COVID-19 AND WATER IN ASIA AND THE PACIFIC

GUIDANCE NOTE

JULY 2021

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Notes:

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On the cover: Water is essential to all living things, and there is a critical need to support the sector in Asia and the Pacific. ADB is committed to supporting recovery from the coronavirus disease pandemic and realizing the “new normal” by taking immediate actions and financing projects and programs, capacity building, and technology and innovation in the region’s water sector (photos by Nasrur Rahman, Afriadi Hikmal, Veejay Villafranca, and Gerhard Joren/ADB).

Cover design by Nonie Villanueva.

Contents

Tables, Figures, and Boxes	v
Acknowledgments	viii
Abbreviations	ix
Executive Summary	xi
1 Introduction and Purpose of the Guidance Note	1
Background and Objectives	1
Water Service Providers	2
Service Provision Under the Three Pandemic Phases	3
2 Response Phase: How the Sector has Felt and Reacted to the Pandemic	6
High-Level Appreciation of COVID-19 and Water Security	6
Impacts to and Responses on Technical Operations	11
Impacts to and Responses on Commercial Operations	16
Financial Impacts	19
Socioeconomic Impacts	23
Impacts on and Responses in Water Resources, Irrigation, and Drainage	27
3 Recovery Phase: Priorities for Pandemic Exit Strategy	30
Public Health and Staff Safety	30
Economic and Financial Recovery	32
Protection of Vulnerable Sectors	33
Enhancing Resilience	35

4	“New Normal” Phase: Building Back a Better Water Sector	37
	Preventing and Responding to Future Health Crises	38
	Accelerating Universal Access to Sustainable Water and Sanitation	44
	Adopting Digital Technologies	49
	Increasing the Resilience of Irrigation Systems	54
5	Potential ADB Support and Way Forward	56
	Lessons for ADB Crisis Response Support	57
	Financing and Capacity Building	58
	Technology and Innovation	61
Appendixes		
	Summary of Respondents to the ADB Survey	63
	Technical Note on SARS-CoV-2 and Water	66

Tables

Tables

1	Description of Water Service Providers	2
2	COVID-19 Water-Related Risk Factors	8
3	Highest and Lowest Ranking Countries in Terms of COVID-19 Water Security Risk	10
4	Changes in Wastewater Discharge Observed by ADB Survey Respondents	12
5	Staff Protection Actions Observed Globally	14
6	Changes in Billing Process or System by ADB Survey Respondents	17
7	Revenue Impacts for ADB Survey Respondents	20
8	Changes in Operating Expenditures Among ADB Survey Respondents	21
9	Vulnerability Assessments Conducted by ADB Survey Respondents—Water Supply, Sanitation, and Wastewater	25
10	Examples of Progressive Actions Taken by Public Water Operators	26
11	Vulnerability Assessments Conducted by ADB Survey Respondents—Water Resources, Irrigation, and Drainage	29
12	Safety Measures Implemented by ADB Survey Respondents	31
13	SDG-6 Accelerators	44
14	Proposed Interventions and Indicative Outcomes to Enhance Agricultural Productivity and Market Access in Central and West Asia	54
15	Actions to Support the Realization of the “New Normal”	57
A.1	Services Provided by WSSW Survey Respondents	63
A.2	Services Provided by WRID Survey Respondents	65
B.1	Guidelines for Protection of Workers Exposed to Raw Water and Wastewater	76
B.2	Summary of WASH-Related Guides Published Since the Beginning of the Pandemic	77
B.3	Operational Guidance for Water and Sanitation Service Providers	79

