Policy reform for safe drinking water service delivery in rural Bangladesh

Report

Author(s):
Hope, Robert; Fischer, Alexander; Hoque, Sonia F.; Alam, Mohammad M.; Charles, Katrina; Ibrahim, Muhammad; Chowdhury, Emdadul Hoq; Salehin, Mashfiqus; Mahmud, Zahid Hayat; Akhter, Tanjila; Thomson, Patrick; Johnston, Dara; Hakim, Syed Adnan Ibna; Islam, Sirajul; Hall, Jim W.; Roman Garcia, Orlando Marcel; El Achi, Nassim; Bradley, David

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Executive summary

The Government of Bangladesh has provided global leadership in progress to improved drinking water access, with an estimated coverage of 98.5 per cent of its over 160 million citizens in 2019. However, the coverage rate decreases to 42.5 per cent when service delivery includes indicators of water quality, proximity and sufficiency (UNICEF/MICS, 2019). Achieving the Sustainable Development Goal (SDG) Target 6.1 of universal and equitable access to safe, affordable, and reliable water services requires moving beyond the existing focus of building water supply infrastructure, and rethinking institutions, information systems and financing to sustain higher levels of service delivery.

This report seeks to support the Government of Bangladesh in its review and reform of the 1998 National Policy for Safe Water Supply and Sanitation, and to introduce the 'SafePani' model as one response to achieving SDG 6.1 in rural areas. The design of the SafePani model is informed by collaborative work of the REACH programme[1] with national and local partners in the coastal zone (Khulna) and central plains (Chandpur). Interdisciplinary research reveals intersecting challenges – hydroclimatic and water quality risks, public finance and private enterprise, and social and spatial inequalities – and highlights opportunities for reforms in policy and practice.

The SafePani model proposes reforms in three areas – institutional design, information systems and sustainable finance. Institutional reform involves clarification of roles and responsibilities allocated from national to local levels. Service delivery models can be designed to network infrastructure at the right operational and political level, with a contractual mandate enforced by independent regulation. Information systems will support regulation by monitoring timely and accurate information of safety, functionality, and affordability of water services. Sustainable finance will advance how to combine public and private resources with new sources of results-based funding to address the increased costs of delivering higher level services. Regular user payments will be central to financial sustainability, and services need to be aligned with growing preferences for on-site and reliable infrastructure for households, schools and healthcare facilities, with affordable tariffs for all water users.

Progressive reforms in institutional design, information systems and sustainable finance can provide a new policy architecture to achieve and sustain safe drinking water services for all, which is a defining challenge to mark the celebration of the nation's 50th anniversary.

1 The REACH programme aims to improve water security for 10 million poor people in Africa and Asia by 2024, see www.reachwater.org.uk. In Bangladesh, the programme is a collaboration between UNICEF, BUET, University of Dhaka, icddr,b and the University of Oxford.

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Contents

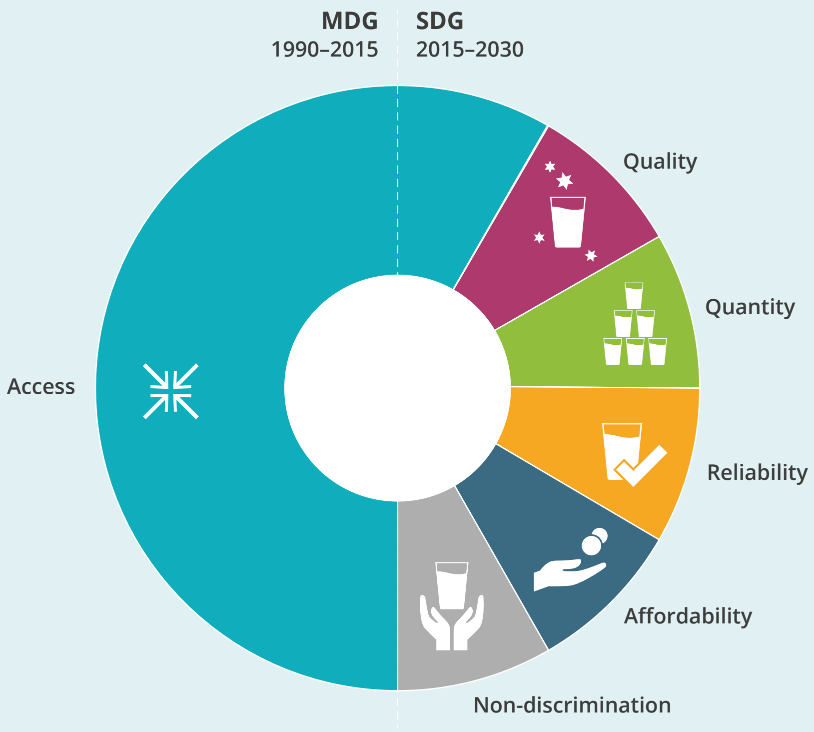
1. Introduction

In 1998, the Government of Bangladesh's National Policy for Safe Water Supply and Sanitation set out a framework "*to ensure all people have safe water and sanitation services at an affordable cost*" (GoB, 1998: 1). The institutional arrangement identified the Local Government Division (LGD) as the body with overall responsibility for services, planning and investment, and also coordination of local government, non-governmental, private sector and civil society organisations involved in service delivery and installation. Critically, under this policy, each organisation is 'responsible for its own activities', with coordination, monitoring and evaluation achieved via a local government-led forum. The flexibility in this policy design contributed to significant progress in increasing access and coverage in line with the Millennium Development Goal (MDG) Target 7c; however, may be for addressing the then contextual priorities, it overlooks other critical dimensions of safely-managed water services, including water quality, service reliability, availability on premises, affordability and equity in distribution. These are now articulated as key priorities under the Sustainable Development Goal (SDG) Target 6.1 (Figure 1). Thus, while 98.5 per cent of the population of Bangladesh have access to a technologically improved source, the percentage decreases to 42.5 per cent when additional SDG indicators like sufficiency, proximity, and water quality are taken into account (BBS/UNICEF, 2021).

As the Government of Bangladesh sets out to update the national policy, this report considers how to build on progress and address gaps. Bangladesh is a global leader in implementation of SDG 6; with a national target for 100 per cent of the population to be using safely-managed drinking water by 2030. Reaching this target will require mitigation of risks in the finance, management, monitoring and regulation of water services for households, schools and healthcare facilities. This report introduces the 'SafePani' model, a revised institutional framework to identify how to allocate risks and responsibilities amongst national and local water sector stakeholders. As each political unit has a differing set of environmental, social and economic factors which shape water service challenges and institutional responses, the proposed institutional model is purposively generic to be applicable and adaptable to the eight divisions and 64 districts in Bangladesh.

The model is characterised by changes to sector financing, information systems and institutional design, drawing upon multiple sources of data and analysis detailed in two associated working papers from Chandpur (Fischer et al., 2021) and Khulna districts (Hoque et al., 2021). The research programme in Bangladesh is led by the University of Oxford, Bangladesh University of Engineering and Technology (BUET), the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b), and UNICEF, in collaboration with the Water Supply Wing of the Local Government Division (LGD), Department of Public Health and Engineering (DPHE), Directorate of Secondary and Higher Education (DSHE) and the Directorate of Primary Education (DPE) of the Government of Bangladesh.

Figure 1: Moving from MDG to SDG.



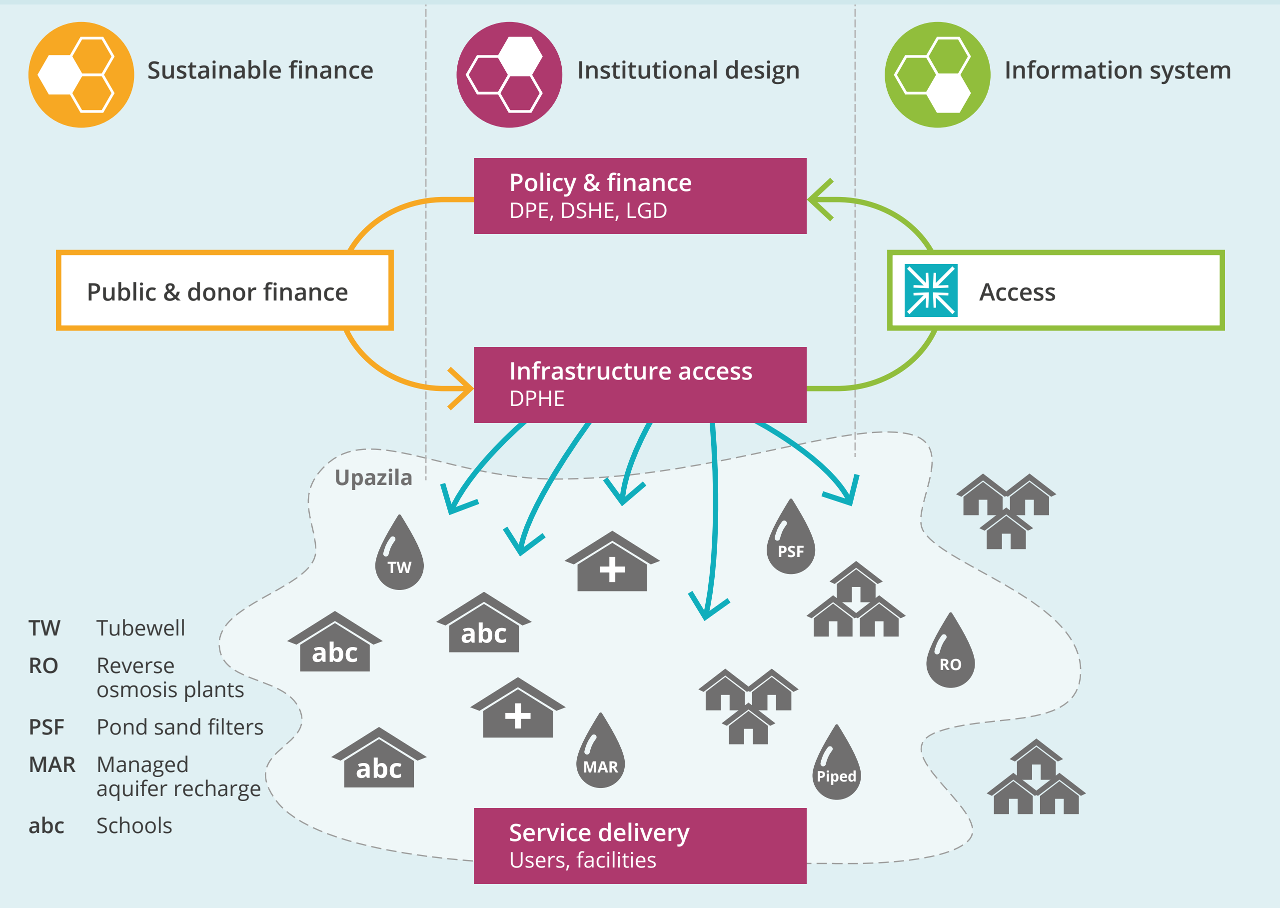
This report is structured as follows. In section 2, we discuss the existing model of rural water service delivery in Bangladesh, in terms of its institutional design, sustainable finance and information systems, with a view to examining opportunities for sectoral reforms. In section 3, we present our research findings from Chandpur and Khulna, highlighting opportunities for a flexible and scalable response to three major barriers to achieving safe drinking water in rural Bangladesh – hydroclimatic and water quality risks, public financing and private enterprise, and social and spatial inequalities. Finally, in section 4, we outline key policy recommendations for the SafePani model that build on timely and accurate information systems to monitor and regulate water service delivery, promote sustainable financing mechanisms and ensure equitable access.


Photo by Sonia Hoque

2. Existing rural water service delivery in Bangladesh

Existing rural water service delivery in Bangladesh focuses on increasing access by installing water supply infrastructure paid for by public funds and external assistance, with periodic project-based mapping of waterpoints and nationally representative surveys providing estimates of sector performance (Figure 2). The expanded focus of SDG 6.1 entails a revised institutional framework to strategically leverage public and private funds, with timely and accurate information systems to support independent monitoring and regulation of water service delivery. Here we discuss the current rural water service delivery model in Bangladesh, in terms of its institutional design, funding and financing mechanisms and information systems, with a view to identifying opportunities for reform in policy and practice.

Figure 2: Existing model for public provision of rural water infrastructure access and MDGs in Bangladesh.



