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PROMOTING RAINFED POND FOR THE TOWN'S WATER SUPPLY SYSTEM: A CASE STUDY OF THE SOUTH-WEST COASTAL REGION IN BANGLADESH

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Abstract: *Bangladesh's coastal area is vulnerable to the changing climatic condition because of its geographic location and low-lying topography, and this vulnerability has been acute due to reducing upland flow during dry periods and sea level rise contributing to saline intrusion and inundation of coastal freshwater resources. Over the past 25 years, salinity intrusion in Bangladesh has increased by about 26 percent with the affected areas expanding each year. According to a study by World Bank in 2014, climate change is likely to further increase river and groundwater salinity dramatically by 2050 and exacerbate shortages of drinking water in the southwest coastal areas. Because of the salinity of both groundwater and surface water in the Mongla port municipality area, compound river water and rainfed pond water became the main source of drinking water here. Currently, Mongla Port municipality located in the coastal belt is supplying water to town dwellers by pipeline with a water treatment system taking raw water from both harvested rainwater and a limited period of river water through ponds. From physical observation, focus group discussion with water users, and interaction with key information providers, the study team assessed the quantity of water against the demand and also analyzed the quality of water both are satisfied. By using secondary data, the study team also analyzed the Mongla River's water salinity and rainfall intensity for assessing its long-run feasibility of it. The result of the study on Mongla Port municipality's water supply shows that it is a well-functional system, that could be replicated in another coastal area as it is a nature-based solution which makes the people and authority adapt it easily with keeping well-functioning.*

Key words: Rainfed Pond, Nature-Based Solution, Salinity in Coastal Area, Climate Change

Introduction

The coastal zone of Bangladesh covers one-third of the whole area's population nearly 40 million. Out of 64, 19 districts are coastal, and the most southwestern five coastal districts, i.e., Satkhira, Khulna, Bagerhat, Pirojpur, and Barguna, have been identified as the hard-to-reach areas. People in these districts have been exposed to different types of water security risks, particularly groundwater contaminated with salinity, which is not suitable for human consumption. Previous studies conducted by many research organizations have consistently reported higher salinity, as well as considerable trace and toxic elements in the groundwater samples from this area. Hoque (2009) estimated that approximately 30 million people are unable to collect potable water and 15 million people are already forced to drink saline groundwater in this region. This is principally due to the higher degree of spatial variability of salinity in both shallow and deeper aquifers. It is a consequence of the complex coastal hydrogeology and land use of the active Ganges–Brahmaputra delta. This water quality constraint, together with complex hydrogeology, leads to the unavailability of suitable freshwater aquifer layers limiting the use of tube wells. Therefore, the coastal people of southwest Bangladesh must rely on alternative options. In these five coastal districts, 12–34 percent of the inhabitants are using alternative sources such as rainwater, surface water, and other unimproved water sources.

Climate Impact Stress of South-west Region

The Southwest (SW) region is more vulnerable comparatively than the other 07 hydrological regions because salinity intrusion is high here. The green and black lines of Figure 01 (left) show the salinity concentrations 01 ppt and 5 ppt respectively which covered almost all areas of the SW region. Three mighty rivers Ganges (in Bangladesh is called Padma), Brahmaputra, and Meghna (originated by Surma and Khusiyara rivers) came from the neighboring country and are dominating whole surface water resources in Bangladesh. SW region's salinity intrusion is high because Padma's branch rivers Garai and Modhumoti are being dried up due to low water flow during the dry season caused by climate change and the withdrawing river water from up land. However, salinity intrusion in South-centre and Southeast regions is comparatively low because up surface flow comes from jointly three mighty rivers-Padma, Brahmaputra, and Meghna, that's why here backflow from the Bay of Bengal is less than the backflow in the SW region. The intrusion of backflow from the sea depends on river flow, that why the study team analyzed the Ganges minimum water flow for having an understanding of salinity intrusion in the SW region.

