Drinking water services in coastal Bangladesh

REACH Working Paper 10

June 2021

icddr,b

SafePani সেফপানি

UNIVERSITY OF OXFORD

Foreign, Commonwealth & Development Office

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Drinking water services in coastal Bangladesh

This report should be referenced as:

Hoque, S.F., Hope, R., Alam, M.M., Charles, K., Salehin, M., Mahmud, Z.H., Akhter, T., Fischer, A., Johnston, D., Thomson, P., Zakaria, A., Hall, J., Roman, O., El Achi, N., and Jumlad, M.M. 2021. Drinking water services in coastal Bangladesh. REACH Working Paper 10. Oxford, UK: University of Oxford.

Disclaimer:

This report is a background working paper supporting the SafePani model proposed in the report titled 'Policy reform for safe drinking water service delivery in rural Bangladesh' (Hope et al. 2021). Hence, large sections of the text and figures from this report have also been published in Hope et al. (2021).

Cover photo by Sonia Hoque.

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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 160 million citizens in 2019. However, the coverage rate decreases to 42.5 per cent when service delivery accounts for indicators of water quality, proximity, and sufficiency (BBS/UNICEF, 2021). Groundwater salinity, coupled with frequent exposure to cyclones and tidal floods, pose significant drinking water challenges for rural populations living in the 139 polders across the coastal zone. 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 presents empirical evidence on the existing state of drinking water services in coastal Bangladesh, highlighting challenges and opportunities for reforms in the institutional design, information systems, and sustainable finances under the proposed 'SafePani' model. The report draws on four years of interdisciplinary and collaborative work of the REACH programme[1] in Khulna district, and is one of the two of background working papers supporting the main report titled **Policy reform for safe drinking water service delivery in rural Bangladesh** (Hope et al. 2021).

Rural water service delivery in Bangladesh involves a decentralised institutional arrangement, with local government institutions being responsible for installation of water supply systems with centrally allocated funds from the national budget, alongside project-based donor finances. Donor funded projects, implemented by local NGOs, remain instrumental in financing non-tubewell infrastructure, but continued reliance on community-based management jeopardises operational and financial sustainability of service delivery, with lack of regular user payments being a significant barrier for timely repair and maintenance in many cases. While self-supply investments and the recent proliferation of water enterprises inject significant private finances into the sector, the extent to which they complement or compete with public water supplies is not well understood. Existing sources of data, from infrequent nationally representative surveys, waterpoint mappings and project-based water quality monitoring, are inadequate for monitoring the SDG indicators of access, quality, quantity, reliability, affordability, and non-discrimination.

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, DU, icddr,b and the University of Oxford.

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.

As the Government sets out to revise the 1998 National Policy for Safe Water Supply and Sanitation, the proposed SafePani model provides 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.

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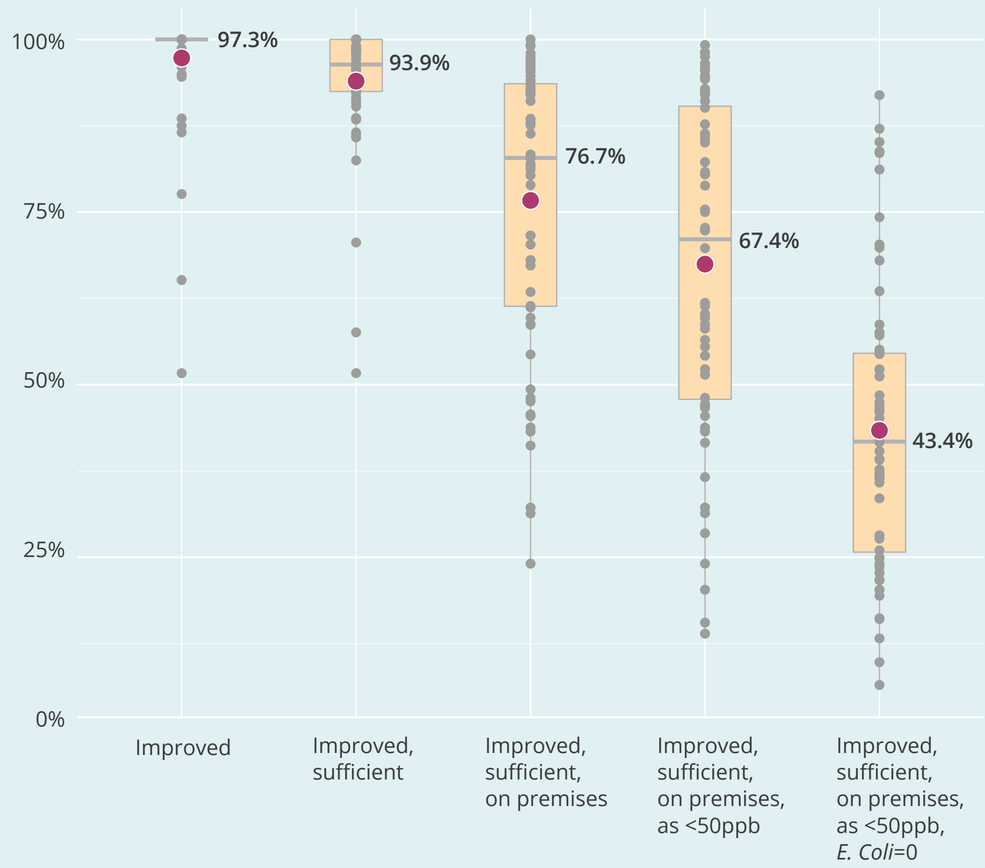
Water vendor carrying 30-litre containers to be sold to households in Surkhali union. Photo by Sonia Hoque.

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, 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.

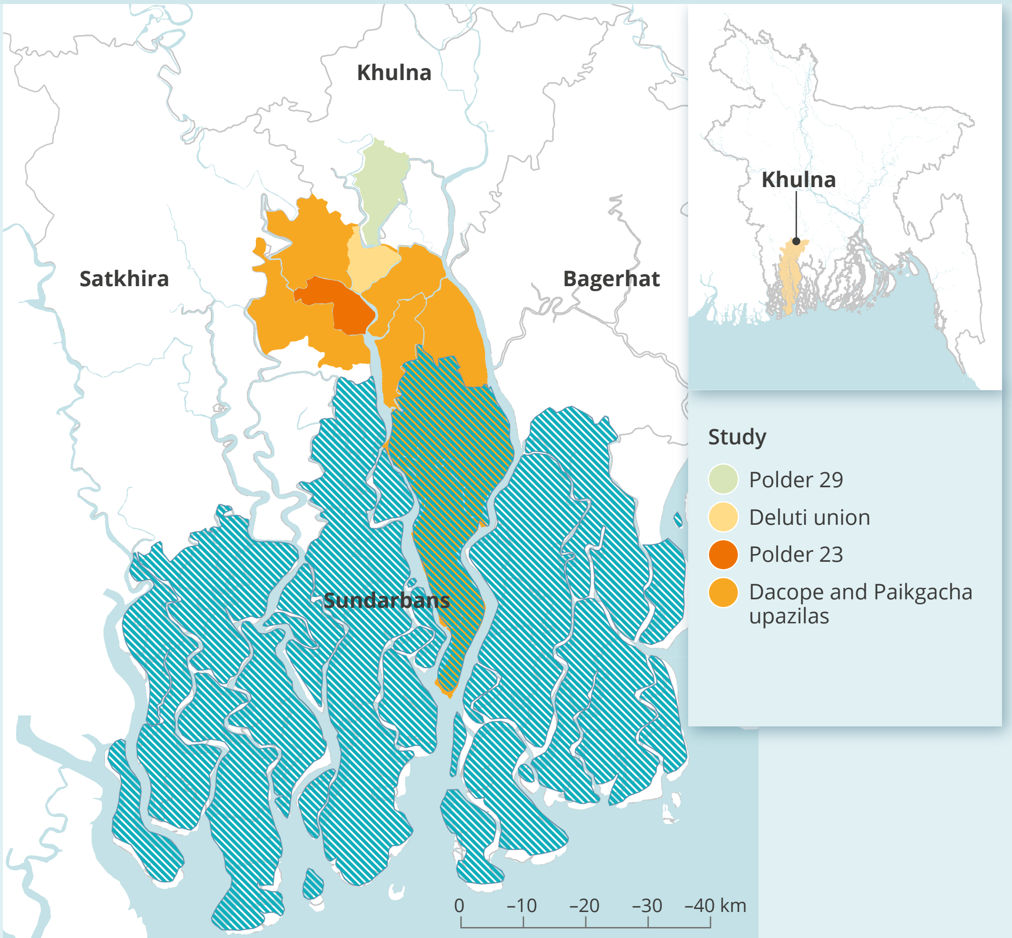
The existing institutional design, sector financing, and information systems in Bangladesh, illustrate a clear focus on increasing access by installing water supply infrastructure through public funds and external assistance, with periodic project-based mapping of waterpoints and nationally representative surveys providing estimates on sector performance. 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. As the Government sets out to update the 1998 national policy, this report considers how to allocate risks and responsibilities amongst national and local water sector stakeholders, recognising the infrastructure financing gaps, operation and maintenance challenges, and socio-spatial inequalities against the backdrop of increasing hydroclimatic risks. This report is one of the two of background working papers, presenting empirical evidence from the coastal zone to support the proposed 'SafePani' model, which is outlined in the main report titled 'Policy reform for safe drinking water service delivery in rural Bangladesh' (refer to Hope et al. (2021)).

Figure 1: State of drinking water services across 64 districts based on SDG indicators (Red points showing mean) (Data source: MICS 2019).



This report draws on four years of collaborative research in Khulna district, led by the University of Oxford, Bangladesh University of Engineering and Technology (BUET), the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b), and UNICEF. It presents multiple sources of data and analysis on hydrogeology, water supply infrastructure, institutions, water quality, and social and behavioural dynamics in Polder 29, generated as part of the REACH project (2015 – 2024) funded by the Foreign, Commonwealth and Development Office (FCDO). Polder 29 is one of the 139 polders (embanked islands) in southwestern coastal Bangladesh, covering parts of Dumuria and Batiaghata upazilas of Khulna district with a population of 61,500 (as of 2011). Additional data were collected from Paikgacha and Dacope upazilas of Khulna district by complementary research funded by the Research England Internal Global Challenges Research Fund (GCRF) (Figure 2). Bangladesh Water Sector Development Plan (2011-25) identifies the coastal region as a priority area for action, owing to its remote geography and vulnerability to multiple natural shocks and stresses. The choice of sites represents the diversity of drinking water challenges in the coastal area along an increasing salinity gradient from north to south.

Figure 2: Study sites in Khulna.



The research methodology and data sources are summarised below (Table 1). 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.

To understand the state of drinking water services across the study sites, we mapped the locations, functionality, installation costs, ownership, and technical specifications of all public and private water supply infrastructure, which included 5935 tubewells, 170 pond sand filters, 132 reverse osmosis plants, three small piped schemes, three community rainwater reservoirs, and one managed aquifer recharge unit. We tested the water salinity of all functional tubewells in-situ, while the water quality for an additional 125 selected waterpoints were tested for arsenic, manganese, iron, chloride, *E.coli*, and *Vibrio cholerae* in the laboratory. Given the high prevalence of informal water vending in these areas, we interviewed 131 mobile distributing vendors to collect data on supply capacity, seasonal variability in operations, and water sources and prices.

To monitor water usage patterns and infrastructure functionality, we fitted dataloggers[2] on the handles of 98 tubewells and pond sand filters, and nine flowmeters on the piped systems and selected multi-user motorised tubewells. We trained the owners and managers of 16 selected waterpoints to record the monthly user payments and operation and maintenance expenditures for a one-year period. We surveyed 5935 households in the study areas to capture the social and spatial variations in access, in terms of main sources, collection times, gendered responsibilities, and costs, and identify how these link to their socio-economic status, geographical locations and wider infrastructure investments in their communities. From these surveyed households, we selected and trained 120 households to participate in a one-year water diary study, which involved documenting their daily water sources, amounts, costs, and itemised household expenditures using pictorial charts.

The research findings are presented in the three following sections, where we discuss the existing state of rural water service delivery in coastal Bangladesh, in terms of institutional design, financing and information systems, respectively. Through these local level findings, we highlight the needs and opportunities for the SafePani model that builds on timely and accurate information systems to monitor and regulate water service delivery, promote sustainable financing mechanisms, and ensure equitable access.

Table 1. Data collection methods in Khulna

Methods	Description	Polder 29 (Dumuria and Batiaghata)	Polder 23 (Paikgacha)	Deluti union (Paikgacha)	Entire Paikgacha and Dacope upazilas
Hydrogeological mapping					
Developed aquifer stratigraphy using data from 31 DPHE borelogs					
Water supply infrastructure					
Tubewell audit	Recorded the locations, installation dates, technical specifications, ownership, maintenance, and usage patterns of all tubewells	2805 (census in southern part) + 354 (sample in northern part)	3129 tubewells		
Alternative sources	Mapped locations of all pond sand filters (PSFs), small piped water schemes, managed aquifer recharge (MAR) units, and community rainwater harvesting reservoirs, along with interviews of the waterpoint managers	19 PSFs, 3 piped schemes, 1 MAR	151 PSFs, 3 community rainwater reservoirs		

2 Data loggers are provided by Oxwater Ltd., a start-up company emerging from University of Oxford research. The data loggers are fitted to the handle of handpumps and transmit data of pump strokes using the mobile network.