2.1 Institutional design

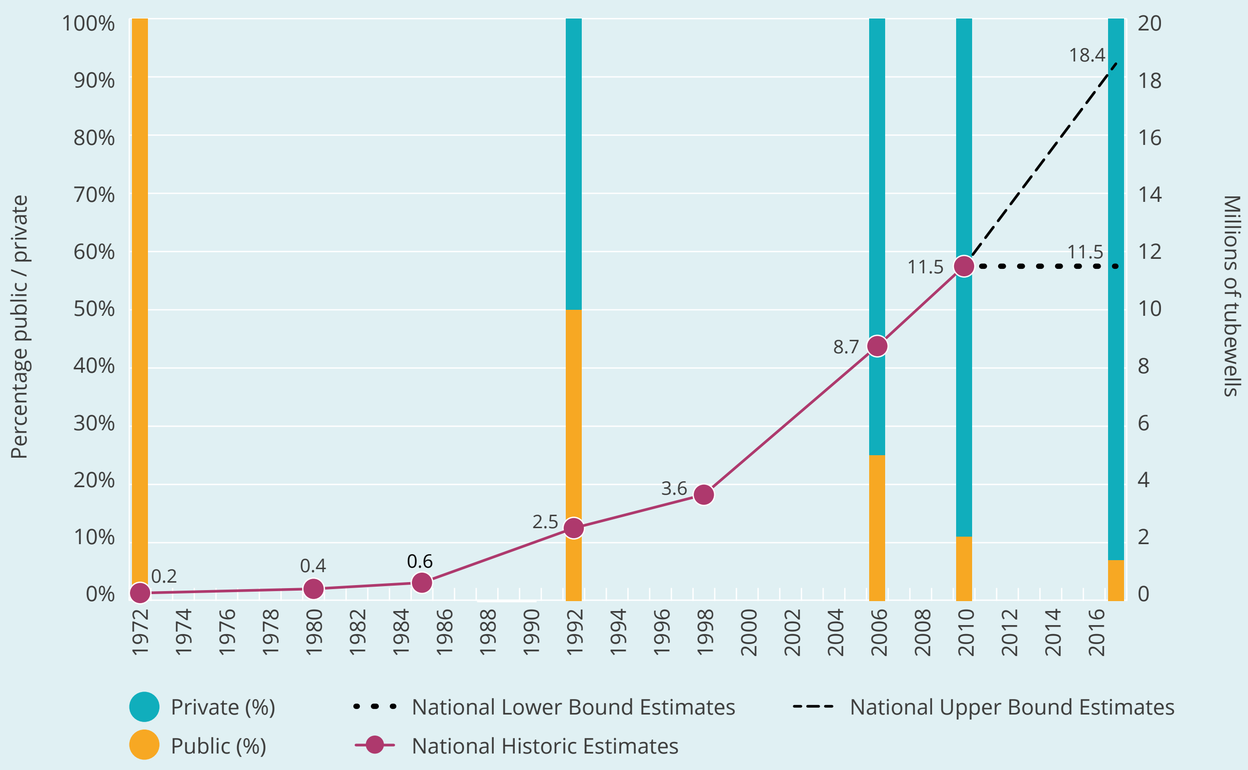
The water supply sector in Bangladesh is led by the Local Government Division (LGD) of the Ministry of Local Government, Rural Development and Cooperatives (MLGRDC), with its Policy Support Unit (PSU) being responsible for formulating policies and strategic plans for overall sector development. The 1998 National Policy for Safe Water Supply and Sanitation emphasises that the installation of water supply infrastructure should be based on user demand and cost-sharing arrangements, with user communities being responsible for subsequent operation and maintenance activities. The policy also recognises the important roles of NGOs and the private sector and calls for increased coordination among sector stakeholders, which is now conducted through the National Forum for Water Supply and Sanitation (NFWSS) under the leadership of the Secretary of the LGD. The Department of Public Health and Engineering (DPHE), under the LGD, is the national lead agency for rural water sector development and is responsible for providing technical support and initial capital financing for infrastructure development. The various Local Government Acts of 2009, formulated as part of the broader decentralisation process, mandate Upazila and Union Parishads (sub-district-level administrative units) to provide and maintain public water supply infrastructure in rural areas with the support of DPHE. However, this process of decentralised decision-making and implementation is challenging in practice owing to a lack of technical capacity, human and financial resources at the local government level.

In practice, community-based management has become the most common service delivery model for water supply infrastructure installed by DPHE and Union Parishads. As of June 2019, there are 1.8 million public waterpoints in Bangladesh, of which 1.27 million are shallow tubewells, 0.47 million are deep tubewells, while the remaining are split between pond sand filters, ringwells and rainwater harvesting systems (DPHE, 2019). At union level, installation of public tubewells require application from a group of households, whereby one individual is nominated as the caretaker. The caretaker is often perceived as the 'owner' of the tubewell and assumes the right to set rules of access. Once the Union Chairman certifies the priority of the application in the light of its necessity in that particular locality and the segment of the population to be served, contractors hired by DPHE conduct the hardware installation at the designated location. While this location should maximise user convenience, in reality, it is installed within the courtyard of the caretaker, who being the most influential person in the group often pays the bulk of the cash contribution (Sadeque and Turnquist, 1995). These processes can result in inequitable allocation of tubewells, particularly in areas with heterogeneous distribution of arsenic and salinity (van Geen et al., 2016). In case of alternative technology options such as small piped schemes or pond sand filters, which are usually financed through bilateral international donor funds, WATSAN (water and sanitation) committees are formed as part of capital investment programs. Local NGOs, which act as implementing partners, provide capacity building, supervision and monitoring support to the WATSAN committee during the post-construction period (Lockwood and Islam, 2016).

Self-supply is not recognised as a formal service delivery model, though the growth of privately financed and managed waterpoints has outpaced public provision. Fischer et al. (2020) estimate that between 2005 and 2018, nine million tubewells were privately installed by unregulated drillers (Figure 3).

This rate of privately financed infrastructure growth, equating to almost 700,000 tubewells per year, is significantly higher than previous estimates of 300,000 new tubewells per year published in the Sector Development Plan (SDP) for Water Supply and Sanitation Sector in Bangladesh (FY 2011–2025) (LGD, 2011: 21). The cost of installing a tubewell declined by 70 per cent between 1980 and 2018 in real terms, making tubewells more affordable for households (Fischer et al., 2020). As a result, the coverage rate decreased from 400 households per tubewell in 1970 to only two households per tubewell in 2018. The rapid emergence and establishment of a self-supply model means the responsibility to manage and maintain water services lies with households and villages with limited coordination or oversight from local government.

Figure 3: Growth in tubewells driven by household self-supply investments (Fischer et al., 2020).



Private sector participation in rural water service delivery is limited, and mainly involves experience from the Bangladesh Water Supply Program Project (2005–09) and the Bangladesh Rural Water Supply and Sanitation Project (2012–17) jointly financed by the government and the World Bank (Ndaw, 2016). These projects, however, failed to attract commercial finance, with most private funds coming from companies or local elites with charitable motives (Leigland et al., 2015). Small water enterprises, including desalination plants and mobile distributing vendors, operate in informal water markets in the coastal zone, but these private investments remain undocumented and outside the oversight of the formal rural water sector (Hoque et al., 2019).

2.2 Information systems

Information about the water sector is obtained primarily through national surveys, including the national census, the Demographic and Health Surveys (DHS) and the Multiple Indicator Cluster Survey (MICS), which are funded by the Government of Bangladesh, USAID, and UNICEF, with contribution from other international donors. These large-scale but infrequent surveys capture household access to drinking water facilities and service levels, in terms of main source, collection time, water treatment methods, and recently, service reliability. In Bangladesh, the MICS established a global precedent to include randomised testing of household water sources for water quality parameters, specifically arsenic and *E. coli*. For schools, the Directorate of Secondary and Higher Education (DSHE) manages a national EMIS database – an online system that captures information around access and functionality of water and sanitation infrastructure, as part of the overall assets and facilities managed by the schools.

In addition to these surveys, administrative data provides the second dynamic source of data for the water sector. The first blanket surveys were conducted between 2000 and 2006, with more than 5 million tubewells in 270 selected upazilas screened as part of the national effort to mitigate arsenic exposure (Johnston and Sarker, 2007). DPHE, with the financial support from UNICEF, conducted a nationwide mapping of public waterpoints to gather information on water quality and functionality of waterpoints installed under different DPHE projects from 2006 to 2012 (DPHE, 2014). Since 2012, DPHE has been publishing annual waterpoint status reports with an inventory of public waterpoints by upazila, including functionality and coverage estimates in terms of population per arsenic safe waterpoint (DPHE, 2019). Since the 1980s, DPHE Zonal Laboratories have been responsible for water quality testing to confirm safety of water supply at installation. In 2007, the DPHE Water Quality Monitoring and Surveillance Circle was created to lead overall laboratory management and services, both for new public water point installations and a fee-for service for other sectors. DPHE, however, does not do any routine quality checking of installed water facilities.

Owing to the extent and dynamic nature of the Ganges-Brahmaputra-Meghna delta, groundwater availability and quality exhibits high spatial and vertical heterogeneity. DPHE-JICA (2006) prepared the first deep aquifer database, comprising 2500 borelogs from DPHE's Research and Development Division and various field offices, along with water quality (arsenic, iron, chloride, and manganese) analyses results from about 1000 deep tubewells. Information on salinity in drinking water is limited, as it is not tracked as part of MICS or DPHE's annual waterpoint status reports.

In summary, Bangladesh has achieved significant progress in improving water access over the last 20 years with public and private initiatives ensuring a basic supply of water for the majority of people. Delivering safe drinking water will require reform to policy and practice to address the known challenges of water quality hazards, limited and variable financial resources, the coordination of multiple stakeholders and effective local service delivery models, which we discuss in the next sections.

2.3 Finance

The SDG Financing Strategy 2017 estimated an additional financial requirement of USD 9.34 billion to achieve SDG 6.1 and SDG 6.2 (General Economics Division, 2017). The government has made progress on WASH financing, with allocations increasing from USD 305 million in 2007–08 to USD 784 million in 2017–18, of which USD 453 million was allocated to the water sector (Rahman et al., 2018). However, the relative growth is low compared to the substantial growth of GDP and the national budget during this period. In 2017, the annual WASH expenditure accounted for 0.46 per cent of the country's GDP, with an average per capita expenditure of USD 7, compared to a global average of 0.82 per cent of GDP and USD 35 per capita respectively (GLAAS, 2019). Moreover, there are significant spatial inequalities in budget allocation with metropolitan cities receiving 16 times more funds than the hard-to-reach regions (char lands, hilly areas and the coastal belt) combined. Public sector funds accounted for about half of the WASH budget allocation in 2017–18, with the remaining 30 per cent from household contributions and 20 per cent from development assistance (Rahman et al., 2018).

In 2017–18, 8.4 per cent of the WASH sector budget was allocated to DPHE (Rahman et al., 2018). DPHE disburses these public funds to the 492 upazilas based on factors such as the upazila's population size and area (JICA, 2015). The money provided to each upazila is then disbursed amongst the Union Parishads. Upazila and Union Parishads also have their own revenue, mostly from holding taxes, rates, fees and charges levied by the local body as well as rents and profits accruing from properties. In practice, however, limited fiscal autonomy and revenue discretion restricts the effectiveness of Union Parishads, which continue to rely on DPHE at the national level for planning and implementation (JICA, 2015). The division of funds by Union Parishad also restricts implementation of large-scale projects that can benefit people regardless of administrative boundaries.

Household contributions to the WASH sector are likely to be much higher than that reported, owing to investments in private tubewells by rural households, which remain outside the formal sectoral accounting. Fischer et al. (2020) estimates that in 2018 rural households invested between USD 94 and 170 million in new water supply infrastructure with an additional USD 83 million being spent on operations and maintenance costs. Overseas Development Aid for the WASH sector in Bangladesh increased from USD 166 million in 2010–11 to a peak of USD 436 million in 2017–18 (GLAAS, 2019, 2012). Of this aid the majority has gone to basic drinking water access, essentially non-utility schemes, most of which will be for rural areas which had 2.9 times the committed levels of funding than the next largest sub-sector (large water supply and sanitation systems). In 2014–15 the majority of ODA was channelled in the form of loans (88.3 per cent) rather than grants, with the ADB, Korea and the Netherlands being the three largest funders. Delivery of aid to the rural water sector is coordinated by the Local Consultative Group (LCG) under the overall umbrella of the National Forum for Water Supply and Sanitation (NFWSS); the sector remains heavily reliant on development assistance.

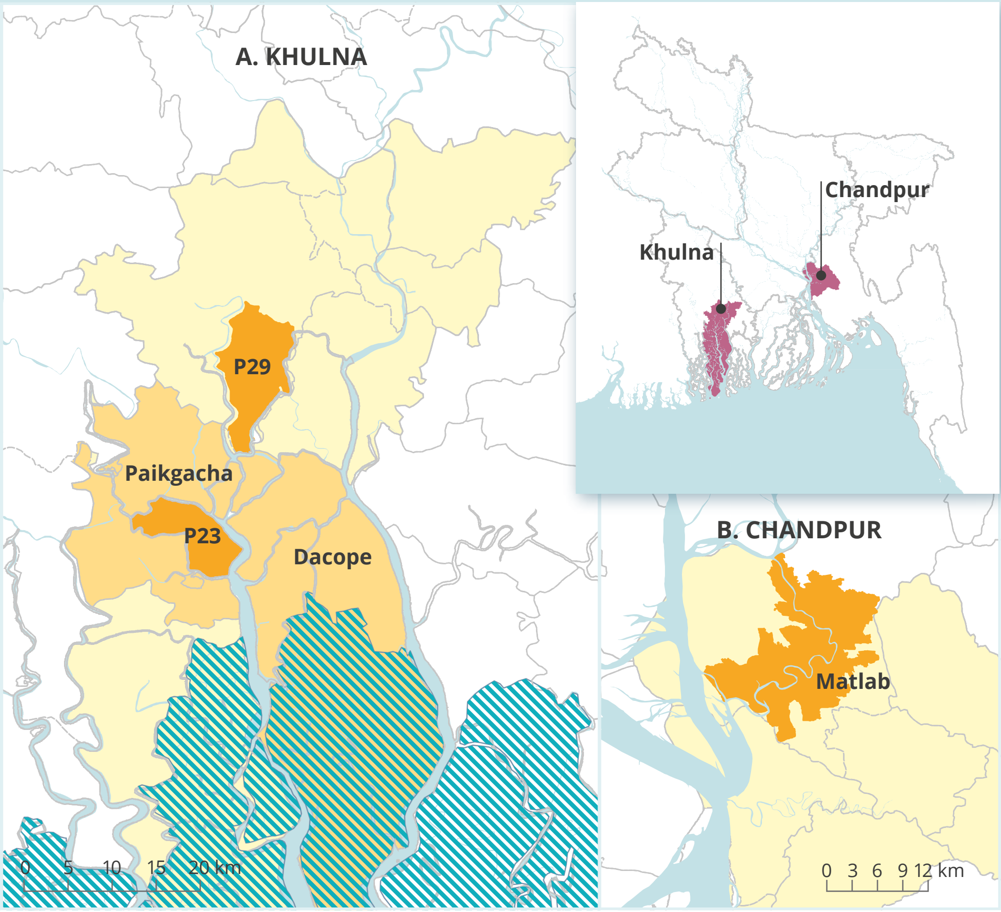

Photo by Abubakar Siddique

3. Results from households and schools in Khulna and Chandpur

Achieving the SDG targets of universal and equitable access to safe, affordable and reliable water services is constrained by three intersecting challenges – a) hydroclimatic and water quality risks, b) public financing and private enterprises, and c) social and spatial inequalities. Hydroclimatic risks include seasonal variability and episodic shocks from cyclones and floods, which affect infrastructure reliability, water quality and water use behaviour. Water quality risks are influenced by the nature and distribution of groundwater contaminants, and infrastructure and management at the waterpoint and storage in the home, school or healthcare facility. Without improved and accountable institutional design, hydroclimatic and water quality risks will weaken national to local government capacity to monitor and regulate drinking water services. This requires stronger coordination and accountability across stakeholders from donors, small water enterprises, vendors, households, and schools to coordinate limited resources and attract new funds to achieve more sustainable services. Eliminating social and spatial inequalities requires identifying and responding to discrimination in service delivery by geography, gender, and wealth, whether resulting from cultural or natural factors, or both.

