3

Chronicles from the Coast

Public and Private Responses to Water Risks in Khulna

3.1 Introduction

About 300 km south of Dhaka, away from the chaotic city life, is Khulna – one of the 19 districts officially demarcated as ‘coastal’ owing to the influence by tidal processes from the Bay of Bengal. While most of Dhaka’s residents are detached from the polluted rivers in their day-to-day urban lives, rural lives and livelihoods in the coastal region are intrinsically linked to the hundreds of tidal rivers and creeks that meander through a fragmented landscape of embanked islands called ‘polders’. Constructed during the 1960–1970s, the network of embankments and sluice gates were designed to control flow of saline water into the low-lying agricultural lands or ‘*beels*’. By increasing food security, improving road communication, and offering protection from storm surges, the polders provided a sense of permanence, encouraging growth of population and settlements. Today, more than 8 million people live across the 139 polders covering a land area of 12,000 km^2 (BWDB, 2013).

These densely populated deltaic floodplains are, however, prone to multiple water risks – from rapid-onset extreme events like cyclones and storm surges to chronic drinking water scarcity due to salinity (Hoque and Shamsudduha, 2024). The water crisis peaks during the driest months of March to May, when months of no rainfall limit recharge of ponds, with decreased upstream flows from the Himalayas causing saline water from the Bay of Bengal to fill the tidal rivers. While groundwater is easily available at shallow depths, salinity often exceeds the drinking water threshold, especially in the southernmost areas close to the Sundarbans mangrove forest. Freshwater may be available at deeper depths, though there are large variations in aquifer availability within short distances. Rainwater offers temporary relief during monsoon, with 2,000 mm of rain occurring within a short period of four and a half months between June and mid October (Shahid, 2011). In a landscape surrounded by water all year round, the scarcity of drinking water is indeed ironic.

The public sector response to these environmental risks has been to improve water supply through infrastructure investments. Since the 1990s, the government and international donors have poured in huge sums of money to build a diverse range of water supply technologies based on the local hydrogeological conditions. In line with the global policy discourse, this infrastructure-led agenda has indeed been successful in increasing access to improved water sources throughout rural Bangladesh, from 65 per cent in 1990 to 97 per cent in 2015 (GED, 2015). Much of this progress can be attributed to the remarkable adoption of tube wells – a transition that was initiated by the public sector but later fuelled by private self-supply investments by rural households. Yet, policy and planning documents consider publicly financed and community-managed water systems as the dominant institutional model for rural water service provision, with privately owned and managed sources not being formally recognised or monitored. Other forms of private sector engagement, such as the growing market of small water enterprises, also remain outside the scope of national accounting. In the absence of any regulatory oversight, this reallocates the responsibilities of financial and operational risks to individual households, schools and healthcare facilities, jeopardising safely managed drinking water services for the most vulnerable.

In this chapter, we draw on the daily water diaries of rural households in Khulna district to present how water source choices vary by local hydrogeology, season, and socio-economic status. We ground these behavioural dynamics within the uncoordinated landscape of public and private investments in water supply infrastructure, with uncertain water quality risks from salinity, arsenic, manganese, and *E. coli*. We argue that the existing institutional arrangement for water supply ‘provision’ in rural households and schools needs to be reformed to address the inequalities in access, environmental, financial, and operational ‘risks’ to safe and reliable services for all. In doing so, we share our experiences of designing, piloting, and scaling a results-based professional water service delivery model for schools in Khulna district. This story of change showcases how high-level government commitment, catalysed by donor funds and science-practitioner partnerships, can trigger in shifts in practice.

3.2 Salinity Risks and Investments in Water Supply Infrastructure

It was mid February 2017, just days after the onset of *Falgun* (spring) season. As we drove down the embankment road along Polder 29, the greyish sediment laden river flowed along the outer side, while vast stretches of paddy fields covered the landward side, often interspersed with settlements. The quintessential Bangladeshi village home comprises mud or tin-walled houses with thatched roofs surrounding a courtyard, shaded by fruit trees. A cluster of houses is likely to be inhabited by

Figure 3.1 Sisters-in-law busy with chores on a typical afternoon in Polder 29.

family members of the same paternal lineage, though each house may belong to a separate household. Cattle munching on haystacks, with cow dung sticks being sun-dried to be used as cooking fuel, are symbols of prosperity. Small ponds can be found among these clusters, with the water being used for washing, bathing and sometimes cooking. Somewhere in the courtyard, there is likely to be a hand pumped tube well – the primary source of drinking water for millions of rural Bangladeshis (Figure 3.1).

Bangladesh's tube well story started in the 1980s – the International Drinking Water and Sanitation Decade. The global political framing of risk at that time revolved around diarrhoeal diseases from drinking microbiologically unsafe water (Fischer, 2019), particularly among infants and children under five, prompting increasing allocation of international aid to developing countries in Africa and Asia to improve access to safe drinking water. The quest for the appropriate low-cost technologies prompted the design and field testing of different handpump models based on the hydrogeology and cultural preference of the place. For Bangladesh, where the water table is very high, UNICEF's No. 6 handpump met all the desired criteria of low installation cost, easy operation and maintenance, and durability (Black, 1990). It is a simple robust suction pump that can be manually drilled through the sand and silt using the sludging method and can be easily repaired as all moving parts are above the ground.

The installation of tube wells was initially led by the Department of Public Health and Engineering (DPHE), the national lead agency mandated for provision of rural water supply, with technical support from UNICEF. However, once the government released its control over local supply chains, the private sector took over, resulting in the growth of domestic production and maintenance capability (Fischer et al., 2020). The easy availability of spare parts and masons, coupled with increased demand for private water sources within one's premises, fuelled the growth of self-supply through shallow tube wells (less than150 m below ground level). Today, it costs around USD 125 to install a shallow tube well via private drillers and USD 275 when installed by DPHE. In comparison, deep tube wells cost more than USD 1,100, thus, their installation is either financed by DPHE or well off individuals. With 1.74 million publicly funded tube wells in 2019 (DPHE, 2019) and an estimated 18 million private tube wells (Fischer et al., 2020), Bangladesh's tube well story is unprecedented.