Methods	Description	Polder 29 (Dumuria and Batiaghata)	Polder 23 (Paikgacha)	Deluti union (Paikgacha)	Entire Paikgacha and Dacope upazilas
Desalination Plants	Mapped locations, technical specifications, ownership, and capital expenditures of all private and public reverse osmosis (RO) based desalination plants	1 RO	4 ROs		131 ROs
Vendor mapping (Mar – May 2020)	Interviewed all 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.	68	63		
Household water use behaviour					
Household survey (Dec 2017 – Jan 2018)	Collected quantitative data on various indicators of multidimensional poverty and drinking/domestic water services for households selected through a stratified random sampling technique	2103 households	851 households		
Water Diary (May 2018 – Apr 2019)	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	120 households			
Water quality					
Salinity measurement	Measured electrical conductivity (EC) 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.	2238 tubewells (southern part)	2977 tubewells		
Seasonal monitoring (Jan and Jun 2020, Mar 2021)	Measuring salinity, arsenic, manganese, iron, *E.coli*, and *Vibrio cholerae* in 125 selected waterpoints across three seasons	125			

Methods	Description	Polder 29 (Dumuria and Batiaghata)	Polder 23 (Paikgacha)	Deluti union (Paikgacha)	Entire Paikgacha and Dacope upazilas
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 7 pond sand filters	98			
Flowmeters (2019-20)	Installed 9 flowmeters at selected points of the three piped systems, the reverse osmosis plant and two motorised boreholes	9			
Economic Analysis					
User payments and O&M costs (Sep 2019 – Aug 2020)	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	16 waterpoints			

Community rainwater reservoir by Akij company in Soladana union.
Photo by Lutfor Rahman.

2. Institutional design

Rural water service delivery in Bangladesh involves a decentralised institutional arrangement, with local government institutions being responsible for installation of water supply systems with centrally allocated funds from the national budget, alongside project-based donor finances. Publicly provided water infrastructure are usually managed by voluntary user committees. Self-supply through household private investments is ubiquitous, though this service delivery model is not formally recognised or monitored. Similarly, small water enterprises operating in informal markets are proliferating in water stressed areas. In this section, we present our research findings on the various modes of rural water service delivery in coastal Bangladesh.

2.1 National and local government

The water supply sector in Bangladesh is led by Local Government Division (LGD) of the Ministry of Local Government, Rural Development and Cooperatives (MLGRDC), with its Policy Support Branch (PSB) being responsible for formulating policies and strategic plans for overall sector development. The most significant policy is the National Policy for Safe Water Supply and Sanitation 1998, which 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 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 to provide and maintain public water supply infrastructure in rural areas under the direction of the DPHE.

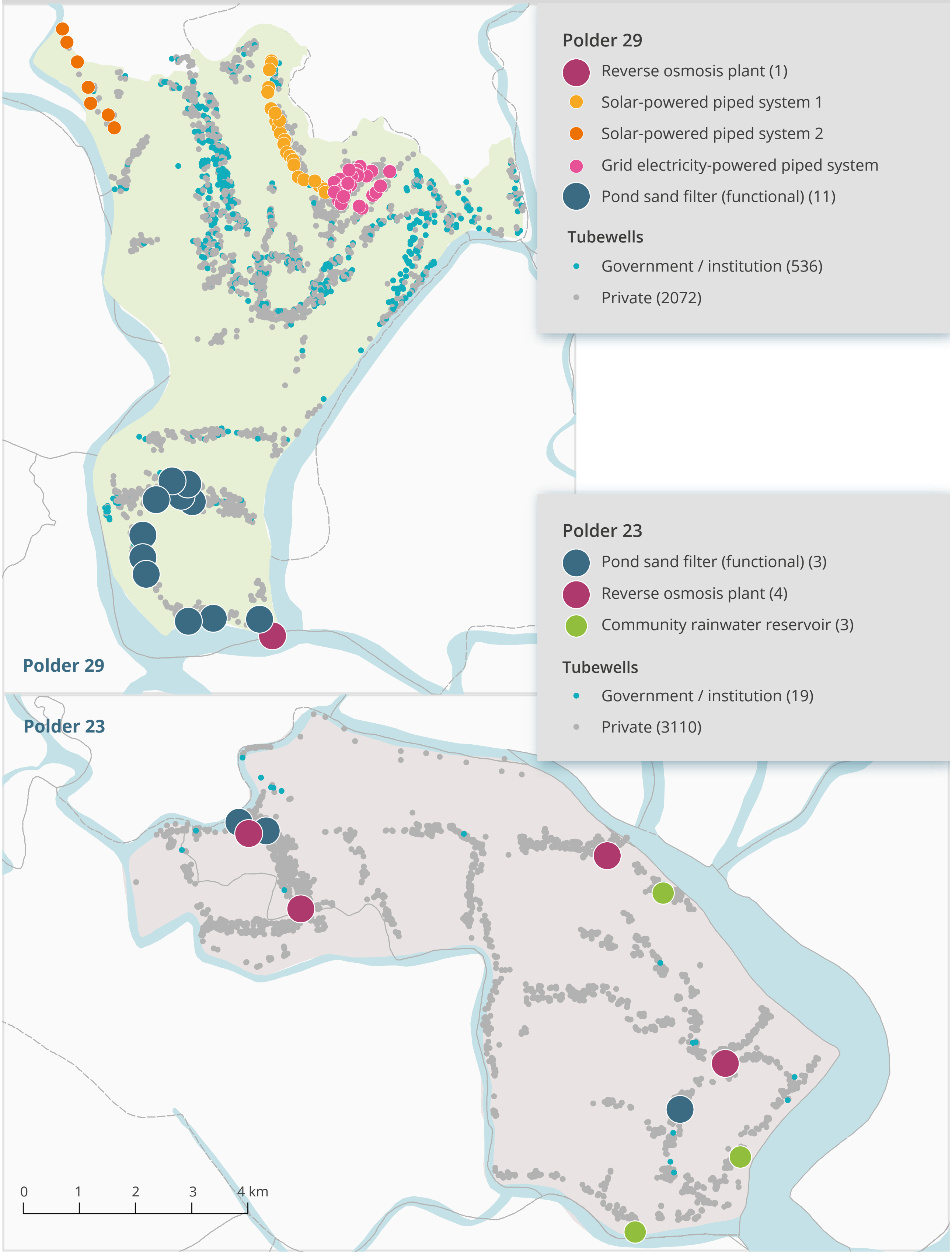
While the Union Parishads have technical capacity to manage point sources like tubewells, they often struggle to with more complex piped water schemes that entail higher levels of coordination and management responsibilities (Lockwood and Islam, 2016). In Sahas union of Dumuria upazila (Polder 29), two solar-powered small piped schemes were installed through the HYSAWA fund[3] in 2014 (Figure 3). The systems comprise 2500 litres overhead tanks supplying water through linear gravity-fed piped networks with 9 and 22 public taps, respectively. Water is pumped continuously with sufficient radiation and the motor is automatically disconnected when the overhead tanks reach full capacity. The Union Chairman oversaw the construction activities awarded to a local company through a tendering process. No user tariffs or management committees were established, with better-off local residents subsequently taking responsibilities for ad hoc repair costs. Locals reported a lot of water wastage, as some people used the public taps for washing clothes and bathing their livestock. Over usage at the nearby taps decreased pressure at ones on the far end, creating longer queues and user dissatisfaction. One of the piped schemes ceased operation since mid-2019 due to local conflicts related to repair responsibilities and funds.

In Sarappur union of Dumuria upazila (Polder 29), a water vending system was started in 2015 through funds from the Upazila Governance and Development Project (UGDP).[4] The vending system sourced water from a pumphouse and used a pick-up truck to deliver one 20-litre container six days a week (at BDT 50 per month, equivalent to USD 0.31 per m^3) to registered households. The project started operation with 115 households; however, within the first six months, additional households signed up, increasing the total to 350. The system, however, ceased operation in early 2017 due to management challenges. Firstly, the tariff was too low to recover operation costs, which included salaries of the driver and an assistant, fuel, and vehicle maintenance cost. Secondly, when the entire southern region of Polder 29 was flooded in mid-2015, it supplied free water to all households in Sarappur union, regardless of their subscription. Thirdly, due to increased requests from an adjacent mouza, which was part Surkhali union under Batiaghata upazila (Polder 29), the truck supplied 50 additional households for three months during the summer of 2016. These households were, however, charged higher tariffs of BDT 150 per month (USD 2.1 per m^3). Such periodic increases in household numbers strained existing resources, increasing the workload of the driver and his assistant, without any salary increments. Moreover, some households refused to pay during the monsoon when they could use rainwater, while others were reluctant to subscribe for the whole year. Decline in revenues during monsoon, without proportional decrease in costs, again jeopardised the sustainability of the system. Finally, the truck was damaged in an accident in early 2017, causing the system to cease operation due to lack of repair funds.

3 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).

4 The Upazila Governance and Development Project (2015-21) aims to promote needs-based rural infrastructure development by Upazila Parishad and ensure closer linkage between Upazila and Union to provide better service delivery to the local communities (www.ugdp-lgd.org).

Figure 3: Public and private water supply infrastructure in Polders 29 and 23.



2.2 Community based management

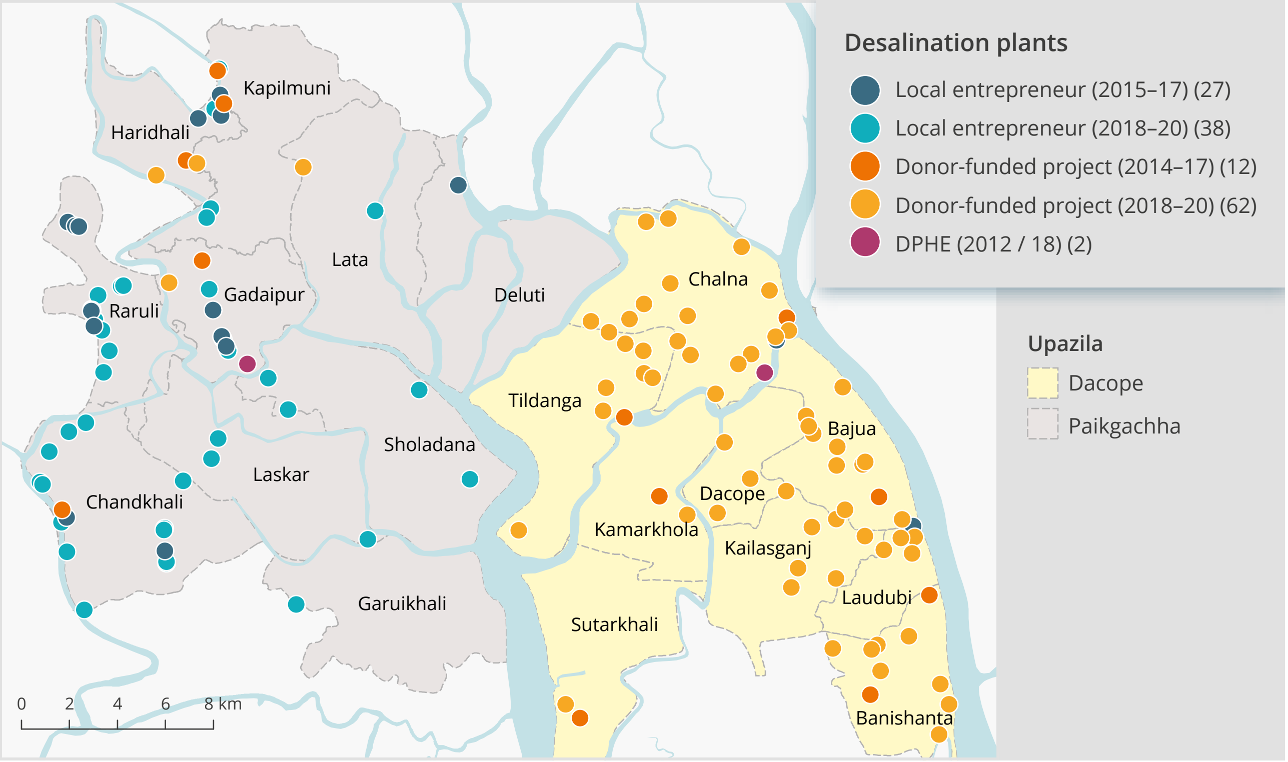
In practice, community-based management is the most common service delivery model for water supply infrastructure installed by DPHE and Union Parishads. As of June 2019, there are 1.8 million public waterpoints in Bangladesh, of which 1.27 million are shallow tubewells, 0.47 million are deep tubewells, while the remaining are split between pond sand filters, ringwells and rain water 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).

We mapped a total of 5707 tubewells in the southern half of Polder 29 and Polder 23, 542 are public tubewells, of which 89 per cent are functional, 82 per cent are classified as deep (>150m) and 78 per cent are used for drinking (Figure 3). This leads to an average of 135 people per functional tubewell, compared to national average of 85 people per tubewell. However, about 49 per cent of these drinking water tubewells exceed the recommended salinity (total dissolved solids) threshold of 1000ppm. Most of these tubewells are located within someone's yard (66 per cent), with the rest being installed within the premises of an institution (e.g. school, healthcare facilities) (14 per cent) or in public places (e.g. markets, mosque) (20 per cent).

