Safe Drinking Water Crisis, Technological Alternatives and Constraints in Bangladesh

Lessons from Singapore

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Abstract

Groundwater resources are the primary source of meeting the water demand in Bangladesh. In rural areas, hand-pumped tube wells have been the primary source of drinking water. Though studies claim that Bangladesh has the potential to achieve universal safe drinking water supply coverage, the presence of excessive arsenic in the shallow groundwater sources, and the encroachment of salinity in the coastal aquifers in coastal regions (Satkhira, Khulna, Bagerhat, Patuakhali, Jhalakathi, Pirojpur, Barisal, Barguna etc.) hind the path. The concerned authorities of government and other non-government organizations assist the coastal people with alternative technologies like Desalination Plant, Arsenic-Iron Removal Plant, Pond Sand Filtration (PSF), Managed Aquifer Recharge, Rainwater Harvesting System, Installation of Shallow, and Deep Tube Wells. But based on case studies and surveys, this article shows how these existing technologies fail to ensure water safety within the coastal areas. The Singaporean water management policy is an example, this article advocates for necessary government intervention to ensure safe drinking water in coastal areas.

Keywords: Safe drinking water; sustainability; Singapore; technological constraint; Bangladesh; salinity.

Introduction

The other name for water is life. This fact has been recognized from the very beginning of human history. Safe drinking water is an essential condition for human existence. Generally, water is used for three major purposes: drinking,

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agricultural production, and industrial production. Scientifically, the quality of water varies depending on the geological positions of different countries. Countries with extensive coastlines and high coast-to-land ratios seem vulnerable to excessive salinity intrusion (Ramasamy et al., 2015). In Asia, countries like Bangladesh, India, Sri Lanka, Indonesia, Timor-Leste, Maldives, and Myanmar have extensive coastlines. In Southeast Asia, Brunei, Malaysia, Cambodia, Papua New Guinea, Singapore, Vietnam, and the Philippines are considered coastal countries (Ramasamy et al., 2015). Evidences suggest that saline or arsenic-contaminated water poses threats to food production as well as to human existence, particularly in the regions affected by salinity.

Being a low-lying deltaic land, the coastal areas of Bangladesh[†] Are vulnerable to salinity intrusion. During the monsoon season, the southwestern districts (Khulna, Jessore, Satkhira, Bagerhat, and Gopalganj) were found to be the highest salt-encroached (Shammi et al., 2019). River salinity in the southern part, including Patuakhali, Barguna, Pirojpur, Khulna, Bagerhat, and Satkhira, has increased by 45% since 1948 (Alam et al. 2017). We witnessed how the hit of cyclone AILA in 2009 dissipated into low lying districts (such as Patuakhali, Khulna, Jhalakathi, Barisal, Satkhira, Barguna, Laxmipur, Bagerhat, Pirojpur, Bhola, and Jessore) along the coastal region of Bangladesh with a sustained wind speed of 120 kmh (Khatun et al., 2018), had contributed immensely to the salinity intrusion within these areas.

The United Nations General Assembly (UNGA)[‡] has explicitly declared that access to clean and safe drinking water and sanitation are human rights. The resolution also stressed the capacity building and technology transfer, especially for developing states, to ensure accessible and affordable drinking water for all (UNGA, 2010). Long before that, General Comment No. 15 on the water right was adopted by the UN Committee on Economic, Social and Cultural Rights in November 2002, stating the indispensability of water for human beings (UNCESCR, 2002). Despite having these many legal frameworks and conventional recognitions, unfortunately, in developing

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[†] This paper studies the scarcity of drinking water in coastal areas of Bangladesh with a coastline of 710 Kilometers (440 ml) on the northern littoral of the Bay of Bengal. It is formed by a deltaic plain of the river Padma (Ganges), Jamuna (Brahmaputra) and Meghna river, following the northeastern part of the Indian Subcontinent (Etzold, 2015).

[‡] Resolution 64/292, on 28 July 2010.

country contexts—2.1 billion people still lack access to safely managed water and 844 million lack even basic water (WHO, 2017).

