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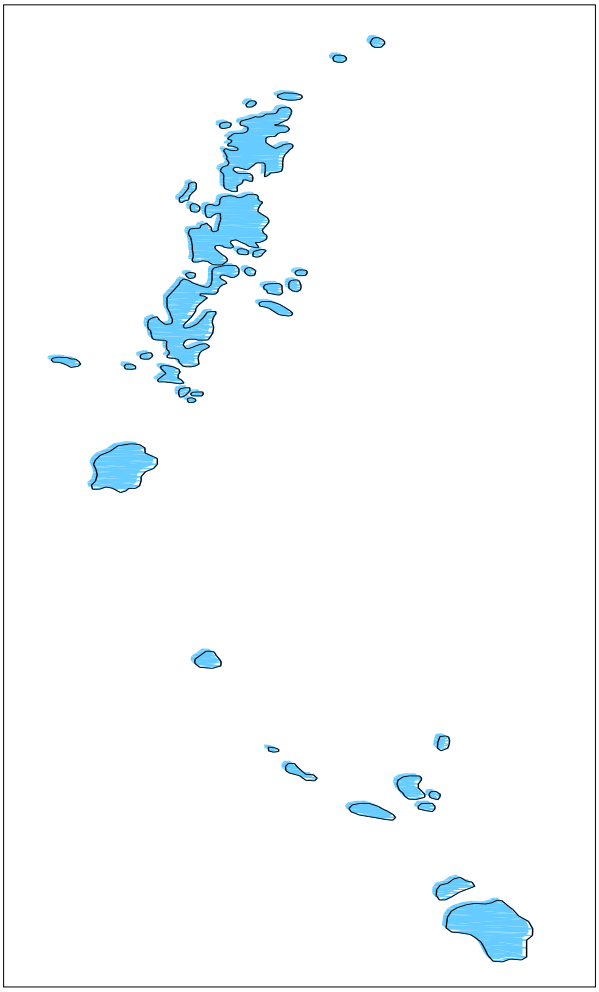
Government of India

Ministry of Jal Shakti

Department of Water Resources, River Development & Ganga Rejuvenation

DYNAMIC GROUND WATER RESOURCES ASSESSMENT OF ANDAMAN & NICOBAR ISLANDS

(As on 31st March, 2020)



CENTRAL GROUND WATER BOARD

EASTERN REGION, Kolkata

July, 2021

PREFACE

The A&N islands comprise an arc-shaped chain of islands in the Bay of Bengal and are characterized by rugged topography, steep slope, low infiltration capacity and close proximity of hills to the sea. Entire islands are occupied by various rock types like marine sedimentary rocks, extrusive and intrusive igneous rocks and coralline limestone. Marine sedimentary rocks are covering 70% area of the total area of islands. The igneous and sedimentary groups of rocks are highly fractured and fissured on account of tectonic activities took place in this area. The geological characteristics of the islands are widely varied and even changes within a short distance.

As per 2011 Census, out of 572 islands present in the Andaman and Nicobar group of islands in the Union Territory of A & N Islands, about 29 are inhabited. The islands receive on an average 3000 mm rainfall per annum, but steep slope does not allow recharging this to the ground water bearing aquifer. In rural areas of Andaman group of Islands and Great Nicobar Island in Nicobar district springs also form dependable sources of drinking water supply, while in the islands like Neil, Havelock, Long island, Little Andaman islands in Andaman group and in major parts of Nicobar group of islands, water supply is catered through dug wells. Although the major rock formation i.e. the sedimentary rock formation possesses good fractures, but they do not form potential aquifers both in shallow and deeper horizons due to preponderance of clay minerals and clogging of fractures by the clayey products. Dug wells constructed in the weathered horizons are yielding meager quantity of water. In the valley areas, dug wells are constructed which are used as a supplementary sources of drinking water in the rural areas of Andaman group of islands. The water supply to Port Blair city is met from the Dhanikhari Dam whose supply is often shattered with the recession of the monsoon rainfall. The scattered dug wells in the city often play a vital role to overcome the severe water crisis. These sources of ground water are becoming polluted by the anthropogenic activities. The loss in surface area in some of the highly earthquake devastated islands during 26th December 2004 have made possible changes in freshwater volume in the islands.

Scientific utilization of groundwater in this Island territory needs assessment of ground water resources from time to time keeping in view of its changes with increase in population, irrigated agriculture and emerging tourism. This also warrants an evaluation of the availability, demand and projected demand scenarios of ground water in the islands. However, ground water being at the state of constant flow, assessment procedure becomes highly complicated involving several variables, which are not possible to measure directly. Nevertheless, the effort towards estimation of ground water resources is to cast at a glance over the existing status of ground water scenario of the A&N islands is pivotal for formulation of developmental strategies and proper planning. This report is the outcome of the efforts made by Dr. A.K. Sinha, Scientist 'B' (Geophysics), Shri Anirvan Choudhury, Scientist-'B'(Hydrogeology) and Shri Awadhesh Kumar, STA(HG), Central Ground Water Board, Eastern Region towards assessment of dynamic component of ground water resources available in the unconfined aquifers of the Island territory of this UT.

As per the present estimation, Andaman and Nicobar islands has Dynamic ground water resource in the tune of **28492.06 ham**.

Place : Kolkata
Date : 30.06.2021

Regional Director
Central Ground Water Board
Eastern Region, Kolkata

CONTENTS

1. INTRODUCTION

a. Background for estimating the total ground water resources of the Union Territory

The Union Territory of Andaman and Nicobar Islands form N-S trending archipelago in the far flung maritime areas of Bay of Bengal. It lies between 6^0 and 14^0 North Latitudes and 92^0 and 94^0 East Longitudes and covers a geographical area of 8249 sq. km. There are three (3) Districts comprising nine (9) Blocks/Tehsils. The islands form two major groups, popularly known as Andaman Group or Northern Group of Islands which constitutes Andaman District where as the other group is called Nicobar or Southern Group of Islands constitute the Nicobar District. Andaman and Nicobar Group of Islands constitute this union territory. As per 2011 census the population of Andaman & Nicobar Island is 380591.

Although the islands receive rainfall to the tune of 3000 mm per annum, steep slope disallow proper recharging of the aquifers. Further the ubiquity of sedimentary rocks in over 70% of the geographical area and abundance of clay minerals in them prohibits good rainfall recharge. Hence potential aquifers both in shallow and deeper horizons could not be formed. Igneous and coralline limestone although possess less geographical areas (15% each) are having good yields of ground water. Springs could be seen abundantly in the islands and they cater to the drinking water supply in the rural areas of Andaman group of Islands and Great Nicobar Island. Dug wells are extensively used in Neil, Havelock, Long island, Little Andaman islands in Andaman group and in major parts of Nicobar group of islands. The water supply to Port Blair Municipal City is met from the Dhanikhari Dam whose supply is often dwindled with the delay in monsoon. The dug wells in the city often play a vital role to overcome the severe water crisis.

