

SUBDIVISIONWISE STATUS OF GROUNDWATER RESOURCES AND ITS FUTURE IN INDIAN SUNDARBAN: SPECIAL REFERENCE TO NORTH AND SOUTH 24 PARGANAS DISTRICTS OF WEST BENGAL

***Jayanta Gour**

Department of Geography (UG & PG)

Sambhu Nath College, Labpur, Birbhum, W.B. PIN- 731303

**Author for Correspondence: jayanta.santiniketan@gmail.com*

ABSTRACT

Indian Sundarban encompasses the hydrologically two most vulnerable districts i.e. parts of North 24 Parganas and entire South 24 Parganas in West Bengal, India. The islands of Sundarbans (including parts of Bangladesh) have been reclaimed for agricultural and settlement purposes since the British colonial period in different phases and still today those reclaimed and cleared mangroves areas are thriving in the brackish environment. The difference is that, recent dwellers are dependent more on groundwater than the surface sweet water like the earlier centuries since 1770 AD. Decadal increase in population, salinity of the decaying tidal channels and shortage of surface water in the form of pools and ponds are forcing the newly settling areas to depend solely upon the groundwater. Presently, about 18.16 million people (as of census year 2011) of the 24 Parganas (N & S) are facing severe difficulties in steady supply of potable water supply. Increase in salinity and choking of the upstream terrestrial channels is also forcing the crop cultivation to pisciculture here which directly and indirectly is deforming the mangrove ecosystem in Indian Sundarban. The government took the initiatives to set up several tidal gauge stations and hydrograph stations for assessing and estimating the groundwater storage, character of aquifers, discharge, conductivity, transmissivity and other hydrological parameters for optimum utilization of this natural resource for human development since last few decades. The central and state governments have been collecting a lot of data but more hydromorphological researches are waited for full inspection and analysis of the database for multidimensional approaches. A hand counted geospatial and analytical research works have been carried out in estimating the present groundwater status in relation to subdivision wise changes focusing on the extending built up areas, decreasing natural vegetation cover and quantifying water index. This study found that the increasing built up areas and changing pattern of natural vegetation cover must be analysed during the groundwater management planning and programmes. This research work has applied the recent satellite data as an integrating tool for groundwater resource analysis and management in consonance to some surficial aspects of the topography of these two districts covering a large part of inhabited Sundarban Delta.

Keywords: *Groundwater, Hydrological parameter, micro-tidal interfluvies, groundwater discharge, aquifer*

INTRODUCTION

The North and South 24 Parganas are the two most cyclone-prone vulnerable districts in India along the north shore of Bay of Bengal (BOB). The North 24 Parganas, although, has no direct contact with the bay-water but is drained by tidal channels which play a major role in its economy. Regular draining of the tidal channels like Ichhamati, Kalindi, Raimangal, Dansa, Boro Kalagachi, Benti, Haribhanga, Gaourchar, Bidyadhari, Hooghly in the maturing alluvium sub-region of the lower Gangetic Plain (Zone-III), is considered to be the major surface water resources for producing of various types of crops and fish products. The North 24 Parganas district (geospatial extent: 88.33°E-89.01°E and 22.12°N-23.25°N) covering an area of 4,094 km², comprises 5 subdivisions viz. the Barasat (Headquarter), Barrackpore, Basirhat, Bangaon and