Tube wells, however, have been less successful in improving drinking water access for the coastal inhabitants. While there is a general trend of increasing salinity towards the Bay of Bengal, the coastal aquifer system is very complex characterised by high degree of spatial and vertical heterogeneity. In general, there are three layers based of depth and the nature and geological age of the sediments – (1) the upper shallow or first aquifer, formed about a 100 years ago and extending down to 50–100 m below the surface; (2) the second or main aquifer, dated as about 3,000 years old, and occurring up to a depth of 200–300 m; and (3) the deep aquifer, estimated to be about 20,000 years old and investigated up to a depth of 350 m (Aggarwal et al., 2000, BWDB-UNDP, 1982). Salinity in the shallow aquifers is extremely variable both spatially and seasonally, often exceeding the official permissible threshold level of 1,000 ppm of total dissolved solids (or electrical conductivity of 1,500 µS/cm). Vertical infiltration of rainwater during monsoon recharges the aquifers, with isolated freshwater pockets from recent precipitation indicating that the aquifers are not hydraulically connected. The deeper aquifers exhibit a more uniform distribution of salinity and continuity on a regional basis, though much of it remains understudied (Akhter et al., 2023, Ahmed, 2011).

In absence of systematic hydrogeological records, inferences about the aquifer system can be drawn from the depths and salinity of existing tube wells. Our water infrastructure mapping in Polder 29, which included all 2,805 public and private tube wells in the southern half (Figure 3.2) and a selected sample of 354 tube wells in the northern half, showed progressive increase in salinity in the shallow aquifer along a north-south transect with a corresponding decrease in the thickness of the deep aquifer. As such, 74 per cent of the tube wells in the northern half were used for drinking compared to only 38 per cent in the southern half, though 55 per cent of all drinking water tube wells exceeded the recommended salinity threshold of 1,000 ppm. The impacts of salinity became more visible as we continued our journey towards the southern end of the polder. The green paddy fields were

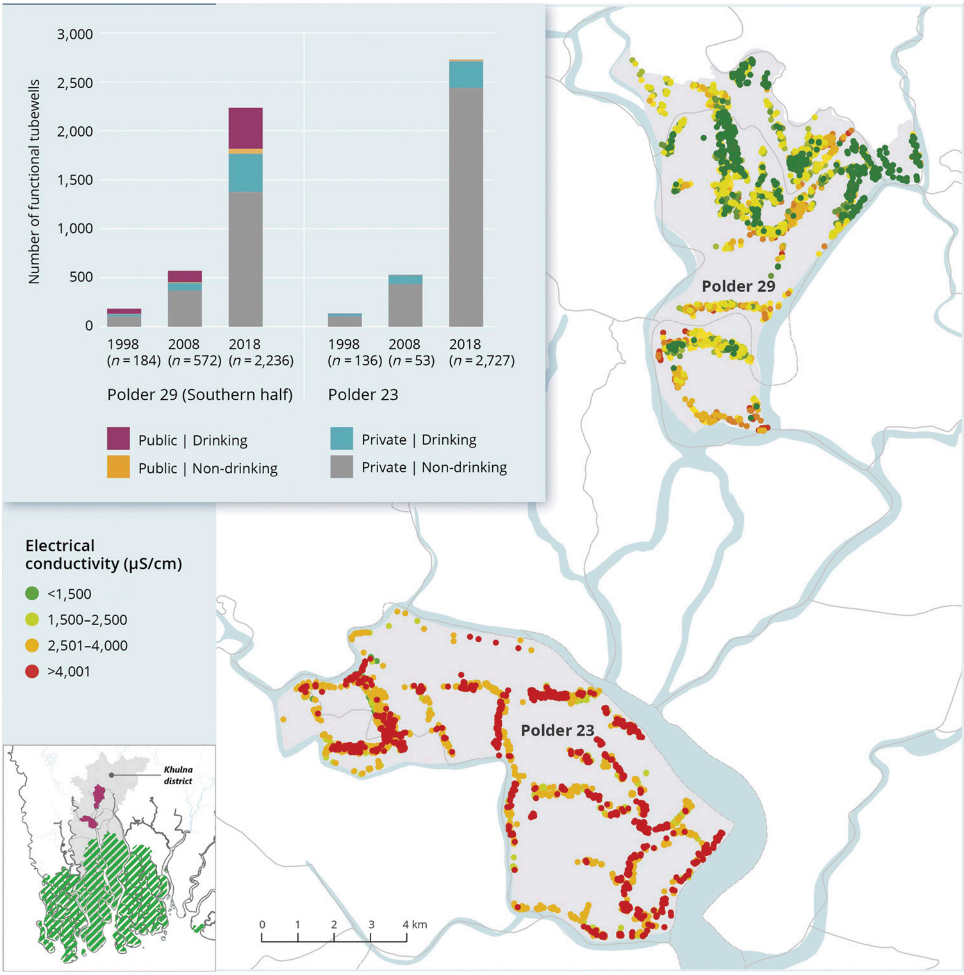

Figure 3.2 Location and water salinity of tube wells mapped in Polder 29 and Polder 23 of Khulna district.

replaced by fallow land with cracks appearing on the topsoil, while a few cattle grazed on the remaining hay. Most houses in the area had provisions for rainwater harvesting, though only better-off ones could afford large plastic storage tanks. It has been months since the last rains, and with the dry season about to intensify in March–April, most households, except for those with tanks, would soon run out of their stored rainwater.

Community water sources in these high salinity areas include pond sand filters and small piped schemes, mostly installed by local NGOs through donor-funded projects. The first pond sand filters were installed by DPHE in Dacope upazila (sub-district) in 1984, with subsequent modifications in design. A pond sand filter comprises a filtration chamber with a layer of sand and brick chips, which

Figure 3.3 Women using *kolshis* and plastic bottles to collect water from a pond sand filter (Photo credit: Lutfor Rahman).

treats surface water from rain-fed ponds that can then be abstracted by a hand-pump mounted on a raised platform (Figure 3.3). As of 2019, there are about 3,500 pond sand filters in the three southwestern coastal districts of Satkhira, Khulna and Bagerhat, though data on functionality is unavailable (DPHE, 2019). For rural piped schemes, donor investments have increased since the 2010s, though recent data from UNICEF/MICS (2019) shows that only 5.5 per cent, 5.3 per cent and 0.7 per cent of the surveyed households in Khulna, Bagerhat, and Satkhira districts respectively use piped water as their main source. We mapped a total of 49 piped schemes in Khulna district in 2022, of which three are in Polder 29 serving between 150 and 300 households within a 1–2 km of the source borehole.