In Bangladesh, the scarcity of safe groundwater resources and salinity gives birth to problems like miscarriage among pregnant women, hypertension, skin diseases, hygiene problems during menstrual cycles, respiratory tract infections and many waterborne diseases like Typhoid, Cholera, Dysentery, and so on. The problems have been exacerbated by the presence of excessive arsenic and iron in surface-ground water. With governmental and NGO support, the people in the affected areas adopted technologies like Pond Sand Filtration (PSF), Desalination Plant (DP), Arsenic Iron Removal Plant (AIRP), Deep Tube-Well, Shallow Tube-Well, and Managed Aquifer Recharge (MAR) as an effort to purify the water.

There is an abundance of literature on water scarcity, water salinity, impacts of salinity intrusion on health, agriculture, and livelihood, and technological solutions etc. However, very few have discussed the constraints of the technologies impeding uninterrupted access to safe drinking water. By analyzing the hindrances of technological alternatives in supplying safe drinking water, the paper contributes to the existing literature.

Objectives and research methodology

The study has two major objectives. One, to disclose the constraints of existing technologies in ensuring safe drinking water and second, to show the road map what lessons the government of Bangladesh (GoB) can learn from Singapore to ensure the coastal people's right to safe drinking water in Bangladesh.

For this study, we applied both the quantitative and qualitative research approaches. We collected data from both primary and secondary sources. Primary data were collected from selected stakeholders and key informants by using open-ended questionnaires. For primary data, we conducted surveys, field visits and have used Key Informant Interviews (KII) and Focus Group Discussion (FGDs).

Consent of the respondents was obtained to record their interviews. Respondents spoke in their native language—Bengali. We have translated the substantial parts into English while transcribing. For secondary data sources, we have solely relied on published reports of national and international organizations, journal articles, newspapers, and relevant books.

Research Area: The selected study area includes Koyra, Dacope, Kaliganj, and Shyamnagar Upazilas of Khulna and Satkhira districts in Bangladesh, covering from 22025'N to 22054'N latitude to 89015'E to 89045'E.

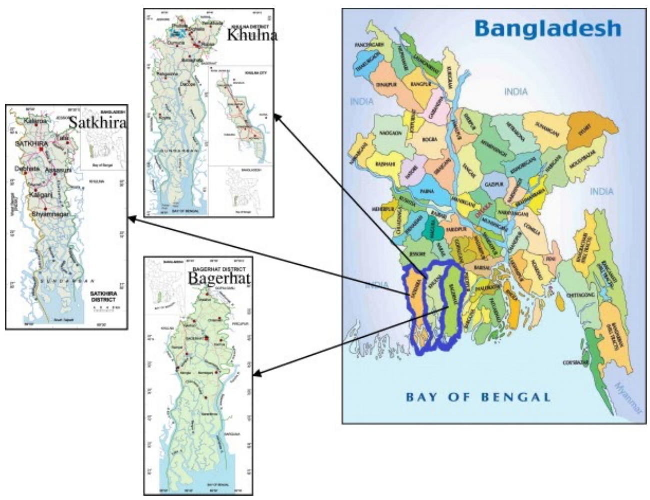

Figure 1. Geographical Location of Satkhira, Khulna, & Bagerhat. Source: Hassan, et al. 2013

Water Supply Technologies & Constraints

Pond Sand Filtration (PSF)

To purify pond water, Slow Sand Filters (SSFs), commonly known as Pond sand Filter (PSFs) are being installed in saline affected areas by the United Nations Children's Emergency Fund (UNICEF) and Department of Public Health Engineering (DPHE) since 1983 (DPHE & UNICEF, 1989). This is a low-cost alternative to ensure a safe water supply. Yokota et al. (2001) argued that PSF is low-budget and it is a coliform and bacteria reduction efficient technology. Despite PSFs inability to purify 100% of pathogens from heavily saline water, it has become the most popular technology for coastal communities (Harun & Kabir, 2012).

We found two types of PSFs (a) traditional PSF, where water is pumped from the pond using the No. 6 hand pump; (b) PSF with solar-powered pump, where water is automatically pumped to the PSF. The study found that each traditional PSFs in different unions of Shyamnagar Upazila is being used by 30 to 50 families, whereas 120 to 170 households can use the solar-powered pumps. The instalment costs vary from BDT 80,000 to BDT 1,70,000 (US$944 to $2006) and it costs around BDT 6,50,000 (US$7671) to install a solar-powered pump. We found that many PSFs were not fully functional. Again, the water quality supplied by the PSFs, after purifying, solely depends on the quality of water collected from corresponding ponds (Harun & Kabir, 2012). Because of excessive salinity intrusion, as well as the existence of Potassium and Chloride, PSFs are not able to meet the standard (0/100ml water) in terms of bacterial contamination. Furthermore, labour-intensive water pumping from pond to filter is a barrier to proper utilization of PSF technology. We also found the PSF equipment requires periodical cleaning and pumping, which is quite difficult as it gets stuck due to high level of salinity. As a result, the durability of PSF appears as a big concern to address.