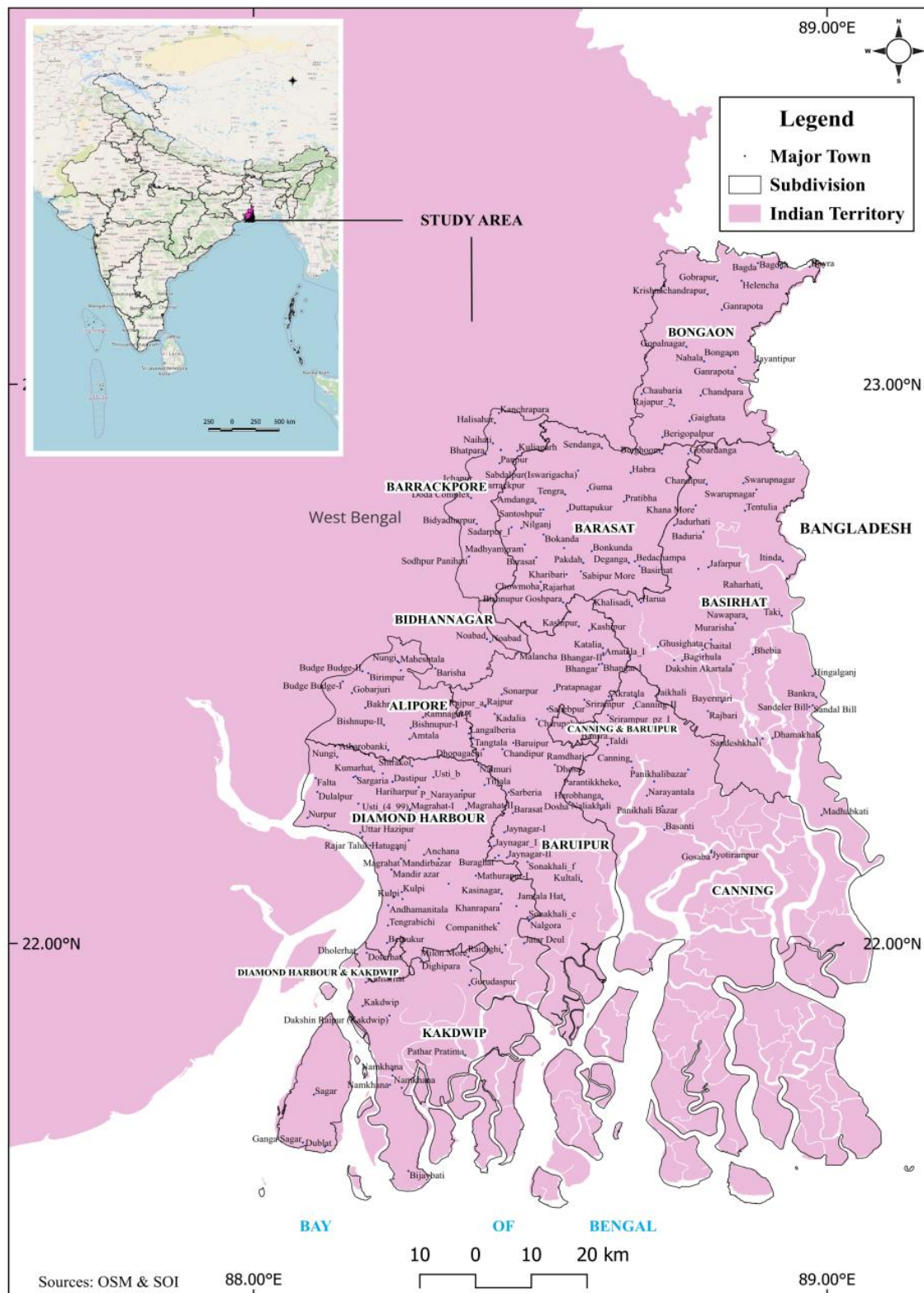


Fig. 1: Location of the study area

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Bidhannagar with a total population of about 10 million people as of 2011 census report. The South 24 Parganas district (geospatial extent: 88.01°E-89.14°E and 21.53°N-22.62°N), on the other hand, has 5 subdivisions (Fig. 1) viz. the Alipore (Headquarter), Baruipur, Diamond Harbour, Kakdwip (shares the shoreline of BOB) and Canning (shares the shoreline of BOB) and covers an area of 9960 km² with a total population of about 8.16 million people as of 2011 census report. Major parts of Kakdwip, southernmost part of Baruipur and southern half of the Canning subdivisions have an average elevation of 1-2 meters above mean sea level and saline tidal and rainwater remains stagnated for several weeks during any severe, very severe and super cyclones. The North 24 Parganas receives more annual rainfall than the South 24 Parganas district. About 1.05% of the total area of North 24 Parganas is covered by reserve forest whereas 42.37% area is under forest cover in South 24 Parganas district (second largest by area in West Bengal) as of year 2024 (Report by Office of The District Magistrate & Collector, 2024).