In case of alternative technology options, such as small piped schemes or pond sand filters, which are usually financed through bilateral international donor funds, water and sanitation (WATSAN) 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). In Sahas union of Dumuria upazila, an electricity-powered piped scheme was installed in 2014 by an international donor with contributions from the community and Union Parishad (Figure 3). It comprises a 10,000-litre overhead tank, supplying water once at a scheduled time each day. Users access water through 29 public taps and pay a monthly tariff of BDT 30 (USD 0.36) per household, which remained unchanged since construction. A local NGO, that implemented the project, helped set-up a voluntary management committee, comprising of a chairperson, a treasurer and tariff collectors. There was a high sense of ownership among the committee members. These people had been closely involved with the NGO since the project inception and had 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. While the system was running quite effectively at the time of this study, the committee had to resist continuous political pressures from the existing union chairman to expand coverage to the unserved communities, which was likely to jeopardise the sustainability of the system built by his predecessor.

In Polder 29, we recorded 14 pond sand filters, of which 11 are functional. Regular maintenance, which involves cleaning and replacing the sand beds about twice a year, and protecting the source pond from contamination, are essential to ensure sustainability of the systems. Most of these pond sand filters are located on private ponds and managed by the pond owners with support from management committees formed during project implementation phase. Performance and sustainability of pond sand filters are dependent on timely repair and maintenance works, supported by regular user payments. Polder 23 is a graveyard of non-functional pond sand filters, with only 3 of the 155 filters being operational while the rest were abandoned within three years of construction owing to poor construction or salinisation of source ponds. Of these, 112 are being used by individual households as rainwater reservoirs.

Figure 4: Map of Paikgacha and Dacope upazilas showing all public and privately funded reverse osmosis plants.

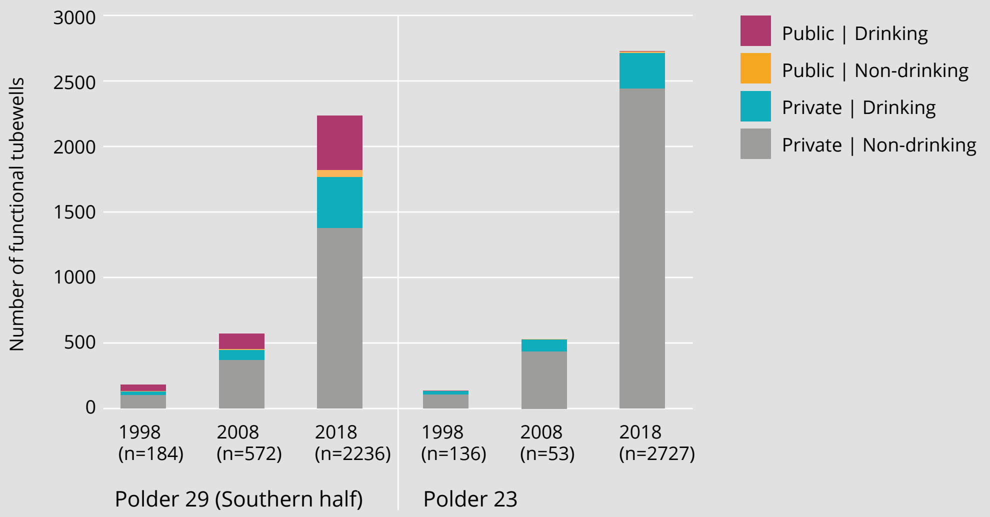


We mapped 63 and 68 desalination plants in Paikgachha and Dacope upazilas respectively (Figure 4), of which 7 per cent and 97 per cent involved project-based funding from donor organisations with support from the government. Forty of these desalination plants, all installed in 2019–20 in Dacope, were provided by the Social Development Foundation (SDF), an autonomous not-for-profit organisation under the Ministry of Finance, while another eight desalination plants were funded by the WaterAid HSBC Water Programme. Other organisations or projects actively participating in the provision of desalination technologies include USAID's Nobojatra project, Promoting Sustainable Livelihoods Foundation, Learning and Innovation Fund to Test New Ideas (LIFT) by Palli Karma-Sahayak Foundation (PKSF) and the Local Government Initiative on Climate Change (LoGIC). Management of these desalination plants are carried out by village committees, with documents outlining the roles and responsibilities of each of the committee members, who are mandated to convene at regular intervals. The day-to-day operations are carried out by a salaried employee, with cash payments from users being deposited in a bank account. Since all these plants have recently started operation, it is premature to assess the effectiveness of community-based management for these social enterprises.

2.3 Household self-supply

Self-supply is not recognised as a formal service delivery model, though the growth of privately financed and managed waterpoints outpace public ones by many folds. Fischer et al. (2020) estimated that between 2005 and 2018, nine million tubewells were privately installed by unregulated drillers. 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 by the Sector Development Plan (SDP) for Water Supply and Sanitation Sector in Bangladesh (FY 2011–2025) (LGD, 2011: 21). The costs of installing tubewells has declined by 70 per cent since 1980 when adjusted to 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 in 2018.

Figure 5: Growth of public and private tubewells in the study sites.



We recorded 5165 private tubewells in Polder 29 (southern half) and Polder 23, the number being ten times higher than that of public ones (Figure 5). About 96 per cent of the private tubewells across all sites were shallow (<150 m) and only 22 per cent were used for drinking, of which 77 per cent exceeded the recommended salinity threshold of 1000ppm. This immense growth in private investment, equating to almost one tubewell per every two households, reflects people's preference for on-site water sources, even when used for non-drinking purposes only. Households in Polder 23 have also been investing in plastic rainwater storage tanks, with 14 per cent of the 851 households surveyed having a private tank, ranging from 500 to 5000 litres in capacity. The rapid emergence and establishment of a self-supply model means the responsibility to manage and maintain water services lies within households with limited coordination or oversight from local government.

2.4 Water enterprises

Private sector participation in rural water service delivery is very 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 private 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, are proliferating in water stressed areas of the coastal zone, but remain undocumented and unregulated.

Alongside the donor-funded desalination plants in Dacope (described in section 2.2), there has been a parallel boom in privately financed desalination plants in Paikgacha (Figure 4). About 84 per cent of the 63 desalination plants in Paikgacha were financed by local entrepreneurs, who are residents with decades of first-hand experience of water scarcity in their communities. All of these plants were installed after 2015, with 72 per cent being installed between 2018–20. Several factors converged to create a ripe 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. The water audit identified 13 different suppliers of desalination technologies, with local sales representatives in Khulna and Satkhira districts. These decentralised plants use grid electricity to draw water from boreholes and desalinate it, though some of the donor-funded plants integrated solar panels as well. There are differences in electricity tariff rates being paid by these plants, as 70 per cent use commercial meters charging USD 0.12 per kWh and 30 per cent use industrial meters charging USD 0.09 per kWh. The allocation of meters is often based on the property type and other associated activities in the properties. All plants have a trade licence, not specific to water supply, and completed a water quality test after installation. While the tests proved that key parameters were within recommended threshold, for some of the plants, the total dissolved solids was as low as 40 mg/l (compared to the standard 1000 mg/l) raising concerns on the health implications of mineral deficient water. Only two of the 62 plants fortify the desalinated water with essential minerals after treatment.

Distributing vendors are commonly sighted in these polders, delivering water in 10-, 20- or 30-litre containers, which are either owned by themselves, their customers, or the desalination plant owners. All vendors own their vehicles, which were primarily purchased for transporting passengers and goods. Half of the 63 vendors supplying water within or to Polder 23, started operation in the past two years with 84 per cent of vendors delivering desalinated water and others sourcing water from ponds or community rainwater reservoirs. In contrast, three-quarters of the 68 vendors in Polder 29 have been operating for more than five years, usually sourcing water from a handful of deep tubewells in Sarappur or Sahas unions and delivering to households in Surkhali union. Another difference between the two sites lies in the seasonality of vendor operations. More than 90 per cent of vendors in Polder 29 operate throughout the year, while in Polder 23, only 40 per cent operate across all seasons. The reduced demand during the wet season in Polder 23 is linked to sharp growth in rainwater storage tanks described above.

2.5 Conclusion

In rural Bangladesh, local government institutions are responsible for installing water supply infrastructure through public funds in line with sectoral policies and plans at national level. Donor funded projects, implemented by local NGOs, remain instrumental in financing non-tubewell infrastructure, but continued reliance on community-based management jeopardises operational and financial sustainability of service delivery, with lack of regular user payments being a significant barrier for timely repair and maintenance in many cases. The progressive growth of privately owned and managed water supply infrastructure, including self-supply through shallow tubewells, desalination plants, and mobile distributing vendors, indicates shifts in risks and responsibilities from public to private actors. In absence of sectoral regulation and performance monitoring, this has resulted in an uncoordinated waterscape of multiple actors with uncertain and unequal distribution of risks related to quality, costs, and reliability.

Reverse-osmosis based desalination plant in Dacope upazila.
Photo by Lutfor Rahman.

3. Sustainable 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).

3.1 Government and donor financing

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, regardless of its need and availability of other resources like tax revenues (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). We mapped all water supply infrastructure in the southern half of Polder 29, serving a population of 31,307 across 42 km^2, and in Polder 23, with 25,528 people living across 56 km^2 in a relatively more saline and remote geography (Figure 3). Government funds are mainly used for installation of shared deep tubewells, although in recent years funds have been diverted to household level rainwater tanks in areas without suitable aquifers, as observed in Polder 23 (Table 2 and Figure 7).

In high salinity areas, we observed a range of alternative sources, including small piped schemes, pond sand filters, and managed aquifer recharge sites, which were financed mainly through project-based donor funds. As described in section 2, three small piped systems with a total capital investment of USD 30,000 were installed in Polder 29 in the mid-2010s, two of which run on solar energy and one on grid electricity.

The two managed aquifer recharge sites in Polder 29, of which one is operational, were financed by UNICEF as part of its wider project involving 100 similar sites across the southwestern coastal districts. Our findings reveal significant differences in the proportions of government/donor and private investments in Polder 29 and Polder 23, highlighting the growing role of private finances in addressing deficiencies in public provision in high salinity areas. Over the past decade, 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.

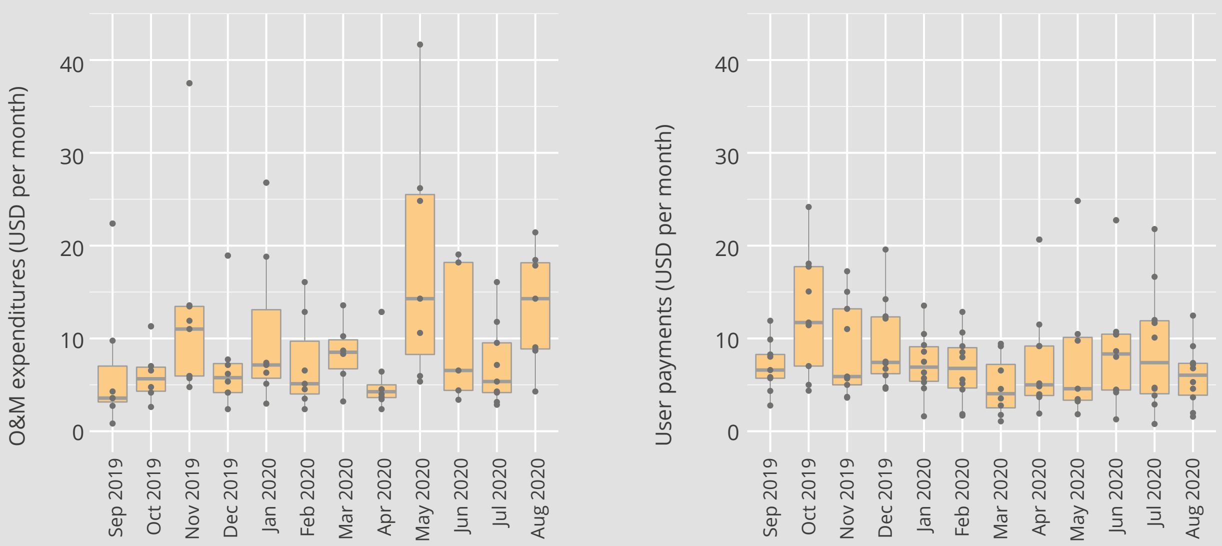
Table 2: Comparison of public and private capital investments in different water supply infrastructure between 2009–2019 (Hoque, 2021)

Site	Population (BBS, 2011)	Type of water supply infrastructure	Number of water supply infrastructure		Average unit cost (USD)	Total capital investment (USD)
			Total	Operational		
Polder 29	31,307	Deep tubewells	335	323	1000	335,000
		Shallow tubewells	52	42	79	4,108
		Pond sand filters	14	11	1000	14,000
		Piped schemes	3	2	10000	30,000
		Managed aquifer recharge	2	1	1000	2,000
		Total				385,108
Polder 23	25,528	Deep tubewells	1	0	1000	1000
		Shallow tubewells	13	13	79	1,027
		Pond sand filters	98	3	1000	98,000
		Rainwater tanks	551	551	182	100,353
		Total				200,380
Total investment by government & donors						585,488
Polder 29	31,307	Deep tubewells	171	163	750	128,250
		Shallow tubewells	1451	1256	79	114,629
		Desalination plant	1	1	8696	8,696
		Total				251,575
Polder 23	25,528	Deep tubewells	2	2	750	1,500
		Shallow tubewells	2493	2382	79	196,947
		Desalination plant	4	4	8696	34,784
		Rainwater tanks	810	810	219	177,390
		Total				410,621
Total private investment						662,196

As described in section 2.2, there has been significant donor investments, with government contributions, in desalination technologies in Dacope upazila over the past couple of years. The production capacity of these government and/or donor financed 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 BDT 1,143,724 (USD 13,780) per plant. The selling price of water ranges from BDT 0.30 to 0.75 per litre, with a median of BDT 0.50 per litre (USD 6 per m^3).