With improved living standards, there have been growing demands for vended water. During the dry season, locally made three-wheeled motorised vehicles called *nossimons* or pedalled vans can be frequently sighted carrying stacks of blue or white coloured water containers. One of the most popular sources for vendors in Polder 29 is a motorised tube well, located in a mosque just beside the river. Owing to its location, water from this tube well is also transported via trawlers to other polders further south (Figure 3.4). To interview the vendor and track his route, we took a ride on the trawler with about a hundred 30-litre containers and a few 200-litre drums of water. After an hour of sailing, as we approached Polder 22, we could see men, women and children lined up on the embankment with *kolshi* (aluminium pitcher), buckets, and bottles. As soon as the trawler docked on the jetty, they swarmed in to fill up their containers before the water ran out.

Figure 3.4 Water from a deep tube well in Polder 29 being transported in 30-litre containers via a trawler to be sold to villages 6–8 km further south (Photo credit: Lutfor Rahman).

Tube wells are not the only sources of vended water. Since the late 2010s, there has been a boom in investments in reverse osmosis-based desalination technologies by donor organisation and grassroots entrepreneurs. We mapped 63 desalination plants in Paikgachha upazila (further south of Polder 29), of which 93 per cent were privately financed by local residents who saw a business opportunity while also addressing water scarcity in their communities (Hoque, 2023). Several factors converged to create a business opportunity for this niche innovation to flourish, including economic growth resulting from shift to export-oriented aquaculture, expansion of rural electrification to remote areas, and availability of cheaper reverse osmosis technology imported from China.

Analysis of the water supply technologies and capital expenditures in both Polders 29 and 23 show a clear trend of increasing private investments with increasing salinity from north to south. Between 2010 and 2020, USD 385,000[1] and USD 200,000 were invested by the government and donors in Polder 29 and Polder

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[1] Exchange rates for BDT to USD are based on the time of data collection and range from USD 1 = BDT 80–100 in this chapter.

23, respectively, compared to USD 252,000 and USD 410,000 being invested by households and local entrepreneurs (Hoque, 2023). Many a times we have heard government officials and residents saying, ‘We suffer a lot for water, because tube well is not ‘successful’ in our area’, resonating the institutional and cultural mindset that tube wells are a symbol of water security. Although piped schemes are the future of rural water supply, whether through public taps or household connections, the inherent inertia to invest public funds in non-tube well technologies can be partly attributed to bureaucratic hurdles. On one occasion, a local engineer of DPHE mentioned, ‘We got an allocation for 26 tube wells per union. If we drill and cannot find any aquifer, we cannot reimburse our contractors. So, we have to install these in areas known to have good groundwater. We cannot pool these funds and install a piped system unless directed by specific projects.’

These variations in water infrastructure type, as dictated by the local hydrogeology, is also reflected in water services for rural schools in Khulna district (see Section A.5 of Appendix for methodological details). The institutional and financing arrangement is more streamlined for government primary schools than for secondary or non-government schools. For government primary schools, capital investment for water and sanitation facilities is financed through the Primary Education Development Programme – a multi-donor and government funded project supporting the primary education sector since the early 2000s, and the installation process is led by DPHE (Fischer et al., 2021). Secondary schools often have integrated ownership, meaning that the government pays for staff salaries while other costs need to be covered through tuition fees. Thus, waterpoints in secondary schools, as well as in private and NGO schools, are installed through school funds, donor-funded projects, and funds from union council or local Minister of Parliament, and in some cases by DPHE, if there is no boundary wall restricting access to the community.

Schools in the northern part of Khulna district often have multiple tube wells, upgraded with submersible pumps and internal plumbing. Those in high salinity areas have rainwater harvesting, but the availability is restricted by tank size and roof catchment area. In Dacope, one of the nine upazilas, many schools have high storage capacities (more than 10,000 litres) owing to multiple donor-funded projects operational in that area for decades. Other technologies, such as reverse osmosis plants, small, piped schemes and pond sand filters, are available in small numbers. For the 15 per cent schools that do not have any drinking water source, teachers’ pay out of pocket to purchase vended water, and students may bring water from home. In many cases, children end up using unsafe sources like shallow tube wells or fetch it from nearby households where available.

With such diverse range of technologies for households and schools, it is evident that significant capital investments have been made by the government, donors, and the private sector over the past few decades. While this infrastructure-led response has surely met the agenda for increasing 'access' to improved sources', to what extent these water services are safe, reliable, affordable and equitable remains unclear. We now explore the social, spatial, and seasonal variations in household source choices and outcomes to unpack who bears the greatest risks, where, and when. These behavioural dynamics can highlight the gaps in existing institutional design and the needs for redistributing the risk responsibilities among the different public and private actors.

3.3 Spatial and Seasonal Distribution of Water Risks among Households

As discussed earlier, drinking water is not a concern for those living in low salinity areas, such as the northern half of Polder 29, where all households rely on deep tube wells all year round (Figure 3.5). Most of these deep tube wells are public, with 30 per cent being owned by an individual or group of households. In areas where groundwater is too saline to drink, such as the southern part of Polder