According to Central Ground Water Board (CGWB), Quaternary deltaic sediments composed of clay, silt, and sand of various grades, gravels, pebbles etc., underlain by Upper Tertiary formations are found in the district of 24 Parganas. (i) Entisols; (ii) Alfisols; & (iii) Aridisols are predominant in these districts. The North 24 Parganas district possess para deltaic fan surface, semi to unconsolidated sediments with intergranular porosity (CGWB & GSI, 2024). Alternate layers of sands, silts and dark grey clays predominate with confined and unconfined aquifer, aquifer with primary intergranular porosity in the entire district of North 24 Parganas except the south-eastern part containing very fine silt and clay of middle to upper Holocene with fresh water is overlain by saline groundwater. The CGWB and State Water Investigation Directorate (SWID) data of West Bengal shows a disparity in groundwater resources from inland to Bayshore and the subdivision wise uneven discharge rate also reveal an uneven use of ground water on the basis of urban, agricultural, industrial and rural areas. The causes and consequences have been discussed with the help of latest Sentinel-2 data, Landsat-08 satellite images from USGS and LISS-III images of Bhoonidhi for correlating the groundwater scenario in response through the NDVI, MNDWI and MNDBI data. The western and north western parts of Sundarban Delta in India are facing continuous increase in population since last century. The satellite data revealed the uneven discharge and groundwater level and unevenness of this resource in Sundarban Delta within North and South 24 Parganas districts and excessive pressure groundwater irrigation may lead to shortage of drinking water in the inhabited islands of Indian Sundarbans.

Objective: The major objective of this geospatial research is to find out the present groundwater status by analysing the database of Central Ground Water Board (CGWB) of Govt. of India and State Water Investigation Directorate (SWID) of Govt. of West Bengal and to find out the present potentiality, future prospect and restoration of groundwater resources in the subdivisions of the two deltaic districts viz. North and South 24 Parganas districts encompass the reclaimed Sundarban Delta in West Bengal, India.

MATERIALS AND METHODS

Due to lack of notable groundwater related research works in consonance to vegetation, built up and water index of the 24 Parganas districts of West Bengal, India, the entire work has been carried out through statistical analysis of the database obtained from secondary sources like CGWB and SWID and compilation the data with recent geospatial data obtained from satellite images from Bhoonidhi and USGS from 2010 to 2024. Sentinel-2 data (with 10% cloud coverage) through QGIS ver. 3.44.2 on EPSG:4326 WGS 1984 and through Surfer 25 software. The geological status has been obtained from the maps available on official portals of North and South 24 Parganas districts of West Bengal. The OSM and DEM has been applied to obtain the relief scenario and Landsat 08 satellite images has been used to obtain the NDVI, MNDWI and MNDBI (cloud cover 10%) values for correlating the groundwater data to present subdivision wise fluvio-geomorphological status. Atmospheric filtration has been carried out for accuracy of the geospatial results.

DATA ANALYSIS: Central Ground Water Board data of North and South 24 Parganas district of West Bengal reveals the facts that the groundwater table varies from east to west and north to south. On the basis of Darcy's Law, the range of groundwater discharge (L/s) can be categorised into the following:

Discharge Rate (L/s)	Category	Remarks
<1 L/s	Very Low	Common in Shallow wells/ Low yield Aquifers for domestic use/Hand pumps
1-5 L/s	Low	Rural Tubewells, Small-scale irrigation and community water supply
5-25 L/s	Moderate	Medium-scale irrigation, small towns and Industrial use
25-100 L/s	High	Productive Aquifer, Large-scale irrigation/Municipal water supply
>100 L/s	Very High	Springs/High-capacity wells, Urban water supply and Industry

On the basis of the above categorization, it is found that the area to the east of urban area of Barasat subdivision has a groundwater discharge of 50-70 L/s, non-urban northern part of Basirhat, central part of Bongaon, of North 24 Parganas (Fig. 2 & 3) with a groundwater discharge >60 L/s approximately.