Figure 01: Location Map

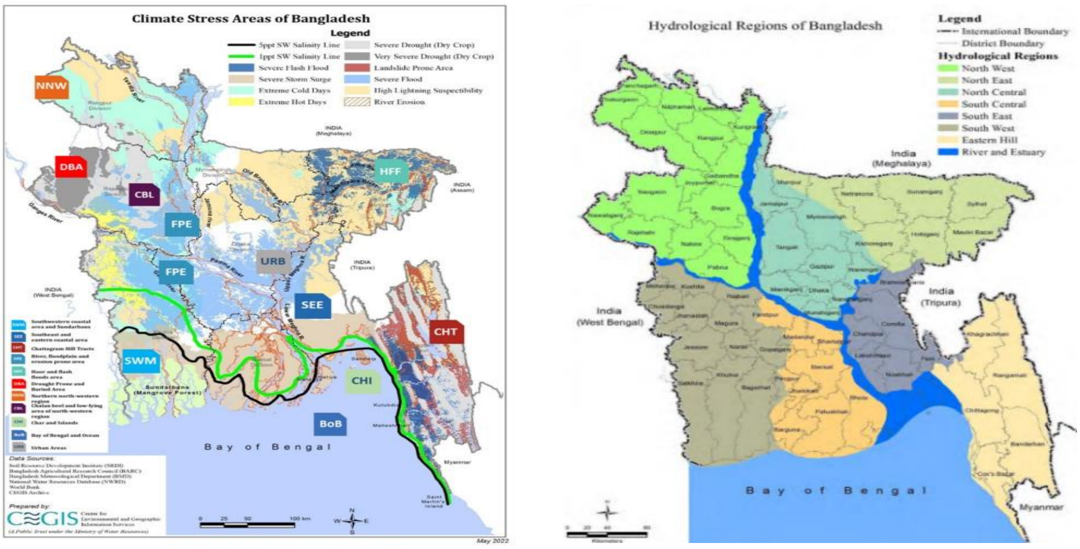
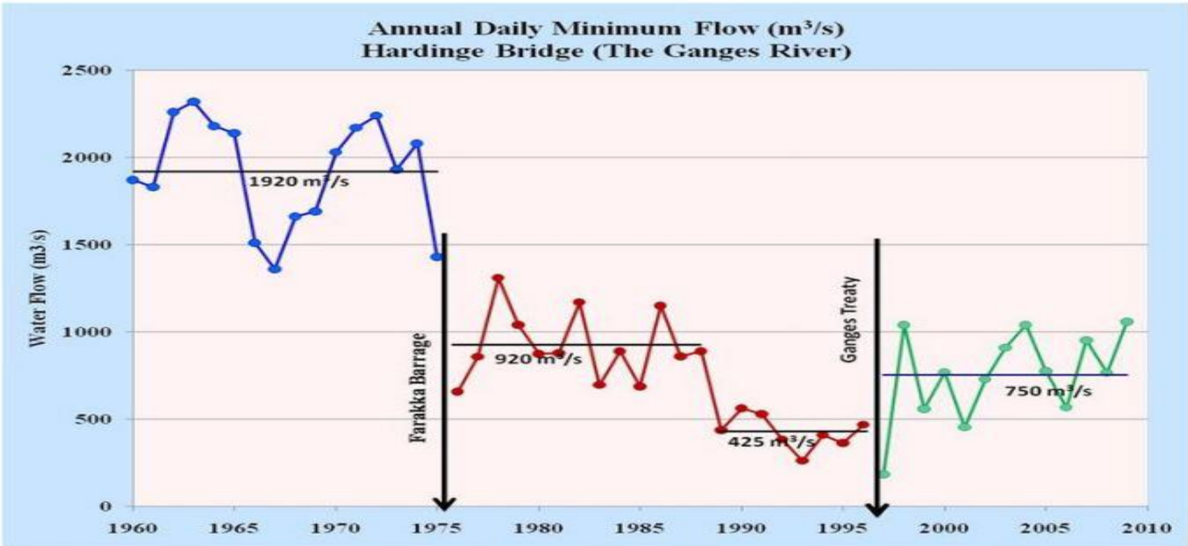


