केंद्रीय भूमि जल बोर्ड

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भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ANDROTT ISLAND, U.T.OF LAKHDWEEP

केरल क्षेत्र, तिरुवनंतपुरम

Kerala Region, Thiruvananthapuram

भारत सरकार / GOVERNMENT OF INDIA

जल शक्ति मंत्रालय / MINISTRY OF JAL SHAKTI

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AND GANGA REJUVENATION

केंद्रीय भूजल बोर्ड / **CENTRAL GROUND WATER BOARD**

केरल क्षेत्र / **KERALA REGION**

REPORT ON AQUIFER MAP AND MANAGEMENT PLAN OF AGATTI ISLAND, U.T. OF LAKSHADWEEP

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September 2020

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AQUIFER MAPS AND MANAGEMENT PLAN OF ANDROTT ISLAND

1.0 Salient information

1.1 About the area

Lakshadweep is a group of islands existing off the west coast of Kerala state in the Arabian Sea with a total geographical area of 32 sq km. There are 36 tiny Islands in the UT of Lakshadweep out of which 10 islands are inhabited. The entire chain of islands exists in a scattered manner and having a distance of 220 to 440 km between them. Androtт Island, located between $10^0$48'N to $10^0$50'N latitude and $73^0$38'E to $73^0$42' longitude, has a total geographical area of 4.90 sq km and is the largest island in the group. It is the nearest island to the mainland and has an east-west orientation and is devoid of a lagoon which is generally present in other Islands of Lakshadweep. The average length and width of the island are around 4.66 and 1.43 km respectively with an average coastal perimeter of 10.59 km. The physiographic map of Androtт Island is shown in the Fig.1.

Fig. 1: Aerial View of Androtт Island from Space (Google Map)

1.2 Population

The Population of Androtт as per the2011 census is 11191 persons with 5500 male (49.14%) and 5691 female (50.85%). The population density is 2312 per sq.km and the overall decadal growth rate during the period from 2001 to 2011 is 4.33%. The literacy rate of Androtт is 91.13%.

1.3 Climate

The climate of Androtт is similar to the climatic conditions of Kerala. March to May is the hottest period of the year. The temperature ranges from 25^0C to 35^0C and humidity range from 70 -

76 percent for most of the year. The average rainfall received is 1600 mm a year. Monsoon prevails here from 15th May to 15th September. The monsoon period raises the temperature to the mercury level between 27- 30 degrees. During the monsoon time, boats are not allowed outside because of the violent sea. The presence of the reef maintains calm in the coastal area. Monthly rainfall data in respect of Androtт island from 2009 to 2017 is given below in Table 1.

Table 1: Monthly Rainfall data of Androtт Island (in mm)

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
2009	0	0	0	5	174	297.3	372.2	274.4	167.6	157.3	253	151.2	1852
2010	6.4	0	0	43.4	108.6	523.2	571	478.4	184	279.2	156	85.4	2435.6
2011	0	0	0.6	111.6	146.8	448.4	477.4	321.6	239.4	334.8	130.2	20.2	2231
2012	1.8	0	0	54	10.8	445.2	233.4	481.9	212.9	125.9	73.2	88.6	1727.7
2013	0	70.8	42.2	14	89.4	717	388.6	183	35.4	142.8	92	10.2	1785.4
2014	0	0	0	13	172.6	128.4	281.8	351.9	196.8	166.4	54.8	28	1393.7
2015	0	0	0	37.6	250.8	349.2	446.9	108.2	115.8	147.9	201.7	81.1	1739.2
2016	20.8	0	0	0	31.2	339.7	410	109.7	145	58.8	5.6	120.4	1241.2
2017	1.2	0	44.2	0.8	206.4	488.8	163.9	433.2	198.7	144.2	66.6	154.2	1902.2

1.4 SOIL

The soil layer developed within the Androtт island is mainly derived from coral limestone, which includes coral sands and lagoonal sands. This soil is highly permeable and allows the rainfall to infiltrate at a greater rate leaving no scope for surface runoff except in a very few local areas where compact soil got exposed.