Desalination Plant

Desalination treatment plants are popularly used to segregate dissolved salts and other minerals from saline water. The plant is effective in getting fresh and safe drinking water in areas where water resources contain a low rate of Total Dissolved Solids (Saleh, 2015). With the assistance of GoB, DPHE, and NGOs, desalination plants have been installed within the coastal belts of Bangladesh. During the River Osmosis (RO) desalination process, a pressure higher than the osmotic pressure is used to ensure the flow of fresh drinking water. The rate of freshwater flow through the membranes increases with the rate of pressure applied. The study found that the desalination plants in our respective research areas are using shallow groundwater with mild salinity concentration (EC 5000-6000 μS/cm). We found that the approximate installation charge of a desalination plant is BDT 16,00,000 (US$18884) to 25,00,000 (US$29506), along with high operation and maintenance charges. As we delved into the constraints, we found that users can collect only 40% of drinking water by desalination plants, whereas the rest 60% of raw water is discharged as brackish water.

Arsenic Iron Removal Plant (AIRP)

An arsenic and iron removal plant (AIRP) is an effective technology to ensure safe drinking water by removing the existing contaminant ingredients from water, like Arsenic (AS) and Iron (Fe). With the assistance of the Secondary Education Quality and Access Enhancement Project (SEQAEO), the DPHE has installed some AIRPs within our studied areas (Rahman et al., 2021). The approximate production cost of installing an AIRP is USD 3000 (Singh, 2017). Rahman and colleagues (2021) found that in a developing country like Bangladesh, the instalment of AIRPs is effective to reduce exposure to Arsenic and Iron, and that the AIRPs to be 67% to 98% effective in AS removal during the pre-monsoon, but it slightly decreases during the post-monsoon (Rahman et al. 2021).

Managed Aquifer Recharge (MAR)

The Managed Aquifer Recharge (MAR) system reduces the contaminated chemicals mixed in the aquifer (e.g., As, Cl) due to the dilution process. The purifying procedure involves recharging the aquifer with pond water after slow sand filters (Rahman et al., 2019). The approach promotes the oxidation and retention of oxygenated pond water to ensure the reduction of As (Arsenic), Fe (Iron), and Mn (Manganese). The MAR system requires the creation of an artificial pond to bring new sands in contact with the aquifer and to enhance the recharge of the aquifer (Zahid, 2019).

Deep Tube-Well

Deep Tube-Well (DTW) is a well-known technological alternative to ensure safe drinking water which works in suction mode. Wherever a potentiometric surface of the groundwater table exists 7.5 m below the ground surface, DTW withdraws groundwater from the deep aquifer. In general, these deep aquifers have a depth of 150m in the basin part. DTW is separated by impervious clay layers, which are geologically and hydro-stratigraphically defined as deeper aquifers (Ground Water Task Force, 2002). We found that the depths of DTWs vary according to the geology of different areas. But aquifers with a depth of more than 100m can be found as arsenic contamination-free. Saha et al. (2018) found that proportionally only 12% of the existing deep aquifers can serve with safe-contamination-free drinking water. The study directly warned the upcoming threats of water scarcity within these areas suggesting the installation of aquifers with specific depths of 150-384 m to ensure safe drinking water within the coastal belts of Bangladesh. We found that the installation of DTWs is generally beyond the affordability of people living in these areas as these instalments are expensive, whereas pumping is not possible with suction mode if the water level is ≥ 30 ft.

Shallow Tube-Well (STW)

Shallow Tube-Well (STW) is widely known as low budget, convenient alternative to access drinking water in rural areas of Bangladesh. According to researchers, shallow shrouded tube wells have a depth ranging from 15 to 20m (Ahmed, 1996). We found that the shallow tube wells are the most common technology for the abstraction of groundwater due to their cost-effectiveness.