Figures

Figures

1	Cycles of Pandemic Response and Recovery Phase	3
2	Global Status of Environmental Surveillance for SARS-CoV-2 Virus, 5 December 2020	8
3	Anticipated Delay in Construction Completion Reported by ADB Survey Respondents	15
4	Investment in Digitization Technologies by Global Utilities	16
5	Pricing Schemes Implemented by ADB Survey Respondents	17
6	Water Service Provider Revenue Loss in the Q1 and Q2 of 2020	19
7	Growth in Utility Capex Estimates, 2017–2021	20
8	Anticipated Delay in Construction Completion Among ADB Survey Respondents	28
9	Estimated Duration Before Overall Financial Situation Returns to Prepandemic Levels Among ADB Survey Respondents	32
10	Isle Survey Results on the Potential Changes in a Post-COVID-19 World	38
11	Graphical Representation of Wastewater-Based Epidemiology	42
12	Global Risk Maps for Antibiotic Ciprofloxacin, 1995 and 2015	43
13	Proportion of Household Water Insecurity Experiences Survey Respondents Reporting Inability to Wash Hands in the Last 30 Days	45
14	Example of Purpose-Driven Coordinated Actions Using the Data and Innovation Accelerators	46
15	Asia-Pacific's Progress in Meeting SDG-6 Targets	47
16	Example Decentralization Strategies in the Typical Water Supply and Wastewater Value Chain	48
17	Digital Transformation Pyramid in the Water Sector	50
18	Health Care for Well-Being and Infrastructure Clusters	59
A.1	Population Served by WSSW Survey Respondents	63
A.2	Legal Nature of WSSW Survey Respondents	64
A.3	Geographic Areas of WSSW Survey Respondents	64
A.4	Geographical Areas of WRID Survey Respondents	65
B.1	Overview of Potential SARS-CoV-2 Dissemination via Waterborne Pathways in Industrialized Countries	67
B.2	A Pictorial History of Coronavirus Research in Water and Wastewater Environments	68
B.3	Seven Virus Concentration Methods Evaluated to Recover CoV from Wastewater	72
B.4	Secondary Biological Treatment Supports Enzymatic Degradation of Organic Material, Including Viruses	73

Boxes

Boxes

1	Accelerating Digital Solutions for COVID-19 Response in Hue, Viet Nam	18
2	Mapping the Vulnerable for Early Response	24
3	Handwashing Technology for Cambodian Schools	34
4	Mobilizing Microfinance for Water and Sanitation in the Philippines	34
5	Strengthening the Utility Supply Chain in Australia	36
6	Understanding Climate Impacts on Sanitation and Public Health in Africa	39
7	Expanding Water Services to the Urban Poor in Metro Manila, Philippines	40
8	Market-Based Sanitation Solutions for Rural Cambodia	40
9	Wuhan Water's "Safe Mode"	41
10	Improving Water Security through Continuous Groundwater Monitoring in Bangladesh	51
11	Smart Pressure Management to Combat Intermittent Water Supply in the Philippines	51
12	Satellite Analytics for Holistic Water Resources and Catchment Management in the Philippines	52
13	Using LIDAR for Irrigation Survey in Indonesia	53
14	Using Technology to Crowdsource Impact Investments for Small-Scale Filipino Farmers	55
15	Developing a Bespoke Innovation Framework for the Philippines and a Water Sector Roadmap for Australia and New Zealand	60

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Abbreviations

ADB	Asian Development Bank
AMR	antimicrobial resistance
CDC	Centers for Disease Control and Prevention
CoV	coronavirus
COVID-19	coronavirus disease
CSR	corporate social responsibility
DMC	developing member country
GW	Global Water Intelligence
HELP	High-Level Experts and Leaders Panel on Water and Disasters
LOD	limit of detection
MERS	Middle East respiratory syndrome
MHV	murine hepatitis virus
NBS	nature-based solutions
nCoV	novel coronavirus
NRW	nonrevenue water
ODA	official development assistance
PPE	personal protective equipment
PPP	public-private partnerships
PRC	People's Republic of China
qPCR	quantitative polymerase chain reaction
QUU	Queensland Urban Utilities
RNA	ribonucleic acid
SARS	severe acute respiratory syndrome
SDG	Sustainable Development Goals
USEPA	United States Environmental Protection Agency
UV	ultraviolet
WASH	water, sanitation, and hygiene
WBE	wastewater-based epidemiology
WHO	World Health Organization

WRC	Water Research Commission
WRID	water resources, irrigation, and drainage/stormwater
WSAA	Water Services Association of Australia
WSSW	water supply, sanitation, and wastewater
WWTW	wastewater treatment works

Executive Summary

This guidance note provides a comprehensive look at the impacts of the coronavirus disease (COVID-19) pandemic on the water sector from March to December 2020, the actions taken by water service providers in response to various challenges, the potential pathways toward postpandemic recovery, and the role of the Asian Development Bank (ADB) in supporting water sector recovery and rejuvenation.