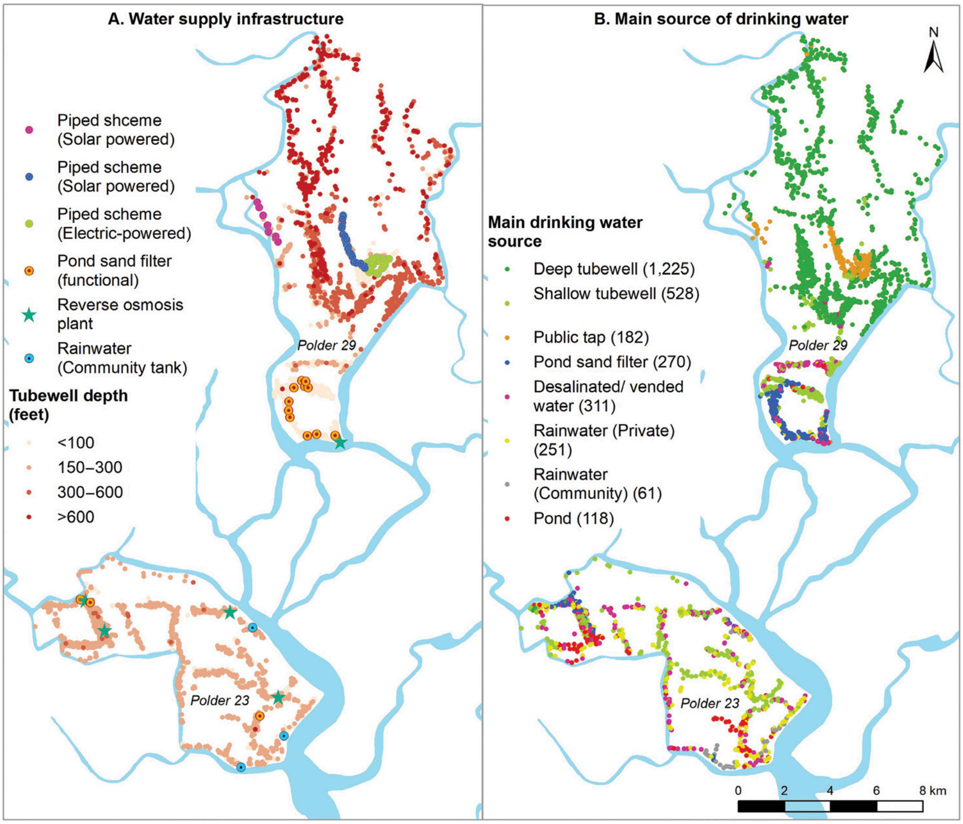

Figure 3.5 (a) Water supply infrastructure and (b) main sources of drinking water in Polder 29 and Polder 23.

29 and our other study site Polder 23, households use multiple sources throughout the year with varied implications for quality, costs, and distance (Figure 3.5). Though widely acknowledged, such variations in water sources are never captured in aggregate statistics used for decision-making. Large-scale surveys, including the 10-yearly national census, the Demographic and Health Surveys and the Multiple Cluster Indicator Survey (MICS), which are funded by the Government of Bangladesh, United States Agency for International Development, and United Nations Children's Fund (UNICEF), capture access to the drinking water facilities and service levels, in terms of the main source, the collection time, water treatment methods, and recently, the reliability of the service. This results in a flawed portrayal of progress, suggesting that 98 per cent of rural Bangladeshis use a safe water source (GED, 2015).

Our water diary study, which included the water-stressed villages in south of Polder 29, revealed the day-to-day changes in water sources and costs. We identified significant spatial clustering in households' water source choices (refer to Section A.3 of Appendix for data analysis methods), indicating proximity to waterpoints and rainfall as the key behavioural drivers (Figure 3.6). Cluster 1, comprising 27 per cent of households, predominantly used vended water for drinking and shallow tube wells for other uses. In contrast, those in Cluster 3 (28 per cent households) reported using shallow tube well for drinking and pond water for other uses. This reflects the variation in groundwater salinity within short distances. While water from shallow tube wells in this region is generally too saline to drink, as is the case for Cluster 1, one private shallow tube well (locally known as *Kalar kol*) located about 1 km north of Cluster 3 had low salinity, making it a lifeline for neighbouring villages. The greatest share of households (40 per cent) belonged to Cluster 2, using pond sand filters as the main source for both drinking and non-drinking uses. The remaining 4 per cent households in Cluster 4 were located further north, and thus, unlike others had access to deep tube wells for drinking. Use of rainwater peaked between July and September for all clusters, particularly Cluster 3, who could avoid walking to *Kalar kol* for a few months. Owing to the curvature of the river, the area of the polder inhabited by Cluster 3 households is prone to riverbank erosion and storm surge inundation. With many households having lost their land and living on the embankment, the area had limited scope for installing water supply infrastructure.

The prevalence of chemical and faecal contamination varied across these different types of sources (Figure 3.7). The water quality in pond sand filters, the most widely used technology in the southern part of Polder 29 (refer to Cluster 2), varies substantially from one source to another depending on maintenance of source pond and the filter media. In general, they are prone to faecal contamination, particularly in the rainy season owing to seepage from nearby latrines or livestock.