While capital investments for non-tubewell sources are financed through government or donor funds, the operation and maintenance costs are the responsibility of the users, with some systems having fixed monthly or volumetric tariffs while others collecting repair costs as and when needed. While pond sand filters do not have any fixed tariffs, users contribute BDT 5-10 for repair and maintenance as and when required, with mean monthly O&M expenditures and user payments being around BDT 500 (USD 6) (Figure 6). However, lumpy expenses, such as re-excavating ponds, cleaning rotten fish, and clearing debris after cyclone Bulbul, were often borne by local elites.

Figure 6: Boxplots showing O&M expenditures and user payments for pond sand filters in Polder 29.

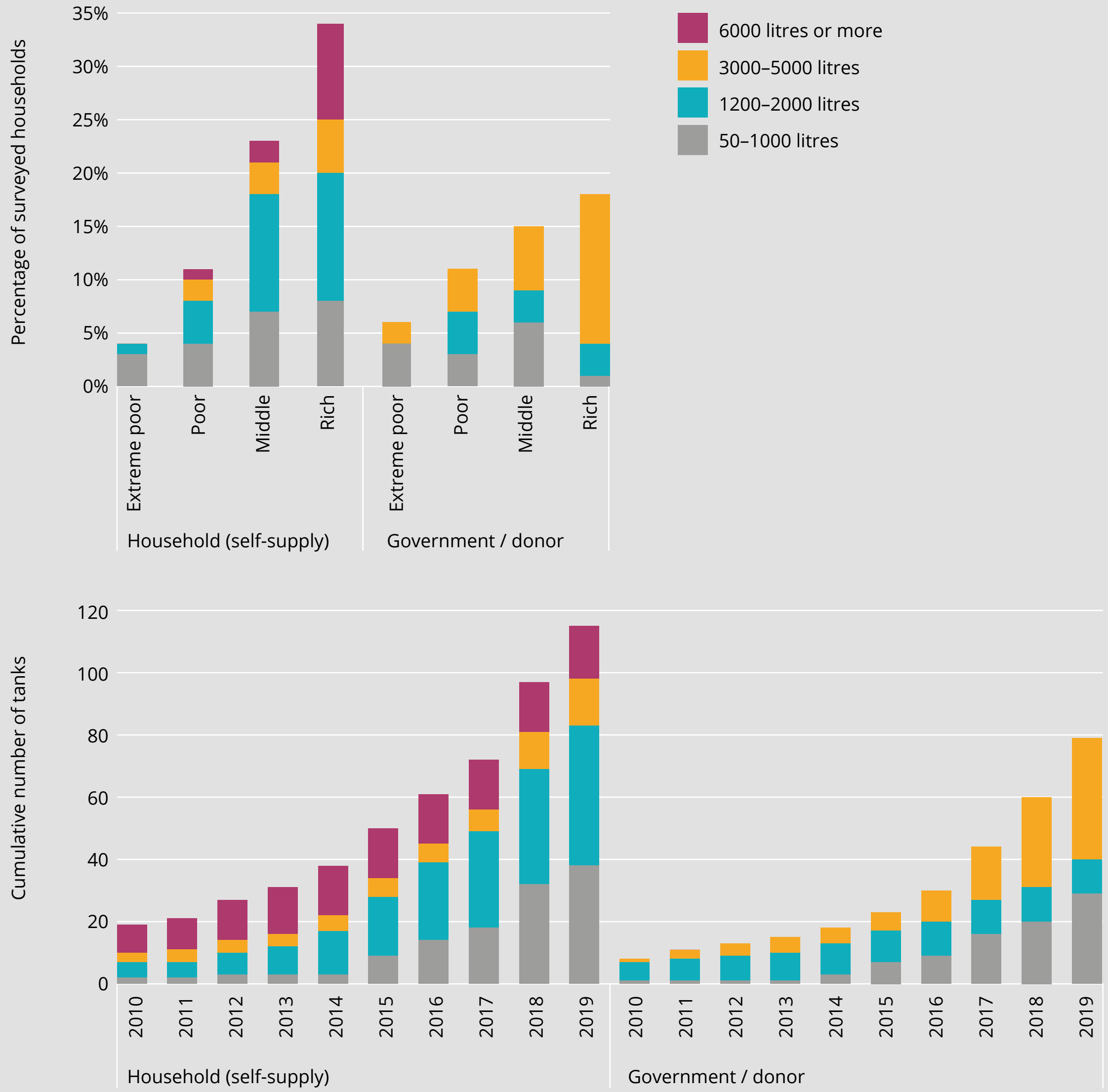


3.2 Self-supply and water enterprises

Private financing comprises self-supply investments by households, market entrepreneurism and charitable contributions. 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. Based on blanket surveys of tubewells, Fischer et al. (2020) estimates that in 2018 rural households invested between USD 94 and 170 million on new water supply infrastructure with an additional USD 83 million being spent on operation and maintenance costs.

Our findings from Polder 29 and 23 show a four-fold growth in private shallow tubewells in the past decade (Figure 5) along with growing investments in rainwater storage tanks (Figure 7). Installation costs varied with tank capacity, ranging from USD 60 for 500-litre ones to USD 307 for 5000-litre ones, with the ferrocement reservoirs costing between USD 361 and USD 722. We also recorded three community rainwater reservoirs in Polder 23, constructed through philanthropic donations from Akij Group, one of the largest industrial conglomerates in Bangladesh, and managed by respective mosque committees. The water is generally free, but villagers contribute to the mosque fund for repair and maintenance.

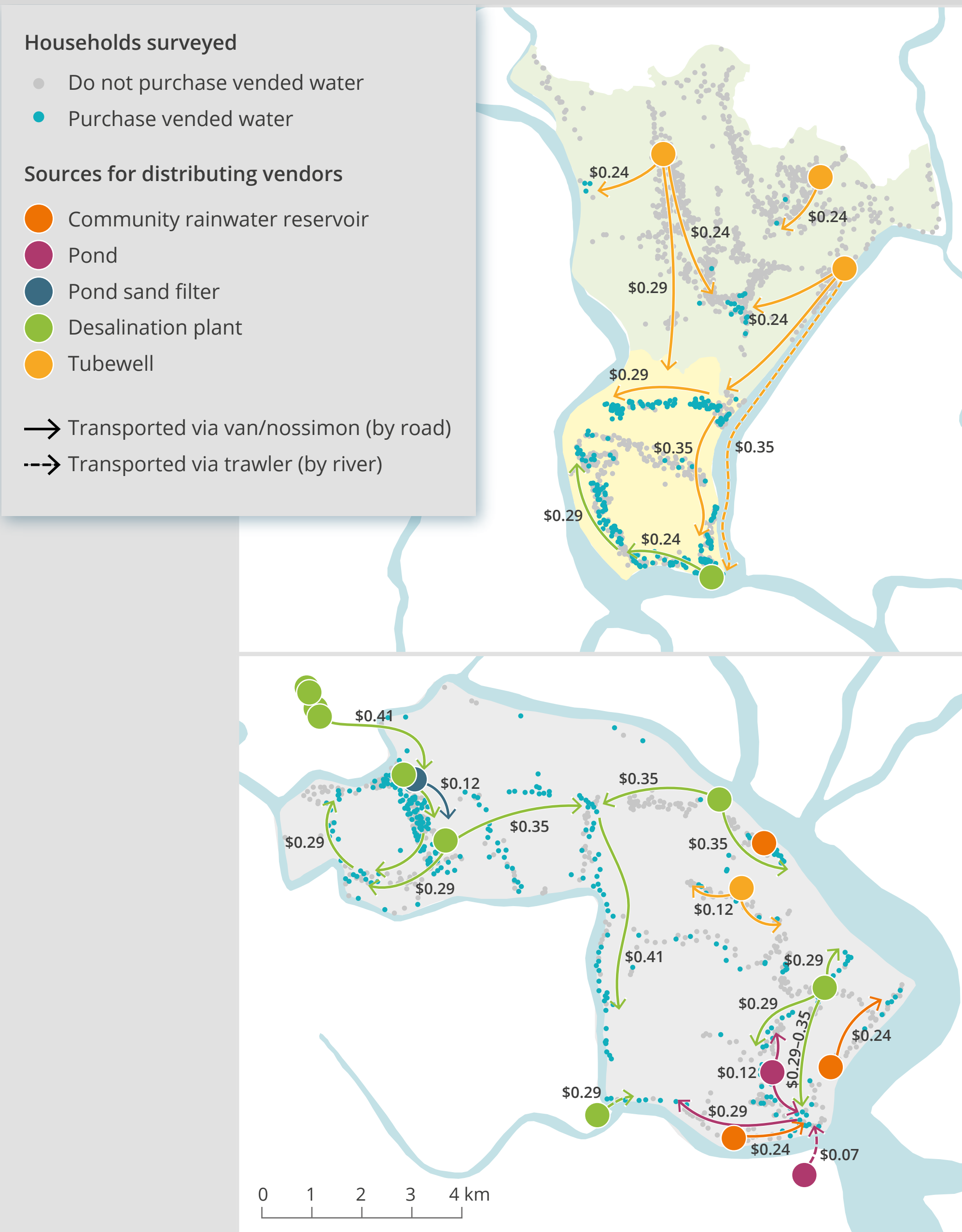
Figure 7: Ownership of privately and publicly-funded rainwater storage tanks by wealth class and year in Polder 23 (Hoque, 2021).



Capital investments for the private desalination plants in Paikgacha upazila (refer to section 2.4), amounting an average of USD 7085 per plant, were financed through personal savings or microcredit by individuals or groups of business partners.

This comprised of USD 5074 for machineries, USD 142 for boring, USD 1568 for constructing the shop and USD 302 for purchasing containers. Production capacities range from 360 to 1080 litres per hour. The selling price of water ranges from USD 0.11–0.18 per 30-litre container (USD 3.7–6 per m^3), with the fortified one (locally called 'mineral water') being sold at USD 0.36 per 30-litre (USD 12 per m^3). Distributing vendors resell water from these desalination plants or fetch it from deep tubewells with low salinity. The selling price depends on the source and distance (Figure 8), with a median of USD 0.29 per 30-litre container (USD 9.7 per m^3). Since the selling prices of tubewell and desalinated water are similar, vendors that source water from tubewells (that is, in Polder 29) earn a much higher profit than those distributing desalinated water, because of higher source prices of the latter.

Figure 8: Sources, routes and costs (per 30-litre cans) of water transported by distributing vendors in Polder 29 and Polder 23 (Hoque, 2021).



3.3 Conclusion

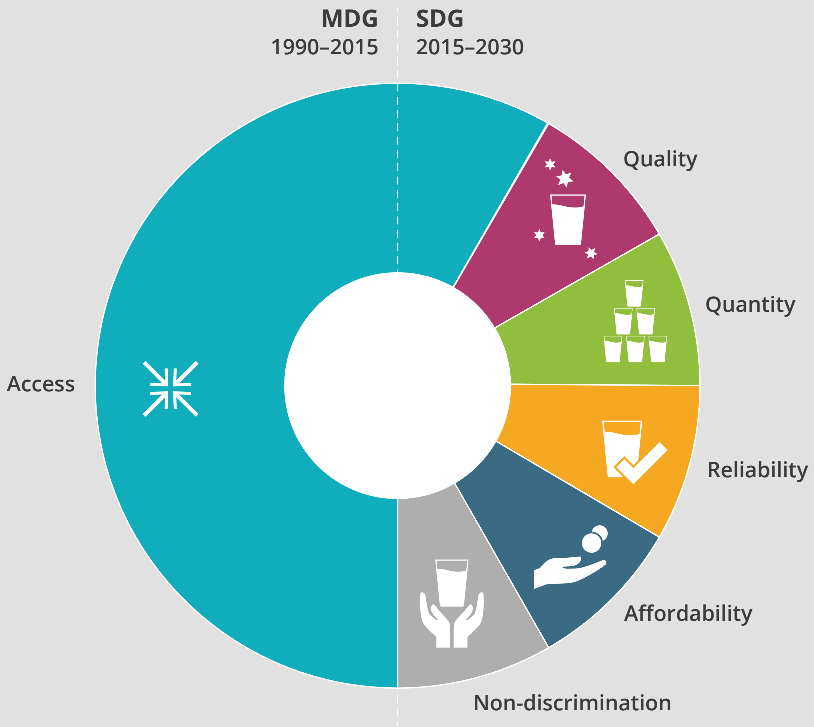
While government and donor funds have traditionally financed rural water supply infrastructure in Bangladesh, these sources are inadequate to reach the SDG targets for rural populations in water stressed areas. Household self-supply investments and small water enterprises are proliferating to address unmet demand though these sources of private finances remain undocumented. Globally sectoral experts are urging governments to separate regulation and service delivery responsibilities and use blended finance to create bankable projects that can encourage mobilisation of private funds. Bangladesh's high population density and demand for better water services in line with its economic growth, coupled with vibrant local supply chains, provide a fertile ground for upscaling private investments in water service delivery in salinity prone areas.

Woman pumping a shallow tubewell installed inside her household premises. Photo by Sonia Hoque.

4. Information systems

Timely and credible information informs institutional design and decisions, and offers pathways to promote accountability and financial sustainability. Previous and ongoing efforts to aggregate information on publicly-funded drinking water infrastructure, their functionality and quality in terms of arsenic and *E.coli* contamination are inadequate for monitoring the SDG indicators of access, quality, quantity, reliability, affordability, and non-discrimination.

Figure 9: Moving from MDG to SDG.



Large-scale surveys, including the 10-yearly national census, the Demographic and Health Surveys (DHS) and the Multiple Cluster Indicator Survey (MICS), which are funded by the Government of Bangladesh, USAID, and 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. 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*.

