

- Calculation of decadal (long-term) trend in depth to water level indicates that except at Parnashala and Mayabunder, long-term decline in groundwater level was observed during pre-monsoon period. In post-monsoon, only 24% of the monitoring wells have recorded rising decadaltrend varying from 0.04 m/yr to 0.08 m/yr.

- Perennial and seasonal springs are numerous in the district like at Panchawati Hills in Middle Andaman and Saddle Hills in North Andaman. However, the base flow from springs contributes to the Submarine Groundwater Discharge (SGD) to the Andaman Sea in the east and the Bay of Bengal to the west. In order to arrest the base flow, construction of subsurface dykes of suitable design and dimension has been taken up at few places by the state government.

- Few springs like Panchawati spring, Parnashala spring, Shankar Nallah and Rampur spring have been tapped by the Andaman Public Works Department for gravity-based water supply to urban, peri-urban and rural area. However, due to post-tsunami effect, many water supply spring sources were damaged due to subsidence around Rangat-Bakultala-Kadamtala-Mayabunder area and uplift around Subhasgram-Durgapur-Diglipur-Shyampur-Radhanagar area.

- An attempt has been made to genetically classify the springs. It has been observed that majority of the springs are fracture/joint springs like those at Rampur, Shankar Nallah and Panchawati, whereas sprigs at Tikadera, Joseb Nallah and Chitrakoot have been classified as seepage springs. The spring at Sabari Nallah (Ward No. 2) has been categorized as depression spring, formed in the topographic low.

- Spring discharge was found to vary substantially, ranging from 43.2 m^3/day in post-monsoon to 1296.0m^3/day during the monsoon period. Variation in seasonal discharge is relatively less for springs with deeper levels in spring flow pattern as compared to springs having shallower depth of spring flow.

- Water conservation and harvesting from traditional surface water bodies is not very much justifiable due to the high annual evaporation loss as a result of proximity of the district to the equator. Therefore, feasibility surveys for construction of artificial recharge structures like check dams and recharge shafts have been proposed during the present study.

- Feasibility survey for construction of water conservation and artificial recharge and also for arresting the saline water ingress in few perennial streams was completed along six streams (Nallah) in North Andaman Island and along nine Nallahs in Middle Andaman Island.

➢ Based on available water supply and demand position (SSAP 2020), an analysis has been made for Diglipur, Mayabunder and Rangat Tehsil to ascertain the excess supply versus demand gap (positive gap) and water scarcity (negative supply versus demand gap) for both the peak summer season and the normal (non-summer) season. As all the springs are recharged through rainfall, reduction in spring discharge is evident during the lean period (summer season) when water scarcity would be most acute.

➢ The water supply versus demand analysis reveals that water scarcity was not observed in 2011 AD in any one of three tehsils. The calculations were based on population estimates as per Census 2011 data. However, based on projected population figures for 2030 AD and 2050 AD, water scarcity during the summer season would be ~0.75 million litres per day (MLD) and ~1.25 MLD respectively for Rangat tehsil. For Diglipur tehsil, water scarcity in summer would be ~0.75 MLD in 2050 AD, whereas the scarcity in Mayabunder tehsil has been estimated to be ~0.15 MLD in the summer of 2050 AD.

➢ The Stage of Groundwater Extraction (SOE) was only 3.73% for North and Middle Andaman district (as on 31-3-2020). This indicates huge potential for development of dynamic groundwater resources. Accordingly, shallow tube wells fitted with India Mark-II or No. 6 hand pumps could be installed for supply of potable water for drinking and domestic use.

➢ Latest available data on groundwater quality (pre-monsoon 2019) indicates that EC of groundwater of the monitoring wells was generally within the Acceptable Limit, with highest EC of 931 µS/cm. Sporadically high iron concentration ranging from 1.1 mg/L at Mohanpur to 2.6 mg/L at Porlobjig was recorded in the central and south-central parts.

➢ Computation of Sodium Absorption Ratio (SAR) indicates groundwater belongs to Excellent category (SAR<10) in all the samples collected from total 37 groundwater monitoring wells. Calculation of Permeability Index indicates 32 samples out of 37 was categorized as Good with PI falling in Class-I (PI>75%) whereas remaining 5 samples were "Moderately Suitable" (PI: 25% to 75%) whereas as per US Salinity Laboratory Classification, 100% samples were under S1 class and 33 out of 35 samples were under C2 class.