1.5 Agriculture and Irrigation

Due to lack of space and surface water, irrigational activities within the island are restricted to a very minimum scale. In general, household farming of coconut and other plants is widely practiced on the island. Groundwater plays a major role in Island cultivation and evapotranspiration loss from the plantations put considerable stress on the freshwater lens and needs to be accounted for effective water management. Agriculture practice with in the island has been broadly categorized into two major classes. The first one mainly includes the Grass, Crops, and Shrubs which extract the water exclusively from the soil moisture zone. Coconut trees and other varieties having deep roots can penetrate below soil moisture zone up to the existing water table and are classified under Deep-rooted plants. The deep-rooted plants were generally grown in the area where the water table is

around 5m bgl. Coconut harvesting is the major agricultural activity in Androtт and its production has been increased from 102.53 lac to 135.1 lac nuts between 2004-05 to 2010-11. The details of coconut harvested during the period from 2004 to 2011 are given in Table 2.

Table 2: Coconut Harvested from 2004 to 2011 in Androtт Island (in lack nuts)

Island	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Androtт	102.53	110.23	115.53	115.80	115.90	135.08	135.10

2.0 Groundwater resource availability and extraction

Groundwater resource available in the Androtт Island is restricted to top few meters within the phreatic aquifer in the form of freshwater lens, considered as the only available direct sources for drinking, domestic and little irrigation purpose. The coral sand act as an aquifer on the island is highly porous, and because of that rainfall gets maximum infiltrated into it and further displace the saline water to further deep to maintain the density difference. Hence there is no chance for rejected recharge from rainfall on the island. In nutshell around 18 to 51 percentage of the annual rainfall got recharged into the groundwater depends on the Intensity, Frequency, and Distribution of the lens. In small island conditions, the estimation of recharge based on the groundwater fluctuation method is not practicable unlike in the case of continental coastal aquifers as the head build-up due to rainfall recharge dissipates within 2-3 days and diurnal fluctuation is nearly the same as seasonal fluctuation. Therefore, the water table fluctuation method cannot be adopted for assessing the dynamic groundwater resources of the Lakshadweep islands. Instead, resource computation is made by finding the ratio between recharge and draft. As per the dynamic groundwater resource calculation for the year 2017, the total groundwater surplus has been computed as 196.7 ham. Evapotranspiration loss of 53.3 ham and water loss due to outflow to sea in the order of 39.3 ha.m were considered while accessing the total resource. After deduction of the various outflow components the available resource in respect of Androtт Island was worked out as 64.8 ha.m with gross annual groundwater extraction of 41.9 ha.m. Based on the above stage of development is computed as 61.7% and categorized as semi-critical. Details of groundwater resource calculation are given in Table 3.

Table 3: Dynamic Ground Water Resources of Androtт Islands (As in March 2017)

#	**Annual components of Water Balance**	**Ha.m**
1	Population (Projected as on 2017)	11482
2	Area (Ha)	484.0
3	Normal Monsoon Rainfall (m)	1.355
4	Rainfall Infiltration Factor (%)	30
5	Total Resource (Water Surplus) (Ha.m)) [2*3*4]	196.7
6	ET loss from Trees for 6 non-monsoon months (Ha.m)	53.3

7	Water loss due to outflow to sea [20% of (3) (Ha.m)]	39.3
8	The buffer zone for reserve during delayed or lesser monsoon period [20% of (3)] (Ha.m)	39.3
9	Balance available resource (Ha.m)	64.8
10	Domestic Extraction @100 lpcd [1*100*365] (Ha.m)	41.9
11	Gross Annual GW Extraction (Ha.m)	41.9
12	Groundwater balance available [9-11](Ha.m)	22.9
13	Stage of groundwater extraction [11*100/9]	64.7
14	Category	**Safe**

2.1 Water level behaviour

The depth of the dug wells range from 2.45 to 4.70 m. and correspondingly depth to water ranges from 0.87 to 4.4 m bgl within the Dug wells exist in AndrotT island. DTW map as generated from the existing water level data monitored from dug wells exists in the island exhibits that overall depth to water level generally shallow and ranges between 0 to 3.00 m bgl. With some exceptional sporadic appearance of water level more 3.00 m.bgl towards the eastern and southeastern parts of the island. The available freshwater lens in Androtт island exhibits maximum thickness in the northwestern part than the rest. In the south, the groundwater is generally saline during the summer months. The maps showing locations of the key wells and depth to water table (pre-monsoon 2016) of Androtт island are given in Fig. 2 and 3 respectively.