The relationship of water and SARS-CoV-2, the virus that causes COVID-19, is complex but is increasingly determinable. Knowledge about this relationship has rapidly evolved in the last few months, and there is consensus on key transmission routes. Various guidelines and protocols have been promulgated internationally that aid water sector organizations in crafting their response and operations. The COVID-19 pandemic highlights the importance of adequate disinfection of water for domestic use and human consumption, as well as wastewater treatment and monitoring of environmental waters. Contact with recreational water (even river water contaminated with untreated sewage) appears so far to be low risk, although not free of risk, so caution should be exercised.

COVID-19 affects all water service providers (e.g., water supply, sanitation, wastewater, and irrigation), but the operational impacts are broader among water supply, sanitation, and wastewater service providers. The pandemic has altered the key drivers of the water sector—water demand and wastewater discharge—which in turn necessitates changes in various aspects of technical and commercial operations. As safety of workers and customers is paramount, the pandemic has posed significant challenges in workforce and human resources management.

Many governments have intervened to ensure the continuity of critical water services during the pandemic, in some cases providing direct financial support to water service providers. In the absence of government relief, the financial burden of the pandemic is currently borne by water service providers. Prolonged uncertainty over how service providers will be compensated for losses incurred due to the pandemic—either through government transfers or increased customer tariffs—may lead to reduced capital and maintenance spending, as well as significant changes to operating and maintenance planning, in the future.

The pandemic highlights persistent inequalities in water and sanitation access. Water sector response has been particularly difficult for urban slums; most responses are temporary measures that do not guarantee sustainable access. Poor households that are connected to the piped network may be temporarily insulated by government-mandated freezing of water rates, suspension of cutoffs, and extension of various payment schemes, including deferral and discounts.

To support the recovery of the water sector, the immediate priorities for recovery follow:

- (i) ensuring public safety through the continuous provision of essential services while protecting the health of staff, which is of paramount concern for all water service providers during the pandemic;
- (ii) supporting the financial recovery of water service providers that strikes a balance between the need to extend continuing financial relief to customers in need and ensuring the resumption of critical capital works that will enable broader water and sanitation access;
- (iii) enhancing service providers' resilience by integrating the lessons of the COVID-19 pandemic into planning and operations; and
- (iv) protecting the well-being and ensuring social outcomes for vulnerable sectors, such as women, children, the disabled, and the poor, who have historically been marginalized from basic public services and who have suffered disproportionately more during the COVID-19 pandemic.

Rebuilding a more sustainable and resilient water sector can be achieved on four levels:

- (i) preventing and responding to future health crises;
- (ii) accelerating the universal access to water and sanitation;
- (iii) adopting appropriate digital technologies; and
- (iv) increasing the resilience of irrigation systems for long-term water and food security.

Future health crises can be prevented and responded to more effectively by integrating water, sanitation, and hygiene (WASH) into the public health strategy (among other social objectives such as improving education poverty reduction and gender mainstreaming), improving crisis preparedness and response management of water service providers, and employing wastewater-based epidemiology. Accelerating universal WASH access in line with Sustainable Development Goal 6 (SDG-6) will require large investments as well as exploring innovative methods for water and sanitation service such as decentralization and employing nature-based solutions.

Digital technologies are increasingly available at cost-effective pricing, but the key in digital innovation is to adopt technologies that add the most value to service providers and their customers. Resilience in irrigation can be achieved by improving productivity and market access, as well as adopting innovations in automation, mechanization, and e-commerce. Table 15 shows practical actions to realize the postpandemic “new normal”—that is, how the lessons and experiences from the pandemic change the way we live, work, and play.

ADB is very well positioned to support the recovery and realizing the “new normal” for the water sector in Asia and the Pacific through financing of projects and programs, capacity building, and promoting technology and innovation.

People wearing protective face masks in Jakarta, Indonesia, 23 March 2020. Indonesian authorities have urged citizens to avoid public gatherings, including religious activities as a precautionary measure against the spread of COVID-19 (photo by Afriadi Hikma/ADB).