Here we summarise findings from our research on water services for schools in Chandpur and households and communities in Khulna district, which are detailed in two corresponding working papers (Fischer et al., 2021, Hoque et al., 2021) (Figure 4). The choice of study sites represents some of the national diversity in drinking water service challenges, in terms of environmental hazards (e.g. geogenic, waterpoint and household/school water quality risks; floods and dry spells), infrastructure technologies, institutional variation (public, market and individual management), and socio-economic heterogeneity by welfare, gender and livelihoods. The methodology and data sources are summarised in the Appendix.

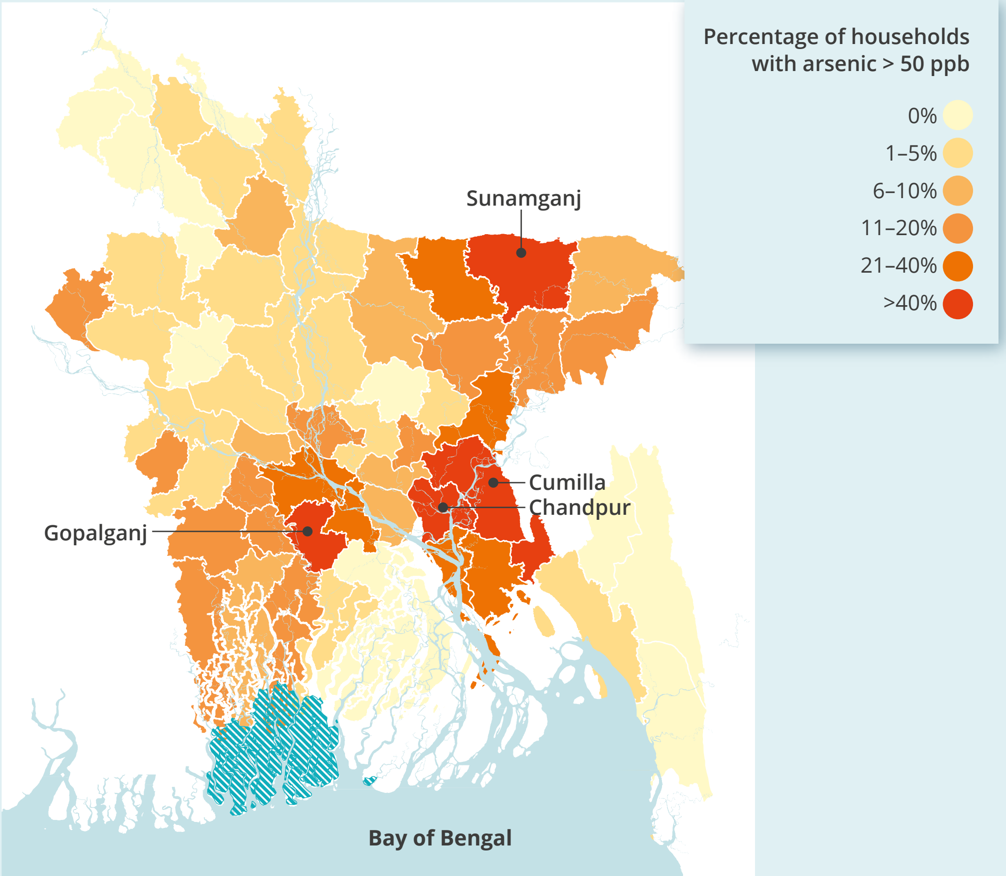
Figure 4: Study sites in Chandpur and Khulna districts.



3.1 Hydroclimatic and water quality risks

Groundwater contamination by naturally occurring salinity, arsenic, and other metals, as well as pathogens, coupled with frequent exposure to cyclones and tidal flooding, poses significant challenges to providing safe and reliable drinking water services in rural Bangladesh. Although Bangladesh has highly productive aquifers within the unconfined sediments of the Holocene age, these geologically young sediments are prone to developing and preserving high concentrations of arsenic, particularly within depths of 30–150m that coincide with shallow well depths (Edmunds et al., 2015). As per the UNICEF/MICS (2019) data (Figure 5), in 22 of the 64 districts more than 20 per cent of the surveyed households are exposed to arsenic above 10 ppb, with the highest risks being recorded in Chandpur, Cumilla, Sunamganj and Gopalganj districts. Nationally, 40.3 per cent of the households used drinking water sources with faecal contamination, which increased to 81.9 per cent at the point of consumption (BBS/UNICEF, 2021). Groundwater salinity limits drinking water supplies for more than 8 million people living in the 139 polders across the south-western and south-central coastal zone. Hydrogeological analysis of data from DPHE borelogs and groundwater samples tested by REACH and previous projects show that salinity in the shallow aquifers (<100m) typically exceed the national threshold of 1000 ppm, particularly in the polders adjacent to the Sundarbans forest (refer to Hoque et al. (2021)).

Figure 5: Distribution of arsenic in drinking water by district (Data source: UNICEF/ MICS 2019).

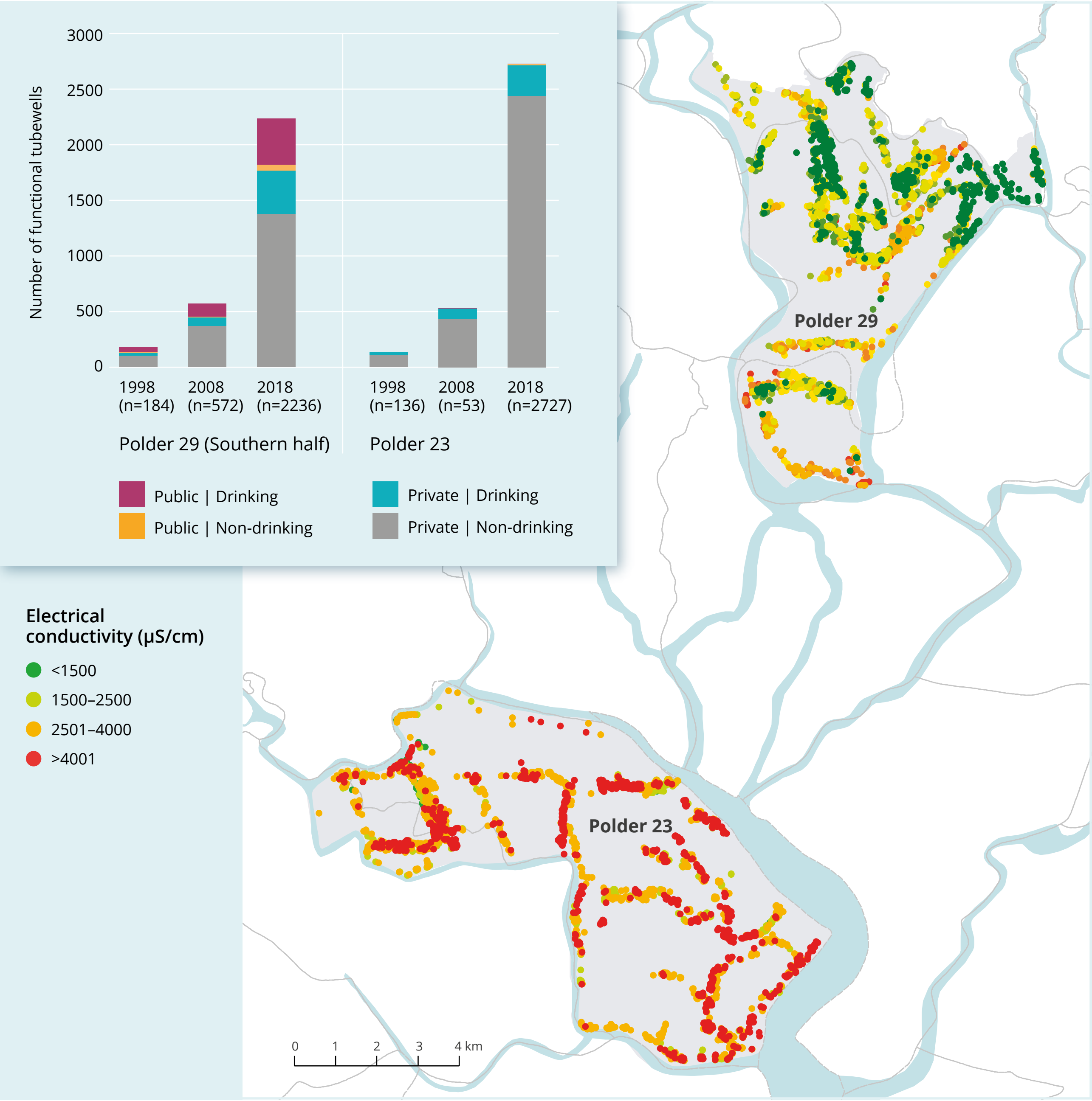


We mapped a total of 5707 tubewells in the southern part of Polder 29 and in Polder 23, of which 11 per cent were deep and 89 per cent were shallow tubewells. About 95 per cent of the functional deep tubewells and 12 per cent of the shallow ones were used for drinking; however, only 44 per cent of the deep and 10 per cent of the shallow tubewells met the salinity threshold of <1000 ppm (Figure 6). Laboratory analysis of water samples from 115 drinking waterpoints in Polder 29 and 125 school tubewells in Matlab showed presence of multiple water quality risks from arsenic, chloride, salinity, iron, and *E. coli* [Box 2 and 3].

The coastal area is highly vulnerable to cyclones and storm surges, being further exacerbated by climate change-induced sea level rise and rising sea surface temperatures. Anthropogenic modifications of natural hydrology by polder construction, coupled with conversion of agricultural land to aquaculture ponds, have led to land subsidence within the embanked areas and significantly increased risks of pluvial flooding (or waterlogging) (Adnan et al., 2020). The two recent cyclones – Bulbul (Nov 2019) and Amphan (May 2020) – led to contamination of drinking water sources in exposed villages as freshwater ponds and tubewells were inundated with saline seawater. REACH data from Polder 29 shows that power outages during cyclone Bulbul disrupted electricity-powered piped water supplies for up to a week, while cloudy and foggy conditions reduced output from solar-powered piped schemes [Box 1].

Similarly, users of pond sand filters incurred additional costs to clear debris and dead fish from source ponds after cyclones [Box 3]. Seasonal changes in rainfall affect household water use behaviour, with users shifting from relatively saline shallow tubewells, pond sand filters and vended water to rainwater during the monsoon months (Jun – Nov) (Hoque and Hope, 2020).

Figure 6: Salinity of water in tubewells with proportion of public and private tubewells used for drinking.



While water quality parameters are usually tested after installation, there are no monitoring systems or regulatory bodies to measure and enforce the drinking water quality standards articulated in the Environmental Conservation Rules 1997. The MICS database provides a population level snapshot of arsenic and *E. coli* every five years, but does not incorporate other parameters including manganese, salinity and iron. The latest MICS campaign illustrates the lack of climate resilience in water supplies, with *E. Coli* contamination increasing with temperature and rainfall (BBS/UNICEF, 2021); similar changes were identified in field research at Polder 29. Given the high spatial heterogeneity in groundwater quality and seasonal variability in water quality and sources used, water managers need access to regular, targeted information on water quality to manage drinking water safety.