- Based on standard guidelines on Master Plan for Artificial Recharge, the available subsurface storage for recharge has been estimated at 116.26 million cubic metres (MCM) whereas the volume of water required for recharge is 154.62 MCM. Non-committed surface runoff available in the form of surplus water has been estimated at 2053.11 MCM.

- Based on feasibility survey along selected stretches of few perennial and seasonal streams (Nallahs), the feasibility for construction of check dams, intake wells and subsurface dykes has been estimated. The calculations show that for the entire North and middle Andaman district, 902 check dams, 779 intake wells and 156 subsurface dykes could be constructed.

- The cost estimate for implementation of rain water harvesting system and construction of artificial recharge structures are given in the State Specific Action Plan for Water Sector (SSAP) published by the Central Island Agricultural Research Institute (CIARI), Port Blair. Using the SSAP data and findings of the ground feasibility survey, the cost for implementation of 2250 rain water harvesting structures has been estimated at Rs. 150.75 Crores.

- Cost for construction of various types of artificial recharge structures, as mentioned in the previous section, has been estimated at Rs. 217.10 Crores.

10.2 RECOMMENDATIONS

Based on the outcomes of present study on aquifer mapping and management, the following recommendations are provided for a scientific and sustainable management of the aquifers in North and Middle Andaman district:

- Large diameter dug wells need to be constructed in the valley fill deposits of perennial Rangat River bed near Parnashala and along the banks of Kalsi River in Bakultala-Kalsi sector.

- Depth of dug well should be restricted up to maximum of ~15 m so that the shallow aquifer (Aquifer-I) could be tapped for sustainable water supply. Over deepening of dug wells would be deleterious as this may facilitate saline water ingress into the fresh water aquifers, particularly along the east coast of the district.

- Construction of tidal bars should be taken up along few of the major perennial streams to arrest the saline water ingress. Tributaries of the main stream (Nallah) should be avoided due to relatively less (<5 m) channel width in the tributaries. The tidal bars would help in regulating the fragile dynamic balance between fresh water and saline water lens developed in the catchment areas of the streams

- Artificial recharge structures recharge shaft, intake wells and subsurface dykes should be constructed as detailed in the relevant section of the chapter on aquifer management plan. While constructing the structures, proper architectural and engineering design should be maintained by the executing department of the state government.

- Percolation tanks may be constructed in upslope areas of Sabari, Kadamtala and Adazig areas for managed aquifer recharge to the shallow, unconfined aquifer (Aquifer-I). Existing percolation tanks need to be closely monitored and may be further developed as a part of renovation and/or construction of 75 *Amrit Sarovar's*in the district an integral part of the Jal Shakti Abhiyan – Catch The Rain 2022 campaign.

- Depending on fund availability, the untapped perennial springs and streams may be developed through the district development fund, funding under the MNREGA scheme and/or AMRUT funds available especially for urban areas.

- In order to improve water use efficiency, sprinkler irrigation system and crop productivity improvement through specific methods like System Rice Intensification should be adopted in a phased manner. However, crop subsidy needs to be given to the small and marginal farmers as per existing local socio-economic profile of the farmers.

- Detailed micro-level studies need to be taken up at village level, initially by selecting an *Adarsh Gram*and adopting the methodology of aquifer mapping and management for sustainable management of village level groundwater resources. Participatory water management needs to be introduced so as to make the villagers aware about the ownership of the village water resources and ensuring active participation of the Gram Panchayat and/or *Jal Doots* for community-based management of both surface water and groundwater resources.

- Conjunctive use practices need to be adopted as a part of integrated catchment area (watershed) management programme. In forested areas of Diglipur, Rangat and Mayabunder tehsil, afforestation needs to be done in a phased manner with funding under the Compensatory Afforestation Fund Management and Planning Authority (CAMPA) for sustainability of discharge in the seasonal springs and streams.