Figure 02 on the annual daily minimum flow (m^3/s) of Ganges water at Hardinge Bridge is taken from a study 'River salinity and climate change' carried out by the World Bank in 2014. This graph shows that before the Farakka Barrage minimum water flow of the Ganges to Padma River was 1920 m^3/s, but after Farakka Barrage it started to reduce and reached a minimum average flow of 425 m^3/s in the time of 1990. After the Ganges water treaty in 1996, the minimum average water flow started to move up to 750 m^3/s.

Figure 02: Annual Daily Minimum Flow, Hardinge Bridge

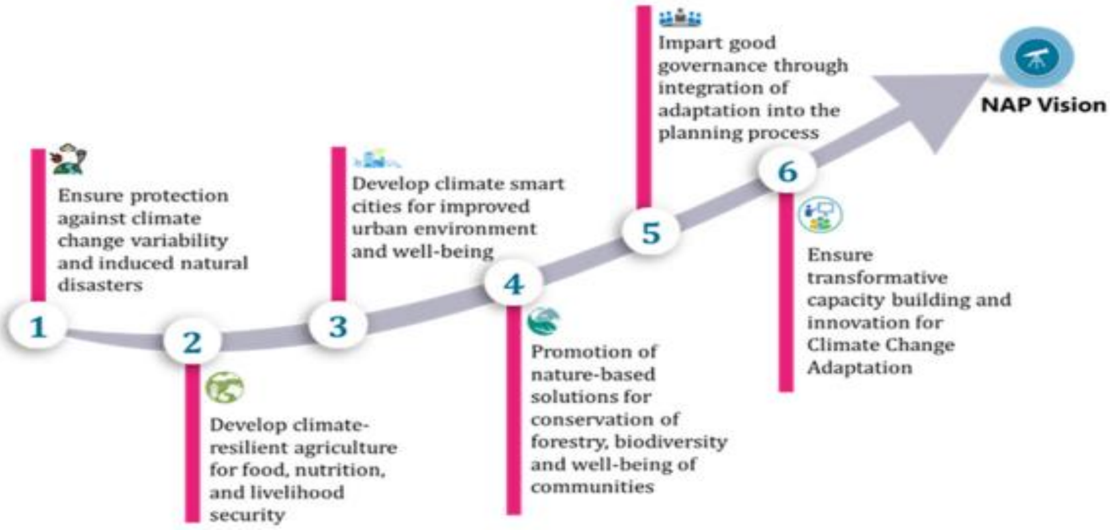


Review of Literature, Country's Strategy, Policy Act

Many works of literature have been taken to review with a view to gathering information about rainfall patterns and intensity. The rainfall patterns in Bangladesh are governed by the seasonally varying meteorological system of the southwest monsoon, in which monsoon and winter seasons are separated by two transitional seasons namely pre-monsoon and post-monsoon (Quadir et al., 2006). Several studies (Choudhury et al., 1997; Quadir et al., 2001) have reported that the precipitation in Bangladesh has been increasing during recent decades. Hussain et al. (2001) found that the mean annual rainfall was 2387.20 mm from 1975 to 1995. May to September were the highest rainfall months when the rainfall was more than 300 mm in over 63.80 percent of the years. Karmakar and Mian (1994) stated, the correlation between pre-monsoon rainfall and monsoon rainfall over the different stations of Bangladesh According to Ahmed and Karmakar (1993). Chowdhury and Debsarma (1992) investigated a significant upward trend of precipitation (by 18 percent) in the north, and west-southwest 11 regions since the early 70 percent, and a downward trend in the south-east. Quadir et al. (2003) reported that the average annual over Bangladesh varies from 1429-4338 mm. About 75 percent of the annual precipitation occurred during the monsoon period, about 15 percent in the pre-monsoon season, and the rest 10 percent occurred in winter and post-monsoon season. In Bangladesh monsoon, average rainfall varies from 1194 mm to 3454 mm (BBS, 2002). More than 70 percent of Bangladesh's annual rainfall occurs in the monsoon (June-September) season (Hussain and Sultana, 1996; Matsumoto, 1998). The main rainfall during the monsoon season ranges from 1000 to 3000 mm in the country. The annual rainfall in the country ranges from 1400 to 5800 mm, but its distribution is uneven.