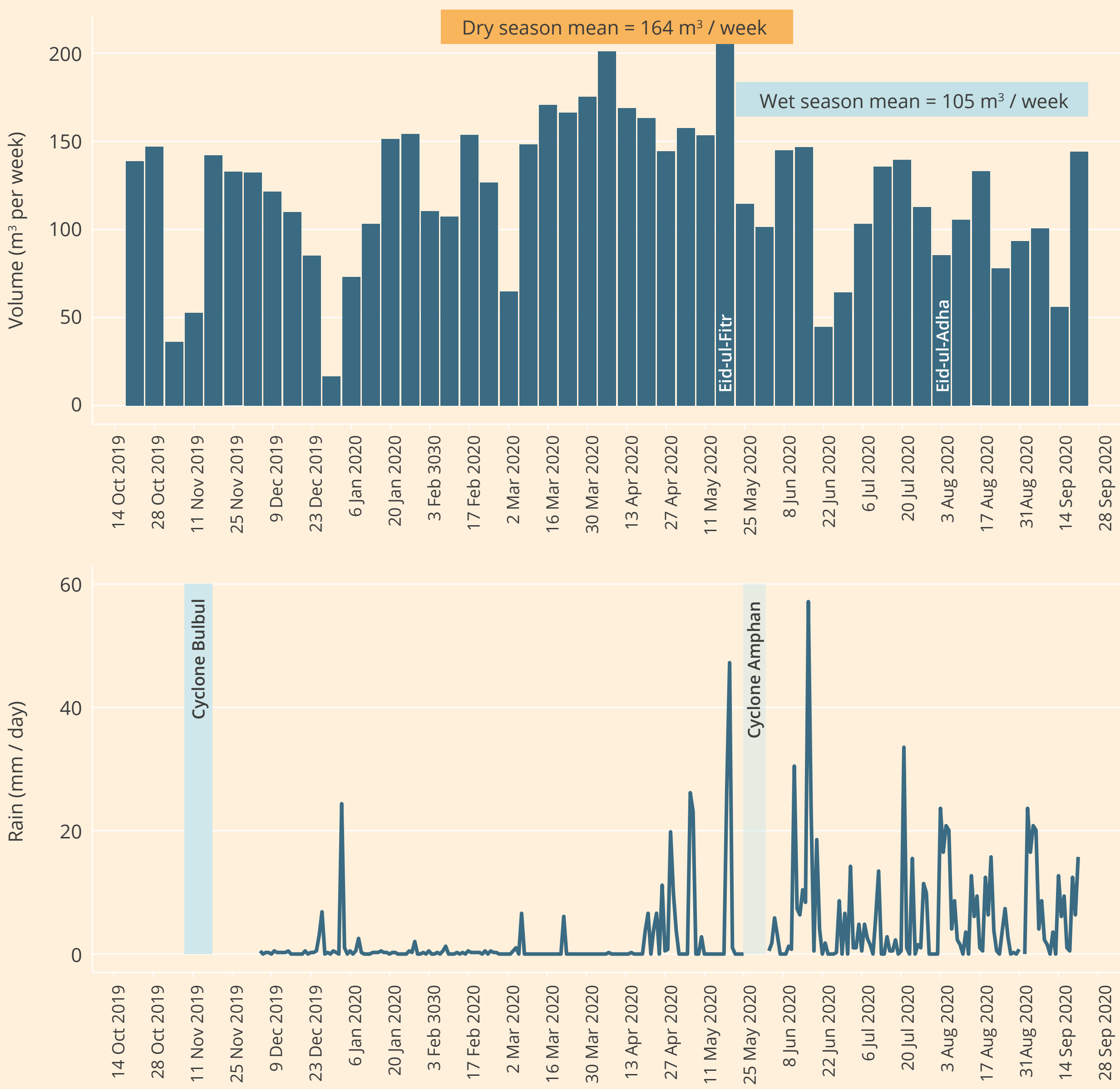
Box 1: Operation and maintenance of piped schemes in Polder 29

There are three small piped systems in Polder 29, constructed in the mid-2010s to serve households in areas within 1–2km of a suitable aquifer, providing relatively safe drinking water. The two solar-powered ones, located in Dighalia and Kapalidanga mouzas of Sahas union, were financed through the HYSAWA fund[2] and comprise 2,500 litres overhead tanks supplying water through linear gravity-fed piped networks with 9 and 22 public taps respectively. With sufficient solar radiation, groundwater is pumped continuously into the overhead tanks and the motor is automatically disconnected when the tanks reach full capacity. During cloudy and foggy weather conditions, pump performance is limited, reducing water supply, while on sunny days the supply is proportional to the cumulative demand. In Kapalidanga, the daily water usage ranged from 23m^3 during the dry summer months from March–May to 15m^3 during the monsoon from June–August (Figure 7). The sharp decline in supply during the last weeks of October and December 2019 were due to breakdown of a floating switch and a cold wave, respectively. There are no user tariffs or management committees, and ad hoc repair costs are often borne by local elites. The piped system in Dighalia has not been in operation since mid-2019 due to local conflicts related to repair responsibilities and funds.

The electricity-powered piped scheme, funded by an international donor with contributions from the community and the Union Parishad, is located in Gajendrapur mouza in Sahas union. It comprises a 10,000 litre overhead tank and 29 public taps, increasing from 16 taps at the time of construction. Between one and three tanks of water is supplied at a scheduled time each day. The system is run by a voluntary management committee, who have been closely involved since the project inception and have played key roles in mobilising community resources, including donating private land for the pumphouse, gathering the funds for community contribution, and suggesting suitable locations for the taps. Users pay a monthly tariff of BDT 30 (USD 0.36) per household, which remained unchanged since construction despite increases in electricity tariffs and user numbers during this period. Between November 2019 and August 2020, the average monthly revenue from user payments was BDT 10,600 (USD 127) against an average expenditure of BDT 8,200 (USD 98), with the latter comprising electricity bills, tank cleaning and tap repair costs, and operator salary of BDT 2000 (USD 24) per month.

2 HYSAWA is a multi-donor funding mechanism, established in 2007, to facilitate capacity building of local governments and finance large-scale water and sanitation infrastructure in participating union parishads (www.hysawa.org).

Figure 7: Water usage at Kapalidanga solar-powered piped system in relation to rainfall.



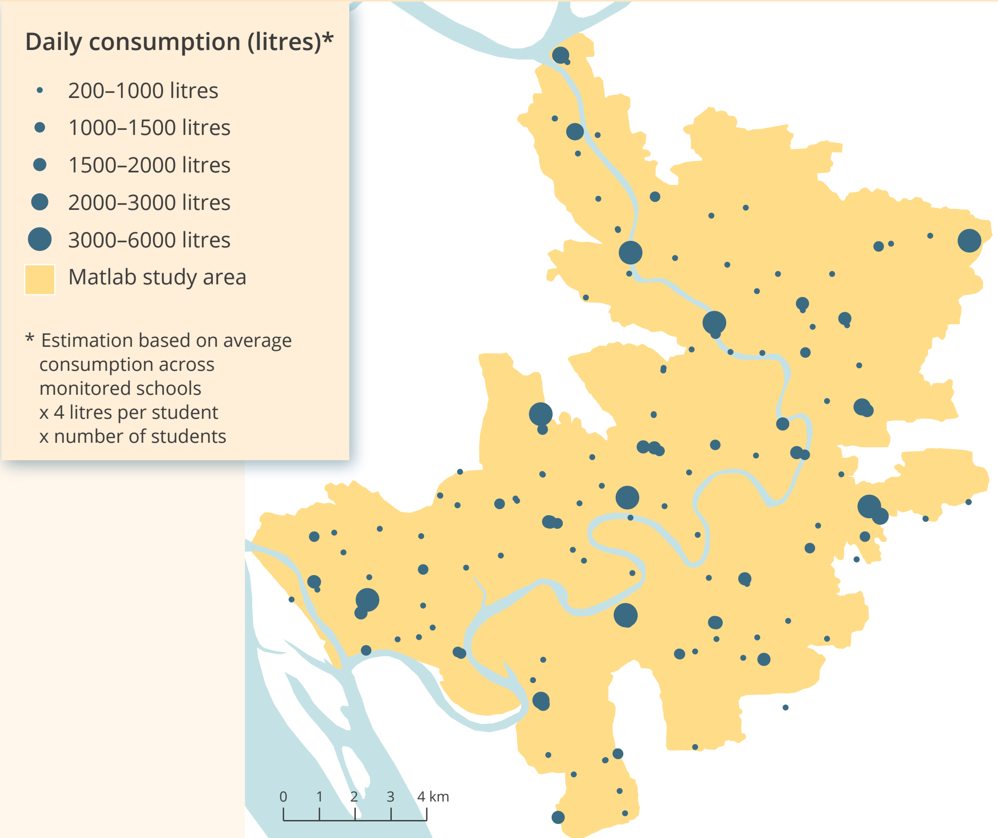
However, users' reluctance to pay their tariffs promptly creates backlogs from time to time, with a couple of committee members filling the gaps and the operator salary being delayed for months.

While operation and maintenance of rural piped schemes have been delegated to volunteering user committees to date, transferring these responsibilities to professional water service providers with clear performance targets can enhance service delivery through regular water quality checks, efficient tariff collection and preventative maintenance. Records of financial transactions, user numbers, volumetric usage and water quality parameters can be updated to national information systems to aid monitoring and regulation, and potentially attract performance-based funding for service expansion thus reducing dependence on public or donor finances.

Box 2: Water quality and usage patterns of school tubewells in Matlab

As of 2016, 73 and 87 per cent of public primary and secondary schools in Bangladesh have access to basic water services (JMP, 2019). However, these estimates are based on data generated by the Directorate of Primary Education (DPE) through the Annual Primary School Census, which predominantly focuses on hardware aspects and is insufficient to provide a comprehensive picture of adequacy, quality, reliability, and maintenance of WASH facilities. To address these information gaps, we conducted a pilot study of 150 primary and secondary schools in Matlab, involving a semi-structured questionnaire survey with school administrators, an audit of all water supply infrastructure, testing of water quality parameters and usage monitoring through data loggers fitted on tubewell handles (Figure 8).

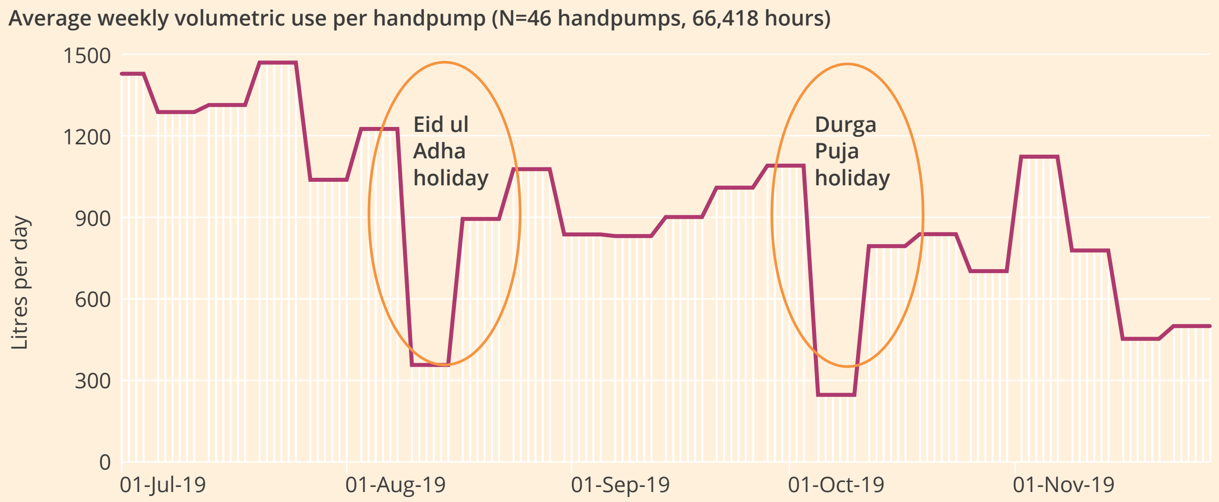
Figure 8: Daily water consumption recorded by dataloggers installed at primary and secondary school tubewells in Matlab.



About 99 per cent of primary and secondary schools reported access to improved water supply infrastructure, with an average of 1.7 tubewells per school, and a median of 92 students per waterpoint. During the study period, water usage ranged from 0.5 to 11.8 litres per pupil per handpump per day (n=45 schools and 54,970 hours of data), with a median daily usage of 3.9 litres per student per pump. School water facilities were used outside of the school day, suggesting water usage by the community as well (Figure 9).

School administrators reported that 83 per cent of handpumps had reliable flow and availability over the 12-month observation period, while the remaining 17 per cent reported various problems including sand in the tubewell, increased friction of the handle which slowed pumping, low water levels, and broken buckets and washers. The data loggers could not differentiate the reliability issues; however, the data identifies when a significant change in use patterns occurs including reductions or spikes in use, which are often related to reliability, functionality, or changed use of the water point. About one-third of repairs, mainly involving minor and low-cost problems such as replacement of buckets or washers, took over ten days, while major repairs, involving handles, cast iron body or rods, took over two months to complete (Figure 10).

Figure 9: Water usage patterns for school tubewells in Matlab.