In addition to these surveys, administrative data provides the second dynamic source of data for the water sector. 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 during 2006 to 2012 (DPHE, 2014). Since 2012, DPHE has been publishing annual waterpoint status reports with upazila-wise inventory of public waterpoints, their 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 fee-for service for other sectors. DPHE, however, does not do any routine quality checking of installed water facilities even on a sample basis. The rapid growth of household tubewells has water quality implications. Households do not invest in water quality testing, which costs between 1 and 3 per cent of the installation cost (Pfaff et al., 2017). The Directorate of Secondary and Higher Education (DSHE) manages a national EMIS database (http://emis.gov.bd/) – an online system that captures information around school facilities, management, and finances, including parameters around access and functionality of water and sanitation infrastructure.

Owing to the complex aquifer system of the Ganges-Brahmaputra-Meghna delta, groundwater availability and quality exhibits high spatial and vertical heterogeneity, with limited information on local hydrogeological profile available prior to drilling tubewells. 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 is limited, as it is not tracked as part of MICS or DPHE's annual waterpoint status reports.

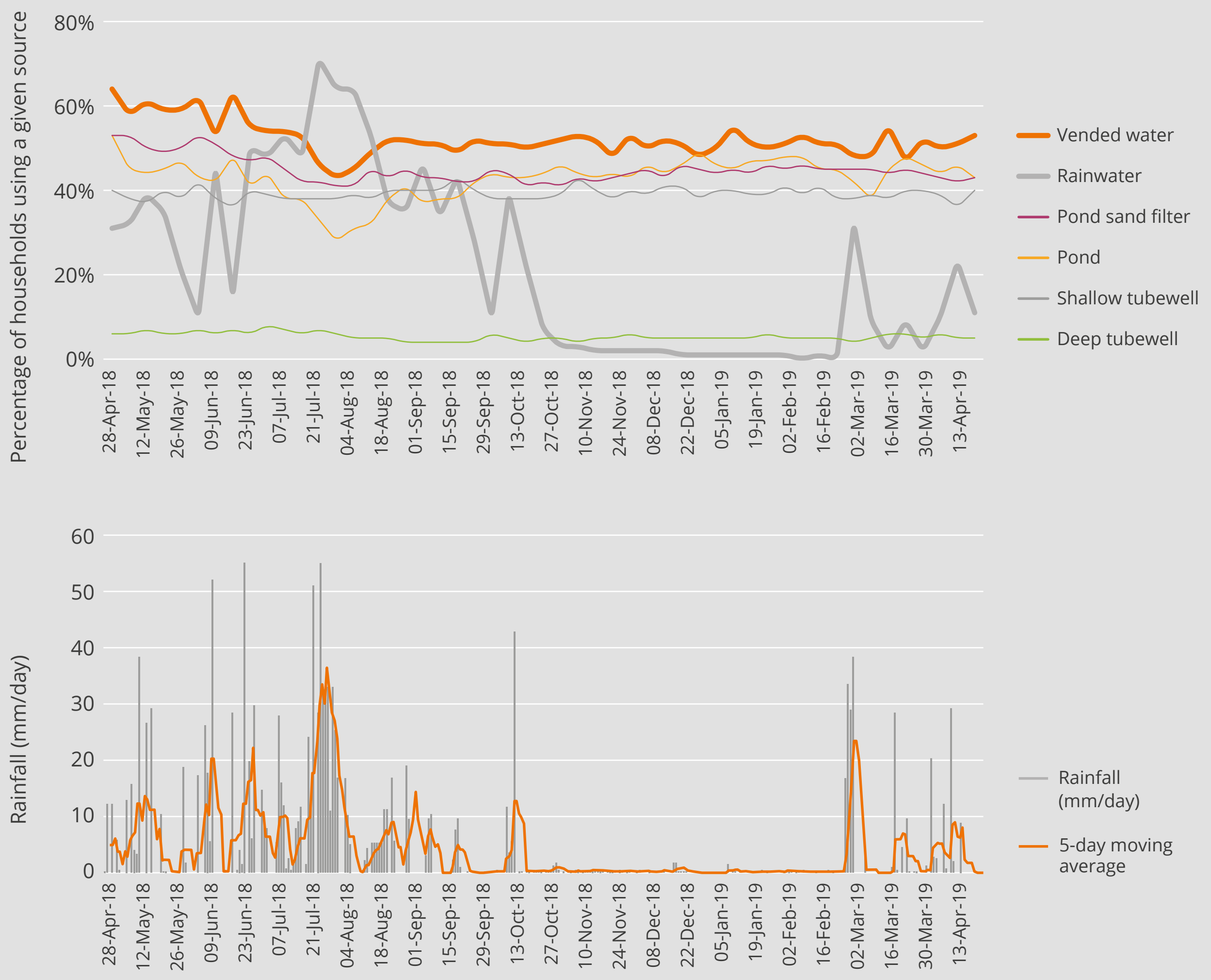
In this section, we present the state of rural water services in Khulna, disaggregated by these SDG indicators, and discuss the need for better information systems for monitoring service performance and taking timely actions to ensure access to safe water for everyone at all times.

4.1 Access

Access to drinking water sources is commonly measured in terms of infrastructure coverage (i.e. number of people per waterpoint) and the main source of drinking water reported by households participating in nationally-representative but infrequent surveys (e.g. DHS, MICS). Our household surveys in Khulna show high spatial heterogeneity in the main sources of drinking water and collection times depending on the groundwater quality and infrastructure investments. As shown in Figure 10, while households in the upper part of Polder 29 (Sahas, Bhandarpara and Sarappur unions) reported using deep tubewells as their main source of drinking water, those in the southern polders (Surkhali, Deluti, and Soladana unions) depended on a diversity of sources, with 11.6 per cent of surveyed households reporting using rainwater, 10.1 per cent purchasing vended water, 9.3 per cent using pond sand filters and 4.3 per cent using surface water as their main source.

Main sources however do not reflect the seasonal variations in sources, as observed in our water diary study (Figure 11). Water stress is particularly high during the dry season, when households run out of stored rainwater and resort to costly vended water or shallow tubewells with high salinity.

Figure 11: Water diary data from 120 households showing variations in water sources in relation to rainfall.

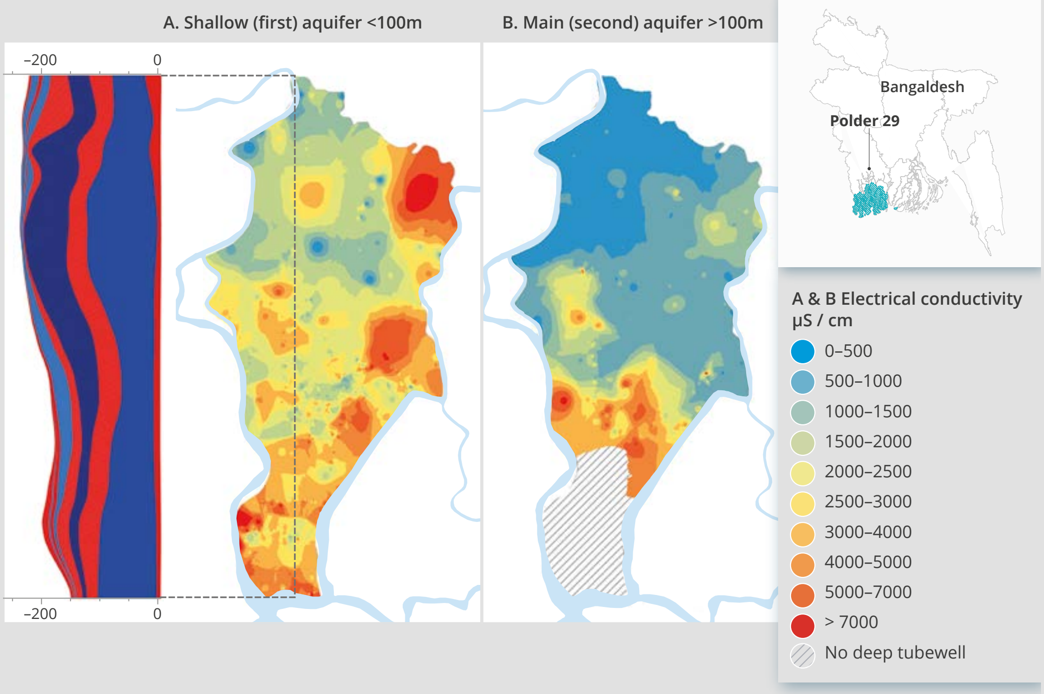


4.2 Quality

Groundwater salinity is the main water quality concern for coastal inhabitants. In polder 29, lithologic analysis of borelog data exhibited high degree of hydrogeologic complexity and aquifer heterogeneity (Figure 12). The shallow aquifer has a thickness of 50-160m across the polder; however, the thickness of the second aquifer ranged from 30-60m in the north and decreased substantially in the south. The delineation of the third aquifer was incomplete because of insufficient lithologic information at greater depths. Despite the presence of good shallow aquifers, availability of drinking water was severely constrained due to high levels of salinity.

In the north and central parts of the polder, salinity in the shallow and main aquifers was usually below 1500µS/cm; however, it increased gradually towards the southern part which lacked suitable main aquifers as well.

Figure 12: Aquifer stratigraphy and groundwater salinity in Polder 29 (Hoque et al., 2019).



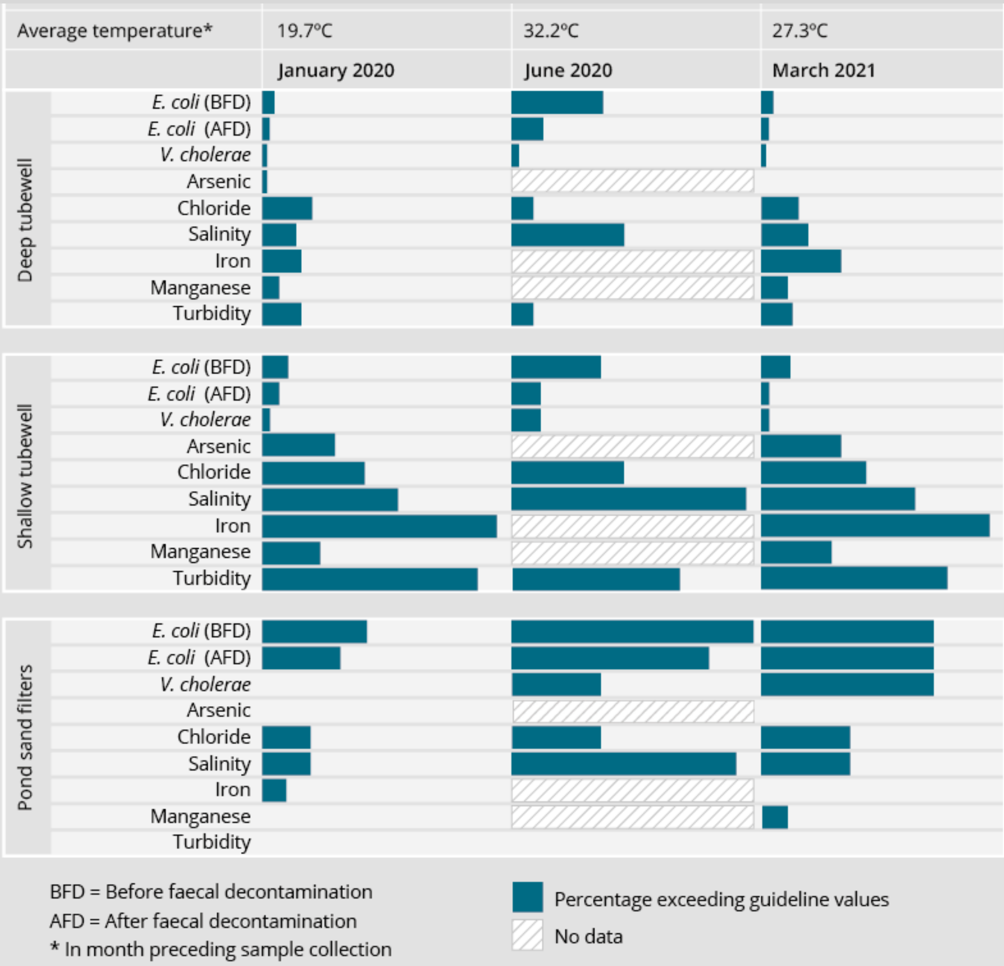
We collected water samples from 125 selected waterpoints in Polder 29 in January and June 2020 and in March 2021 and tested for arsenic, manganese, iron, chloride, salinity, turbidity, *E. coli* and *Vibrio Cholerae* contamination to determine seasonal variation in water quality (Table 3).

Faecal contamination increased with rainfall. Between January and June, the percent of deep tubewells in which *E. coli* was detected (after decontamination of the handpump) rose from 3 per cent to 13 per cent; for shallow tubewells, the change was from 7 per cent to 12 per cent. For pond sand filters, at the point of collection, this seasonal difference was even greater with *E. coli* detection increasing from 30 per cent in January to 78 per cent in June. This seasonal variation in water safety highlights the need to evaluate water safety in different seasons to verify if water systems can provide safe water, or if treatment is required.

Hygiene conditions were assessed by measurement of *E. coli* before decontamination of the tap or handpump. Overall, the percentage of waterpoints contaminated with *E. coli* decreased from 22 per cent to 11 per cent after the decontamination of their outlets. Contamination at the handpump or tap associated with hygiene issues showed greater seasonal variability than water quality, with the percent of deep tubewells at which *E. coli* was detected before decontamination rising from 5 per cent in January to 36 per cent in June; for shallow tubewells, the change was from 11 per cent to 38 per cent; for pond sand filters the change was from 40 per cent to 100 per cent.