- The ecology of the district is fragile and needs controlled groundwater development and monitoring. Therefore, it must be ensured that uncontrolled abstraction of the groundwater resources in unregulated manner must be checked with penal provision.

- There is an urgent need to establish State Ground Water Authority in order to regulate the groundwater abstraction for industrial uses, keeping in mind the rapidly developing economy in the urban areas like Rangat and Diglipur.

- Both roof top and open area rain water harvesting system needs to be implemented in the lines of the “Blue Pipe” programme recently launched by the Port Blair Municipal Council (PBMC) in South Andaman district.

PART – II

DETAILED AQUIFER MANAGEMENT PLANS OF ISLANDS

NORTH & MIDDLE ANDAMAN DISTRICT,

UNION TERRITORY OF ANDAMAN & NICOBAR ISLANDS

CHAPTER-10

10.1 Aquifer Information and Management System

North Andaman Island, N&M Andaman District, Andaman & Nicobar Islands (378Sq.km area covered under NAQUIM)

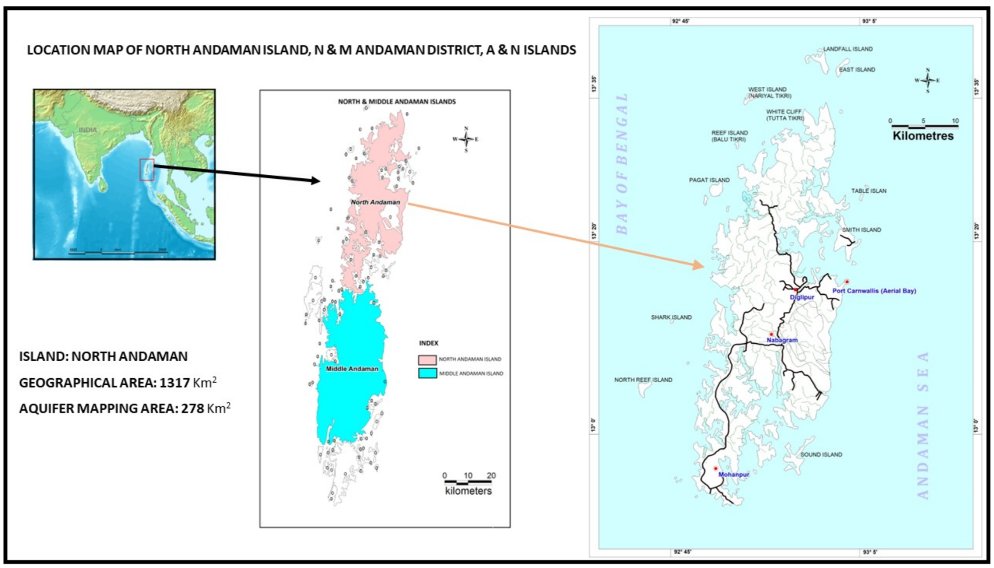
General Information	
U.T. Name	Andaman & Nicobar Islands
District name	N&M Andaman district
Island Name	**North Andaman Islands**
Location	

Figure 10.1 Location map of North Andaman Island, N&M Andaman district, A & N Islands

Geographical Area	1317 sq. km.
Basin/Sub-basin	Andaman Fore Arc Sub basin
Principal Aquifer System	Weathered sedimentaries & fractured ultrabasics.
Major Aquifer System	Two aquifer systems exist.
Normal Annual Rainfall	3180 mm

Aquifer Disposition	Two types aquifer system: Aquifer – I: Depth up to 32m; weathered mantle of sedimentary & igneous rocks Aquifer – II: Depth 23 – 90 m; Fractured ultrabasic, highly crushed
Status of GW Exploration	Exploratory Wells: 2 Observation Wells: 0
VES investigations by CWB:	0
Dug wells inventory:	
Aquifer Characteristics based on hydrogeological and geophysical investigation	Aquifer – I: Depth up to 29-32 m; weathered mantle of sedimentary rocks, valley fill area and igneous rocks Discharge: 10 to 25m^3/ hr Aquifer – II: Depth 23 –90 m; fractured ophiolites (mafics and ultramafics) Discharge: 10 to 25 m^3/hr
Groundwater Monitoring Status	16 Dug Wells