Scientific utilization of groundwater in this Island territory needs assessment of groundwater resources from time to time keeping in view of its changes with increase in population, irrigated agriculture and emerging tourism. This also warrants an evaluation of the availability, demand and projected demand scenarios of ground water in the islands. However, ground water being at the state of constant flow, assessment procedure becomes highly complicated involving several variables, which are not possible to measure directly. Nevertheless, the effort towards estimation of ground water resources is to cast at a glance over the existing status of ground water scenario of the A & N Islands for formulation of developmental strategies and proper planning.

Administrative Base map showing major islands of Andaman and Nicobar group of islands is shown in **Plate-1** and Administrative set-up of Andaman and Nicobar Islands is depicted in **Table-1.**

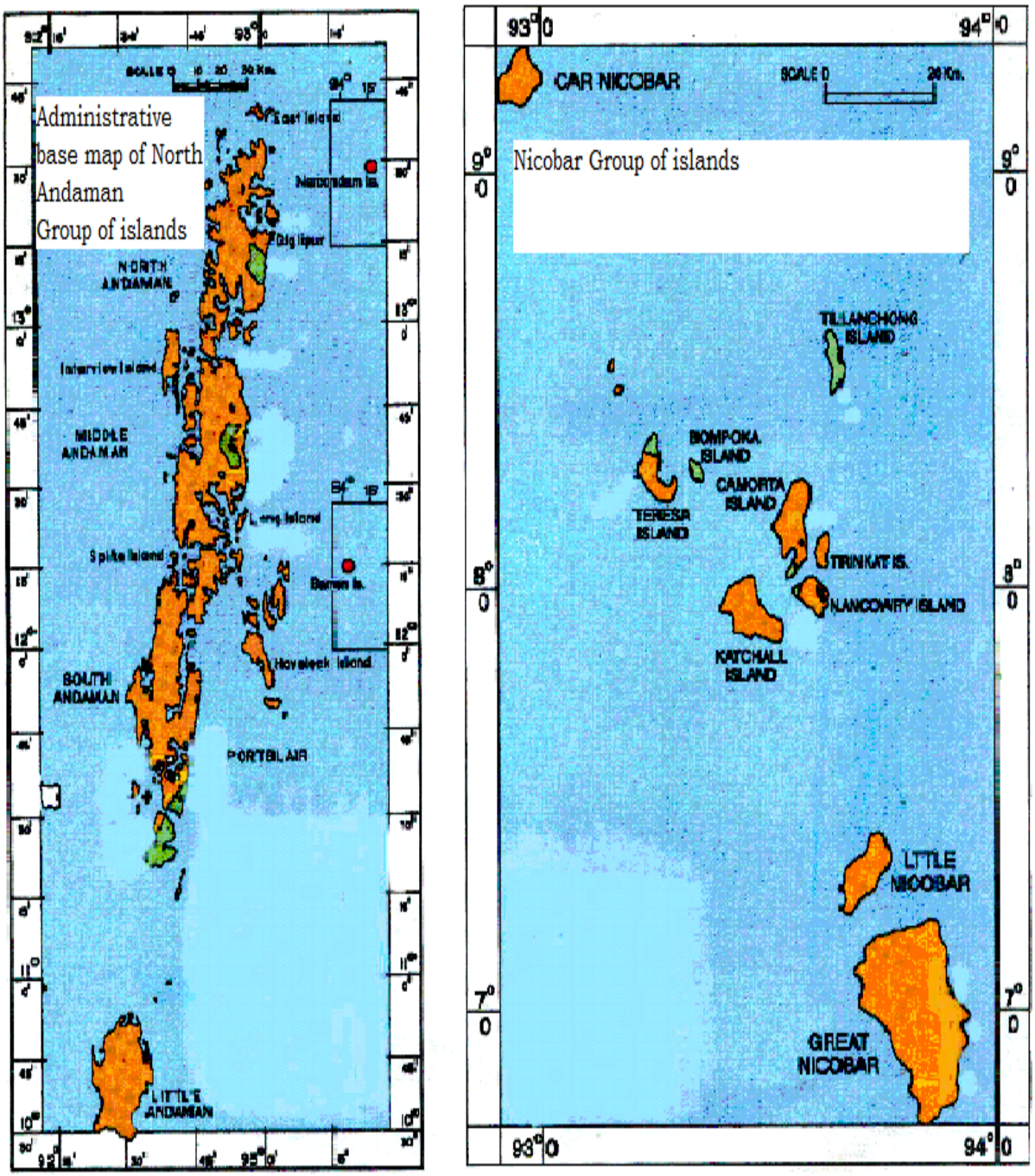


Plate-1: Administrative map showing major islands of Andaman and Nicobar Group of Islands

Table-1: Administrative set-up of Andaman and Nicobar Islands

District	Name of Block/Tehsil	Islands
North and Middle Andaman	Mayabunder	North Andaman (Mayabunder Tehsil) Stewart Island Aves Island Interview Island
	Rangat	Middle Andaman North Passage Island Long Island Porlob Island Baratang Island Strait Island
	Diglipur	Peel island Narcondam Island East Island North Andaman (Diglipur Tehsil) Smith Island
South Andaman	Port Blair	Havelock Island John Lawrence Island Neil Island South Andaman (Port Blair Tehsil) Rutland Island North Sentinel Island Little Andaman Island
	Ferrargunj	South Andaman (Ferrarganj Tehsil) Flat Bay Island Viper Island
Nicobar District	Car Nicobar	Car Nicobar
	Nancowry	Chowra Tillangchang Teressa Bampooka Katchal Kamorta Nancowry Trinket Little Nicobar Kondul Pulo Milo Great Nicobar

b. Constitution of state-level committee for ground water resources estimation as on 31st March 2020

By considering similarity of purpose, the Andaman and Nicobar Administration is of view to continue with earlier committee formed for dynamic water assessment 2017 vide order No. 3462, dated 09.11.2018, in connection with reassessment of Dynamic Ground Water Resource 2020 as desired by Ministry of water Resources, River Development & Ganga Rejuvenation, Central Ground Water Board vide Letter No. 29-20/2018-PWD/1266, dated 03.12.2020. The composition of the Committee is as under:

1.	Principal Secretary (PWD)	-	Chairman
2.	Secretary (Department of Science & Technology)	-	Member
3.	Chief Engineer, APWD	-	Member
4.	Superintending Hydrogeologist, CGWB	-	Member
5.	Director (Agriculture)	-	Member
6.	Director (Industries)	-	Member
7.	Director (ANSWSM), CE's Office, APWD	-	Member
8.	Representative from NABARD	-	Member
9.	Regional Director, CGWB	-	Member Secretary