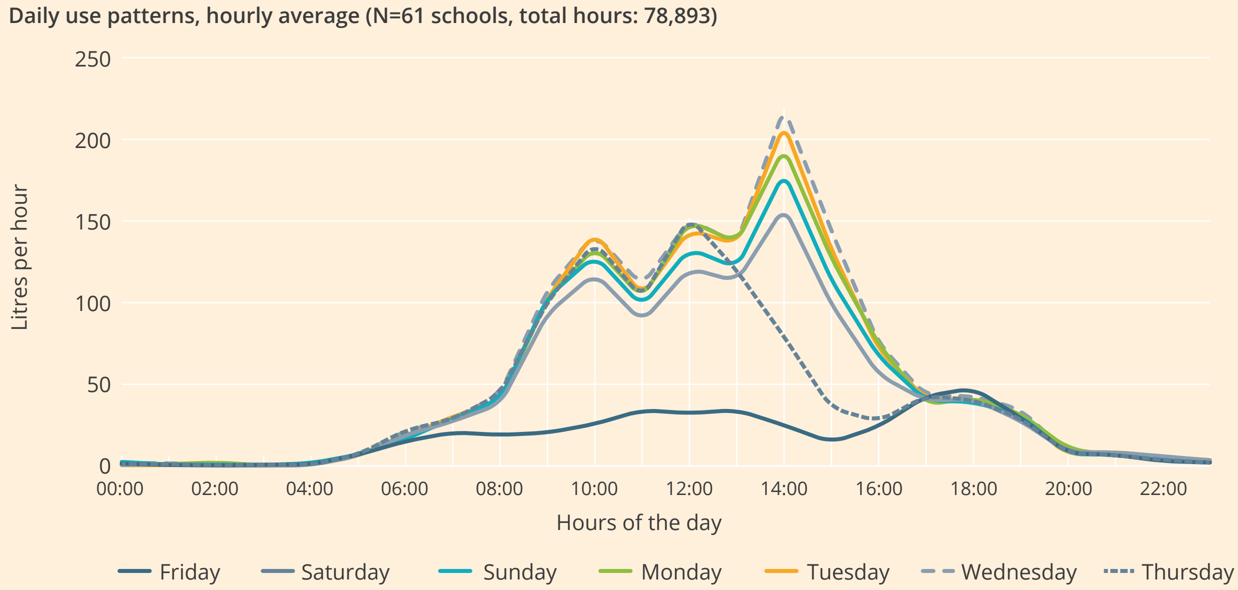
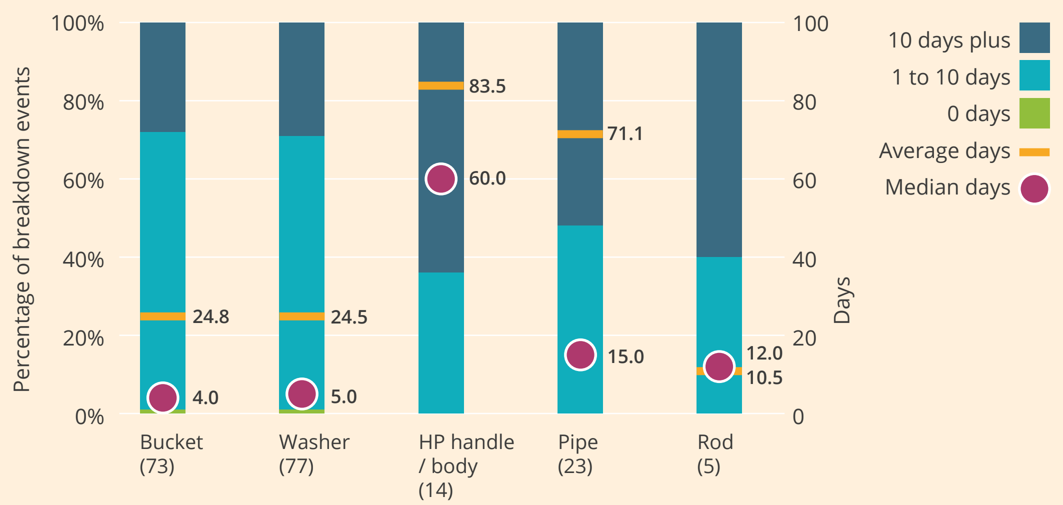


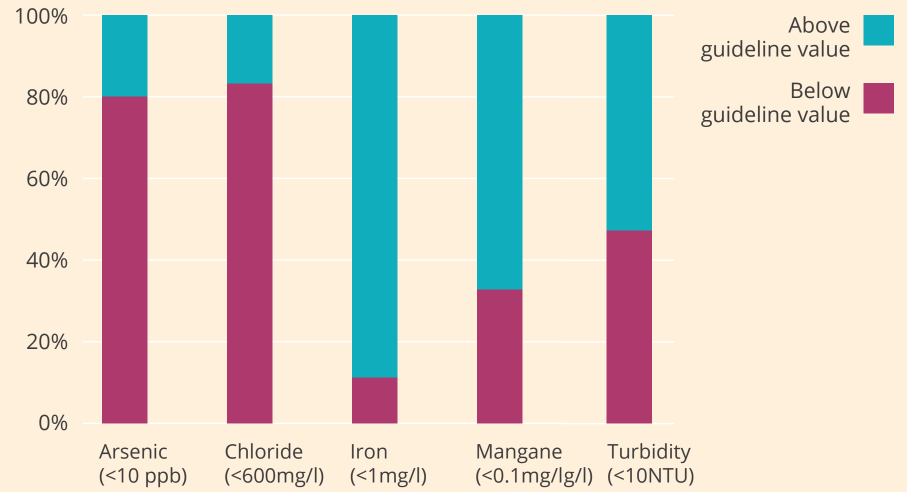
Figure 10: Average repair time by breakdown type for school tubewells in Matlab.



Analysis of water quality parameters by icddr,b in November 2019 showed iron and manganese concentrations exceeding national guidelines for drinking water in most schools (Figure 11). Arsenic contamination exceeded the WHO guideline of 10 ppb in 20 per cent of tubewells, with 14 per cent having concentrations above 50 ppb. Unlike at the coast, salinity was not a significant concern among users in Matlab, with values mostly below 1000 mg/l. Faecal contamination was detected in 11 per cent, 6 per cent, and 18 per cent of the water samples before decontamination of the handpump, after decontamination, and at point of use, respectively.

Management of service reliability and water quality risks currently lies with the individual school administrators, with no provisions for regular water quality checks post installation and significant variations in capacities and finances for prompt maintenance. Coordinated management with allocated funds can dramatically improve performance of water services, fostering a 'safe, non-violent, inclusive and effective learning environment' (SDG 4a).

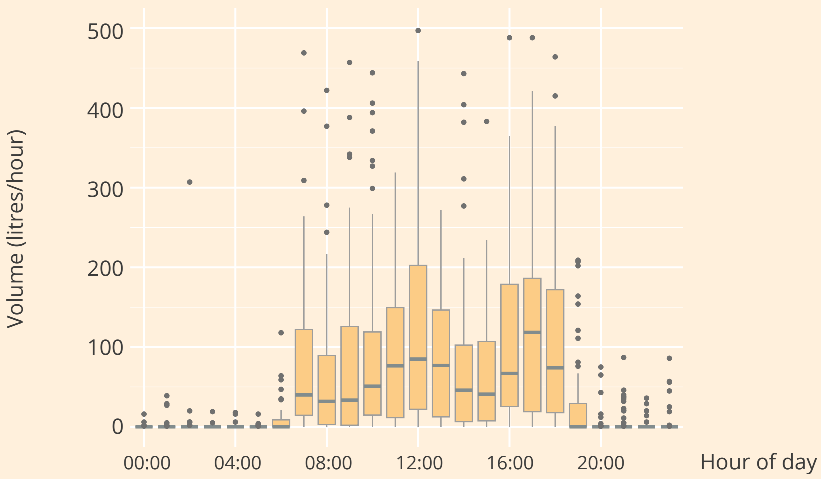
Figure 11: Water quality of school tubewells in Matlab (Guideline values in brackets).



Box 3: Operation and maintenance of pond sand filters in Polder 29 and Polder 23

Pond sand filters (PSFs) are key sources of drinking water for households in the southern part of Polder 29, where groundwater salinity in the shallow aquifers typically exceeds the national threshold of 1000 ppm and deep aquifers are not available. Data loggers installed on 9 of the 11 functional PSFs showed a median daily usage of 1300 litres per PSF, with water collection peaking at noon and later afternoon (Figure 12). Water quality varies across PSFs, with user preferences depending on taste and smell; while chemical water contamination can increase in the dry season as the ponds start to dry out, faecal contamination is highest during the monsoon (Figure 13).

Figure 12: Quantity of water pumped from PSFs by time of day.



Regular replacement of the sand layers and prevention of contamination of the source ponds are crucial for sustainability of PSFs. Management is usually led by the pond owner in collaboration with other committee members. While PSFs do not have fixed tariffs, users pay between BDT 5–10 for purchasing sand, replacing tubewell parts, and associated labour costs when needed. However, not all users contribute which often creates resentments among those who pay. Total user payments per month (with a median of 110 users per PSF), as well as monthly O&M expenditures, from nine PSFs during September 2019 and August 2020 averaged at BDT 500 (USD 6), with large ad hoc expenditures being sponsored by a few local elites (Figure 14). For example, after cyclone Amphan in May 2020, one of the PSFs 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.

Figure 13: Water quality of outlet tap of ten PSFs.

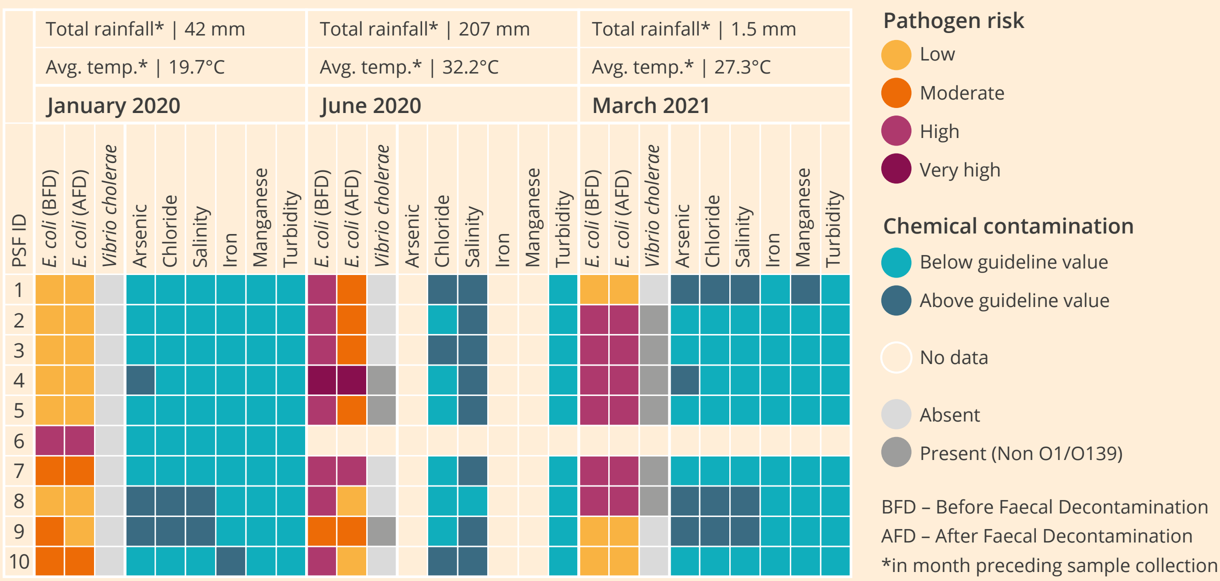
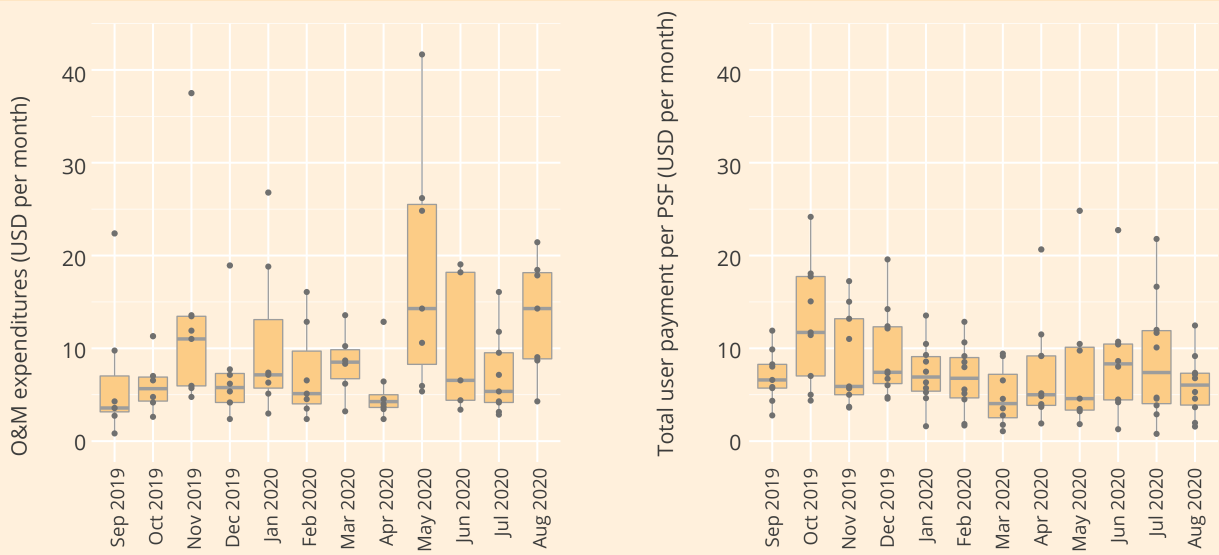


Figure 14: User payments and O&M expenditures of nine PSFs in Polder 29.



In contrast to the relatively good functionality rate of PSFs in Polder 29 (11 out of 14), only 3 of the 155 PSFs recorded in Polder 23 were operational at the time of the survey, with an average functionality of three years post construction. Commonly cited reasons for non-functionality were poor design and construction causing seepage of water, and contamination of source ponds by saline sea water. Of the non-functional ones, 84 per cent were being modified for use as private rainwater reservoirs.