Our survey found shallow aquifers all around the Upazilas and unions with a maximum depth of 100 m. Our study found that the approximate cost of installing a shallow, deep tube well is around BDT 15,000 to 25,000 (US$177 to $295). It is worth mentioning that we have found how ineffective these instalments of STWs are, as these aquifers cannot ensure the removal of iron or salinity from contaminated water sources. Unfortunately, the water collected from STW is vulnerable to surface pollution due to the poor disposal of human and industrial waste on the ground.

Rainwater Harvesting System

The average rainfall is approximately 3000mm in the coastal areas of Bangladesh. Almost 75 percent of this rainfall occurs during the monsoon season, from mid of May to September (Ahmed, 1996). The process of storing rainwater during the wet season to use the water in the dry season is popularly known as rainwater harvesting (Masum et al., 2018). The process involves the concentration, storing and collection of rainwater which serves the purposes of domestic chores, industrial uses, agricultural production and many (Sutherland et al. 2000). For collecting rainwater in the coastal zone, the most popular system is the rooftop catchment system though there are other two ways of collecting it; the in-situ catchment system and the run-off catchment system (Islam, 2017). We found that different types of RWH systems had been installed by other organizations where people are suffering from both arsenic and salinity contamination of water from surface and groundwater sources. The Community Rainwater Harvesting System (CRWH) is also popular. The average cost for installing an RWH system varied from BDT 10,000 to 1,50,000, (US$118 to $1170) depending on the size of the storage tank and other facilities. The rainwater is not sufficient for round the year as it solely depends on rainfall, its intensity, and frequency.

Policy lessons from Singapore

Singapore has no water sources like aquifers or lakes. The People's Action Party (PAP) established a unitary state to construct Singapore as an ideal state (Ullah, Ho and Kathy, 2021). Approximately 5.69 million people in Singapore (UN, 2021) use an average of 430 million gallons of water per day. With no particular water resources, how Singapore managed to develop such a strong water management system is a miracle to the world. Singapore became independent in 1965 from Malaysia under the strategic leadership of its first

Prime Minister, Lee Kuan Yew (Oei, 1998). Singapore's economic miracle has been one of the most cited issues in the public and private discourse, and the foundation of which was laid by Prime Minister Lee (Irvine et al., 2014; Ullah, Ho and Kathy, 2021). He introduced the Singaporeans to the holistic development of urban environmental management, and under his close supervision, the Public Utility Board (PUB) was established to supervise electricity, water, and piped gas (Irvine et al., 2014). PUB runs the National Taps of Singapore Program for meeting the countrywide demand for water. Water from local catchment areas, imported water (from Malaysia); reused water (known as NEWater); and desalinated water are the four national taps of Singapore. According to the government data, imported water from Johor satisfies about 50 percent of the national demand for water, Desalination up to 25, NEWater can meet up to 40 percent, and the local catchments help to make up the rest (The Straits Times, 2018). We believe that Bangladesh has many lessons to learn from Singapore on some particular aspects to solve the safe drinking water scarcity in the coastal belts.

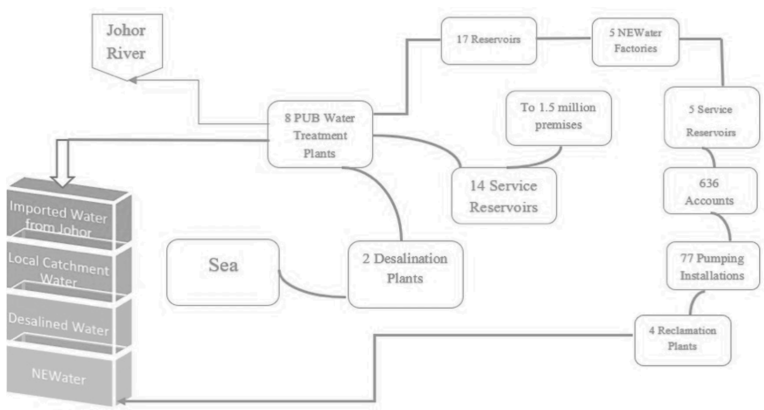

Figure 2. Singapore's Water Supply
Source: Adapted from PUB. Singapore's National Water Agency, 2021 https://www.pub.gov.sg/watersupply/singaporewaterstory)

Formation of an authority like the PUB of Singapore: In Bangladesh, under the National Water Management Plan we found nearly ten different institutions[§] To work on water management. We have found that there is a

[§] WARPO as a secretariat of the National Water Management Council to monitor national planning and implementation, DPHE, the Bangladesh Water Development Board (BWDB) to develop the main and regional rivers, the Local Government Engineering Department to support floodproofing and cyclone protection measures, the department of disaster management for the preparedness and continuation of relief operations, the Bangladesh Haor and Wetland Development Board to ensure integrated lack of coordination among institutions. In Singapore, however, we learned that the Ministry of Sustainability and the Environment (MSE) has a statutory board named PUB, which manages all Singapore's water management issues in an integrated fashion. This means there is no coordination issue in handling whole-of-government initiatives to ensure water security. We are sure that the formation of such a board or body increases efficiency and helps the government to remain focused on water issues.