Charter

- Under the directive of MoWR, Dynamic groundwater (GW) resource assessment of entire country has been continuing following Groundwater Estimation Committee (GEC) norm-1997.
- The assessment is done by CGWB, the apex GW organization in MoWR in liaison with the concerned State/UT Govt./Administration where Ground Water Research and Development Department is existing.
- The GEC-1997 had continued till 2013 for groundwater resource assessment for the entire country.
- The GEC-1997 norm has been modified in 2015 as per the directive of MoWR and regarding the GW Resources assessment as per GEC-2015, MoWR has directed CGWB to approach all state/UT Govt. to assess the GW resources for 2017.
- Since rainfall is the prime source of recharge to GW and the rainfall for the entire year of 2019-2020 is available, the GEC committee has recommended to MoWR to assess it for a calendar year 2019-2020 ending in31.03.2020.
- In A & N Islands, the resource is calculated by CGWB in the absence of R & D Department on GW in A & N Administration. CGWB renders all needful help in matter of Water Resource Development and Management, particularly GW to A & N Administration.
- Since ground water is a scarce commodity in A & N Islands, as also in view of extreme population pressure on the Islands due to tourism boom, CGWB, Govt. of India has recommended GW Resource estimation in A & N Islands at a regular interval as in other parts of India.
- MoWR had earlier desired to calculate the GW Resources of the entire country including A & N Islands.

- As per this norm, the State/UT-wise Dynamic Groundwater Resources are being estimated at regular interval.
- The basic groundwater resource assessment unit is an Administrative block. In some cases i.e. in few north-eastern states, where block boundaries are not defined, the assessment is done as per watershed basis.
- In A & N Islands, it is done island-wise for the inhabited islands.
- The GW Resources of A & N Islands, being assessed, need to be put forward before a committee for their understanding it as also to know the status of GW Resource development in various inhabited Island.
- In A & N Islands, APWD is the nodal Stake holder Department beside others. Accordingly the name and head of various stake holder departments are proposed for constitution of a committee with the approval of the competent authority in A & N Administration.
- In view of above the task was given by MoWR to CGWB for needful.
- A & N Island falls under the jurisdiction of CGWB, Eastern Region, Kolkata is already on the job for calculation of Dynamic Groundwater Resources of A & N Islands.

The final report on Dynamic Ground Water Resources of A & N Islands as on 31st March 2020 is prepared by considering suggestions provided by the expert committee. The major propose are as follows:

- Ground water draft per person per day as per APWD - 55 lit
- Non-monsoon recharge by ponds -60 days out of 125 days of non-monsoon period.

2. HYDRO-GEOLOGICAL CONDITIONS OF ANDAMAN AND NICOBAR ISLANDS

2.1 GEOLOGY

Geologically marine sedimentary group of rocks comprising shale, sandstone, grit and conglomerate; extrusive and intrusive igneous rocks (volcanic and ultramafic) and coralline atolls and limestone occupy the entire geographical area. Amongst these, the Sedimentary Group is most pervasive and occupy nearly 70% of the entire area of the islands while the igneous group covers nearly 15% while the rest 15% goes to the coralline and limestone formations. All these rock formations have been subjected to chain of tectonically active zone, evident from the occurrence of shallow and deep focus earthquakes in the islands. Because of tectonic activity, the Igneous and Sedimentary group of rocks are highly fractured and fissured. These fracturing in hard rock form conduits for movement of ground water in the deeper horizon. The geology of the islands is highly varied within a small distance.

Late Cretaceous igneous rocks, the ophiolite suite, marine sedimentary rocks of Paleocene to Oligocene age and Recent to Sub-Recent beach sand, mangrove clay, alluvium and coral rags are predominant in the area. The Ophiolite suite of rocks comprises a wide variety of acidic to ultrabasic plutonic rocks and their equivalent basic volcanic rocks occur in sporadic patches in both Andaman and Nicobar Group of Islands.

Other rock types, white clay beds and raised coralline limestone are of late Pliocene to Pleistocene age. The rocks of this group are generally rendered good aquifers due to krastification. The ophiolite and marine sedimentaries have undergone different phases of folding, faulting. The area is considered to be orogenically active even today. The generalized geological succession of Andaman and Nicobar Islands is given in **Table-2**.

Table-2: Generalized Geological Succession of Andaman & Nicobar Islands

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

2.2 RAINFALL

In the current decade the rainfall distribution has become highly whimsical and dwindling. Prior to 1990 the rainfall used to commence from 1st week of May every year while now it is receded to 1st week of june as happened in 2001, 2002 and 2003. In 2004 the rainfall in Andaman District has been close to normal. However, the Tsunami devastated Southern Group of Islands are not receiving appreciable rainfall. The annual rainfall of Andaman and Nicobar Islands in year 2019 is **2954.43 mm**. Since the islands are isolated, having wide variation in rainfall, hence preparation of iso-hyetal map is not feasible.

2.3 CLIMATE

The area enjoys tropical humid climate due to its geographical location. Relative humidity ranges from 79% to 89%, average wind speed is 7 to 10 km/hr, maximum temperature varies between 27^0 to 33^0C and minimum temperature fluctuates between 21° to 25° C. Evaporation rate is very high, i.e. 1500-1800 mm/year because of situation of the archipelago close to the equator i.e. 6^0N to 14^0N**.**

2.4 HYDROGEOLOGY

Hydro-geologically, there are three major formations in the Andaman and Nicobar Group of Islands:

a) Porous formation consist of beach sand with coral rags and shale,
b) Thin cover of alluvium in the valleys and foot hills adjacent to valleys
c) Moderately thick pebbly valley fill deposits (colluvium) in the narrow inter-montane valley constitute the water table aquifer.

The thickness of beach sand and alluvial deposits ranges between 3 to 6 m. and sometimes ranges up to 9 m. In Great Nicobar the thickness is thinner, only 2 to 2.5 m. The colluvial deposits in narrow inter-montane valley e.g., Beadnabad valley have much higher potentiality. One bore well of 152 mm diameter was drilled by CGWB down to 16.50 mbgl tapping the total thickness of the saturated colluvial deposits and yielded 72 m^3/hr. and pumping for 500 minutes did not show any deterioration in chemical quality. The drawdown was recorded as 5.67 m and Transmissivity was calculated as 127m^2/day. The well could cater to the domestic need of 10000 rural populations.