The country's strategy, the 8th Fiver Year Plan has been reviewed. The country's policy regarding water policy (1999), water supply and sanitation policy (1998), national arsenic mitigation policy (2004), climate change strategy and action plan (2009), national adaptation plan (2023), coastal zone policy (2005), water act (2013), water rules (2018) along with country's 8th Five Year Plan (FYP) were reviewed.

Figure 03: National Adaptation Plan

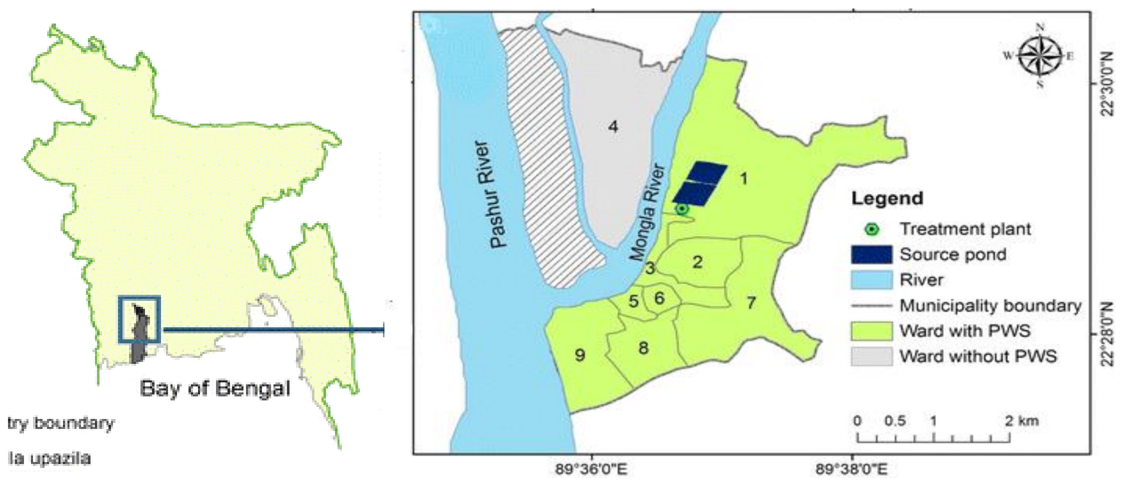


According to the National adaptation plan formulated in 2023, Figure 03 shows that a nature-based solution is best for adaptation. A rainfed pond is an option for water supply for coastal areas in Bangladesh where water scarcity is acute. Water Act and Water Rules are giving support for restoring the ponds for drinking purposes and giving security anyway these ponds could not be used for other purposes instead of drinking water. 8th FYP has been focusing on digging rainfed ponds for ensuring safe water for people in the coastal area, especially in the SW region. The national water policy (1999) and national water supply and sanitation policy (1998) are inspiring to adapt rainwater harvesting where possible. Coastal Zone policy and Climate change strategy also give importance to rainwater harvesting for drinking purposes in coastal areas in Bangladesh.

Study Area

Mongla Port municipality is situated under the Bagerhat district in the southwest coastal region of Bangladesh. This municipality was established in 1990 and became an 'A' class municipality in 2012. The municipality has 8615 Holding Numbers where 2980 HHs relate to pipeline water supply. The literacy rate among the town's people is 53.6 percent.