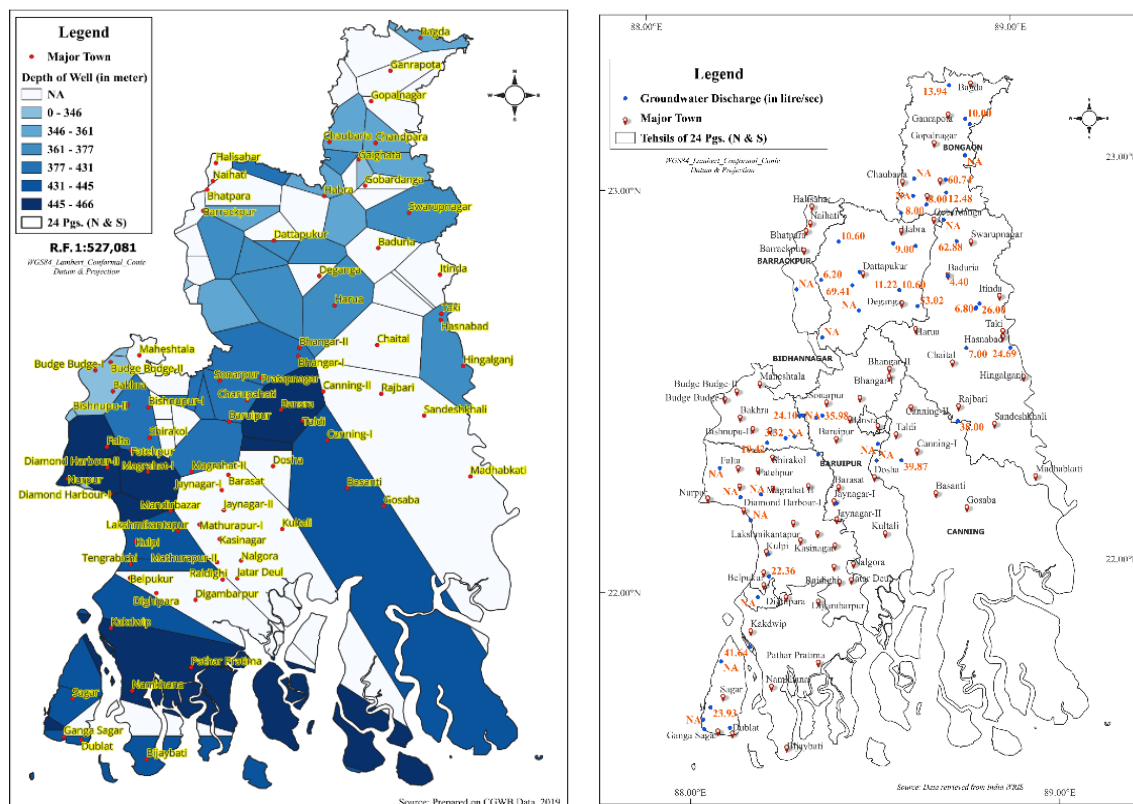


Fig. 2: Depth of Wells in meter (L) and Discharge in L/s (R) of 24 Pgs. (N&S), West Bengal. (Source: CGWB, Govt. of India)

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Barrackpore and Bidhannagar subdivisions of North 24 Parganas have a groundwater discharge ranging 20-40 L/s of groundwater discharge where water is mainly used for municipal water supply and for industrial uses. Tiljala surrounded areas of Diamond Harbour subdivision and Kakdwip town surrounded areas of Kakdwip subdivision of South 24 Parganas have a groundwater discharge ranging between 40-60 L/s. Paratikheko area of northwestern part of Canning subdivision has discharge of ≤ 40 L/s. The rest of South 24 Pargana district has a 6-30 L/s of groundwater discharge.

The Sagar Island of Kakdwip subdivision has a discharge of 20-40 L/s groundwater discharge. Medium-scale irrigation has been found according to the SWID.

As per the geospatial data analysis the north eastern part of Basirhat subdivision (around Swarupnagar and Mallickpur) and northern part of Kakdwip (around Kaorakhali) of North 24 Parganas district, has an average elevation of 1 meter elevation but the groundwater level varies from 50m b.g.l. to 350-400m b.g.l. The data also reveals the fact that the northern part of the Sundarban Delta where elevation is above 10m from MSL, has an average groundwater depth of 100-200m b.g.l. (Fig. 4). This indicates a large-scale sediment depth in Kakdwip subdivision than that of Basirhat subdivision. Sonarpur area contains fresh groundwater compared to the alkaline groundwater of Kakdwip in South 24 Parganas (Majumdar and Kar, 2013). So deep tubewells are predominant in southern parts of Sundarbans than the northern parts. Strong link between electrical conductivity (EC) and Na^+ , and a moderate link between EC and HCO_3^- , Cl^- , and NO_3^- has been found in Namkhana block (Das *et al.*, 2024). This suggests that conductivity rises with the concentration of these ions. Large-scale irrigation, urban municipal and industrial uses of groundwater can be identified through the groundwater discharge data analysis where it is ranging between 25-100 L/s (Fig. 2-4), although, confined and unconfined aquifers and aquifers with primary intergranular porosity is found along the western margin of Barrackpore and Bidhannagar subdivisions along Hugli River and along the Ichhamati River in North 24 Parganas district (Paul & Das, 2021). The aquifers in North 24 Parganas are interconnected due to spatial variations in grain size (Das, 2015).