The fissured formation consists of the Upper Cretaceous Ophiolite Suite of rocks including the basic volcanics, the ultrabasic and intermediate to acid plutonic rocks. Based on the compactness and fracturing of these rocks as revealed by exploratory drilling carried out in parts of the island the rocks are again classified as consolidated group and semi consolidated group. The fractured upper Cretaceous igneous rocks and the Lower Tertiary conglomerate, grits, graded sandstone (greywacke) and their weathered upper mantle form the aquifers, the weathered mantle is seldom 3 to 4 m thick but adjacent to the valleys it is about 6 m. The saturated thickness of the weathered mantle and the immediately underlying shallow fracture zones form the

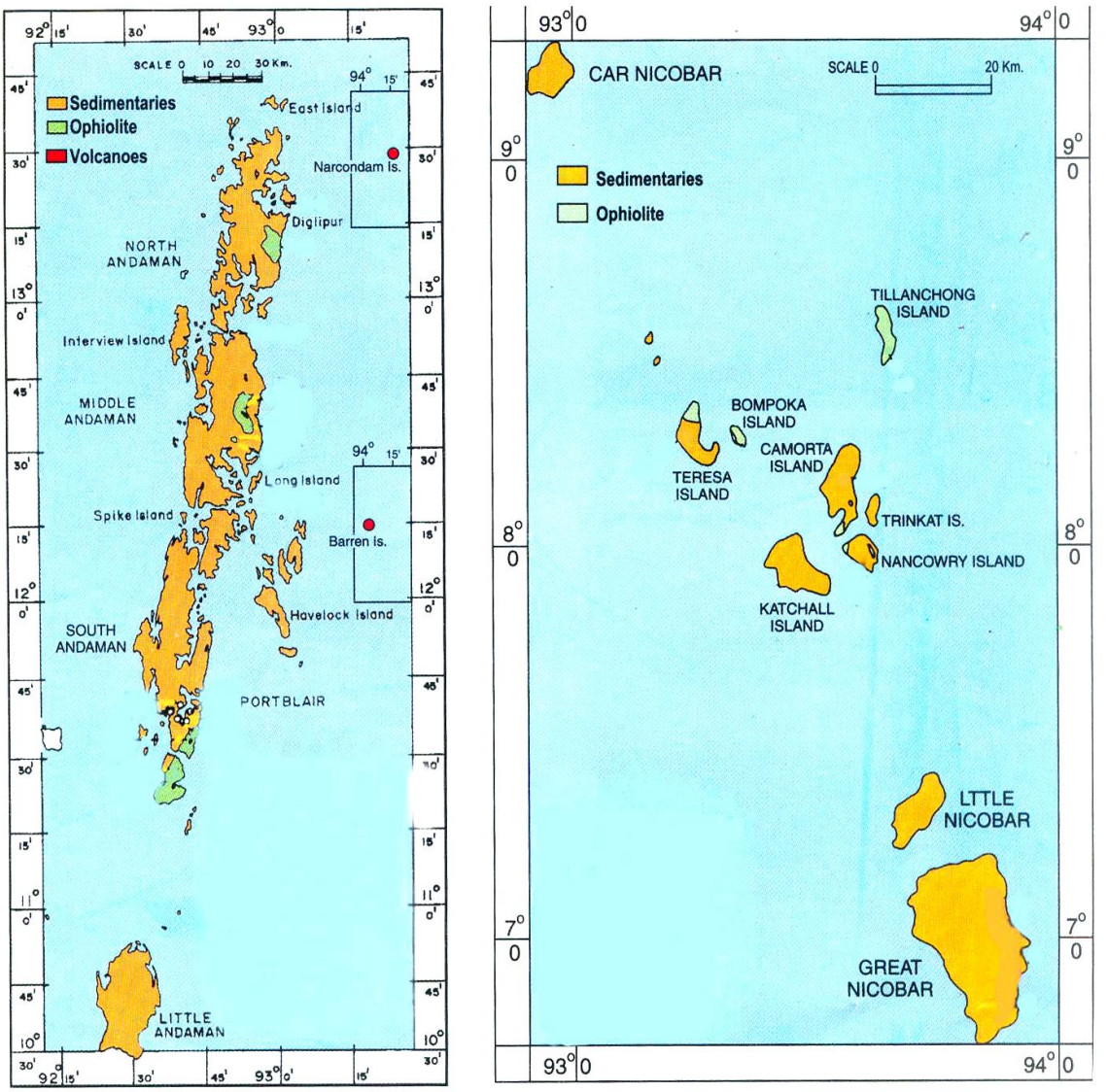
water table aquifer. Deeper fracture zones within 60 m below ground level form semi-confined to confined aquifer. The generalized geological succession of Andaman & Nicobar Islands has been given in Table-2 and Geology and Hydro-geological map of the islands is shown in plate-2.

The fractured volcanic rocks at places e.g. Brichganj, Hamfreganj are not productive as the yield of the tube wells were in the order of 1.18 m^3/hr and 0.52 m^3/hr respectively. It appears that the fractured volcanic rocks are most productive where they are intruded by the ultrabasics. The area covered by the fractured sedimentary rocks, 13 exploratory bore holes were drilled and 2 bore holes were found successful i.e. at Potheropore and Dithaman Tank. At both the places Mithakari Sandstones and Shales were encountered, the productive fracture zones at Prothrapore between 25 to 60 meter, but yielded 17 m^3/hr water which is brackish. The borehole at Dilthaman Tank yielded very less but EC value was less and water potable. The boreholes drilled at other places in the sedimentary rocks through dark grey shale of Mithakari Group were found dry.

It is apparent from the study that the weathered sandstone are poor aquifers whereas the weathered volcanic rocks act as moderate to good aquifers at suitable locales. Results of 18 exploratory bore wells in South Andaman show that the deeper fractures imparting secondary porosity and permeability are restricted within 60 m bgl in sedimentary rocks and within 52.7 m in the volcanic and the intermediate plutonic rocks. The most productive fracture zones are in the volcanic rocks as noticed at Calicut in the depth range of 14-20 m, and 45-52 m where an intrusion of ultrabasic rock (Serpentinites) was noticed. The yield of the bore well was recorded as 44.67 m3/hr, draw down after 500 minutes of pumping was 8.23 m, Transmissivity was calculated and found to be 39.6 m^2/day.

The area covered by semi consolidated Lower Tertiary sedimentary rocks in the Great Nicobar Island were also explored and found the thin bedded fine grained sand stone – clay stone alternation cannot be properly termed as aquifers. The maximum discharge obtained by tapping 31 m thick fine grained, soft argillaceous sand stone within 20 - 92 m bgl, was 187 litre/hr and quality of water was found good. Better discharge has been found in the same Island, but the quality of water was brackish (EC 4503 µS/cm at 25^0 C).