Figure 04: Study Area



DISCUSSION AND RESULT ANALYSIS

Rainfall Intensity of the Study Area

Availability of rainfall data, rain curve in the hydrological map of the country, and 41958 # rain gauge is the best for choosing as it is situated at Mongla. Data was collected from Bangladesh Agricultural Research Council (BARC)' webpage. Monthly and yearly rainfall from 1991 to 2019 has been analyzed, in Figures 05 and 06. Yearly rainfall in Mongla from 1919 to 2019 showed no continuous degradation or upgradation but showed a fluctuation that did not follow a time interval. After analysis, it was seen, yearly rainfall was unpredictable from 1991 to 2019. For example, in 1992 annual rainfall was 1232 mm, and the next year in 1993 it was 1853 mm, and the previous year in 1991 it was 1997 mm, which means that there was a huge gap in consecutive two years. In addition, after 10 years it was 2786 mm in 2002. On the other hand, another observation was found, in 2017 annual rainfall was 2100 mm, and since then it was around 2000 mm with fluctuation. Rainfall intensity from lowest to highest was 1258 mm to 2786 mm respectively, but we can assume an average rainfall in Mongla is 1800 mm based on analyzed and correlation with literature.

Figure 05: Yearly Average Rainfall, Mongla

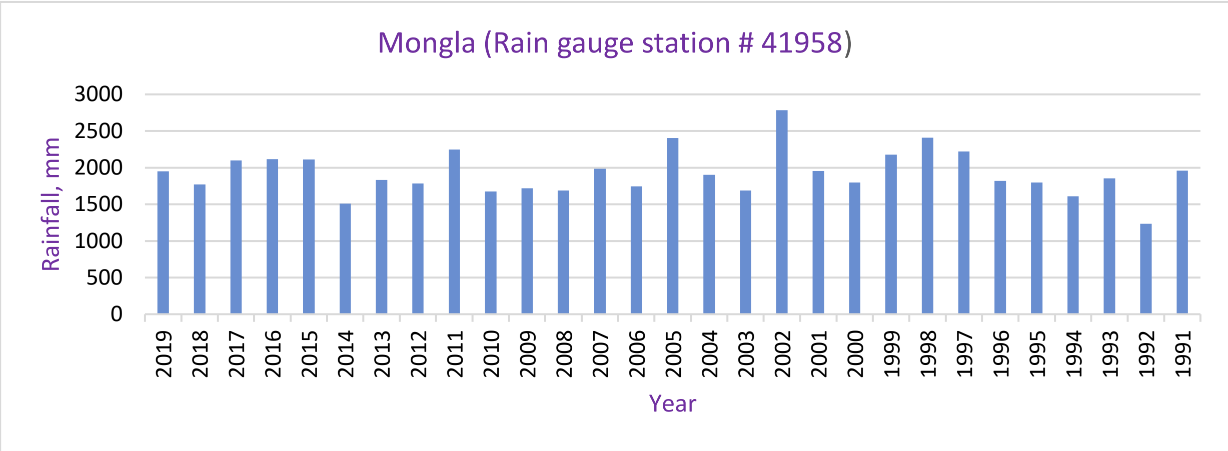
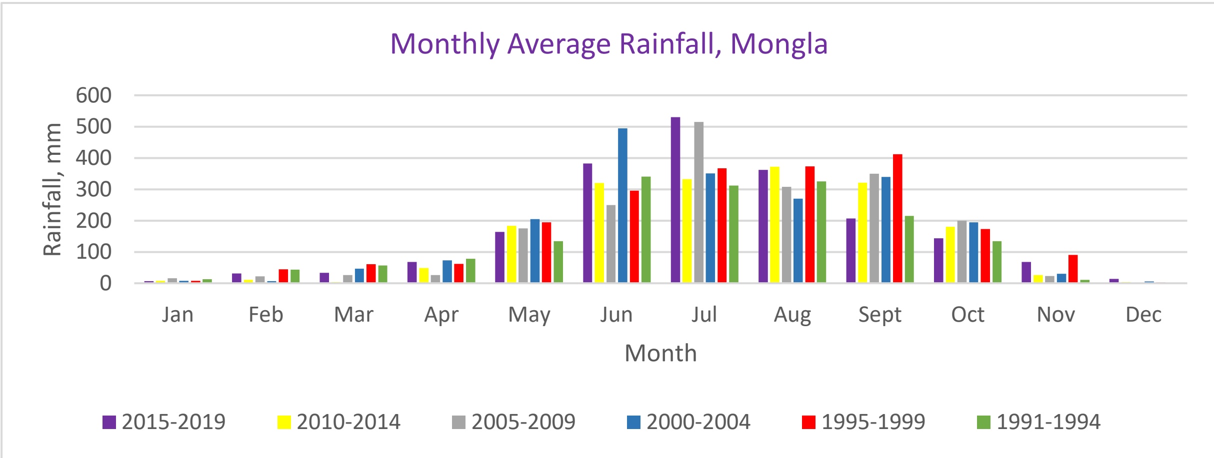