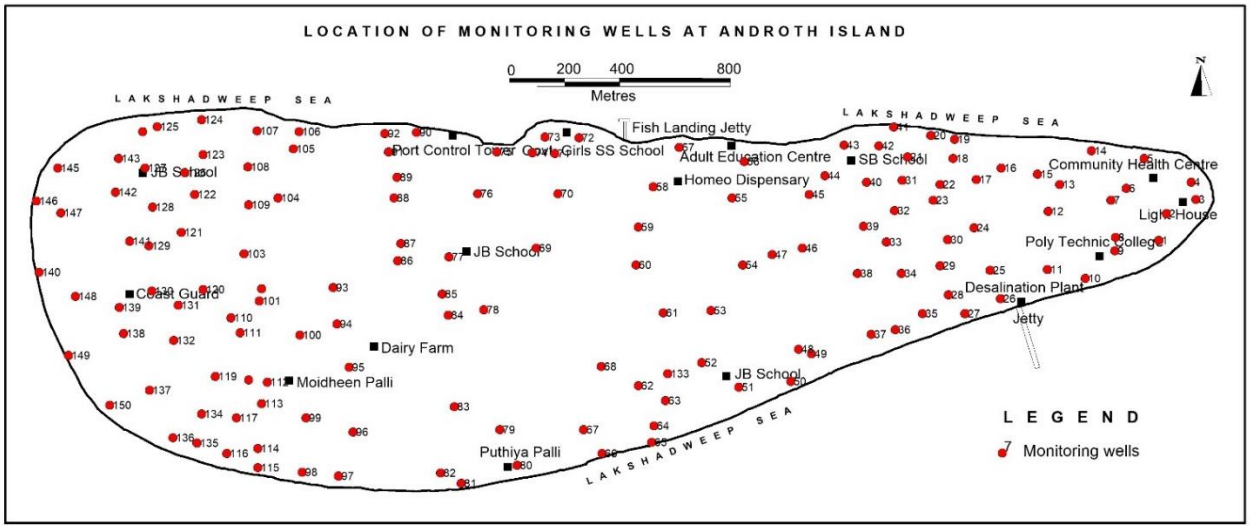

Fig. 2: Key well locations in Androth island

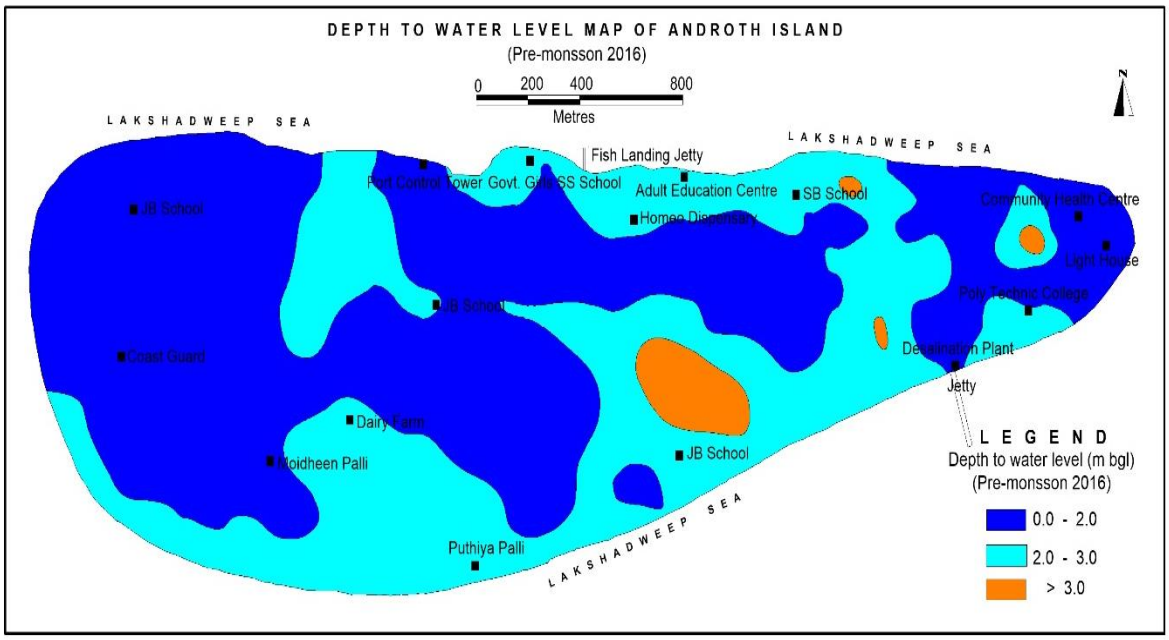

Fig 3: Depth to water level map of Androtт Island

2.2 Existing & Future Water demand

Based on the Groundwater resource estimation carried out during April 2017, the total Groundwater resource available and its extraction on the island are as follows. The gross annual groundwater resource available is 196.7 ham. Groundwater Draft by Domestic sector is 41.9 Ha.m, further loss due to Evapotranspiration and buffer zones accounted around 53.3 Ha.m and 39.3 Ha.m respectively. The stage of groundwater development as computed from the ratio of total surplus resource and gross annual extraction has brought out around 64.7.1% with a safe category. The future groundwater demand can be approximately calculated by considering the population growth rate for the draft figure.