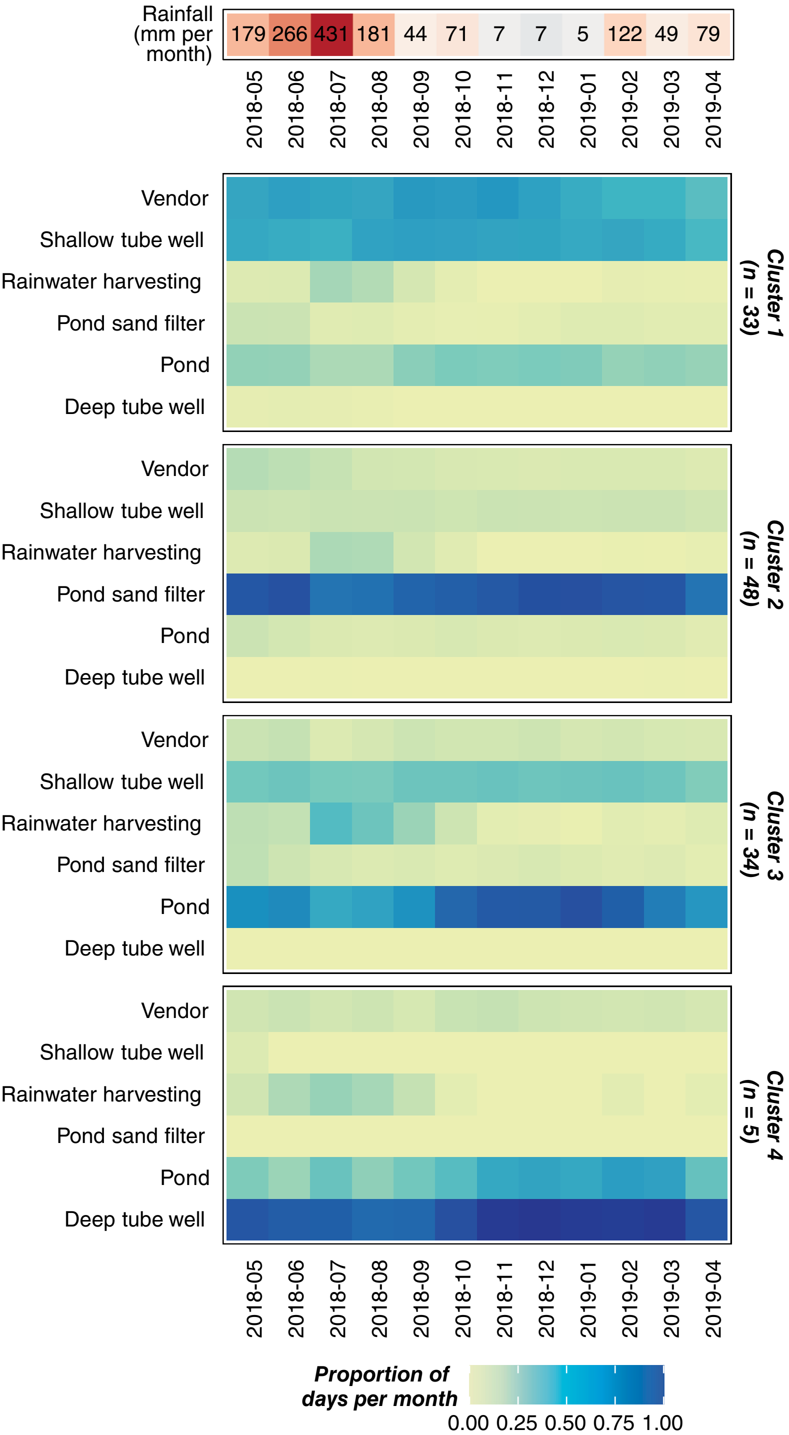

Figure 3.6 Water sources used by 120 diary households during 2018–2019 in relation to rainfall.

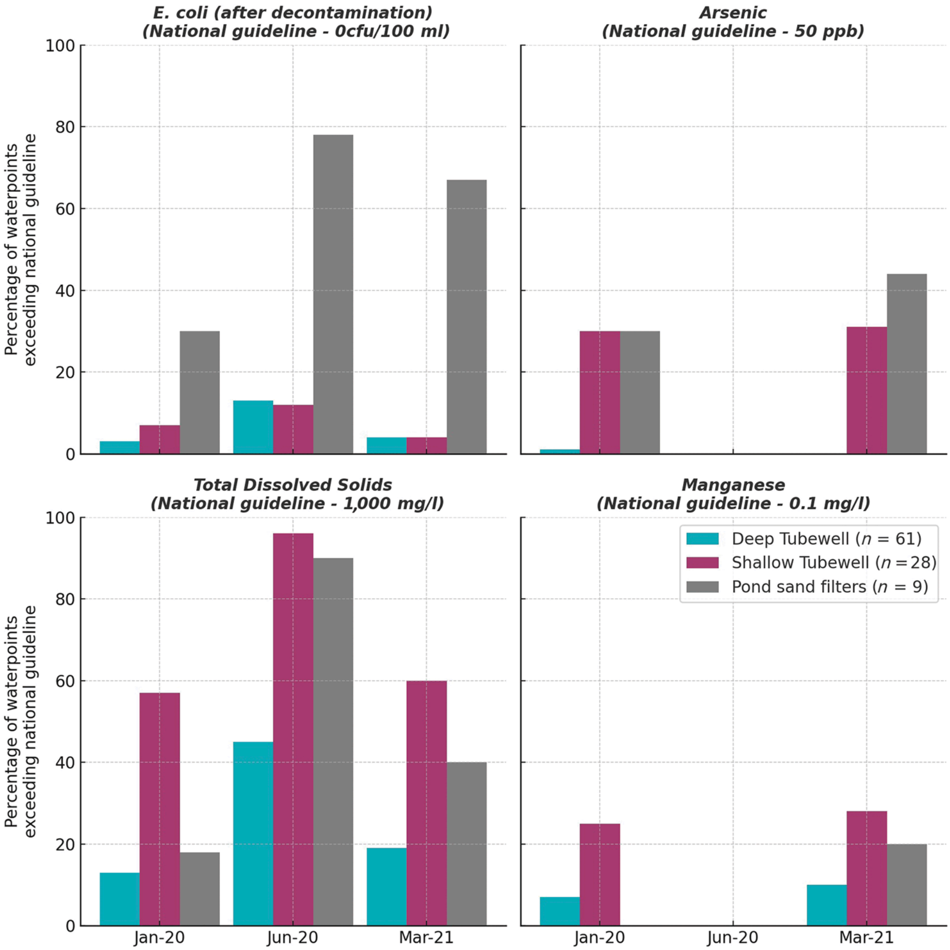

Figure 3.7 Seasonal variations in chemical and faecal contamination across 97 waterpoints in Polder 29.

Inundation by saline water from storm surges poses another challenge, as exhibited by June 2020 samples collected after cyclone Amphan in the previous month. Vended water from deep tube wells and reverse osmosis plants are generally free from contamination, though many prefer the former owing to better taste. As one participant explained, ‘The vended water [from Sarappur tube well] is as natural as coconut water, but this [desalinated] water is treated with chemicals.’

These variabilities in water quality by source and time of the year, however, are not reflected in national statistics. During the MDG era, assessment of safety was simply based on whether a source was ‘improved’ or ‘unimproved’, thus, making tube wells safe by default. Starting from 2012, DPHE’s Annual Waterpoint Status reports show upazila-wise ‘coverage by safe waterpoint’, where ‘safe’ is defined as having arsenic below the national guideline of 50 μg/l. These statistics are based on test results for public waterpoints at the time of installation, as there are no provisions for routine quality checking even on a sample basis. Indicators like salinity and faecal contamination are neither measured nor reported. Donor-funded or privately installed sources, which serve the bulk of the population in water stressed areas, are completely unaccounted for. The MICS 2019 was the first nationally representative survey to test for *E. coli* at the point of use. Results indicate that when arsenic and faecal contamination are considered, only 43 per cent of households use a safe water source on premises, down from the widely reported statistic of 98 per cent having access to improved sources (BBS/UNICEF, 2021).

Indicators for affordability, such as household water expenditures, are not available either, though this is a concern for all countries and contexts without piped water connections. Cost is the main deterrent for using better quality vended water, ranging from USD 0.24 to USD 0.35 per 30-litre container (USD 8.0–11.7 per m^3) (Hoque, 2023). Of the 120 diary households, 23 per cent did not purchase vended water at all, 44 per cent purchased water regularly throughout the year, and 33 per cent restricted their consumption to the dry season or as and when needed. With high usage of vended water, households in Cluster 1 had a median annual expenditure of USD 56, which was four times that of Clusters 2 and 3 with USD 9 and USD 14 respectively (Figure 3.8). Such differences were not observable for food expenditures.