Figure 06: Monthly Average Rainfall, Mongla



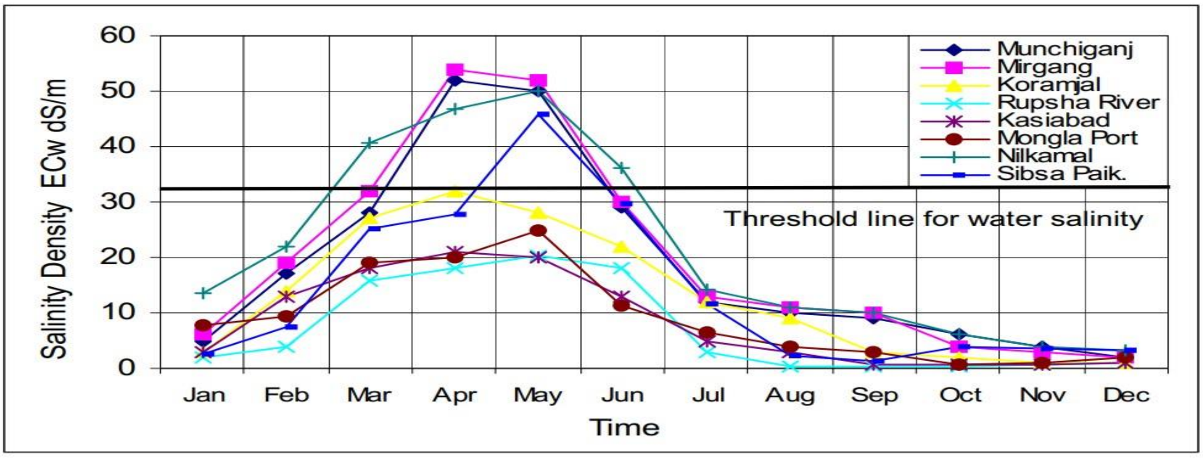
From 1991 to 2019, monthly rainfall showed at the figure, there was a fluctuation in their intensity, but maximum rainfall has been happening from June to July. Monthly rainfall also shows significant rainfall has been happening from May to October. Rainfall is shortened than in earlier decades. From analyzing the monthly rainfall from 1991 to 2019, the study team assumes the monthly rainfall for calculating the effective harvested rainwater for Mongla Port municipality

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Rainfall, mm	0	0	0	70	150	300	320	270	160	120	0	0