Groundwater Quality	Phreatic Aquifer (Aquifer – I); Brackish in nature, drinking, irrigation and industrial purpose. *Deeper Aquifer (Both Aquifer II) this water is well suited for drinking and domestic use.
Groundwater Resource	*GW Availability: 3149.23 ham *GW Draft: 133.62 HAM *Stage of GW Development 7.33 %
Existing and Future Water Demand	*Present demand for All Usage: 133.62ham *Future Demand for Domestic and Industrial Use: 3015.38ham
Aquifer Management plan	

Groundwater Management Issues

1. Thegeologic formations inN-M Andaman district are highly variedand majorpartsareoccupiedby impervioussedimentary rockswheregroundwater developmentpossibilityisinthelowkey.Theserocksareunfit forconstructionofbore wells/tubewells.Dugwellsarefeasibleinsuch formationsbutyieldisrestricted.However,in selectlocations especially nearthe drainageit may dischargein muchhighertune.Inthe districtappreciablequantity ofwatercould beavailablefromshallow andporousCoralline limestone Formations through dugwells.
2. Ground water resources are limited and only in pockets it is available so chances of over exploitation due to heavy extraction is inevitable.
3. Potential surface water sources are limited and these are dependent on rainfall.
4. Because of climatic change often relatively fewer rainfall is received. With the recession of monsoon, the rain dependent surface water reservoirs go dry and in rural areas the spring yield is dwindled.
5. Because of huge forestry the areas for development of water resources are also limited.

Groundwater Management Plan

Since ground water resources are limited and the islands receive copious rainfall, the fresh water resources are managed through rainwater harvesting in reservoir and ponds. However, due to limitation of utilisable land resources due to the presence of dense forestry as also environmental regulations, water resources management has not been done full proof by the A&N Administration. Due to ongoing climatic change and heavy population pressure the gap in demand and availability has been widened day by day. The R&D work by CGWB has enabled the A&N Administration to adopt many new plans based upon ground water, rainwater harvesting, spring development to manage the water resources to a great extent. The following plans were envisaged to tackle the crisis of water resources in the Island.

1. To augment water supply in the rural areas adopting the artificial recharge cum conservation of ground water.
2. Development of freshwater lake.
3. Augmentation of freshwater supply through desiltation of existing reservoirs, ponds/lakes, wells in and around Port Blair and their protection.
4. Construction of small and medium dams in rural areas.
5. Construction of new ponds in rural areas and in the environs of Port Blair.
6. Rejuvenation of springs
7. Adopting artificial recharge practices in groundwater worthy areas for sustainable Management.

AR & Conservation Possibilities

Ground water resources in North Andaman Islands should be augmented by means artificial recharge. Roof top harvesting structures must be made mandatory for all.

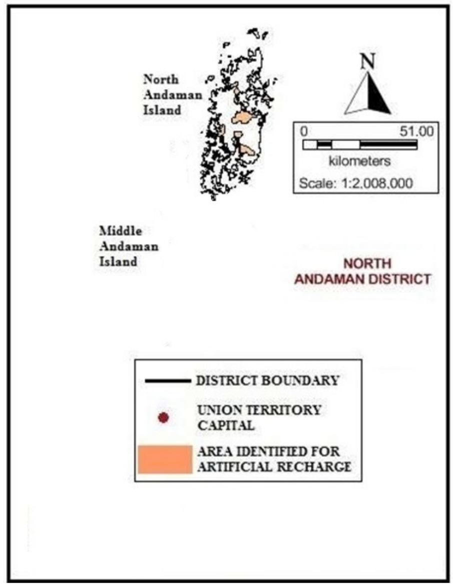


Fig:10.2 Area identified for Artificial Recharge/Water Conservation in North Andaman Island

10.2 Aquifer Information and Management System

Middle Andaman Island, N&M Andaman District, Andaman & Nicobar Islands

(300 Sq.km area covered under NAQUIM)

General Information	
U.T. Name	Andaman & Nicobar Islands
District name	N&M Andaman district
Island Name	**Middle Andaman Islands**
Location	