However, several idiosyncratic factors influenced household water sources choices and expenditures as well. One of the households in Cluster 1, who recorded high usage of vended water, described,

> We buy our drinking water from Sarappur tube well, about 3 containers a week. For cooking, I normally get it from Zia's [pond sand] filter, but in the rainy season when the roads become muddy, I use the stored rainwater. My daughter and granddaughter have been staying with us for more than a year now. Zia is my daughter's husband. They got married almost 10 years ago, but she had difficulty in conceiving. She underwent several treatments and finally when she got pregnant, doctors told her to be in bed rest. So she moved back in with us. After the birth of our granddaughter, we had several parties and relatives visiting us. Our water expenses increased during that time. Our granddaughter is very precious. We in fact bathe the child using water from the new desalination plant.

Habits and individual preferences thus drive inter- and intra-household differences in choice of sources, particularly for rainwater and desalinated water. Rainwater harvesting was widely practised; while most households used 50-litre earthen pots (locally known as *motkas*), about 14 per cent had 200-litre plastic drums and 3 per cent had large 1,000–2,000-litre storage tanks. Whether the rainwater was used for both drinking and cooking or for cooking only varied depended on how well individuals tolerated it. While some cited it as their most preferred source, others

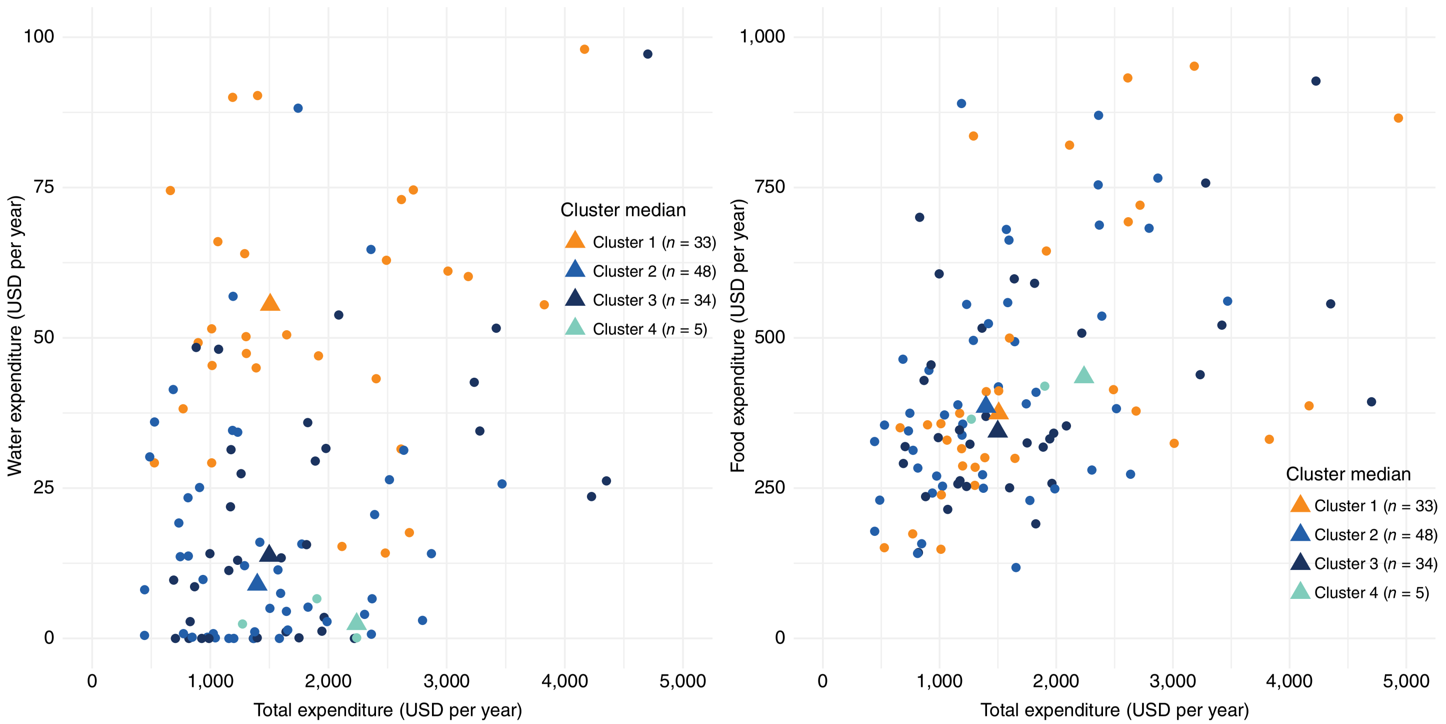

Figure 3.8 Annual water and food expenditures against total expenditures for 120 diary households in Polder 29 in 2018–2019.

complained about coughs, bloating or diarrhoea resulting from drinking rainwater. One household in Cluster 3 noted,

> We normally drink rainwater in the monsoon and go to Kalar kol [Shallow tube well] during the dry season. But my son, who currently studies in Gopalganj [nearby district], cannot drink the water from any of these sources. So whenever he comes to visit, we buy water from Sarappur mosque [Deep tube well].

3.4 Institutions for Managing Operational Risks in Communities and Schools

Despite continued public and private investments in water supply infrastructure, households face unequal water risks, in terms of safety, costs, and physical burden of water collection, and these risks are exacerbated when the infrastructure becomes non-functional due to seasonal unavailability of water, source contamination, or technical malfunctions. The existing institutional arrangement dictates that, for publicly or donor-funded water infrastructure, users should undertake all operational and maintenance activities with monetary contributions from regular tariffs or ad hoc payments (Hope et al., 2021a). This community-based management model emerged in the 1980s as an alternative to the ‘supply-driven’ models of the post-colonial states that struggled to extend basic services to the expanding population. Community management was championed as a ‘demand-driven’ approach that decentralised responsibilities to local people by encouraging active involvement of users in construction and maintenance. Community water management was an expedient product of its time – a pragmatic response in many countries emerging from colonial rule in the 1960s with limited administrative capacity or financial resources.