River's Water Quality

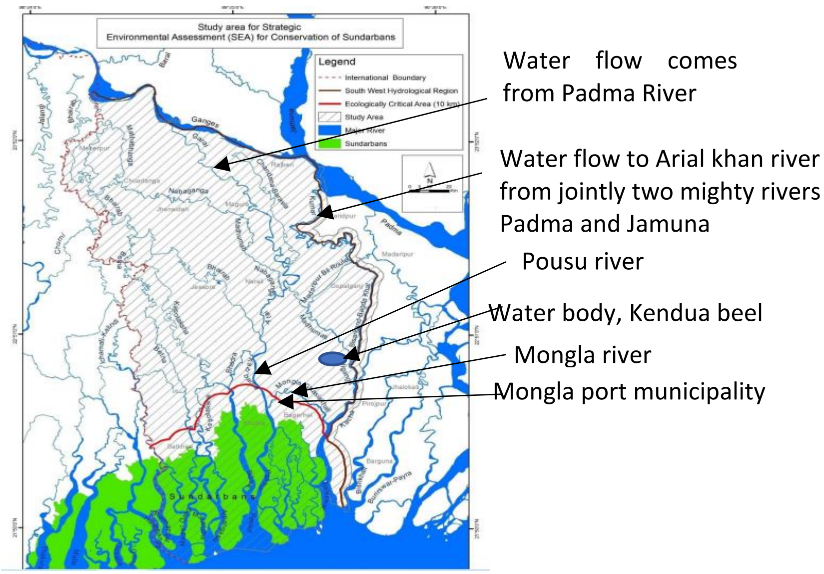
From published different journals following figure was analyzed for getting an understanding of river water's salinity passing by the Mongla port municipality area. The river's water at Mongla port municipality from where water has been collecting municipality is September to December as salinity level during that period is 0.25 to 0.30 dS/m. During interaction with concern persons of Mongla port municipality and physical observation of water collecting practice it was seen that Mongla port municipality is collecting river's water from September to Mid of January every year.

Figure 07: River's Water Quality



The river basin was analysed for why Mongla River's water is acceptable salinity for drinking purposes from September to December than Pousu River.