Plate-2: Geology and Hydrogeology of Andaman & Nicobar Islands



Geology and Hydrogeology of A&N Islands

Sedimentary Formations including Coralline Formations and limestones :
Sedimentaries are poor water yielders both in shallow and deeper horizons Borewells are not Feasible, Dugwells yiela poor to moderate, Springs yield moderately, Drainage density high, rain water harvesting through check and sub surface dam s, ponds feasible; Coralline Formations and limestones form prolific ground water reservyrs in shallow to moderately deep horizons, Dugwells pre-ponderant, springs highly emanating.

Volcanics and Ophiolitses (Igneos formations):
Highly fractured formations, potential fractures avaiable upto 60m. , Borewells, Dugwells, ponds are feasible. High discharging perennial springs available.

Ground water level conditions – water level, fluctuation, trend

In sedimentary rock in valleys and adjacent to Bays, depth of dug wells are generally restricted to 3.5 to 4 m bgl, depth to water level in the dug wells in valleys 2.5 to 2.75 m, and in the igneous rock in same physiographic unit depth to water level generally less than 3 mbgl, with a seasonal fluctuation around 1.5 to 2.5 m. Sp. Capacity of lower Tertairy Sandstone, was found very low in the range of 1.12 to 2.61 lpm/m, in the weathered volcanic rock sp. Capacity values was in the order of 0.79 and 9.55 lpm/m.

During pre-monsoon in 2019, minimum water level 0.38 mbgl at Port Blair in South Andaman and maximum of 14.12 mbgl at Bednabad (Tube-well) in South Andaman have been recorded; during post-monsoon 2019, maximum water level of 9.10 mbgl at Calicut in South Andaman and a minimum of 0.44 mbgl in Knoppuram also in South Andaman have been recorded. Average depth to water level in respective islands is as follows:

Table 3: Average depth to water level in different islands

Islands	South Andaman	M. Andaman	N. Andaman	Long Island	Havelock Island	Neil Island
Pre-monsoon 2019	2.42	1.57	2.04	2.28	2.61	4.68
Post-monsoon 2019	1.41	0.85	0.51	0.74	1.90	3.70
Fluctuation 2020	1.02	0.72	1.53	1.54	0.71	0.98

In order to study the behaviour of ground water regime with time and space in Andaman & Nicobar Islands, 112 Hydrograph Monitoring Stations were established in seven islands, viz. South Andaman, North Andaman, Middle Andaman, Long Island, Havelock Island and Neil Island. Periodic water level measurements are being taken 2 times in the year, for pre-monsoon period during May and for the post-monsoon period during December.

Ground water quality

The quality of ground water throughout the island is neutral to alkaline as envisaged from the analytical results of water samples collected from the existing monitoring stations and reference wells (all dug wells). It is generally of the calcium bicarbonate type, and the bicarbonate content varies from 91 to 427 ppm greatly predominates over the chloride content varying between 14-202 ppm. Computation of the chloride-bicarbonate ratio of ground water from the islands show that the ratio varies between 0.1 to 0.2 which indicates that there has been no large scale saline water intrusion at any place in the islands. In general the ground water is fresh with low mineralization having Electrical Conductivity (EC) ranging from 292 to 1120 μs /cm at 25^0 C, baring a few cases eg.1340 μs/cm at 250 C at Marina Park, (South Andaman) and at Sitanagar, (North Andaman), > 200 μs /cm at Saitankhari (South Andaman). Iron concentration in ground water are mostly within the permissible limit, except Namunanagar (1.36 ppm), Light House (2.15 ppm), at Annicut (2.59 ppm). As the islands are located in scattered manner, preparation of EC map is not logical in this hydro-geological set up.

3. Ground Water Resource Estimation Methodology – GEC' 2015 - brief description

In India, first attempt to estimate the ground water resources on scientific basis was made in 1979. A High Level Committee known as Ground Water Over Exploitation Committee was constituted by Agriculture Refinance and Development Corporation (ARDC). This committee had estimated GW resources of the country however recommended that the methodology should be revised with increasing availability of data to make it more scientific. Accordingly, the Ground Water Estimation Committee (1984) came up with a revised methodology based on water balance approach (GEC–1984) for assessment of ground water potential and evolved new norms. In 1997 further refined methodology of ground water resource estimation has been proposed (GEC-1997). In 2015 an analytical and more refined methodology of ground water resource estimation has been proposed (GEC-2015).

The methodologies adopted for computing ground water resources are generally based on the hydrological budget techniques. The hydrologic budget technique is a specialised form of water balance equation that requires quantification of the processes of inflow and outflow from a ground water reservoir, as well as of changes in storage. A few of these parameters are directly measurable; some may be determined as a derivative of measured values or through some indirect methods of estimation.

3.1 Salient Points of GEC - 2015

- **Assessment Unit**
  Hard Rock – Watershed, as inflow/outflow across watershed boundaries is negligible.
  Alluvial Areas – Administrative Block
- **Hilly areas** having slope ≥ 20% are not considered; **in some islands huge area possesses slope ≥ 20%.**
- Where the assessment unit is watershed, ground water assessment is converted in terms of an administrative unit by converting the volumetric resource into depth unit & then multiplying this depth with the corresponding area of the block.
- Each unit is to be delineated into command & non-command areas. Ground Water assessment in command & non-command areas are done separately for monsoon and non-monsoon season.
- Mainly two approaches at present
  A) Ground Water fluctuation method, which is based on is based on ground water balance equation i.e. (input-output = storage). For assessing this equation, various components are assessed separately for monsoon and non-monsoon seasons as well as separately for command and non-command areas using norms recommended by GEC 1997.

  B) Rainfall infiltration method, recharge assessment is done only when data of sufficient duration is available. Overall components are computed separately for monsoon and non-monsoon seasons and for command and non-command areas.

In GEC-2015, the threshold limit of minimum and maximum rainfall event which can induce recharge to the aquifer is to be considered while estimating ground water recharge using rainfall infiltration factor method. It is suggested that 10% of Normal annual rainfall may be taken as minimum rainfall threshold and 3000 mm as maximum rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall is to be deducted from the monsoon rainfall and balance rainfall would be considered for computation of rainfall recharge. The same recharge factor may be used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall may be taken as zero, if the normal rainfall during the non-monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non-monsoon rainfall may be estimated for normal rainfall, based on recent 30 to 50 years of data.

3.2 Basic Steps of Groundwater Resources Assessment

- Demarcation of assessment units/sub-units: units - block (predominantly alluvial states), watershed (pre-dominantly hard rock states)/sub-units within assessment units-command, non-command, poor quality area;

- Computations of season-wise (monsoon & non-monsoon) gross ground water draft;

- Computations of season-wise (monsoon & non-monsoon) recharge from other sources – recharge from canal seepage, surface water and ground water irrigation, recharge from tanks & ponds, recharge from water conservation structures. Recharge from other sources is estimated using norms recommended;

  In A & N Islands, ponds are mostly of same size: 30m*22m*3m

- Computation of season-wise (monsoon & non-monsoon) rainfall recharge

  - Monsoon rainfall recharge: using two methods namely Water level fluctuation method and Rainfall Infiltration Method

  - Non-monsoon rainfall recharge: using Rainfall Infiltration Method.