3.0 Aquifer disposition

3.1 Number of aquifers

The islands are composed mainly of coral reefs and the coral sands are derived from it. Coralline sandstone constitutes the major aquifer material on the island which mainly consists of calcareous sand of beach facies, strandline facies, dune facies, and anthropogenically modified varieties. The grain size and other physical characteristics, Coralline grit and gritty conglomerates,

coralline limestones, and shingles resemble submerged reef facies. The calcareous sand and other materials deposited over the island has risen approximately up to 5 m above mean sea level. In general, aquifer act as phreatic with depth to water level observed within the range of 0.8 to 4.4 m bgl. The freshwater exists as a thin lens floating over the saline water with definite hydraulic continuity. Large diameter wells are the most common and traditional groundwater abstraction structures in Andrott. In almost all the wells, hard coral limestone is exposed near the bottom. The sand below this hard layer has caved in most of the wells. As the subsurface information in respect of this island is not available in the form of exploratory drilling etc, the aquifer map as generated from the available depth to water level data and electrical conductivity is given in Fig. 4.

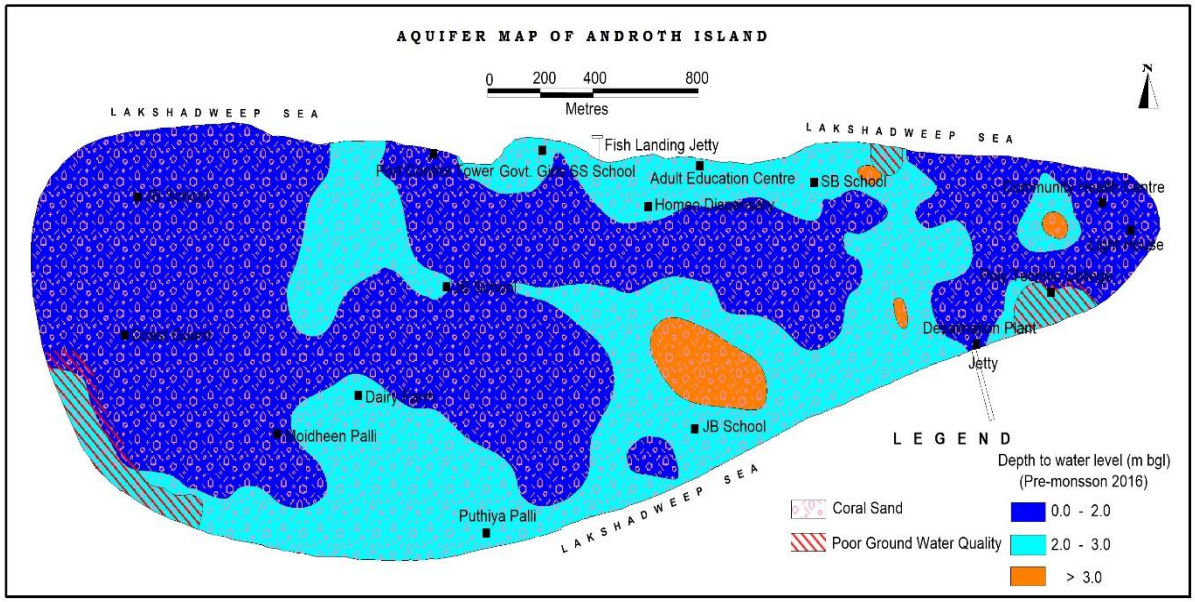

Fig.4. Aquifer map of Androth Island

3.2 Groundwater quality

The quality of groundwater on the island is good and potable for domestic purposes. It is mainly Mg- Ca- Bicarbonate type and is suitable for irrigation and other purposes also. The pH value ranges from 7.10 to 7.64. The EC values are generally within the range of 520-11740 µS / cm at 25°c. The chloride content shows the value < 1000 mg/l. Groundwater in the southern tip of the island is brackish and is fresh and potable in the other parts of the island. Lakshadweep Public Works Department is maintaining a chemical lab for monitoring the groundwater samples periodically from selected observation wells. The details of chemical analysis are given in the Table 5. The spatial variations in EC are depicted in Fig. 5.