Figure 08: Mongla River Flow Analysis

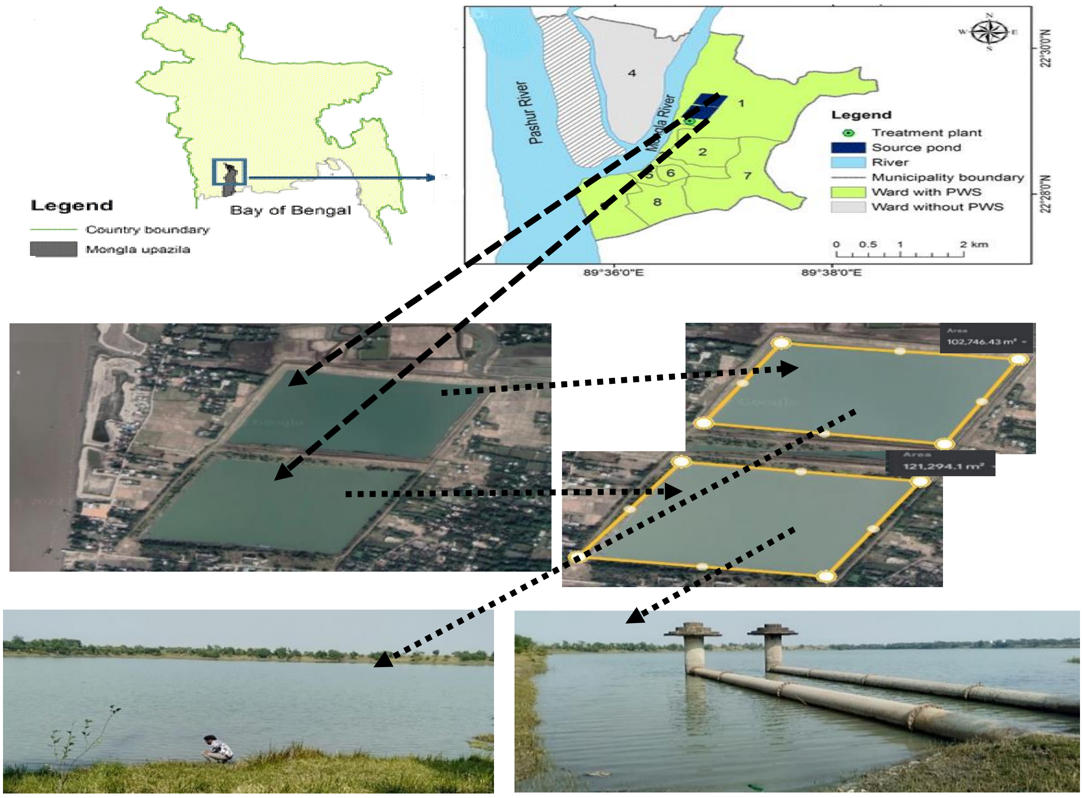


Mongla River's water comes from multiple water bodies, one of them being Kendual beel. Basically, the Arial khan river originated from two mighty rivers- Padma and Jamuna have been contributing their flow to the branch's river from which the Mongla River originated. The river morphology of Mongla River makes it for comparatively less senility than Pousu

Calculation of Pond's Water Capacity

The rainfed pond's catchment area was analyzed physically, and interaction with the municipality and Google map has been shown in the below map and pictures. The total catchment area of the ponds is 224,040 square meters. And the average depth is 1.5 meters. The total volume of the pond is 336060 m^3.

Figure 09: Water Bodies



Water Demand Vs Supply

Pond's volume is 336060 m^3. Currently, 2980 Households and 220 establishments relate to the pipeline water supply system. So, the current monthly water demand is 61500 m^3 considering 2980 HHs and 220 establishments.

Table 10: Water Demand Vs Supply

Month	Current Water Demand (m^3)	Harvested Rainwater (m^3)	River's Water (m^3)	Cumulative water (m^3) after Monthly Consumption
January	61500	0	0	268,500
February	61500	0	0	207,000
March	61500	0	0	145,500
April	61500	15,680	0	99,680
May	61500	33,600	0	71,780
June	61500	67,200	0	77,480
July	61500	71,680	0	87,660
August	61500	60,480	0	86,640
September	61500	35,840	150,000	124,340
October	61500	26,880	364,620	330,000
November	61500	0	61,500	330000
December	61500	0	61,500	330000

Water Quality

For getting an understanding of water quality, the study team analyzed the water quality data tested by Mongla Port municipality and discussed with users at different levels such as Riksha Van pullers, labours, teachers, shopkeepers, and house owners, especially females. During the interaction, the study team asked them if its sweet water. how much salinity do they feel during drinking and when it increases? Did you get a smell? Are they satisfied with this water? Most answered where salinity is acceptable, but 15 percent said during the dry season salinity is high but drinkable. No smell they found but sometimes get more turbidity said 25 percent responded. The municipality's water data showed that the salinity range is 600 mg/l to 850 mg/l. The study team observed and analyzed the treatment facility, baffle filter with alum dosing aiming to get turbidity below 5 NTU, sand filtration and chlorination system, and testing data of residual chlorination at the endpoint of service which are almost okay. But sometimes get more turbidity, users responded, because of poor operation like alum and chlorination dosing does not give properly.

Pictures: Treatment Facility

Conclusion

The study team found from the analytical results that Mongla River's water salinity is acceptable for four months from September to December which is not sufficient to meet the water demand all-round the year. In this case, rainwater harvesting in the pond when river water is not available gives support to addressing the water demand all-round the year. In addition, from April to August, water is sweeter than in other months as rainwater reduces the concentration of salinity of pond water. So, from the facts and statistics of the result, this study is telling what technology is taken at Mongla Port municipality for the town's water supply system is sustainable due to adapting the nature-based solution. Therefore, this study has been evidenced to promote this nature-based technology in climate-vulnerable coastal areas where it is feasible.

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