While the onset of monsoon is expected to lower water salinity due to dilution, 59 per cent of samples at the point of collection (handpump or tap) collected in June 2020 exceeded the national threshold of 1000mg/l, with high prevalence in the pond sand filters and shallow tubewells. This could be due to inundation during cyclone Amphan in late May 2020, which caused storm surges and inundation of freshwater sources. However, salinity levels in most of the collected samples recorded in March 2021 were close to those obtained in January 2020 indicating recovery.

Figure 13: Percentage of sampled waterpoints in Polder 29 exceeding the national guidelines for drinking water.



Arsenic contamination was observed, with 92 per cent of waterpoints having concentrations < 50 µg/l in March 2021; this is comparable to those reported in MICS 2019 for Khulna Division (89.5 per cent < 50 µg/l). However, it is notable that 15 per cent of deep tubewells and 57 per cent of shallow tubewells had arsenic concentrations over the WHO guideline of 10 ug/L. Elevated levels of manganese and iron, which are not usually considered in assessing risks, were also detected in the March 2021 samples, with 15 per cent and 42 per cent of waterpoints exceeding the national guidelines of 0.1 mg/l (for manganese) and 1 mg/l (iron) respectively. Exposure to high levels of manganese has been associated with impaired cognitive function in children (Zoni and Lucchini, 2013).

The health impacts from high levels of iron and salinity have not been strongly supported by evidence yet. However some studies show positive correlation between salinity and maternal and neo-natal health outcomes (Khan et al., 2011; Khan et al., 2014). Elevated levels of these contaminants affect the palatability, causing users to choose alternative water sources that may taste better but not necessarily be safer.

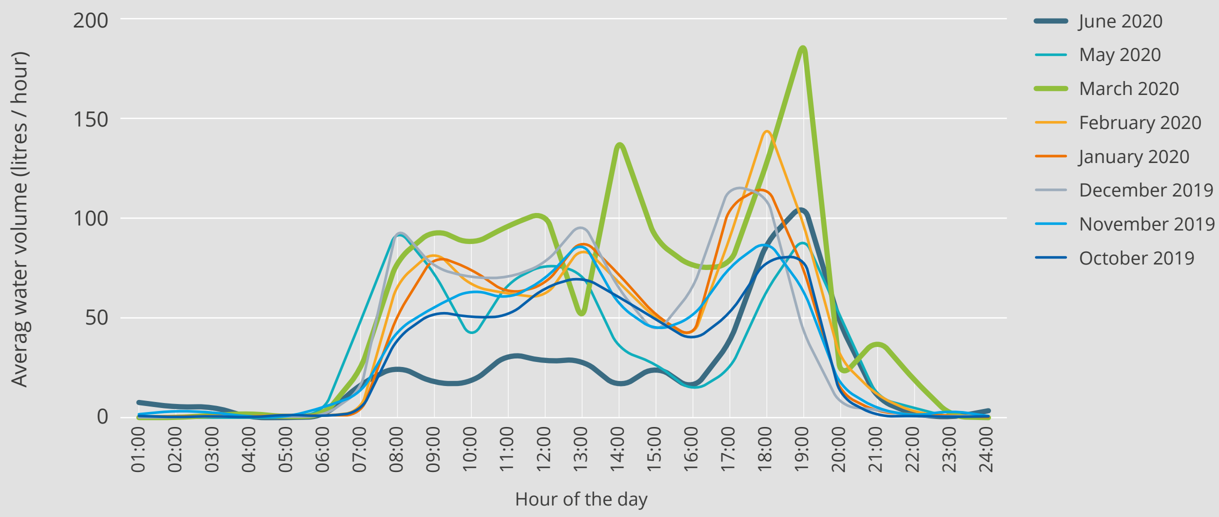
Considering these multiple water quality risks, less than half (45 per cent) of sampled waterpoints were safe, that is, providing drinking water free from *E. coli*, and having arsenic, manganese and iron below guideline values. When disaggregated by source type, shallow tubewells and pond sand filters exhibited higher risk of salinity and chemical contamination than deep tubewells (Figure 13). Managed aquifer recharge tubewell showed elevated levels of both chemical contamination and biological contamination. Water from piped systems and reverse osmosis based desalination plants had better quality throughout the year.

4.3 Quantity

Monitoring the quantity of water supplied by both individual and the network of public waterpoints can support informed decisions on infrastructure performance, user demand and reducing inequalities. We installed data loggers in school and community tubewells and pond sand filters, and flowmeters in piped schemes and motorised tubewells in Polder 29 to continuously monitor the water usage at different types of water supply systems.

Data loggers installed on functional pond sand filters showed a median daily usage of 1300 litres per pond sand filter, with water collection peaking before lunch (1pm) and before sunset (5pm). Total volume of water pumped in March 2020 (peak dry season) is much higher than that in June 2020, showing shifts to rainwater sources in monsoon (Figure 14).

Figure 14: Quantity of water pumped from pond sand filters in Polder 29 (2587 hours of data from five PSFs) highlighting the difference in demand between the dry season (Jan-20) and the wet season (June 20).



Daily demand at some community tubewells is almost three times higher than that of pond sand filters. One example is the Jorakol ("Twin tubewells") – two public tubewells near the electricity-powered piped system in Sahas union. Prior to construction of the piped system, these tubewells (both 450 feet deep) were the only source of drinking water for households in the mouza. Those not served by the piped system still depend on these tubewells, with our observation study recording 632 households comprising 2382 people using it on a regular basis. As per the dataloggers, users pumped an average of 4483 litres of water a day in April 2020 (peak of dry season, Figure 15). School tubewells are also used by the wider community, as observed by pumping activities before and after normal school hours (Figure 16).

Figure 15: Quantity of water pumped at the Gajendrapur 'twin' tubewells showing usage peaking during March and April 2020 (dry season).

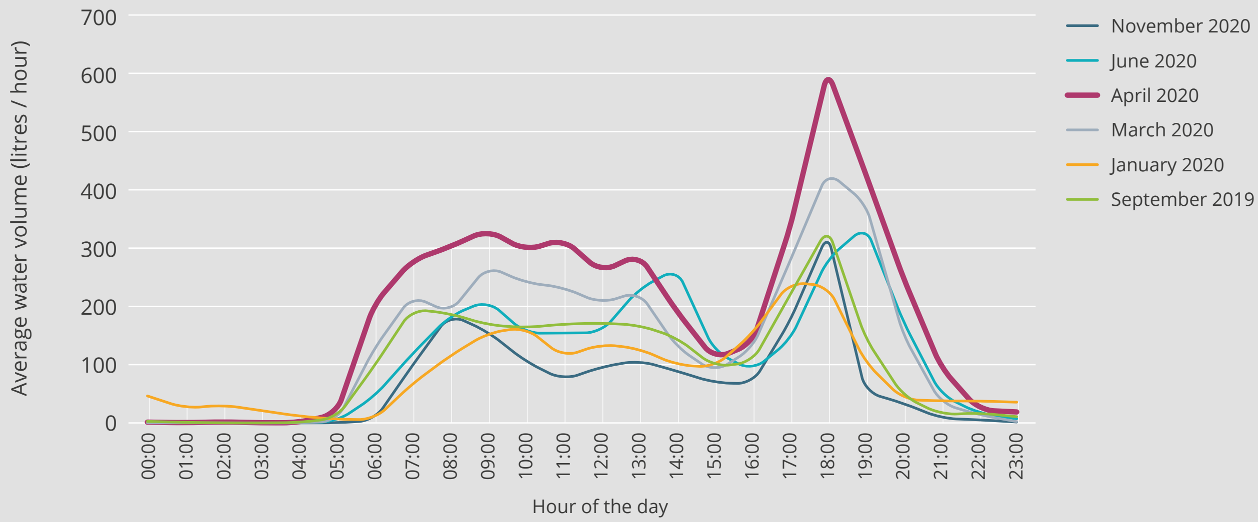
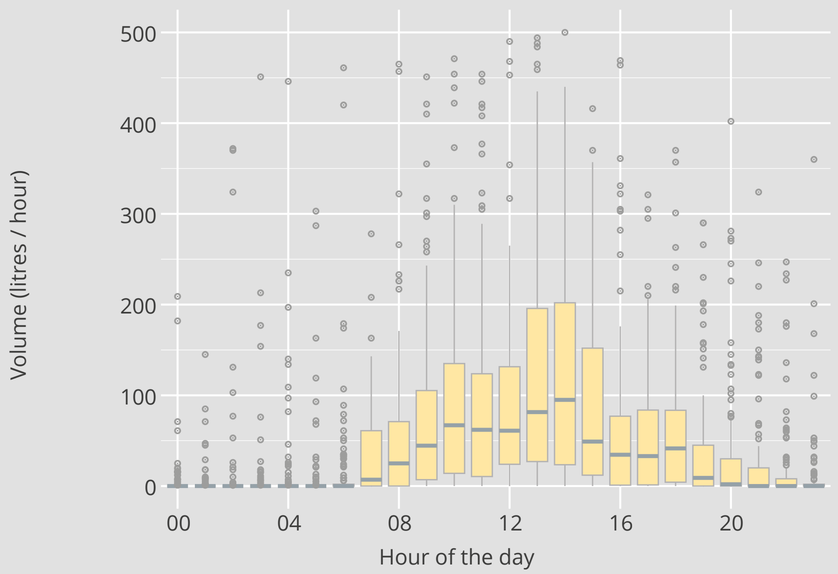


Figure 16: Quantity of water pumped at primary and secondary schools in Polder 29 (2525 hours of data from 15 schools between July 2019 to February 2020).



4.4 Reliability

Access to a safe water supply which is unreliable for extended periods, particularly during dry periods or climate shocks, has limited value. Reliability, measured as the availability of water services when required, is often difficult to measure with recall surveys of uncertain accuracy. The data loggers and flowmeters installed at school and community waterpoints showed variations in user demand and water supplied in response to seasonal changes, festivals, infrastructure breakdown and climatic shocks.

Figure 17: Water usage at Kapalidanga solar-powered piped system in relation to rainfall.

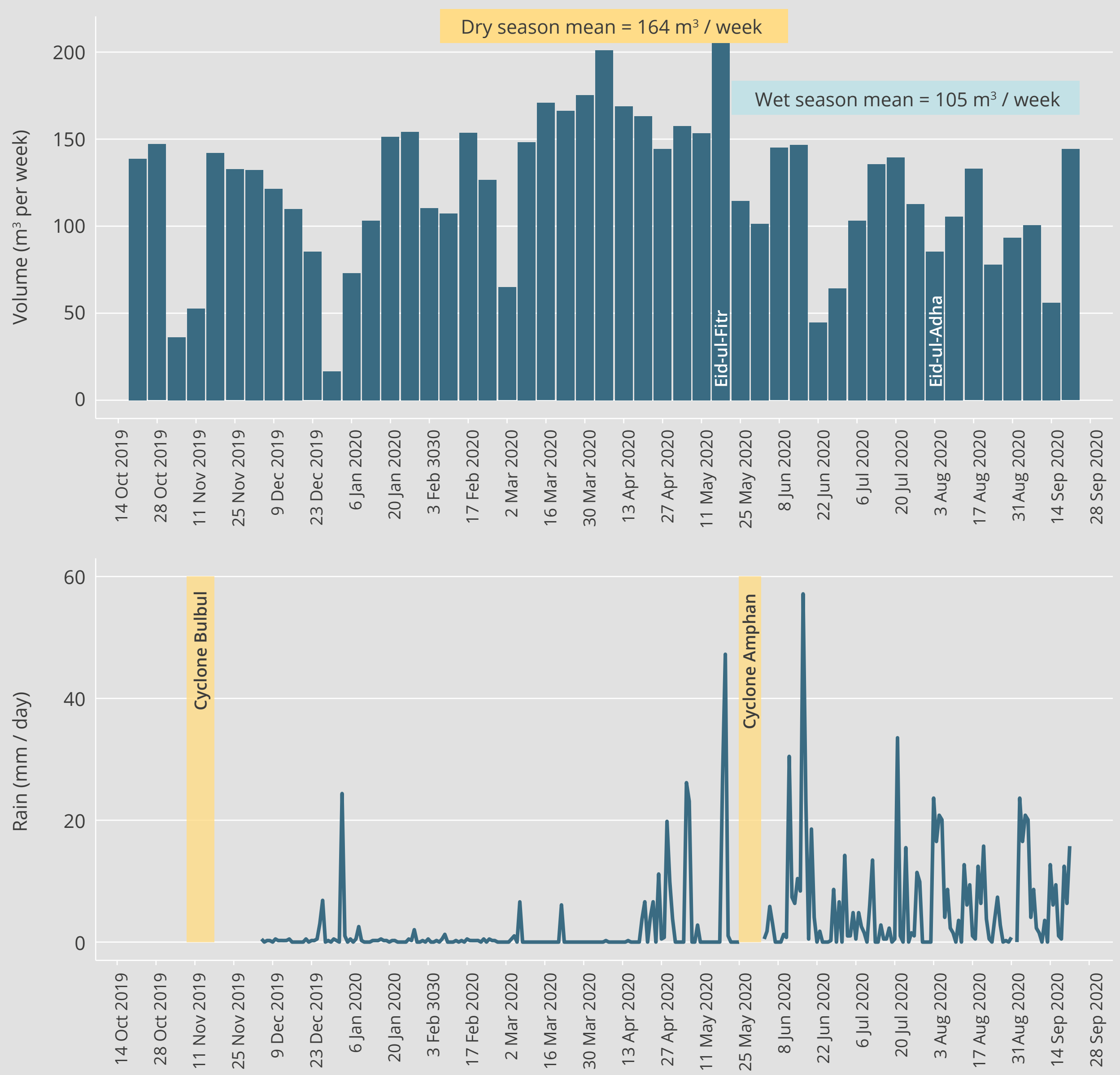


Figure 17 shows the water supplied by the solar-powered piped scheme in Sahas union, which serves households through 22 public taps along a 2 km gravity-fed linear pipeline. During cloudy and foggy weather conditions, the solar energy required to pump groundwater limits the supply, while on sunny days the supply is proportional to the cumulative demand. The daily water usage ranged from 23 m^3 during the dry summer months from March-May to 15 m^3 during the monsoon from June-August. 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.