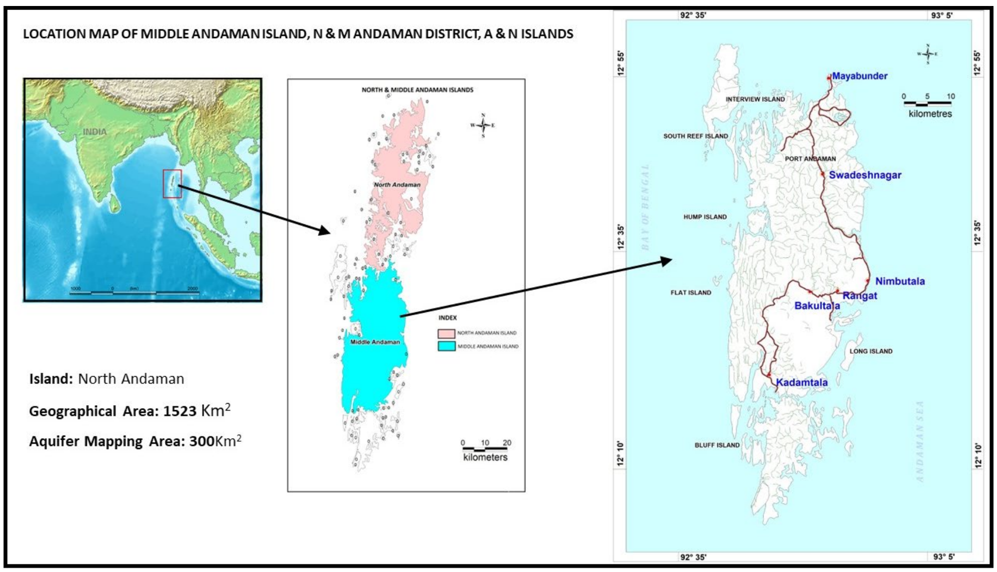


Fig.10.3 Location map of Middle Andaman Island, N&M Andaman district, A & N Islands

Geographical Area	1523.00 sq. km.
Basin/Sub-basin	Andaman Fore Arc Sub basin
Principal Aquifer System	Weathered sedimentaries & fractured ultrabasics.
Major Aquifer System	Two aquifer systems exist.
Normal Annual Rainfall	3180 mm

Aquifer Disposition

Two types aquifer system:
Aquifer – I: Depth 29.8 -32.0 m; Porous alluvium/colluvium overlies

ultrabasics & igneous rocks
Aquifer – II: Depth 13-23, 42-30 & 45-52 m; Fractured ultrabasic, highly crushed.

Status of GW Exploration:	Exploratory Wells: 04 (Rangat, Culvert no64/65, Panchawati, CulvertNo 69 as per historical data) Observation Wells: 0
VES investigations by CWB:	0
Dug wells inventory:	
Aquifer Characteristics based on hydrogeological and geophysical investigation	Aquifer – I: Depth up to 32 m; Porous alluvium/colluvium overlies ultrabasics & igneous rocks, Discharge: 25 m^3/hr Aquifer – II: Depth 13-23, 42-30 & 45-52 m; all fractures in Fractured ultrabasic, Discharge: 10 m^3/hr, 10 m^3/hr, 12 m^3/hr respectively.
Groundwater Monitoring Status	21 NHS Dug Wells
Groundwater Quality	*Phreatic Aquifer (Aquifer – I); Brackish in nature, irrigation and other Industrial purpose. *Deeper Aquifer (Both Aquifer II) this water is well suited for domestic consumption including drinking.
Groundwater Resource	*GW Availability: 5970.85 ham *GW Draft: 194.37 HAMM *Stage of GW Development 14.53 %
Existing and Future Water Demand	*Present demand for All Usage: 194.37 ham *Future Demand for Domestic and Industrial Use: 5761.7ham

Aquifer Management plan

Groundwater Management Issues

1. Thegeologic formations inN-M Andaman district are highly variedand majorpartsareoccupiedby impervioussedimentary rockswheregroundwater developmentpossibilityisinthelowkey.Theserocksareunfit forconstructionofbore wells/tubewells.Dugwellsarefeasibleinsuch

formationsbutyieldisrestricted.However,in selectlocations especially nearthe drainageit may dischargein muchhighertune.Inthe districtappreciablequantity ofwatercould beavailablefromshallow andporousCoralline limestone Formations through dugwells.