Installed Technologies Need to be Cost-Effective: A study found that in the coastal areas of Bangladesh, only 30% of the total households have PSFs within 400m of their residences, and about 46% of the households do not have PSF within 2 km of their houses. The study also calculated the required time for water collection and found that PSFs are more than 2 hours for 55% of the households (Islam et al., 2013). We found a resident of Sutarkhali Union under Dacope, a 25-year-old woman Aleya Begum saying

I wake up before dawn almost every day and walk five kilometres away to collect drinkable water from a water plant installed by a Non-Government Organization. I have a family of six members, and I fetch drinking water for all of them. I have ponds nearby, but due to salinity, the water is used neither for drinking nor for cooking. Our suffering does not end within walking; I need to queue up near the water plant for hours to get my turn to fill my water pot. It even becomes midday when I return home with drinking water. There is no one to hear us!

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development strategies for the management of haors and wetlands, Department of Fisheries, Department of Environment, Private Sectors, and Non-Government Organizations.

Table 1.

PSF	***RWHS***
Cost for 60 Households • *Total construction cost Tk. 66,000 (* • *Maintenance Cost Tk. 3,000/year (including cleaning by chlorine and repairing for any damage is detected)* ***Cost per Household*** • *Total construction cost is Tk 1100* • *Maintenance Cost TK 50/year* *Economic Life = 15 years* *Total cost = {1100 + (50*14)} = TK 1800* *Annual Payment = (1800/15) = TK 120* *Cost/L = [1800/ (25L * 365d * 15 years)]* *= TK 0.013/L* ***Cost/L = 0.013 (Cheapest)***	***Cost per Household*** • *Cost of construction Tk 29,000* • *Maintenance cost Tk 200/year* *Economic Life = 15 years* *Total cost = {29000 + (200*14)} = Tk 31800* *Annual Payment = (31800/15) = TK 2120* *Cost/L = [31800/ (25L * 365d * 15 years)]* *= TK 0.032/L* ***Cost/L = 0.032***

Source: Islam et al., 2013.

Calculated Cost of PSF & RWHS by DPHE

Undoubtedly, the households living in the coastal areas are paying much for RWHs, CRWHs, and PSFs in terms of both; time and money [i.e., a big portion of their income] to get access to safe drinking water. What does Singapore do exceptionally? Singapore takes the water quality, production and management costs into account so that people can access to safe drinking water without financial burdens. Moreover, the success story of Singapore on water resources management reminds us to come up with out-of-the-box ideas and innovations and to allocate a substantial budget on water research and sustainable planning.

Conclusions

Despite the fact that access to safe drinking water is a universally acknowledged human right, coastal residents are denied it is owing to their physical position. To protect coastal residents from many lethal diseases, issues such as salt intrusion, arsenic poisoning, and other technological impediments to accessing affordable and safe water must be addressed. Singapore serves as an example for us, demonstrating how to spend on long-term water project management in the face of scarcity, which we may emulate to ensure human survival.

Natural disasters are growing, and the adverse effects of climate change are responsible for the low durability of water technologies in coastal areas. Therefore, the budget allocation from Annual Development Plans should give priority to the issue. The Union and ward level Water and Sanitation Committee (WATSAN) and capacity building of caretakers of water sources should function under the direct supervision of the DPHE. NGOs and private actors should take one step ahead to deal with the existing water technological constraints. Business agencies operating in coastal areas should allocate a budget for establishing advanced water technologies as part of their Corporate Social Responsibilities (CSR). A separate policy and comprehensive work plan can be formulated. Existing legal frameworks and practices concerning leasing water bodies for surface water should be amended according to priorities. The surface water in ponds and canals should be preserved as the sources of drinking water, agricultural irrigation and household chores.

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