The institutional culture of the community-managed model is one of ‘egalitarianism’, whereby users share the environmental, operational, and financial risks equally (Koehler et al., 2018). In Bangladesh, community management has been widely successful in case of tube wells owing to the simplicity of the technology and the easy availability of mechanics and spare parts. The handpump technology has a lifespan of 10–15 years. For high usage tube wells, fast-wearing parts such as washers, check valve, nuts and baseplate need to be replaced every few months. Given the low-price tag, the bulk of such costs are often borne by a local elite, with small contributions from users. This is in contrast with countries in Sub-Saharan Africa, where lack of local markets makes it very difficult to source spare parts, resulting in longer downtimes. We return to this later in the next chapter on rural Kenya.

Operational and financial risks are much higher for alternative technologies like pond sand filters and piped schemes, which in turn are often located in areas with high environmental risks from salinity. Pond sand filters require regular maintenance, which involves cleaning and replacing the sand beds and protecting the source pond from contamination. While pond sand filters do not have any fixed tariffs, users make small contributions for purchasing sand, replacing tube well parts, and associated labour costs when needed. However, not all users contribute which often creates resentments among those who pay. Monthly user payments and expenditures from nine pond sand filters during September 2019 and August 2020 averaged at BDT 500 (USD 6) (refer to Section A.4 in Appendix A1 for data collection methods). However, after cyclone Amphan in May 2020, one of the pond sand filters incurred a large expense of BDT 11,000 (USD 130) to hire machineries and labour to clear out tree branches and dead fish from the pond. Such large and unexpected expenses are often borne by a few relatively well-off households if there is good leadership from an active management committee.

Politics and local power dynamics can also exacerbate operational and financial risks, as seen in case of a solar energy operated piped scheme in Polder 29. This donor-funded scheme was executed by the Union Chairman who claimed it as a flagship project during his time in office and promised to serve water free of cost to win votes. While the scheme ran smoothly initially, it broke down after four years owing to a minor technical fault. Though the repair cost was trivial, the system remained non-functional for years owing to a lack of community ownership, which was further instigated by the new Union Chairman who blamed it on poor construction. During this time, users living close to the pumphouse reverted to a public tube well while those further away walked long distances or paid vendors to deliver water. Thus, when responsibilities for management are not clearly defined or borne by designated entities, the risks are passed on to users.

For schools, the responsibilities of operation and maintenance are borne by individual school administrators using funds from the annual school budget or the routine facilities maintenance fund allocated every three years. The institutional culture of these ‘bureaucratic’ management model is ‘hierarchical, with rational procedures and decision-making tools in place to avoid extreme uncertainties (Koehler et al., 2018). For waterpoint management, this translates to routinised operation and maintenance activities using dedicated funds, though this is not always the case in practice. With limited budgets of BDT 50,000–70,000 (USD 500–700) per year, government primary schools struggle to undertake any major repair or rehabilitation work, other than replacement of tube well parts as needed, and cleaning of rainwater tanks and catchments prior to onset of monsoon. On average, small tube wells parts such as washers, buckets, nuts need to be replaced every four months, costing BDT 500 (USD 5) per repair, while large parts like tube well body or handle may need replacement once every four years, with costs of BDT 2,500 (USD 25) per repair (REACH, 2023a). In contrast, operating and maintaining a reverse osmosis plant, which involves frequent replacement of media and dosing media, may cost up to BDT 50,000 (USD 500) per year which is beyond what most schools can afford.

3.5 Reallocating Responsibilities to Professional Service Providers

The disparity in risks associated with water services for households and schools is profoundly demarcated by geographical and seasonal variations. This encompasses factors such as water availability, safety, and the costs of infrastructure installation and maintenance. Yet the institutional and financing model for bearing these risk responsibilities are similar, creating vast inequalities in services. While a deep tube well in a low salinity area can provide safe water all year round with negligible cost or maintenance responsibilities for users, those using a piped scheme have to pay for and maintain a relatively complex infrastructure for a limited quantity of drinking water only. In areas lacking suitable technologies, an ‘individualist’ risk management culture emerges, whereby informal water vendors earn a living by selling water to those who can afford to pay. If the risks can be pooled together at an appropriate scale (e.g. at district or upazila level), and the responsibilities are allocated to one entity (i.e. a private organisation contracted by the local government), there is opportunity to improve the safety, reliability, affordability, and equity of services.

Globally, especially within urban contexts, non-governmental entities have been incorporated into the water supply chain through diverse public–private collaborations or full-fledged privatisations. Professional maintenance service providers are emerging globally using results-based funding from donors and foundations in 16 countries in 2023 (McNicholl and Hope, 2024). An example is the Kenyan social enterprise FundiFix, responsible for timely repair and maintenance of handpumps and piped schemes in exclusive service areas in Kitui and Kwale counties (REACH, 2016). Developed by colleagues at the University of Oxford since the early 2010s, the experiences and lessons learnt from the FundiFix model facilitated the design and piloting of a professional service delivery model for coastal Bangladesh. While rural Bangladesh benefits from easy access to spare parts and skilled technicians for handpump repair, more intricate technologies like piped systems and reverse osmosis plants present challenges that require extensive technical and financial support. Another major risk, prevalent in both countries, is that of water safety, and in absence of monitoring, the risks remain uncertain.

This led to the conception of the SafePani model, advocating for a shift from the infrastructure-led approach of building access to a professional service delivery model (Hope et al., 2021a). The proposed change would entail DPHE to transition from direct service provision to monitoring and regulation. Concurrently, the responsibility of operation and maintenance could transition from local communities and schools to professional service providers operating in an exclusive service area under contractual agreements with the government. Monitoring and regulation need to be supported with better information systems on infrastructure coverage, functionality, water quality, and costs. At the same time, the sector financing can include results-based contracts where government and donor funds pay after delivery of agreed service targets, such as reliability (uptime) and water safety. In late 2021, we initiated a two-year pilot programme to demonstrate the SafePani model in Khulna district. Through funding from the REACH Programme, the Bangladeshi non-profit organisation HYSAWA was contracted to deliver professional maintenance services to all government schools and healthcare facilities in eight selected unions (REACH, 2023b). We opted to showcase the SafePani model within government institutions due to the uniformity in their governance structures, which in turn, facilitated the scalability of the model.

The SafePani pilot phase had three overarching objectives.