- Annual Replenishable Ground Water Resources: sum-total of Monsoon and non-Monsoon ground water recharge

- Allocation for Natural Ground Water Discharge during Non-Monsoon season:
  5 -10% of Annual Replenishable Ground Water Resources; **as Andaman & Nicobar Islands show high slopy areas, therefore Natural Ground Water Discharge of 10% of Annual Replenishable Ground Water Resources has been considered**.

- Net Annual Ground Water Availability: Annual Replenishable Ground Water Resources – Allocation for Natural Ground Water Discharge.

- Stage of Ground Water Development = $\frac{\text{Gross Annual Ground Water Draft}}{\text{Net Annual Ground Water Availability}}$

- Categorization of Assessment units based on - Stage of Ground Water Development and long term Water Level Trend as enumerated below

  The categorization of Assessment Units is shown in **Table-4.**

Table 4: Categorization of Assessment units

Sl. No.	Stage of Ground Water Development (%)	Significant Long term Decline		Categorization
		Pre-monsoon	Post-monsoon	
1	≤ 70%	No	No	SAFE
		Yes/No	No/Yes	To be re-assessed
		Yes	Yes	To be re-assessed
2	> 70% and ≤ 90%	No	No	SAFE
		Yes/No	No/Yes	SEMI- CRITICAL
		Yes	Yes	To be re-assessed
3	> 90% and ≤ 100%	No	No	To be re-assessed
		Yes/No	No/Yes	SEMI-CRITICAL
		Yes	Yes	CRITICAL
4	> 100%	No	No	To be Re-assessed
		Yes/No	No/Yes	OVER- EXPLOITED
		Yes	Yes	OVER- EXPLOITED

Note:

1. 'To be re-assessed' means that data is to be checked for the purpose of categorization.
2. **The long term ground water level data should preferably be for the period of 10 years.**
3. The significant rate of water level decline may be taken between 10 and 20 cm per year depending upon the local hydro-geological conditions.
4. However, for all practical purpose, in contrast to GEC-1997 methodology, under GEC' 2015 Methodology, only the stage of ground water development will be taken into consideration for assigning categorization of assessment unit.

5. Procedure followed in the present assessment including assumptions and Computation of Ground Water Resources Estimation in Andaman and Nicobar islands

- As per the GEC norm the watershed or administrative unit could not be applied here since the islands are generally separated. For these reason respective Island wise water resources were calculated. Here Islands are forming the units. There are 36 Islands, which were previously dwelled by people. But, as per Census 2011, habitation has been encountered only in 29 islands. Therefore, the task of ground water resource estimation has been taken into consideration only in these 29 islands. As there is wide variation in lithology, rainfall infiltration also varies; so, the range of rainfall infiltration factor as utilized during the resources calculation varies from 0.04 to 0.22. Total Annual rainfall in Andaman and Nicobar Islands for the year 2019 is 2954.43 mm. During calculation, the inter-montane valley and relatively flat topographical areas are considered as recharge areas. The hilly areas (573770 ha) having slope more than 20% are deducted from the geographical area available in the inhabited islands. The rechargeable area in the inhabited island is 211387 ha out of total geographical area of 785157 ha. Since water level data of all the Islands are not available, the rainfall infiltration method is adopted for computation of annual replenishable ground water resource. As Andaman and Nicobar Islands show high slopy areas, therefore, Natural Ground Water Discharge of 10% of Annual Replenishable Ground Water Resources has been considered. In present area, all the ponds constructed by irrigation department are of similar size of 30m*22m*3m; also, in these islands rainfall takes place for about 8 months i.e. 240 days and the rest i.e. 125 days are non-rainfall days as suggested by APWD. For recharge by ponds, 1.44mm recharge by one hectare in one day has been considered.

- During meeting with the members of SGGWCC on **G W assessment as on 31st March 2020,** Director, ANDW&SM, A & N Islands opined that during non-monsoon period in A & N Islands ponds contain water for 60 days out of 125 non-monsoon days as said before and as per his suggestion, calculation of recharge by ponds in non-monsoon has been carried out accordingly. Also, APWD opined that 55 litres should be considered for calculation of ground water draft per person per day as the organization is following the same in practice.

- In South Andaman, water for domestic need is made available by APWD from the storage of Dhanikhari Dam; accordingly, calculation for G W draft for domestic purpose is considered as '0'.

  The deduced figures of Ground Water Assessment of Andaman and Nicobar Islands are presented in the **Table-5** as on 31st March 2020.

Table 5: Important figures of G. W. Assessment of A & N Islands as on 31st March 2020

Ground water Assessment year & Unit	**2019-2020 & Islands**
Total annual ground water recharge	**31551.31 ham**
Net annual ground water availability	**28492.06 ham**
Current Annual Gross Ground Water Draft for drinking and industrial purpose	**739.49 ham**
Annual allocation of ground water for domestic water supply up to 2025	**694.73 ham**
Available ground water for future use for irrigation and industries	**27688.35 ham**
Stage of Ground Water development	**0.0 % to 18.34 %**
Categorization for future ground water development	**Safe**

The available calculation and record suggested that the net annual ground water availability is 28492.06 ham, and 694.73 ham is allocated for domestic use upto year 2025.

Per capita consumption is taken as 55 lpcd. The available ground water for future use for irrigation and industries is 27688.35 ham and the stage of development ranges between 0 % to 18.34 **%.**

As regards the static ground water resources, since detailed drilling data is not available to ascertain the average depth of saprolite (weathered mantle) and fractured horizon, it could not be attempted.