While cyclone inflicted damages in Polder 29 are comparatively lower than that usually observed in Koyra, Dacope, Assassuni and Shyamnagar upazilas of Khulna and Satkhira districts, both cyclone Bulbul and Amphan damaged certain waterpoints, leading for long-term service disruptions and/or increased expenditures for repair. For example, one of the pond sand filters in Polder 29 has been non-functional for more than 10 months, as the source pond was inundated with saline water during Amphan and the estimated repair costs of BDT 8000 (USD 95), coupled with lack of initiative from the manager, deterred the repair. In contrast, where pond sand filter managers were active, removal of tree debris and dead rotten fish were carried out soon after the cyclone, with elite members paying the repair costs upfront. The southern part of the polder is also prone to erosion, with a large section of the embankment collapsing in mid-2015, destroying houses and freshwater ponds, which were once used for drinking.

4.5 Affordability

Global and national monitoring of water affordability usually involves estimating the percentage of household income or expenditure on water services, with those spending between 3 and 5 per cent deemed to be within the 'affordable' threshold. Data for such metrics are derived from nationally representation but infrequent surveys (e.g. DHS/MICS) and only account for the 'main source' of water. While such methods may be suitable for contexts with 24/7 access to potable piped water, they are inadequate to capture the multiple sources used by rural households for different purposes at different times of the year, and the resulting trade-offs in quality, costs, and distance. As per the ratio method, those who depend on free but contaminated water sources like ponds and unimproved wells, whether due to poverty or preference, as well as those who forgo other essential goods and services to pay for water, will be wrongly identified as having 'affordable' services.

To capture these dynamic water choices and payment behaviours, we conducted a 52-week water diary study in Polder 29 with 120 households, who were trained to record their daily water sources, costs, and quantities using structured pictorial diaries (Hoque and Hope, 2020). Our water diary shows inter-household and seasonal variations in water sources and expenditures. 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 (Figure 18). 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.

Onset of monsoon around July caused significant drop in weekly water expenditures, owing to overall shifts from vended to rainwater sources (Figure 19). During the Covid-19 lockdown in April and May 2020, which coincided with the peak dry season, many households purchased vended water on credit as they were unable to pay due to loss of income.

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

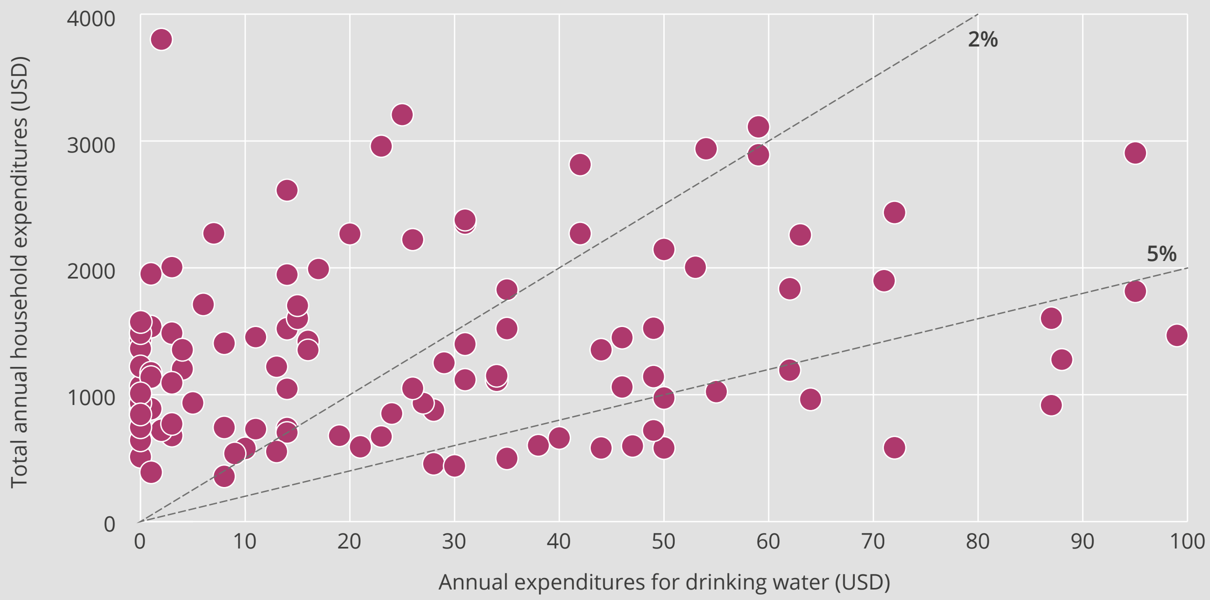
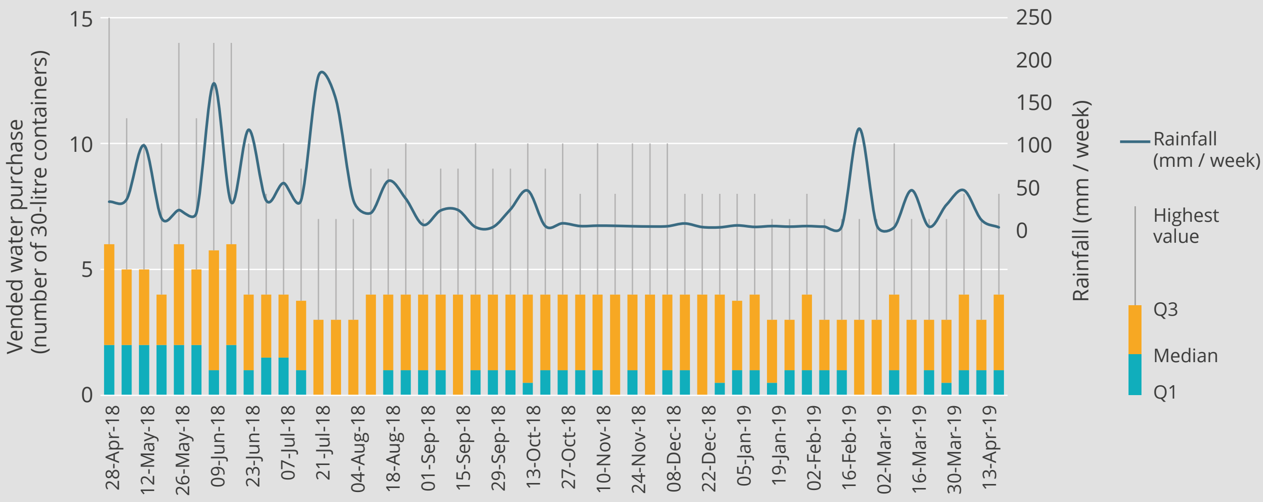


Figure 19: Consumption of vended water by 120 water diary households in Polder 29 in relation to rainfall (Hoque, 2021).

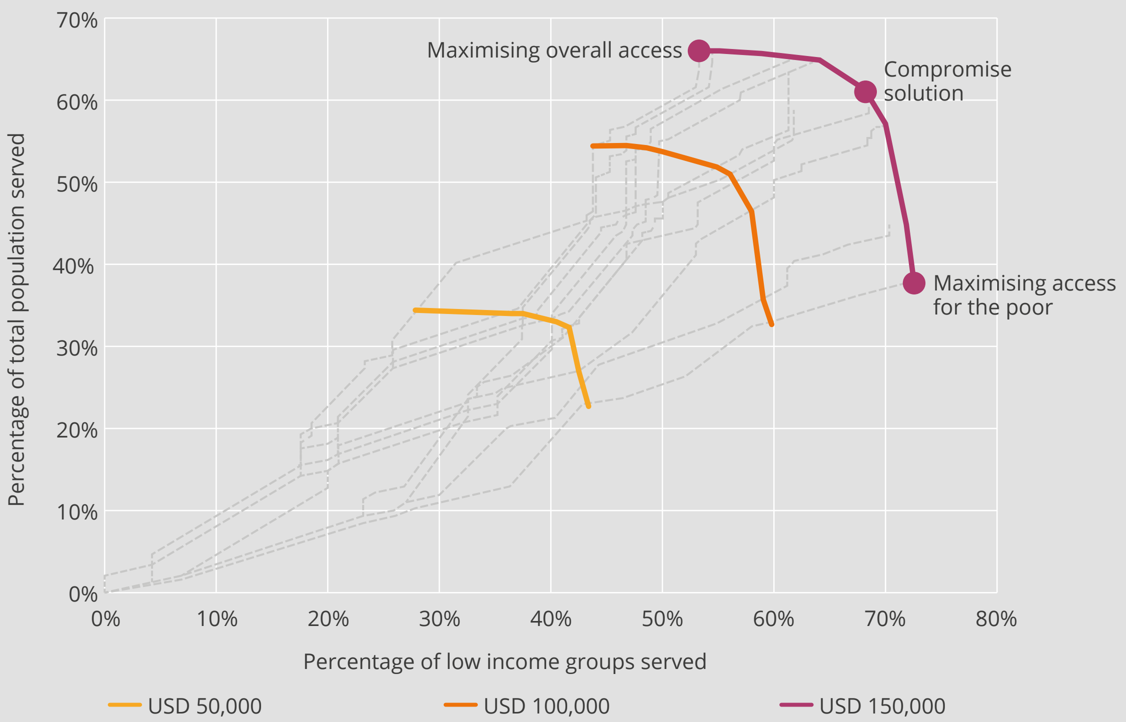


4.6 Non-discrimination

Non-discrimination recognises that no individual or group should be excluded or marginalised from safe, sufficient, reliable, and affordable water services by their gender, age, health, disability, geography, wealth, ethnicity, religion or by other cultural, economic, political, or social differentiation. Everyone at home, school or work has the same right to drinking water services. The notion of progressive realisation acknowledges this is a process over time with policies, regulation and information systems providing a platform to support decision-making and effective service delivery.

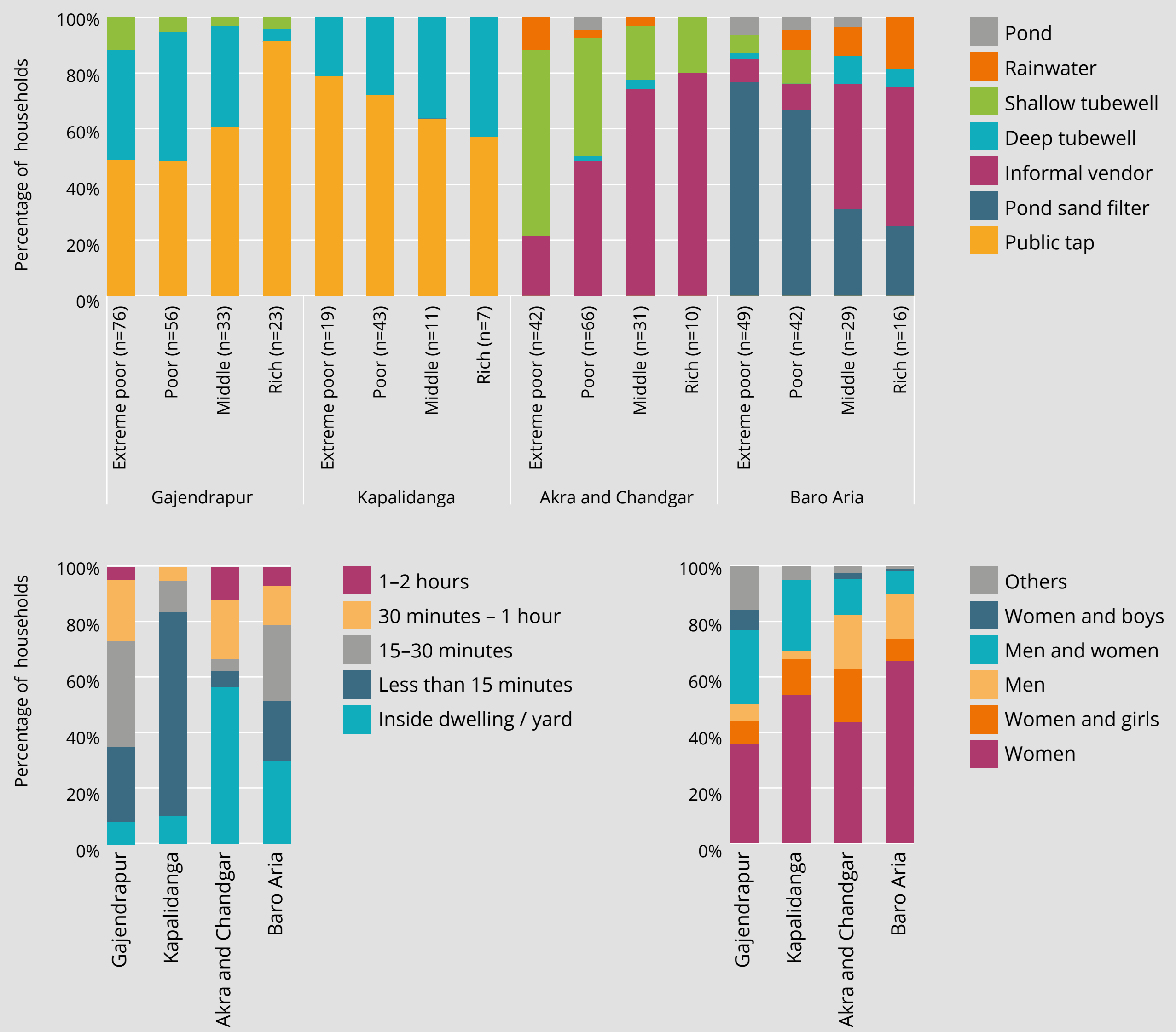
Our work features emerging insights into this indicator. Here, we touch upon discrimination by geography and wealth. In Polder 29, the distribution of public tubewells corresponds to areas where challenges of groundwater salinity are lower, in this case, the northern area. In contrast, the southern area, 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 20). Information systems can both make these trade-offs more transparent and guide planning where potential synergies in coverage and inequality can be addressed.