First, we aimed to demonstrate the operation of the model in practice. This involved preventative maintenance of water points and prompt repair services upon problem identification, monitoring water safety through sanitary inspections and laboratory tests of microbial and chemical parameters and taking remedial actions like shock chlorination upon detection of faecal contamination. Where needed, existing water supply systems were first rehabilitated to acceptable standards, for example, by reconstructing tube well platforms or resurfacing rainwater catchments.

Second, we engaged with relevant government agencies from central to local levels to introduce the idea of professional service delivery. Since the inception of the pilot phase, a national steering committee and district working group were formed, with quarterly meetings to report progress and plans. If any actions were necessary but beyond the scope of SafePani, for instance, installation of new water supply infrastructure in institutions lacking any drinking water sources, they were reported to relevant government agencies.

Third, we aimed to build technical and management capacity for professional water service delivery at local level. In doing so, we formed a local team comprising engineers, managers, community mobilisers, and water quality technicians to lead the day-to-day tasks of service delivery. We also established a purpose-built laboratory in the SafePani Khulna office to test for *E. coli*, while responsibilities for chemical tests were borne by DPHE district laboratory.

The pilot phase demonstrated that professional service providers can ensure water safety and reliability, with a cost of less than USD 1 per student per year (REACH, 2023a). It garnered government interest to upscale the model to 1,200 schools and healthcare facilities in Khulna district through results-based funding. In 2024, the government formally committed to fund 45 per cent of costs for the district scale-up till 2030, the rest coming from donors managed by the Uptime Catalyst Facility, a UK registered charity. The SafePani model is flexible in design with its current focus on public facilities able to expand to local villages as results and resources provide the evidence for a universal approach over time.

Professional service delivery will be of significance for operation and maintenance of rural piped schemes, which are particularly critical for areas without good groundwater. Our audit in 2022 found that 27 of the 49 rural piped schemes in Khulna district were non-functional, equating to USD 1.2 million in wasted capital funds in addition to the daily coping costs borne by unserved households. It is logical and politically expedient to introduce professional service delivery before new water supply construction begins to provide an accountable and mutually acceptable approach to increase the returns on investment.

3.6 Conclusion

Living in coastal Bangladesh is a good working definition of being water insecure. Cyclonic storms and storm surges of various intensities batter the flat floodplains pre- or post-monsoon. Salinity in groundwater and tidal rivers constrains drinking water supplies, particularly in the dry summer months. The region's high vulnerability to climate change has increasingly attracted donor and NGO activities, with a cycle of infrastructure interventions for flood protection embankments and drinking water technologies.

The diaries offer daily and seasonal insights into the risks and responses to increase water security. First, we can see the distributional inequalities and individual choices by households to navigate their water insecurity. Second, there is a growing understanding of how water safety is a foundation to achieving water security from both natural contamination and bacteriological risks. Third, there is optimism and evidence that progress can be made by working closely with government partners to deliver safe drinking water for schools and health clinics.

Given a choice, most rural people prefer not to pay for water. If there is a free or low-cost alternative, regardless of the real or perceived quality, this tends to drive daily decision-making. Summer rains provide a good source of high-quality water collected at home, though contamination is likely to be high, without good hygiene practices. Drinking water payments are commonly driven by scarcity and aesthetics (taste, appearance, smell) not concerns of microbial or chemical contamination. Desalination or vendors provide a lifeline to the most vulnerable communities, though at a cost. Few households choose to regularly pay for vended services, even though it is a fraction of other costs, such as food. The argument that water is unaffordable has to be balanced against these behavioural choices and should avoid the assumption that people won't pay because they can't pay. Cultural practices matter. We see the health of a baby or the arrival of a close family member shifts water payment choices.

Unlike food expenditure, drinking water payments rise and fall during the year. Again, one has to be careful with assumptions and causality. Most households in water scarce areas have no regular access to a good service all year. While infrastructure access is high, water quality and reliability are often low. Why would anyone pay from limited funds for a poor service? Without providing an inclusive and safely managed drinking water service, it is premature to assume that demand is low. However, the legacy of policy driving access means households have made considerable investments in local technology, the shallow tube well. Displacing this investment will be difficult without a superior and low-cost alternative.

This brings us to our second reflection on water quality. Water insecurity in coastal Bangladesh is heavily influenced by water safety concerns. As noted, past policy failed to take water quality adequately into account in agreement with global development goals and donor funding. The bleak recalculation of Bangladesh's progress is halved once water quality is factored into the arithmetic. From nearly everyone with safe drinking water to less than half in the stroke of a pen. To the government's credit, they are making meaningful progress to track water quality (*E. coli* and arsenic) in nationally representative surveys to guide future policy and investments. Given the widespread occurrence of highly saline water with major health risks for many vulnerable groups, it would be relatively cheap and easy to track salinity in addition to the efforts being made on *E. coli* along with known risks from arsenic and growing concerns with manganese (BBS/UNICEF, 2021).

This leads to some positive progress in our third reflection. Working closely with national and international scientists in the REACH Programme, the government has successfully piloted a safely managed drinking water model for rural schools and health clinics. While the majority of investments have historically targeted drinking water in villages, there has been a blind spot with public facilities. As any epidemiologist will tell you: it is not how much good water you drink but how much bad water you drink. Safe water in the village and unsafe water in public facilities will generate limited education, health, or economic benefits. Public facilities provide a less political and more scalable approach to introduce safe water services than villages. In the latter, local management, including the associated revenue, makes changes slow and contentious. Even bad water makes money where few alternatives exist. Government control is limited in making changes at scale quickly in contrast to public facilities where consensus based on clear science and policy mandates is simpler.

The SafePani model offers an inclusive architecture where the major gains in improving water safety and reliability can be scaled out to neighbouring villages who can see the improvements being delivered. In parallel, if the district scale- up in Khulna is successful it could be applied to 65,000 public primary schools and 18 million pupils nationally. Such progress may take time and also provide the means to make strategic investments in piped water systems which would greatly simplify water safety in the future. Given Bangladesh's high population density, a networked system managed by a professional service provider could rapidly transform water security at scale quickly and relatively low cost. Neighbouring India provides a sense of how political momentum and investment can deliver results at scale quickly. However, the ultimate prize is sustaining the services for decades to come for which Bangladesh has carefully designed sustainability into the SafePani model.