6. COMPUTATION OF GROUND WATER RESOURCES IN ANDAMAN AND NICOBAR ISLANDS

a. Salient features of the dynamic ground water resources assessments including the type assessment units, total number of assessment units in the state, base-year of collection of data, year of projection of data

i) Assessment Unit: Inhabited islands of Andaman and Nicobar islands.

ii) Assessment Sub Unit: Non-Command area in the 36 Islands (29 inhabited islands) of Andaman and Nicobar group of islands.

iii) Total number of Assessment Units in Andaman and Nicobar islands:
36 Islands (29 inhabited islands) of Andaman and Nicobar group of islands.

iv) Total Number of sub units: 36 Islands (29 inhabited islands) of which, all are non commands.

v) Base Year of Collection of Data: 2019-2020

b. Assessment sub-unit-wise method adopted for computing rainfall recharge during monsoon season (WLF/RIF)

Rainfall infiltration (RIF) method has been adopted for computing rainfall recharge during monsoon as well as non monsoon.

c. The total resources of the state, existing development, balance available for future development, stage of development, categorization of assessment units and other relevant salient features of the resources assessment in the state

For estimation of dynamic ground water resources of Andaman and Nicobar islands, Rainfall infiltration Factor (RIF) has been adopted for computation. Total 36 Islands (29 inhabited islands) have been taken into account for ground water resource calculation. These 36 islands are belonging to three districts namely North & Middle Andaman district, South Andaman district and Nicobar district. For three districts stage of ground water development ranges from **0.0 % to 18.34 %.** All the islands are coming under safe category.

d. Spatial variation of the Ground water recharge and development scenario in the State/ district-wise:

District wise variations of recharge from rainfall during monsoon have been assessed. Total annual recharge in the Andaman and Nicobar Island is estimated as **31551.31** ham and total natural discharges is calculated as **3059.25** ham. Net ground water availability of the island is estimated as **28492.06 ham.**

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

The loss in surface area in some of the highly earthquake devastated islands have made possible changes in freshwater volume in the islands. In 11 (Eleven) islands parts of their area have been submerged due to tsunami/earthquake effect. It's important to note that parts of the Andaman group of islands and the entire Nicobar group of islands were subsided during the plate collision and submerged. Net availability of ground water resources have been increased in comparison to the values obtained in previous ground water resource estimation in the islands in 2011, 2013 and 2017.

Table - 7: Comparison of the Estimate 2011, 2013 and 2017

Comparative Criteria	Resource Assessment 2012-13 (ham)	Resource Assessment 2016-17 (ham)	Resource Assessment 2019-20 (ham)
Total annual ground water recharge	41449.03704	33157.6484	**31551.31**
Net annual ground water availability	37304.1333	32131.5236	**28492.06**
Current Annual Gross Ground Water Draft for drinking purpose	573.5286975	908.1757	**739.49**
Annual allocation of ground water for domestic and industrial water supply up to next 25 years	1135.6245	711.1960	**694.73**
Available ground water for future use	36153.92984	30512.1517	**27688.35**
Stage of Ground Water development	0.005% to 10.09%	0.0 % to 10.13 %	**0.0 % to 18.34 %**
Categorization for future ground water development	Safe	Safe	**Safe**

f. Ground water recharge in the poor quality zone

The topography of Chowra Island is such that whatever may be the rain fall gets recharged does not reside into the aquifer and it immediately gets discharged into the sea.

g. Additional annual potential recharges

In all the assessment units, computation of rainfall recharge during monsoon and non monsoon has been computed using only Rainfall Infiltration Method (RIF). So, Percent Deviation (PD) factor as per the guidelines by GEC'97 methodology does not arise here.

General description of the ground water assessment unit, recharge from rainfall, recharge from other sources, natural discharge and annual extractable ground water resource of the Andaman and Nicobar islands (as on 31st march 2020) is shown in **Annexure-I**. Ground water extraction, annual ground water allocation for domestic Use as on 2025, net ground water availability for future use, stage of ground water extraction and categorization assessed in dynamic ground water resources of the Andaman and Nicobar islands (as on 31st march 2020) is given in **Annexure-II**.

References

Central Ground Water Board, 2013: Ground Water Information Booklet, North-Middle Andaman District, A & N Islands, Scientific Report Series "E", Serial No. 47

Central Ground Water Board, 2013: Ground Water Information Booklet, South Andaman District, A & N Islands, Scientific Report Series "E", Serial No. 49

Central Ground Water Board, 2013: Ground Water Information Booklet, Nicobar District, A & N Islands, Scientific Report Series "E", Serial No. 50

Annexure-I

Sl. No	District	Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area(Ha)	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
1	N & M ANDAMAN	AVES ISLAND	20	16	1.54	0	0	0	1.54	0.15	1.39
2	N & M ANDAMAN	BARATANG ISLAND	29760	8200	4353.75	0.13	0	0.03	4353.91	435.39	3918.52
3	N & M ANDAMAN	EAST ISLAND	611	306	88.62	0	0	0	88.62	8.86	79.76
4	N & M ANDAMAN	INTERVIEW ISLAND	13300	2800	270.3	0	0	0	270.3	27.03	243.27
5	N & M ANDAMAN	LONG ISLAND	1790	1102	468.08	0	0	0	468.08	46.81	421.27
6	N & M ANDAMAN	MIDDLE ANDAMAN	153550	18713	1445.17	5.32	0	1.33	1451.82	145.18	1306.64
7	N & M ANDAMAN	NARCONDAM ISLAND	681	361	34.85	0	0	0	34.85	3.49	31.36
8	N & M ANDAMAN	NORTH ANDAMAN	137599	23774	2754.04	4.66	0	1.16	2759.86	275.99	2483.87
9	N & M ANDAMAN	NORTH PASSAGE ISLAND	2196	1006	97.11	0	0	0	97.11	9.71	87.4
10	N & M ANDAMAN	PROLOB ISLAND	845	307	29.64	0	0	0	29.64	2.96	26.68
11	N & M ANDAMAN	SMITH ISLAND	2470	891	86.01	0	0	0	86.01	8.6	77.41
12	N & M ANDAMAN	STEWART ISLAND	723	363	35.04	0	0	0	35.04	3.5	31.54
13	N & M ANDAMAN	STRAIT ISLAND	601	201	106.72	0	0	0	106.72	10.67	96.05
14	NICOBAR	BOMPOOKA ISLAND	1346	506	146.54	0	0	0	146.54	14.65	131.89
15	NICOBAR	CAR NICOBAR ISLAND	12691	7001	3717.15	0.13	0	0.03	3717.31	371.73	3345.58
16	NICOBAR	CHOWRA ISLAND	828	208	0	0	0	0	0	0	0
17	NICOBAR	GREAT NICOBAR ISLAND	104454	94411	9114.01	0.67	0	0.17	9114.85	911.49	8203.36
18	NICOBAR	KAMORTA ISLAND	18803	6001	579.31	0	0	0	579.31	57.93	521.38
19	NICOBAR	KATCHAL ISLAND	17430	6430	620.72	0	0	0	620.72	62.07	558.65
20	NICOBAR	KONDUL ISLAND	466	343	33.11	0	0	0	33.11	3.31	29.8
21	NICOBAR	LITTLE NICOBAR ISLAND	15902	3102	299.45	0	0	0	299.45	29.95	269.5
22	NICOBAR	NANCOWRIE ISLAND	6682	1182	114.1	0	0	0	114.1	11.41	102.69
23	NICOBAR	PULO MILO ISLAND	129	95	9.17	0	0	0	9.17	0.92	8.25
24	NICOBAR	TERESSA ISLAND	10126	1116	107.73	0	0	0	107.73	10.77	96.96
25	NICOBAR	TILLANGCHANG ISLAND	1683	702	372.72	0	0	0	372.72	37.27	335.45
26	NICOBAR	TRINKET ISLAND	3626	726	70.08	0	0	0	70.08	7.01	63.07
27	SOUTH ANDAMAN	FLATBAY ISLAND	936	330	31.86	0.03	0	0.01	31.9	3.19	28.71
28	SOUTH ANDAMAN	HAVOCK ISLAND	11393	3833	417.48	0.33	0	0.08	417.89	20.89	397
29	SOUTH ANDAMAN	JOHN LAWRENCE ISLAND	4198	1008	97.31	0	0	0	97.31	9.73	87.58
30	SOUTH ANDAMAN	LITTLE ANDAMAN	73439	4790	2543.23	0.8	0	0.2	2544.23	254.42	2289.81
31	SOUTH ANDAMAN	NEIL ISLAND	1890	1243	143.99	0.2	0	0.05	144.24	14.43	129.81
32	SOUTH ANDAMAN	NORTH SENTINNEL ISLAND	5967	907	87.56	0	0	0	87.56	8.76	78.8
33	SOUTH ANDAMAN	PEEL ISLAND	435	185	17.86	0	0	0	17.86	1.79	16.07
34	SOUTH ANDAMAN	PORT BLAIR	134820	13197	1488.93	8.65	0	2.16	1499.74	74.99	1424.75
35	SOUTH ANDAMAN	RUTLAND ISLAND	13717	6007	1739.67	0	0	0	1739.67	173.97	1565.7
36	SOUTH ANDAMAN	VIPER ISLAND	50	24	2.32	0	0	0	2.32	0.23	2.09