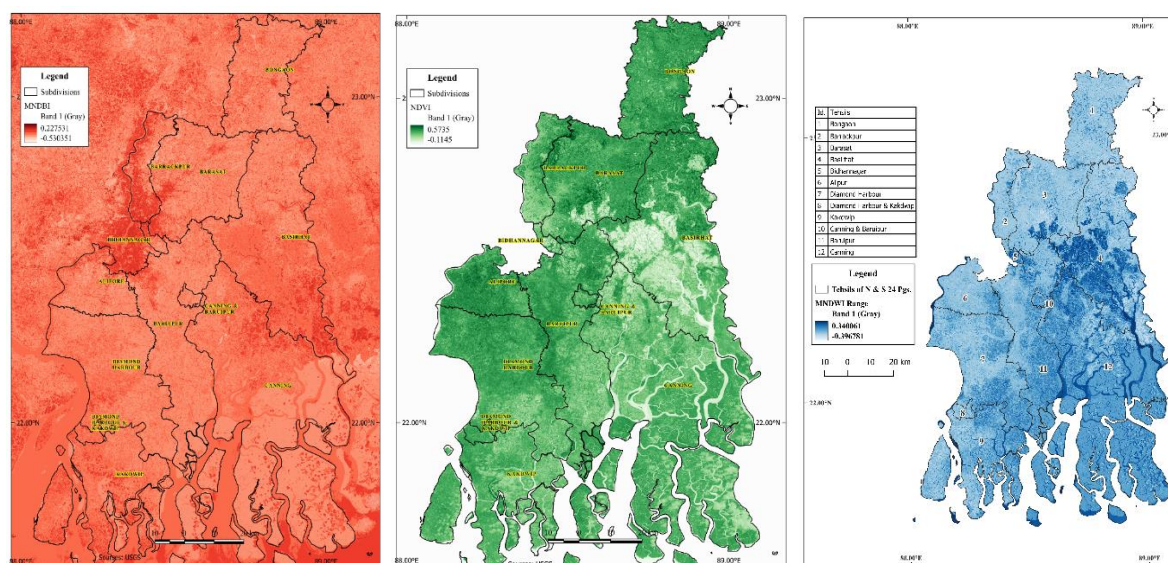


Fig. 3: Modified Normal Difference Built-up Index (L), Normal Difference Vegetation Index (M) and Modified Normal Difference Water Index (R) of 24 Pgs. (N&S), 2024.