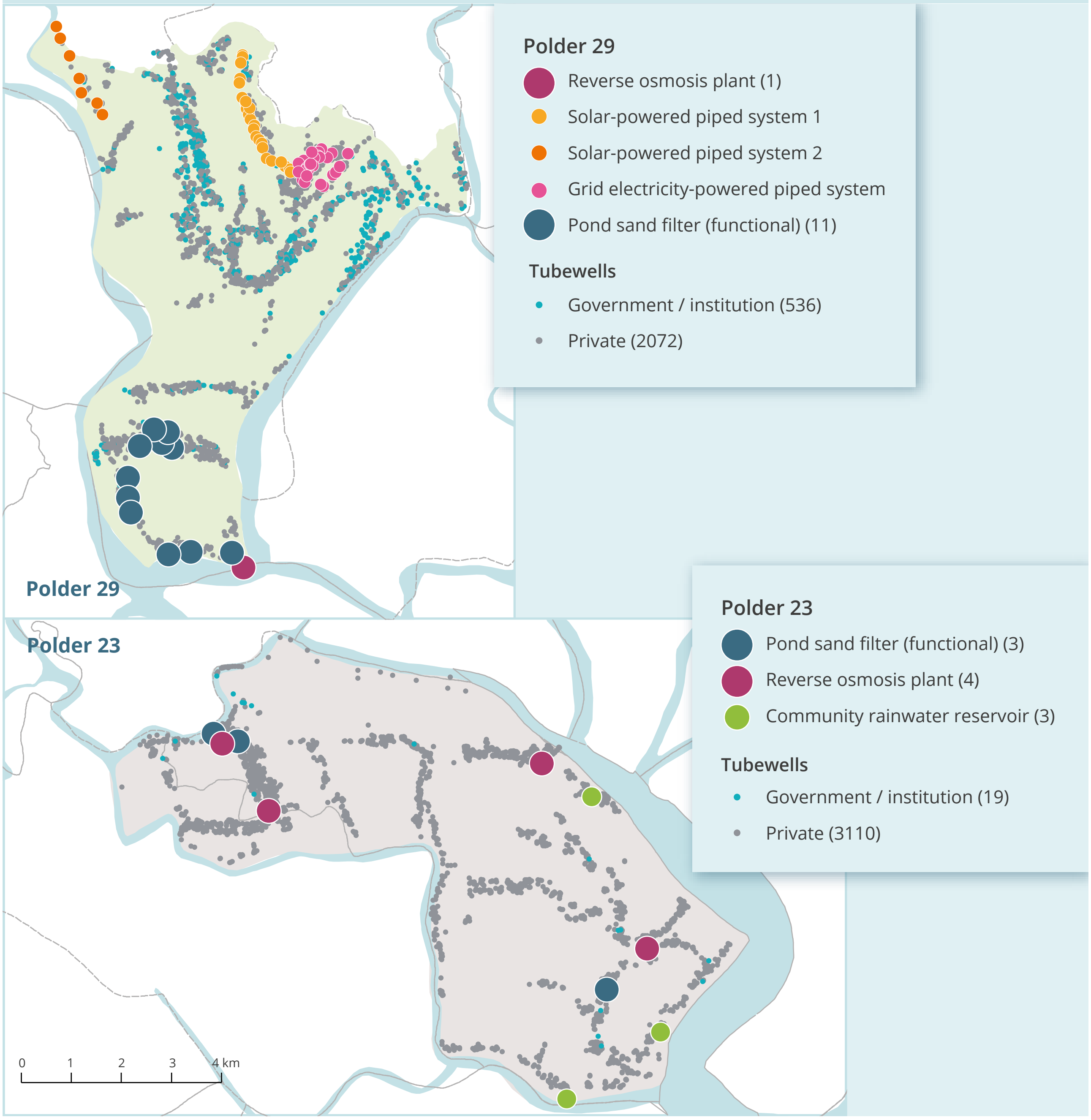
3.2 Public financing and private enterprises

Public investments in community tubewells have been instrumental in increasing access to safe and reliable water in areas with favourable hydrogeology. However, areas with complex water quality challenges require capital investments in alternative technologies such as piped schemes, pond sand filters, and desalination technologies, which are often met through ad hoc donor-funded projects. While household self-supply investments in shallow tubewells and rainwater storage tanks inject significant private funds into the rural water sector, the extent to which it complements or competes with public water supplies is not well understood.

We mapped all water supply infrastructure in the southern half of Polder 29, serving a population of 31,307 across 42km^2, and in Polder 23, with 25,528 people living across 56 km^2 in a relatively more saline and remote geography (Figure 15). Our findings revealed significant differences in the proportions of public and private investments in the past decade, during which USD 385,000 and USD 200,000 were invested by the government and donors in Polder 29 and Polder 23, respectively, compared to USD 252,000 and USD 410,000 being invested by households and local entrepreneurs (refer to Hoque et al. (2021)). This indicates that gaps in public provision in high salinity areas are being addressed through private investments, which creates an additional financial burden on households living in vulnerable locations.

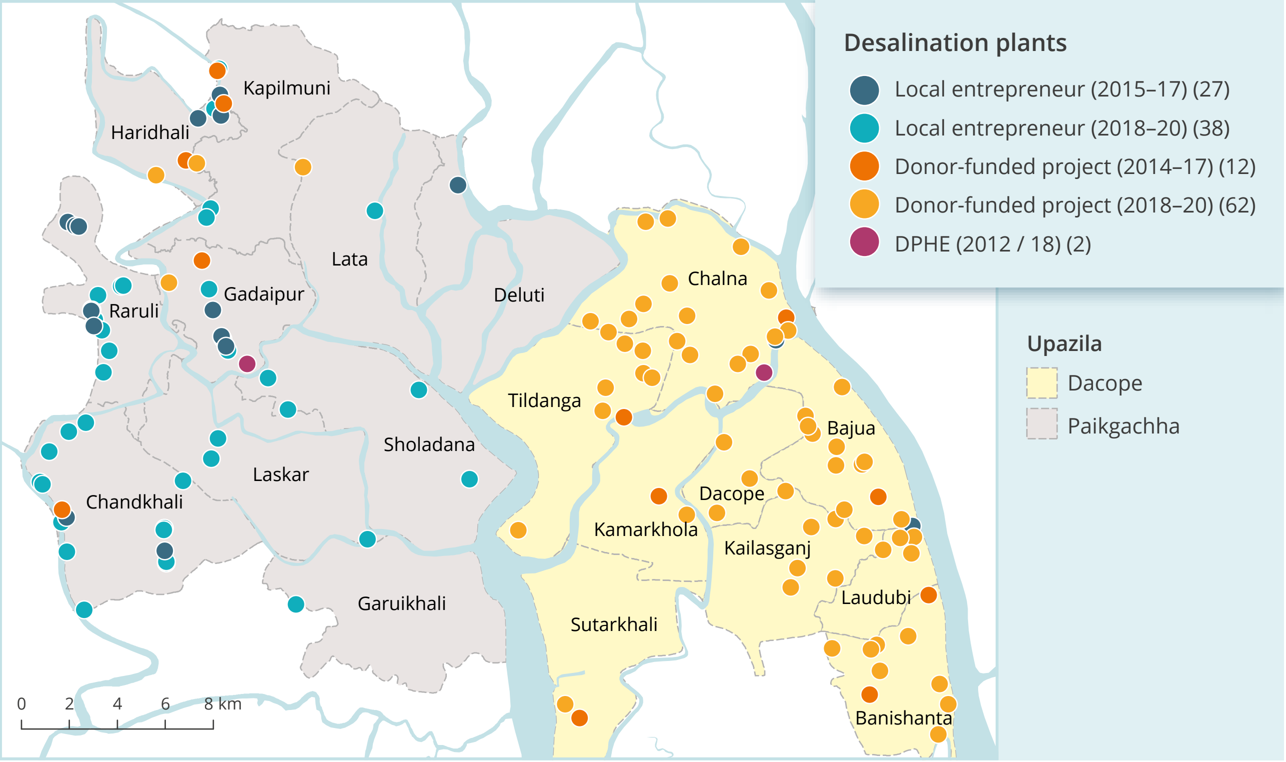
Recently, there has been a boom in desalination (reverse osmosis) plants in coastal areas where sources of fresh water are limited. We mapped 63 and 68 desalination plants in Paikgachha and Dacope upazilas respectively (Figure 16), of which 7 per cent and 97 per cent involved project-based funding from donor organisations with support from the government. The production capacity of these desalination plants range from 360 to 2000 litres per hour (median = 1000 litres per hour), with an average capital investment, including costs of machineries, boring, shop construction, and container purchase, of USD 13,780 for government/ donor-funded plants and USD 7,085 for those financed through personal savings or microcredit by individuals or groups of business partners. The selling price of water ranges from BDT 0.3 to 0.75 per litre, with a median of BDT 0.5 per litre (USD 6 per m^3). Distributing vendors are commonly sighted in these polders, delivering water from desalination plants, deep tubewells and community rainwater reservoirs in 10-, 20- or 30-litre containers. The selling price depends on the source and distance with a median of USD 0.29 per 30-litre container (USD 10 per m^3).

Figure 15: Public and private water supply infrastructure in Polders 29 and 23.



With higher volumetric costs than those found in New York, Tokyo or London, local people adjust by selectively using water from these sources as budgets and essential needs permit. Water users face the twin threats of living in a fragile environment with no public water provision, with small unsubsidised water enterprises bearing the risks of bridging the gap. Vendors and enterprises fill a public provision gap facing costs that reflect the context and associated risks of private investment.

Figure 16: Map of Paikgacha and Dacope upazilas showing all public and privately funded reverse osmosis plants.



3.3 Social and spatial inequalities

Hydrogeological constraints on groundwater availability and inadequate investments in water supply infrastructure result in social and spatial inequalities in access to safe and affordable drinking services. While households in low salinity areas in the northern part of Polder 29 fetch water from deep tubewells all year round, households in the southern part of Polder 29 and in Polder 23 reported using pond sand filters, shallow tubewells, vended water and surface water as their main source. Household water diaries show inter-household and seasonal variations in water sources and expenditures (Figure 17and Figure 18). About 20 per cent of the diary households incurred no expenditures as they used pond sand filters, deep tubewells, shallow tubewells or rainwater throughout the year. Another 35 per cent spent less that BDT 2000 (USD 24) a year as they purchased vended water occasionally for drinking only, while about 15 per cent spent more than BDT 5000 (USD 60) a year and purchased about 600 litres a month for both drinking and cooking. The onset of monsoon around July caused significant drop in weekly water expenditures, owing to overall shifts from vended to rainwater sources.

Figure 17: Household water expenditures in relation to total expenditures, rainfall and sources used during the 52-week study period.

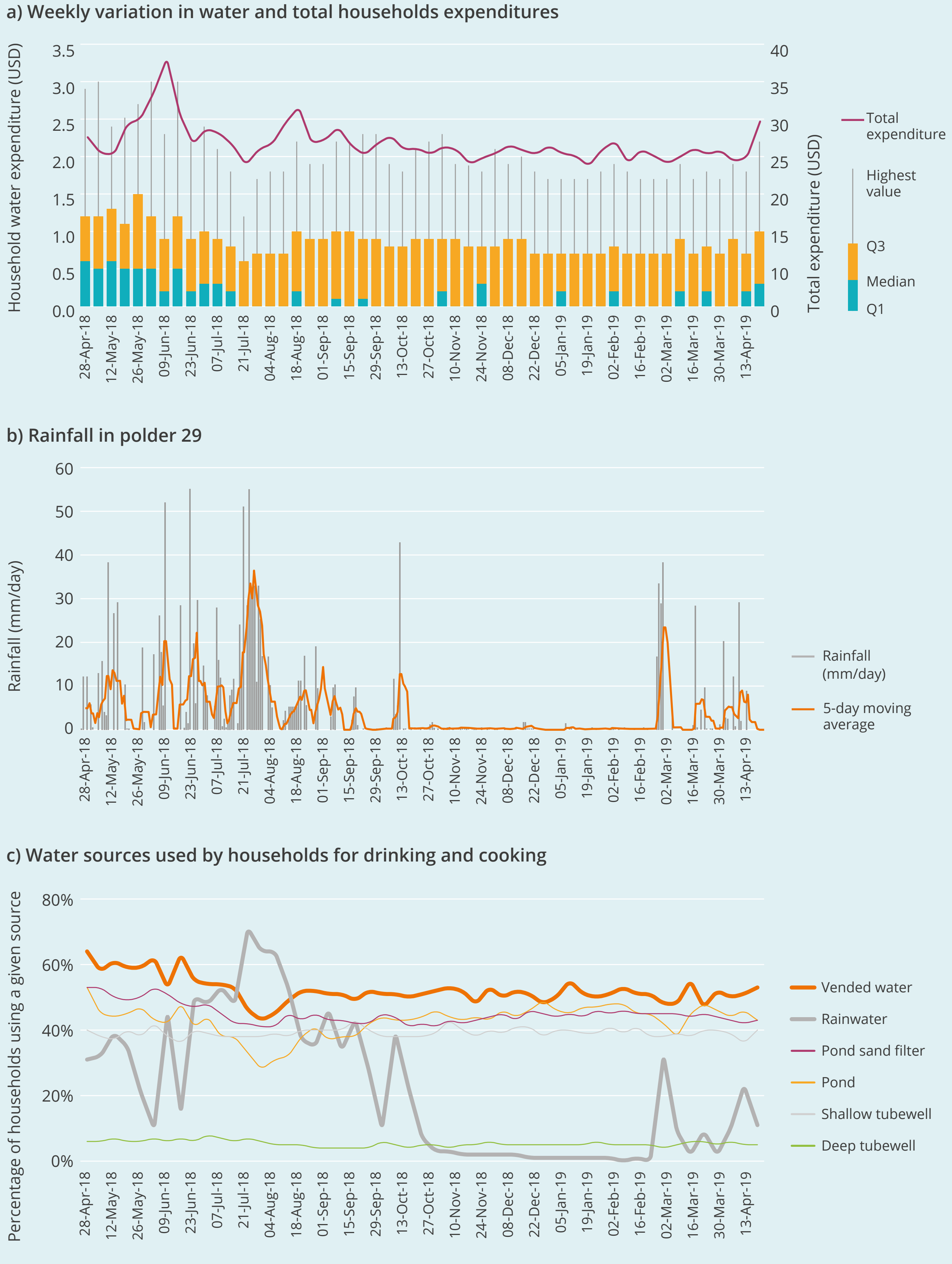
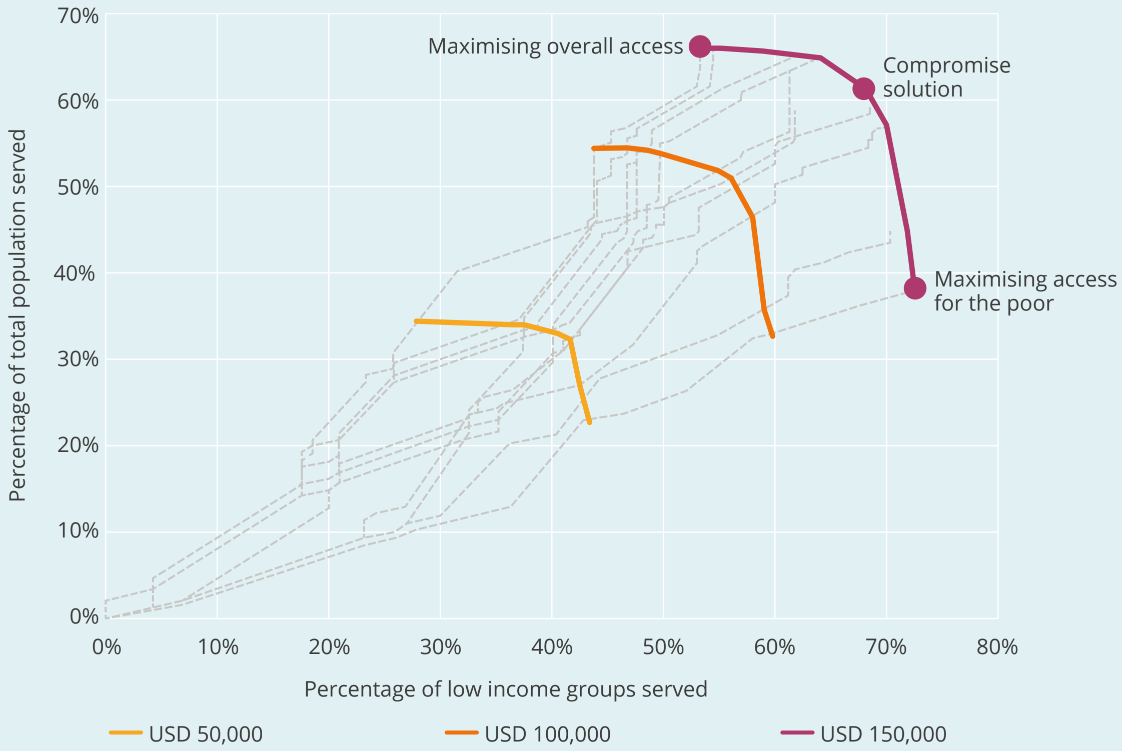