2. Ground water resources are limited and only in pockets it is available so chances of over exploitation due to heavy extraction is inevitable.
3. Potential surface water sources are limited and these are dependent on rainfall.
4. Because of climatic change often relatively fewer rainfall is received. With the recession of monsoon, the rain dependent surface water reservoirs go dry and in rural areas the spring yield is dwindled.
5. Because of huge forestry the areas for development of water resources are also limited.

Groundwater Management Plan

Since ground water resources are limited and the islands receive copious rainfall, the fresh water resources are managed through rainwater harvesting in reservoir and ponds. However, due to limitation of utilisable land resources due to the presence of dense forestry as also environmental regulations, water resources management has not been done full proof by the A&N Administration. Due to ongoing climatic change and heavy population pressure the gap in demand and availability has been widened day by day. The R&D work by CGWB has enabled the A&N Administration to adopt many new plans based upon ground water, rainwater harvesting, spring development to manage the water resources to a great extent. The following plans were envisaged to tackle the crisis of water resources in the Island.

8. To augment water supply in the rural areas adopting the artificial recharge cum conservation of ground water.
9. Development of freshwater lake.
10. Augmentation of freshwater supply through desiltation of existing

reservoirs, ponds/lakes, wells in and around North Andaman Island and their protection.

11. Construction of small and medium dams in rural areas.
12. Construction of new ponds in rural areas and in the environs of Middle Andaman
13. Rejuvenation of springs
14. Adopting artificial recharge practices in groundwater worthy areas for sustainable Management.

AR & Conservation Possibilities

Ground water resources in Middle Andaman Islands should be augmented by means artificial recharge. Roof top harvesting structures must be made mandatory for all.

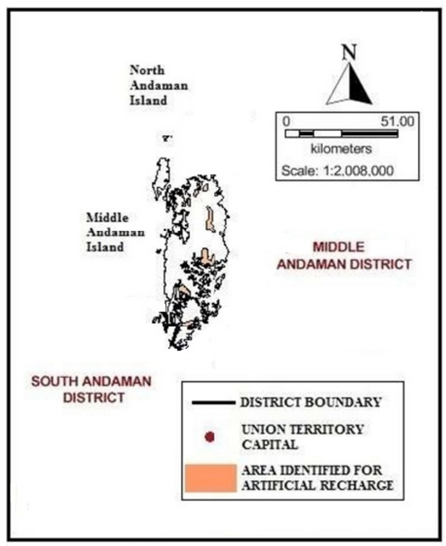


Fig:10.4 Area identified for Artificial Recharge/Water Conservation in Middle Andaman Island

REFERENCES

Chakraborty, T. L., 1990: The systematic Hydrological Surveys in parts of Middle and South Andaman District, Andaman and Nicobar Islands. Technical report series 'A', No. 55, Hydrology of Andaman and Nicobar Islands and Ground water Development Prospects, 2000: Central Ground Water Board, Eastern Region, Ministry of water resources, Calcutta

Kar, A. 2006: Abridged report with strategies, recommendations and guidelines for development of ground water resources and rain water harvesting post- Tsunami, as per different hydrogeological situation, in the water sheds of Andaman and Nicobar Islands, Technical report series D, No. 189

Brahma, S., Kar, A. 2009: Ground water management studies in Baratang Island and parts of middle Andaman Islands, South & North-Middle Andaman District, A & N Islands, Technical report series D, no. 216

Gayen A, Kar Amlanjyoti, 2013: Ground water information booklet North-Middle Andaman District, A & N Island, Government of India, Ministry of Water Resources, Scientific report series 'E' Serial No. 47

Roy Indranil, Chakraborty S., Kar A. & Pati G. C.,2014: Groundwater Hydrogeology of Andaman and Nicobar Islands. Proceedings of the Workshop on Conservation of Water Resources in Andaman & Nicobar Islands: Issues and Challenges; Central Ground Water Board at Port Blair, A & N Islands,

State Specific Action Plan (SSAP) for Water Sector in Andaman and Nicobar Islands, 2020: ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Island