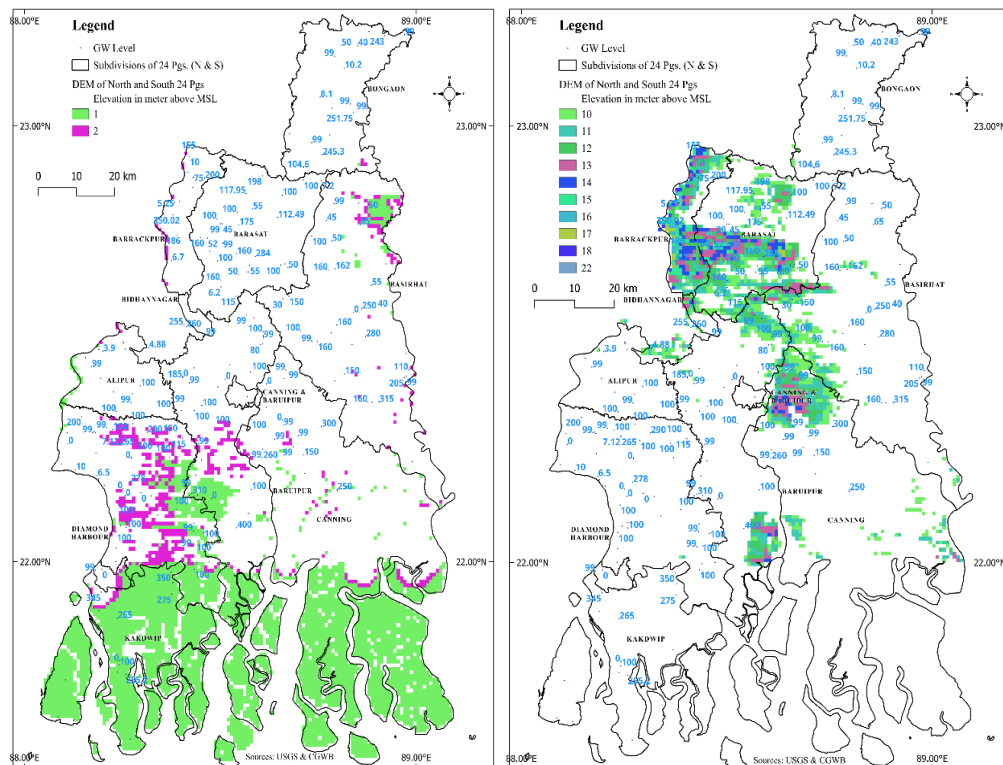


Fig. 4: (a) Groundwater depth in 24 Pgs. (N & S) in places having <2m elevation and (b) Groundwater depth in 24 Pgs. (N & S) in places having >10m elevation above MSL

RESULTS AND DISCUSSION

The discharge data analysis indicates that the maturing parts of Sundarban Delta in 24 Parganas has a steady discharge of groundwater between 20-60 L/s and productive aquifers can be traced in and around those parts of these two districts where the groundwater discharge is ≥ 60 L/s. Western part of the Sundarban Delta in India has steady and almost productive aquifers but the groundwater discharge is limited to below 70 L/s. The agricultural fields (Fig. 3) generally depend upon the groundwater aquifers and the discharge ranges between 10-50 L/s in Indian Sundarban encompassing 24 Parganas districts. The south eastern part of North 24 Parganas district particularly Habra-I, Hingalgaon (under Sundarban) and Sadeskhali-I having deeper aquifer at >15.4 m b.g.l. and are generally flowing condition and shallow aquifers are brackish in nature. At present, the Deganga and Habra-II community development blocks having shallow aquifers between 10-20 b.g.l. with about yield rate of 40 L/s. The saline bay water of BOB is denser as compared to fresh water and over harnessing of the fresh groundwater may increase the chances of intrusion of brackish water into the coastal aquifers of Sundarbans (Sudha Rani *et al.*, 2021). The increase in groundwater irrigation may increase the depth of groundwater level and may become brackish if not checked and monitored. Deep Tubewell Water harnessing must be discouraged. Rather, deep large ponds (small or medium) along the groundwater line should be made both for groundwater recharge and rabi irrigation purposes. Selection of the sites of the ponds should be done after the analysing of the microlevel topography of the interflaves because breached tidal channel banks may spill it with saline water. So, storing and harvesting of the rainwater must be given more priority for sweet water supply in dry seasons in the interflaves. The ponds must be in such a location that neither tidal flood nor the overflowing during heavy rain can create worse conditions of waterlogging.

Water Quality data of CGWB and other research works although showed the arsenic beyond permissible limit of 0.01 mg/l in densely populated Alipore and Basirhat subdivisions, Ill treatment of groundwater may

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spread this issue in other subdivisions if unchecked (Singh *et al.*, 2024). The chloride content in groundwater is still tolerable in Bongaon, Basirhat and Canning subdivisions (between <150 mg/l) but it is becoming intolerable and risking the rest of the subdivisions in South 24 Parganas particularly. High salinity towards the north east of Sundarban Delta and brackish water do not encourage agricultural practices and these regions are fluvio-geomorphologically not mature and still under active estuarine environment as well. But, if the saline water fishery as found in Sandeshkhali area increases, this may reduce the groundwater to vulnerable level. Groundwater irrigation dependency is increasing day by day in immature deltaic parts of Sundarban Delta particularly where there is little hope for single crop cultivation. Side by side, the prevailing active estuarine environment with frequent tidal inundation during cyclonic storms and restricted forest zones force them to go for the saline water pisciculture in the south eastern part of Sundarban Delta. This may reduce the crop productivity in surrounding agricultural fields as infiltration of saline surface water store may move unidirectionally and increase the groundwater contamination as well. State government must keep intensive monitoring on misuse of groundwater resources all over these two districts as negligence may degrade the sustainability of the groundwater resources in mature Sundarban Delta within the in Basirhat (in North 24 Parganas) and southern Diamond Harbour, south-eastern Baruipur, northern Kakdwip and north-eastern Canning (in South 24 Parganas) subdivisions of 24 Parganas in future because built-up areas and fishery areas are notably increasing as noticed during the geospatial analysis of these two districts. Rainwater harvesting by increasing the number of ponds for surface water irrigation must be promoted to avoid further salinization of the shallow groundwater layers in West Bengal.

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