Table 4: Hydrochemistry of select groundwater samples collected from open wells in U.T of Lakshadweep

#	Name of Island	No of Samples	pH	EC (µS/cm)
1	Andrott	150	6.1- 8.00	530 - 3500

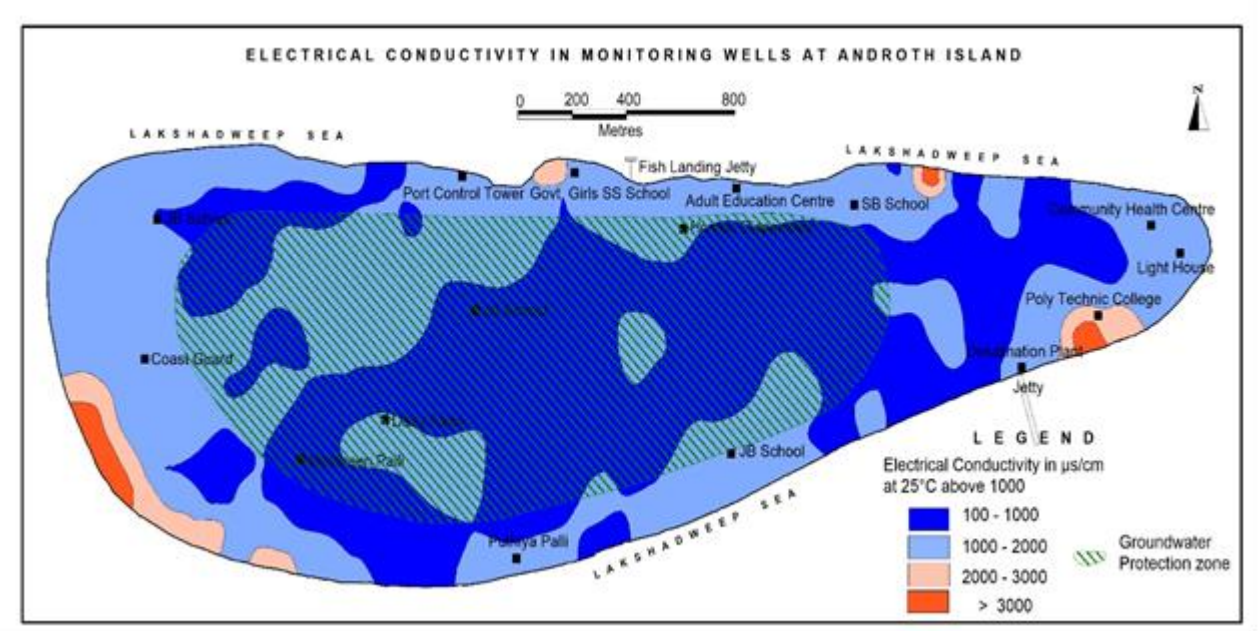

Fig.5. Spatial variations in EC in Androth Island

It has been generally observed that groundwater quality in the islands shows variation due to the effects of tide, rainfall recharge, groundwater draft from wells, etc. As the horizontal flow of groundwater is relatively insignificant the freshwater occurs in the form of a lens which contracts and expands in response to the above factors. During the diurnal tidal fluctuations of the sea, the freshwater lens shows the variation in water quality and becomes brackish during low tides and fresh during high tides especially where the lens thickness is low. Heavy withdrawal of groundwater from a point source can induce the upconing of saline water and consequent quality deterioration. Rainfall recharge has improved the quality of the lens that exists beneath by reshaping the lens shape. In addition to the above marine aerosols can influence the groundwater quality.

4.0 Groundwater resources, extraction, contamination and other issues

4.1 Groundwater resources and extraction

The major component of the groundwater draft in the Lakshadweep islands is from domestic consumption. Almost all households have their dug well and more than 75% of the wells are fitted

with small capacity (normally 0.5 HP) electric pumps. Androtт boasts of the maximum number of dug wells of around 1660 nos, with a good density of 345/sq km. An estimate of around 100 lpd was considered as per capita consumption for the domestic draft, the final domestic extraction Fig. as derived is in the order of 41.9 Ha.m. whereas the available resource is of 64.8 Ha.m after deducted for ET loss, Water loss due to outflow to sea, etc. From the above, the stage of groundwater development as attained is 64.7% which is in the safe category.