Figure 20: Trade-offs between total population served and low wealth people served for constrained investments in water infrastructure in Polder 29 (Roman et al. 2021).



Wealth inequalities were observed both in terms of choice of source and ownership of private tubewells and rainwater storage tanks. Data from four selected mouzas in Polder 29 with varied salinity and infrastructure contexts illustrate the wealth differences in main source, collection times and responsibilities (Figure 21). About 62 per cent of rich and middle-class households in the saline mouzas (Akra/Chandgar and Baro Aria) used vended water compared to 22 per cent of poor and extreme poor ones. Since poorer households could not afford vended water, they resort to pond sand filters or walk up to 3km to fetch water from tubewells in distant mouzas. The choice to purchase vended water was also determined by individual preferences, presence of able-bodied members to fetch water, and presence of individuals with special needs, like children or members with ill-health. Interestingly, we observed higher proportions of men involved in water collection in these sites due to two main reasons. In some households, men used their own/hired vehicles to fetch water from tubewells in other mouzas; while in others, men helped in bringing the water containers left by the vendors near main roads.

Figure 21: Main sources of drinking water highlighting wealth inequalities across four selected mouzas in Polder 29 (Hoque et al., 2019).



In Polder 23, we observed significant wealth differences in tubewell ownership, with 35 per cent, 61 per cent, 75 per cent and 85 per cent of households from the bottom to the top wealth class having a private tubewell in their premises. Likewise, about 34 per cent of rich households invested in rainwater storage tanks, compared to 4 per cent of extreme poor.

4.7 Conclusion

Existing sources of data, from infrequent nationally representative surveys, waterpoint mappings and project-based water quality testing, are inadequate to track the progress in SDG indicators and identify local pockets of rural populations without access to safe drinking water services at all times. Snapshot measures of access do not capture the seasonal variations in water sources, quality and costs, and spatial and social inequalities prevalence in these salinity-prone coastal polders. Regular monitoring of performance indicators, including water quality, operation and maintenance expenditures, user payments, and service reliability, supported by local level data being updated to publicly accessible information systems, can enhance accountability, management, and efficiency of service delivery

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Piped system at Gajendrapur village, Sahas union. Photo by Sonia Hoque.

5. Recommendations

Existing institutional design, sector financing and information systems in Bangladesh focus 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 22). 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. The SafePani model proposes reforms in the three following areas, which are discussed in detail in the main report (Hope et al., 2021).

5.1 Institutional design

Three areas of reform are proposed to allocate responsibility and regulate performance from national to local levels. First, national government needs to 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 in defined and exclusive service areas. Second, an independent 'Drinking Water Services Regulator' should be established to 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. 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.

5.2 Information systems

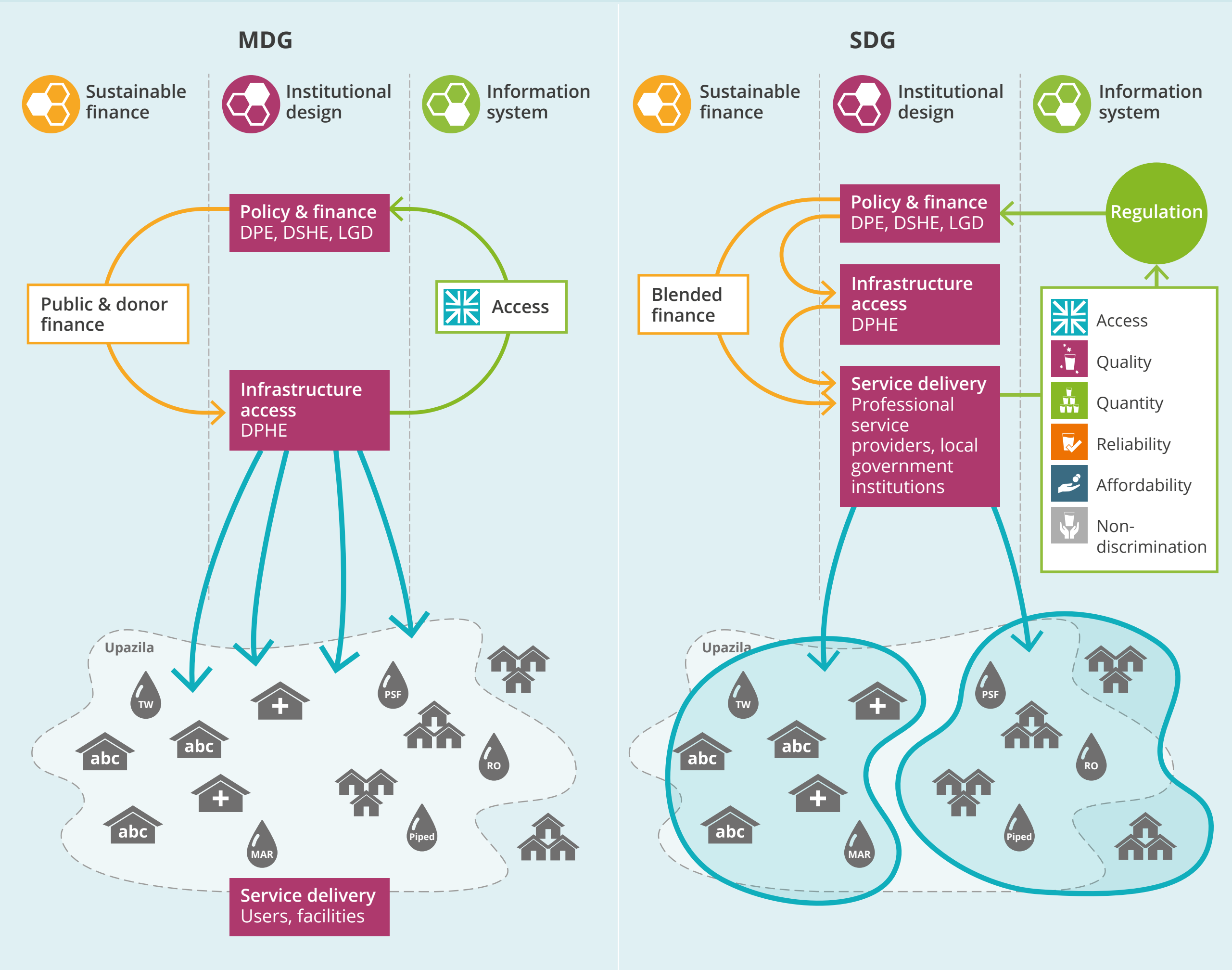
Information systems should guide policy and regulation to monitor progress and guide performance improvement based on transparent and timely data. While professional service providers will be able to generate routine data on infrastructure, revenue, cost, reliability, functionality and other indicators, 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. A management information system (MIS) should consolidate monitoring data with a public interface allowing public scrutiny and engagement.

Management and oversight should rest with the regulator with a shared platform open to all national and local government partners. Public communication can extend beyond the MIS to include awareness raising and provision of information to households, schools, healthcare facilities and other stakeholders.

5.3 Sustainable finance

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. 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. 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.

Figure 22: (a) Existing and (b) Proposed design for rural water service delivery in Bangladesh.



Sector coordination will act to identify and license enterprises and their role in service delivery in exclusive service areas. 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.

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.

Acknowledgements

The authors gratefully acknowledge the support of the Government of Bangladesh, with special thanks to Muhammad Ibrahim (Additional Secretary) and Md Emdadul Hoq Chowdhury (Joint Secretary) of the Local Government Division under the Ministry of Local Government, Rural Development and Cooperatives, Md Saifur Rahman (Chief Engineer) of the Department for Public Health and Engineering (DPHE), and Mohammad Helal Hossain (Deputy Commissioner) of the Khulna District Commissioner Office. We would also like to acknowledge the time and contribution of all the local waterpoint owners and managers, and household respondents who participated in the data collection in Khulna. The fieldwork in Khulna was conducted by Sheikh Rabiul Islam, Al Helal, Lutfor Rahman, Abu Bakar Siddique, Chandon Das, and Kalyan Chakrabotty.

The study is part of a programme collaboration between UNICEF-Bangladesh and the REACH programme, including the University of Oxford, Bangladesh University of Engineering and Technology (BUET), and the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b). This report is made possible by the REACH programme funded by the Foreign, Commonwealth & Development Office (Project Code 201880). However, the views expressed and information contained in it are not necessarily those of or endorsed by FCDO which can accept no responsibility for such views or information or for any reliance placed on them. Additional funding has been provided by UNICEF-Bangladesh under a Partnership Collaboration Agreement with the University of Oxford co-funded by the REACH programme, and the Research England Internal Global Challenges Research Fund (GCRF).

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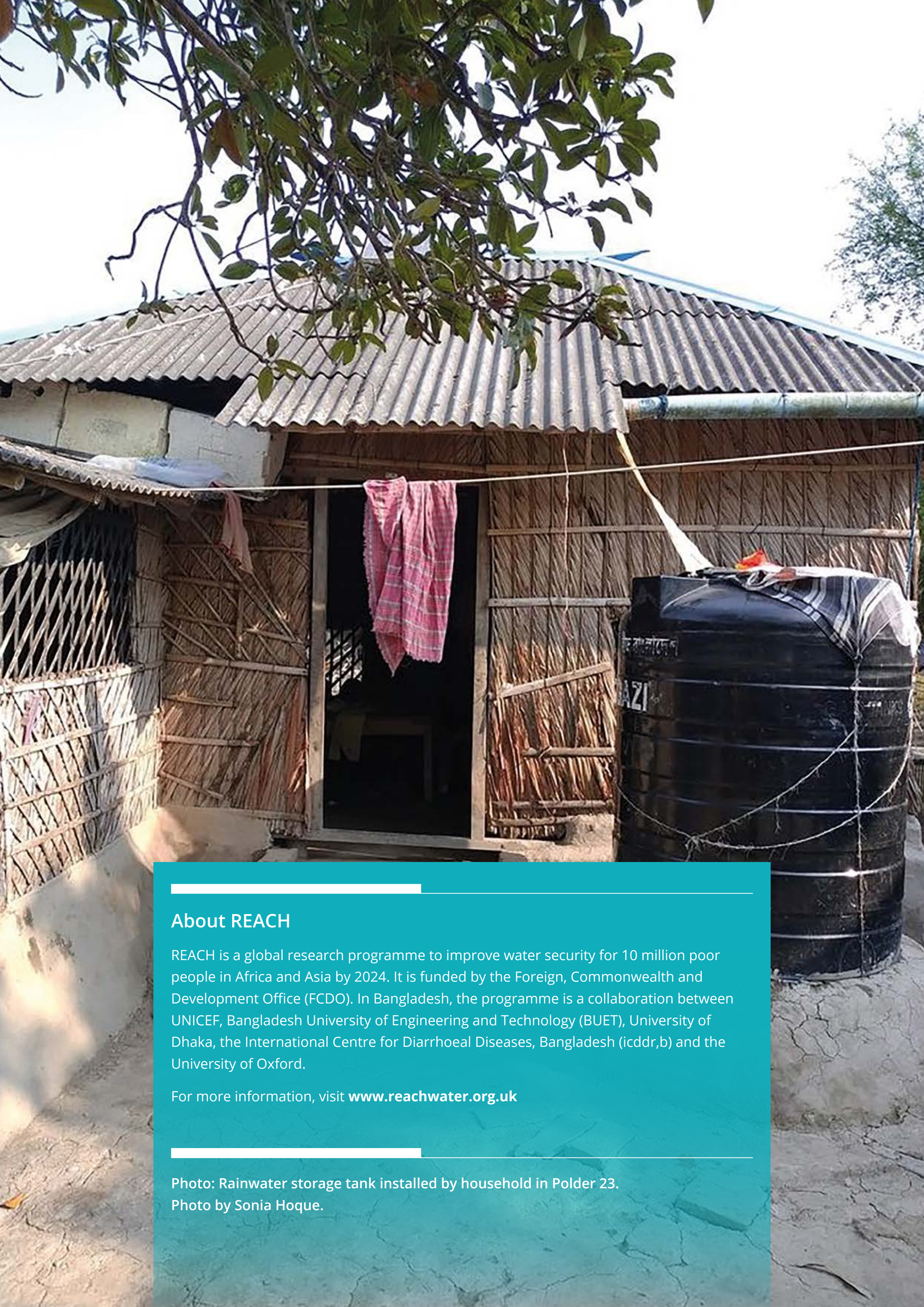

About REACH

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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Photo: Rainwater storage tank installed by household in Polder 23.
Photo by Sonia Hoque.