Annexure-II

S. No.	District	Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-ExploitedE/Critical/Semicritical/Safe/Saline)
1	N & M ANDAMAN	AVES ISLAND	0	0	0.004015	0	0.01	1.38	0	Safe
2	N & M ANDAMAN	BARATANG ISLAND	0	4.501106	13.14913	17.65	14.5	3899.52	0.45042516	Safe
3	N & M ANDAMAN	EAST ISLAND	0	0	0.036135	0.03	0.04	79.73	0.03761284	Safe
4	N & M ANDAMAN	INTERVIEW ISLAND	0	0	0.034128	0.03	0.04	243.23	0.01233198	Safe
5	N & M ANDAMAN	LONG ISLAND	0	0.816944	2.386918	3.21	2.63	417.82	0.76198163	Safe
6	N & M ANDAMAN	MIDDLE ANDAMAN	0.75	44.04292	128.6587	173.45	141.83	1120.02	13.2745056	Safe
7	N & M ANDAMAN	NARCONDAM ISLAND	0	0	0.036135	0.03	0.04	31.33	0.09566327	Safe
8	N & M ANDAMAN	NORTH ANDAMAN	0.054	33.67597	98.37553	132.11	108.45	2341.69	5.31871636	Safe
9	N & M ANDAMAN	NORTH PASSAGE ISLAND	0	0	0.006023	0	0.01	87.4	0	Safe
10	N & M ANDAMAN	PROLOB ISLAND	0	0	0	0	0	26.68	0	Safe
11	N & M ANDAMAN	SMITH ISLAND	0	0	1.387183	1.39	1.53	75.88	1.79563364	Safe
12	N & M ANDAMAN	STEWART ISLAND	0	0	0.004015	0	0.01	31.53	0	Safe
13	N & M ANDAMAN	STRAIT ISLAND	0	0	0.090338	0.09	0.1	95.95	0.09377012	Safe
14	NICOBAR	BOMPOOKA ISLAND	0	0	0	0	0	131.89	0	Safe
15	NICOBAR	CAR NICOBAR ISLAND	0.1984	0.1984	41.25613	41.66	45.48	3299.7	1.24522504	Safe
16	NICOBAR	CHOWRA ISLAND	0	0	0	0	3.24	0	0	Saline
17	NICOBAR	GREAT NICOBAR ISLAND	0.0294	0.142838	18.60551	18.77	20.51	8182.69	0.22880868	Safe
18	NICOBAR	KAMORTA ISLAND	0.009	0.136132	8.52786	8.67	9.4	511.84	1.66289463	Safe
19	NICOBAR	KATCHAL ISLAND	0.006	0.135145	4.47271	4.6	4.93	553.59	0.82341359	Safe
20	NICOBAR	KONDUL ISLAND	0	0	0	0	0	29.8	0	Safe
21	NICOBAR	LITTLE NICOBAR ISLAND	0	0	0.696603	0.7	0.77	268.73	0.25974026	Safe
22	NICOBAR	NANCOWRIE ISLAND	0.0102	0.136526	2.356805	2.5	2.6	99.95	2.43451164	Safe
23	NICOBAR	PULO MILO ISLAND	0	0	0.046173	0.05	0.05	8.2	0.60606061	Safe
24	NICOBAR	TERESSA ISLAND	0.186	0.194323	6.209198	6.59	6.84	89.74	6.79661716	Safe
25	NICOBAR	TILLANGCHANG ISLAND	0	0	0.08833	0.09	0.1	335.35	0.02682963	Safe
26	NICOBAR	TRINKET ISLAND	0	0	0	0	0	63.07	0	Safe
27	SOUTH ANDAMAN	FLATBAY ISLAND	0	0	0.012045	0.01	0.01	28.7	0.03483107	Safe
28	SOUTH ANDAMAN	HAVOCK ISLAND	0.009	0.009	14.60256	14.62	16.1	380.88	3.68261965	Safe
29	SOUTH ANDAMAN	JOHN LAWRENCE ISLAND	0	0	0	0	0	87.58	0	Safe
30	SOUTH ANDAMAN	LITTLE ANDAMAN	0.232	0.232	43.52862	44	47.98	2241.36	1.92155681	Safe
31	SOUTH ANDAMAN	NEIL ISLAND	0.006	0.006	7.030265	7.03	7.75	122.06	5.41560743	Safe
32	SOUTH ANDAMAN	NORTH SENTINNEL ISLAND	0	0	0.034128	0.03	0.04	78.76	0.03807107	Safe
33	SOUTH ANDAMAN	PEEL ISLAND	0	0	0	0	0	16.07	0	Safe
34	SOUTH ANDAMAN	PORT BLAIR	13.296	13.296	234.8072	261.38	258.85	1139.33	18.3456747	Safe
35	SOUTH ANDAMAN	RUTLAND ISLAND	0	0	0.803	0.8	0.89	1564.81	0.05109536	Safe
36	SOUTH ANDAMAN	VIPER ISLAND	0	0	0	0	0	2.09	0	Safe