4.2 Groundwater quality issues

Contamination of groundwater through Human waste, sewerage, biological wastes, and fertilizers is another major threat to this island. The traditional burial grounds also contribute to groundwater contamination to some extent added pollution issues in the groundwater field.

4.3 Groundwater management issues

Some of the management issues identified in the sustainable development of groundwater resources in the Androtт Islands are summarized below

- Absence of surface water resources in the islands naturally putting stress on limited available groundwater resources.
- Deterioration of groundwater quality especially during summer months.
- Existing supplies are unable to cope with the rapidly increasing demands for drinking and domestic uses.
- Indiscriminate groundwater extraction at places, resulting in the up-coning of saline water and consequent quality deterioration.Considering the available groundwater resource and quality issues as referred. It had been concluded that to mitigate present and future demand, additional resources need to concentrate. Hence in addition to groundwater extraction, some other supplementing sources and management practice needs to be adopted on the island.

5.0 Groundwater resource and quality enhancement

5.1 Rainwater Harvesting Systems

Rainwater collection has long been recognized as the most suitable and adoptable method to make up the shortfalls in groundwater availability in Androtт Island. Rainwater is being collected

from the rooftops of the buildings in storage tanks of various capacities ranging from 5000 to 10,000 thousand liters and in some cases, up to 50,000 liters. Such tanks are normally attached to Government quarters, non-residential buildings, and some private houses. The water collected from the rooftops is made to flow to the collection through a filter, designed to remove suspended particles. The water is then chlorinated and distributed to the public. Operation related to the pumping and distribution of water is entrusted with the respective Village (Dweep) panchayats. Community rainwater harvesting systems using public buildings such as hospitals and schools have also been implemented in Androtт, from which the harvested water, after filtration and chlorination in a centralized unit, is pumped into overhead tanks for distribution along with water collected from other sources such as groundwater, desalination plants, etc. In addition to this Rehabilitation, Restoration, Renovation, and Protection of available ponds and wells need to be taken up.

5.2 Groundwater Quality monitoring

Ground Water Quality Testing Laboratories already installed on the island needs to be upgraded to monitor more parameters. A stringent groundwater monitoring schedule needs to be worked out for quality monitoring from select wells. The local Public Health authorities are kept informed of any change in the quality of groundwater, especially salinity.

5.3 Groundwater regulation

The Lakshadweep Ground Water (Development and Control) Regulation, 2001 was promulgated on August 6, 2001. As per the regulation, a Ground Water Authority is to be constituted in the U.T of Lakshadweep, which will have the powers to control and regulate the extraction and use of water in any form in any of the islands in Lakshadweep. The Authority was constituted in 2019.

5.4 Others Methods

- Encouraging the use of water-efficient domestic fixtures like taps/ flush tanks to improve water use efficiency and reduce wastage.
- Decentralized garbage/waste treatment systems to prevent further contamination of available freshwater resources.
- Installation of a desalination plant in the Island to reduce stress on groundwater

- Sensitization and capacity building of stakeholders at all levels on the importance of water conservation and ways and means for its judicious management for ensuring the long-term sustainability of water resources.

5.5 **Demand side interventions**

Groundwater is the only conventional source of freshwater in Androth Island, which is being supplemented by rainwater harvesting. Groundwater Resources estimation carried out for Androth Island has brought out the status of available recourse. Dug wells are suitable for extraction from shallow unconfined aquifer were the thickness of coral sand is limited. Island specific extractable groundwater resource against the danger of salinity has to be implemented through micro-level schemes. Wherever the groundwater is not adequate to provide water to the entire population, this has to be supplemented by the desalination of brackish water through Reverse Osmosis.

Optimize utilization of the available resource by encouraging rainwater harvesting. At least some of the water, which otherwise is wasted, could be utilized for part of the year by educating the masses and thereby recognizing the value of water as a scarce resource on the Island. Groundwater contamination by pathogens has been recorded in many wells. Generally, guidelines of 30 meters separation between domestic septic tanks and water supply wells have been applied and found to give inadequate protection from pathogens, especially in permeable aquifers. The U.T. administration has taken steps to ensure the installation of scientific septic tanks in all newly constructed houses and other buildings.

5.6 Training

The islanders should be educated about the danger of over-exploitation of the precious resource and the limitations of island conditions. Necessary Training to technical, professional, and managerial levels is required as an ongoing requirement to improve the skills of local personnel in the assessment, development, and management of their water resources.