Figure 18: Annual expenditures for drinking water in relation to total household expenditure for 120 water diary households during 2018–19.

Household wealth status emerged as a significant determinant of consumption of vended water and self-supply investments. In Polder 23 significant wealth differences in tubewell ownership were observed, with more than twice as many households in the top wealth quartile (85 per cent) having a private shallow tubewell compared to the bottom quartile (35 per cent). Wealth also reduces water risks with higher wealth households eight times more likely to have rainwater storage tanks than the lowest wealth households.

Figure 19: Trade-offs between total population served and low wealth people served for constrained investments in water infrastructure in Polder 29 (Roman et al., 2021).



In Polder 29, the distribution of public tubewells corresponds to areas where challenges of groundwater salinity are lower, in this case, the northern area. In contrast, the southern area, has higher salinity with people facing limited options and often higher prices due to a reliance on vended water, which has higher costs of delivery. The public choice to prioritise access is deliberative and promotes an efficiency argument with increased coverage at a lower unit cost of installation. This contrasts with an equity argument with a lower increase in coverage favouring the most in need at a higher unit price. Multi-criteria spatial optmisation modelling has illustrated this trade-off in maximising overall access to low-salinity waterpoints and maximising access to the poorest populations for hypothetical investments of USD 50,000 to USD 150,000 in Polder 29 (Roman et al. 2021). (Figure 19). Information systems can both make these trade-offs more transparent and guide planning where potential synergies in coverage and inequality can be addressed.

While informal water markets and self-supply investments are proliferating to address gaps in public provision, such individualised coping strategies are likely to leave behind the poor and vulnerable, who may resort to lower service levels due to affordability constraints. To ensure that no one is left behind, investment decisions need to be guided by better local level information that highlights social and spatial inequalities.

Photo by Sk Rabiul Islam and Al Helal

4. SafePani – Policy recommendations

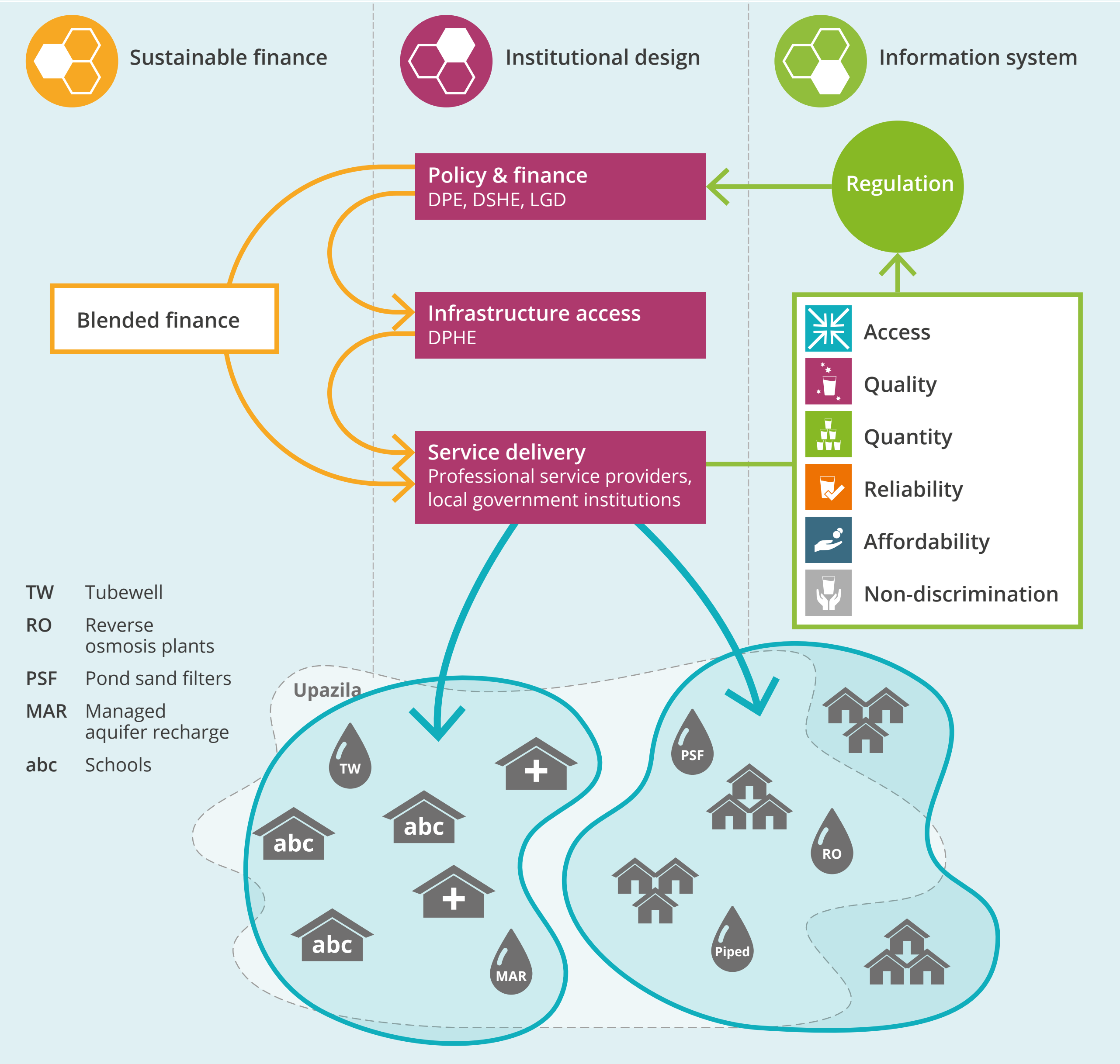
The 1998 National Water Policy in Bangladesh was designed around a public mandate to increase access to infrastructure, not to ensure the sustainable delivery of safe and reliable services. The policy was written before the exponential growth of privately financed tubewells shifted rural households away from reliance on publicly provided water points. Future policy has an opportunity to not only recognise the role of households in rural systems but also create new service delivery models to incentivise private investments from households and small water enterprises to combine public and private funding. Two fundamental challenges need to be addressed.

First, institutional change will entail responsibilities to be clearly allocated and regulated from national to local levels with information and monitoring systems to allow progressive improvement of the quality of water services in terms of safety, functionality, and affordability. Service delivery models can be designed to network infrastructure at the right operational and political levels. Legal provision can make provision for exclusive service areas and independent regulation and enforcement to ensure no one is left behind.

Second, financing service provision will require public and private funds to be more effectively combined to deliver results. Information systems will improve the allocation of funding and can attract new sources of funds based on performance. User payments will be central to financial sustainability with preferences for on-site infrastructure, such as piped water to homes and facilities, requiring tariffs to be affordable for all water users.

Here, we propose a revised service delivery framework – the SafePani model – with key policy recommendations in areas of institutional design, information systems, and sustainable finance (Figure 20).

Figure 20. Proposed SafePani design for rural water service delivery in Bangladesh



4.1 Institutional design

Three areas of reform are proposed to allocate responsibility and regulate performance from national to local levels. First, national government can focus its leadership in policy design, sector coordination and infrastructure planning. This can be supported by resourcing and delegating responsibilities to local government institutes to build capacity to manage and monitor service delivery, including operation and maintenance, in defined and exclusive service areas. National partners and local stakeholders can support government agencies at the appropriate level aligned to overall policy and strategic priorities. The subsidiarity principle will guide resources and responsibilities to the lowest institutional level to ensure the effective and inclusive delivery of services to all public water supply infrastructure serving villages, schools, healthcare facilities, public places and places of worship.

Second, an independent 'Drinking Water Services Regulator' should be collectively designed to support national measurement and monitoring with public reporting of progress against agreed benchmarks. The geographic scope will initially focus on areas outside major urban centres and cities with further discussions to determine future coordination. This is deliberative as regulation often starts in urban centres with more people and higher service levels whilst rural areas are relegated to distant and uncertain support. Funds need to be allocated from national budgets and ring-fenced to ensure independence with powers to progressively enforce standards and protocols. This can replace infrequent national water monitoring approaches, with more frequent data that provides critical information back to water safety managers, capturing climate vulnerability as well as informing national reporting against the SDG. The Drinking Water Services Regulator should advance national policy with a clear mandate to monitor, measure and enforce water quality and affordable tariffs, license professional service providers, and report performance on an annual basis for public review. Local government institutes will support the timely collection and reporting of indicators.

Third, national policy will recognise the role and functions of professional service delivery providers at the operational level to ensure public infrastructure is managed and monitored effectively over time. Service providers will take on the role of managing and maintaining all public water supply infrastructure in a mandated and exclusive service area. This will not include household water infrastructure, such as shallow tubewells, though may include water quality testing or education awareness in consultation with the local government institutes. Exclusive service areas can be determined by local government and include all existing and future public water supply infrastructure. Existing private sector enterprises, including drillers, vendors, kiosks, private tubewells and other infrastructure, will be documented, licensed, and monitored against regulation standards. Coordination with national ministries should ensure that schools and healthcare facilities will be served also. Professional service delivery may be suited to private sector actors though the policy may wish to allow the independent regulator to determine if public sector provision is feasible and desirable in certain locations.

In summary, if policy, regulation, and service provision are designed at the right scale and resourced appropriately, there will be a foundation for progress, subject to supporting information systems, which we turn to next.

4.2 Information systems

Information systems should guide policy and regulation to monitor progress and guide performance improvement based on transparent and timely data. We identify three areas working across national and local scales: a) monitoring and measurement, b) management information systems, and c) public communication. The Drinking Water Services Regulator is the appropriate body to manage information and support national and local government partners.

Monitoring and measurement should be informed by standards determined by the regulator. While professional service providers will be able to generate routine data on infrastructure, revenue, cost, reliability, functionality and other indicators, water quality will require technical support.

This should include wide-ranging water quality testing at installation and targeted testing after installation based on an agreed risk-based approach through a water safety plan. It is recommended that regulatory testing responsibility is placed on public DPHE labs with funding from an independent agency, not from line agencies using services. A minimum pooled operating budget will include randomised comparison testing with non-government agencies to build transparency and accountability.

A management information system (MIS) should consolidate monitoring data with a public interface allowing public scrutiny and engagement. The MIS will provide necessary data for regulation, policy and planning. Management and oversight should rest with the regulator with a shared platform open to all national and local government partners. Coordination with existing systems will determine an appropriate design. Resources for innovation and collaboration with research institutes and the private sector will promote new and emerging technologies to promote flexible, cost-effective and transparent information flows (Thomson, 2021). The handpump data loggers piloted in Khulna and Matlab are indicative of the role and potential of automated reporting at scale.

Public communication can extend beyond the MIS to include awareness raising and provision of information to households, schools, healthcare facilities and other stakeholders. Given the known risks with water quality and the extensive use of shallow tubewells by millions of households, the regulator can develop strategies to inform different stakeholder groups at local and higher levels. Local government and professional service providers will be key actors in communicating messages to target audiences. This approach will increase the knowledge of primary water users and is complementary to wider sector strategies to meet financing challenges.

4.3 Sustainable finance

Finance is the third pillar of sector reform. We propose recommendations across three areas: a) households and small water enterprises, b) funding for facilities and c) results-based funding.

Private funding includes household investments and small water enterprises. Household demand for water supply on premises is not being met by public provision. Sector finance is not effectively combining public and private resources resulting in inefficient allocation of limited funds and water supplies of uncertain water quality. When defining exclusive service areas, local governments can undertake market assessments to evaluate the demand for alternative drinking water service levels, including piped systems, submersible pumps, and licensed vendors. Government can commission research to understand the scale and scope of aligning household funds with public water infrastructure goals. Priority efforts should focus on geographies with high water quality risks and low welfare.

Small water enterprises include an emerging class of investors in small piped systems, reverse osmosis plants, vending or other services for drinking water, including local drillers. Without coordination in wider government planning, capital may be misallocated. Sector coordination will act to identify and license enterprises and their role in service delivery in exclusive service areas.

Regulation and licensing of enterprises should determine if the Bangladesh Standards and Testing Institute (BSTI) has appropriate rules and taxation codes to protect consumers of water services and produce incentives to attract enterprise capital to support public policy goals. The legal status of small water enterprises appears uncertain and open to interpretation with local government able to determine the length and scope of service contracts. Commercial loans vary subject to the classification of the enterprise as determined by the Bangladesh Bank. A green financing classification for drinking water would avoid high commercial loan rates for small water enterprises restricting market entry. Measures should be taken to provide clear and consistent legal provision within a coherent policy of how private enterprise can engage.

Funding for drinking water supplies in schools and healthcare facilities is a national responsibility with installation led by DPHE. Within an exclusive service mandate, these facilities could be combined with other public water infrastructure to create economies of scale in monitoring and management. Under the status quo, after installation, the school bears the responsibility of management and maintenance. It is recommended these responsibilities are taken up by a professional service provider as part of the exclusive service area under local government oversight. Coordination with existing mandates across ministries will need review and consideration of existing information systems and reporting.

Results-based funding provides a new class of funding to combine domestic funds with donor and private sector support. To qualify for funding under a results-based contract, professional service delivery providers share verifiable operational and financial data to demonstrate measurable results in terms of reliability of water supply infrastructure, volume of water produced, and local user payments. Further work is exploring metrics for water quality, affordability, and other indicators. Under the Uptime Consortium, a pilot programme has demonstrated proof-of-principle in four African countries with plans for a global fund (McNicholl et al., 2020, McNicholl et al., 2019). Professional service delivery models are central to the design of results-based funding and present synergies with the Government of Bangladesh's policy and practice to deliver safe water to everyone.

4.4 What's next?

We propose three courses of action based on the recommendations. First, the concept of the SafePani model and associated recommendations across institutional design, information systems and sustainable finance can support the government's policy reform process. Second, donors and other stakeholders can consider how an independent regulator may be established and funded in coordination with wider government reform. Third, the REACH programme will continue to collaborate with government agencies, building on the research findings to test the SafePani model in coastal Bangladesh.

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Authors

- **Prof Robert Hope** | School of Geography and the Environment & Smith School of Enterprise and the Environment, University of Oxford, UK
- **Dr Alexander Fischer** | School of Geography and the Environment, University of Oxford, UK
- **Dr Sonia Ferdous Hoque** | School of Geography and the Environment, University of Oxford, UK
- **Mohammad Monirul Alam** | WASH section, UNICEF Bangladesh
- **Prof Katrina Charles** | School of Geography and the Environment, University of Oxford, UK
- **Muhammad Ibrahim** | Additional Secretary, Local Government Division, Ministry of Local Government, Rural Development & Cooperatives, Government of Bangladesh
- **Md Emdadul Hoq Chowdhury** | Joint Secretary, Local Government Division, Ministry of Local Government, Rural Development & Cooperatives, Government of Bangladesh
- **Prof Mashfiqus Salehin** | Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Bangladesh

- **Dr Zahid Hayat Mahmud** | Laboratory of Environmental Health, International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b)
- **Tanjila Akhter** | Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Bangladesh
- **Dr Patrick Thomson** | School of Geography and the Environment, University of Oxford, UK
- **Dara Johnston** | WASH section, UNICEF Sudan
- **Syed Adnan Ibna Hakim** | WASH section, UNICEF Bangladesh
- **Dr Md Sirajul Islam** | Environmental Microbiology Laboratory, International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b)
- **Prof Jim Hall** | Environmental Change Institute, School of Geography and the Environment, University of Oxford, UK
- **Orlando Roman Garcia** | Institute for Construction and Infrastructure Management, ETH Zürich, Switzerland
- **Dr Nassim El Achi** | School of Geography and the Environment, University of Oxford, UK
- **Prof David Bradley** | School of Geography and the Environment, University of Oxford, UK

Contacts | robert.hope@ouce.ox.ac.uk • malam@unicef.org

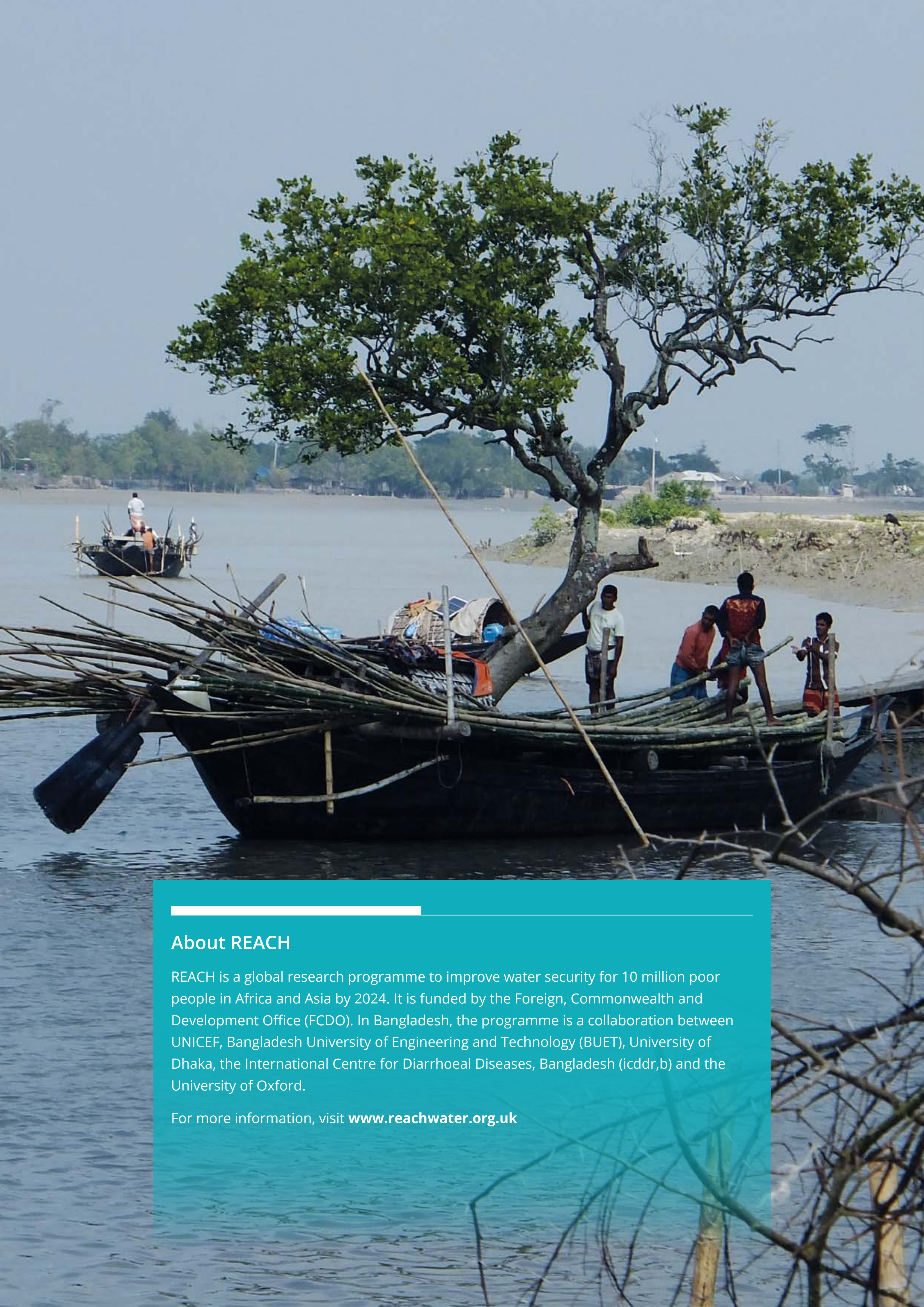
7. Appendix

Table 1 outlines the data collection methods used to gather empirical evidence from Khulna and Chandpur districts. Ethical permissions for the research design and execution followed the University of Oxford and icddr,b protocols to ensure informed consent, confidentiality and protection of all human subjects who participated in the studies. The environmental and human subject data will be released into the public domain by the REACH programme complying with conditions of public funding by the UK FCDO.

Table 1. Data collection methods in Khulna and Chandpur districts

Methods		Description
KHULNA | Polder 29		
Water supply infrastructure	Tubewell audit (2018)	Recorded the locations, installation dates, technical specifications, ownership, maintenance, and usage patterns in two phases Phase 1: All tubewells (total – 2,805) in Sarappur and Surkhali unions and selected mouzas of Sahas union Phase 2: A sample of 354 tubewells in Sahas, Bhandarpara and Dumuria unions
	Alternative sources (2018)	Mapped locations of 19 pond sand filters, three small piped water schemes, one reverse osmosis plant, one managed aquifer recharge unit, and one community rainwater harvesting system, along with interviews of the waterpoint managers
Household water use behaviour	Household survey (2018)	Collected quantitative data on various indicators of multidimensional poverty and drinking/domestic water services for 2,103 households selected through a stratified random sampling technique
	Water Diary (2018–19)	Trained 120 households in the southern part of the polder to document their daily water sources, amounts, costs and itemised household expenditures using a pictorial diary for 364 days
Water quality	Salinity measurement (2018)	Measured electrical conductivity in-situ for all functional tubewells and pond sand filters included in the water audit, using Ohaus ST300C-G Portable Conductivity Meter, 0–199.9 mS/cm.
	Seasonal monitoring (Jan 2020, Jun 2020, and Mar 2021)	Measuring salinity, arsenic, manganese, iron and *E. coli* in 125 selected waterpoints across three seasons

Methods		Description
Usage and functionality	Dataloggers (Ongoing)	Installed dataloggers to monitor usage patterns and breakdown on handpumps at 44 primary and secondary schools, 47 multi-user community waterpoints, and seven PSFs
	Flowmeters (2019–20)	Installed nine flowmeters at selected points of the three piped systems, the reverse osmosis plant and two motorised boreholes
Economic Analysis	User lists	Gathered lists of all users (households) for 21 waterpoints/ systems by listing all water collectors for 2–3 consecutive days
	User payments and O&M costs (2019–20)	Trained owners/managers of 16 select waterpoints/systems to maintain regular logs of all user payments and O&M expenditures incurred for a one-year period
KHULNA | Paikgacha and Dacope, including Polder 23		
Water supply infrastructure	Desalination Plants (2020)	Mapped locations, technical specifications, ownership and capital expenditures of all private and public desalination plants (n=132) in Paikgacha and Dacope upazilas
	Tubewell audit (2020)	Recorded the locations, installation dates, technical specifications, and ownership of all tubewells (n=3,130) in Polder 23
Water quality	Salinity measurement (2020)	Measured electrical conductivity in-situ for all functional tubewells and pond sand filters included in the water audit, using Eutech CON 450 portable meter
Vendor mapping	2020	Interviewed all (n=131) mobile distributing vendors delivering water to/within Polder 29 (Sarappur and Surkhali unions) and Polder 23 (Soladana and Laskar unions) to collect data on supply capacity, seasonal variability in operations, and water sources and prices.
Household survey	2020	Collected quantitative data on various indicators of multidimensional poverty and drinking/domestic water services for 1955 households in Deluti union and Polder 23 (Soladana and Laskar unions)
CHANDPUR | Matlab		
Water supply infrastructure	Blanket infrastructure audit (2017)	Recorded the locations, installation dates, technical specifications, ownership, maintenance, investment, and usage patterns of 254 public and 3,830 private tubewells across ten selected villages
School intake and outtake survey	School administrators (2018 and 2019)	Administered surveys to 165 school administrators or water point managers with pre-set and opened questions.
Usage and functionality	Data loggers (2018–2019)	Installed data loggers to monitor usage patterns and breakdown on handpumps at 150 primary and secondary schools across the icddr,b Matlab enumeration area
Water quality	Sampling school water (Nov 2019)	Measured salinity, arsenic, manganese, iron, turbidity and *E. coli* in 125 primary and secondary school tubewells



About REACH

REACH is a global research programme to improve water security for 10 million poor people in Africa and Asia by 2024. It is funded by the Foreign, Commonwealth and Development Office (FCDO). In Bangladesh, the programme is a collaboration between UNICEF, Bangladesh University of Engineering and Technology (BUET), University of Dhaka, the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b) and the University of Oxford.

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