1 Introduction and Purpose of the Guidance Note

Background and Objectives

The coronavirus disease (COVID-19) pandemic has raised global alarms on public health and safety; to curtail widespread transmission, water utilities have been at the forefront of ensuring regular water supply provision to communities. The pandemic also underscored the importance of sanitation and wastewater management, amidst initial fears that Severe acute respiratory syndrome-related coronavirus (SARS-CoV-2) may persist in sewage or water bodies and either remain infectious or lie dormant with the ability to regain infectivity at a later date.

To understand the impact of COVID-19 on the water sector, it is important to look at the impacts on service providers, authorities, and organizations responsible for water management. By their nature of providing essential services to various sectors in society (including agriculture, industry, and marginalized communities), water, wastewater, sanitation, irrigation, and drainage service providers and authorities (collectively water service providers or simply “service providers”) contribute to many development outcomes such as poverty reduction, food security, rural development, and public and environmental health protection.

This guidance note comprehensively examines the impacts of the COVID-19 pandemic on the water sector from March to December 2020, the actions taken by service providers in response to various challenges, and the potential pathways toward postpandemic recovery.

This paper serves three objectives:

- (i) Provide interim stock of and guidance on the recent developments in the water sector with respect to the ongoing COVID-19 crisis.
- (ii) Summarize the key learning and lessons of the water organizations and service providers dealing with the challenges of COVID-19 first-hand
- (iii) Outline fundamental principles for effective recovery of the water sector toward a sustainable and resilient “new normal.”

Different readers are also provided with various actionable insights. To the Asian Development Bank (ADB), the recommendations set out in this guidance note can aid in developing projects and programs in support of the water sector’s recovery and progressive improvement, resilience, and sustainability. To developing member countries (DMCs) and service providers, it reflects on the impacts that they may have encountered or experienced and therefore glean practical insights based on responses observed elsewhere. Finally, to policymakers and researchers, it aggregates knowledge on COVID-19 impacts on the water sector and points to recommendations for further study and inquiry as the world navigates this crisis.

Water Service Providers

The management of water resources and systems for the delivery of public services are collectively handled by service providers and various sector institutions. Although there are often overlaps in their responsibilities and activities, these entities can be distinguished by the services they provide. Table 1 identifies the key responsibilities of water service providers encompassed in this Guidance Note. To collect primary data on water sector impacts and responses, ADB conducted a survey among service providers in DMCs. Appendix A summarizes the respondents to the ADB survey, which ran from 2 October to 17 November 2020.

Table 1: Description of Water Service Providers

Service Provider Scope	Key Responsibilities
Water resources and river basin management	Managing the watershed environment and flood protection, monitoring environmental water quality, engaging multiple catchment stakeholders and, in some cases (usually government authorities), permitting or monitoring water resources allocations such as through water use permits or rights.
Irrigation	Provision of irrigation water services to farmers including expansion, management, and maintenance of reservoirs and storage facilities, canals, and channels, and ensuring water flow.
Water supply	Abstraction and treatment of raw water, delivery of treated water to customers (either to end-user taps or communal standpipes), and provision of customer services; expansion and maintenance of the water treatment and distribution system.
Sanitation and fecal sludge management	Human waste containment, toilet and pit emptying, conveyance or transport of waste, treatment of fecal sludge, and disposal of treated waste; in some cases, recovery and reuse of resources from treated waste. Some sanitation service providers may also operate communal toilet facilities.
Sewerage and wastewater treatment	Conveyance of raw sewage through a sewer network system including pumping stations and rising (pressure) mains, and may also include drainage water in the case of combined sewer systems. The conveyance terminates at a wastewater treatment plant (or water reclamation plant) for processing prior to discharge of treated effluent to a body of water. The sewerage system and treatment plant may be operated separately by two different service providers. Wastewater treatment plants may also receive influent waste from sanitation or septage transport service providers.
Urban drainage and stormwater management	Expansion and maintenance of urban drainage conveyance, channels, and waterways (natural or man-made); conveyance typically terminates at a body of water without treatment.

Source: Asian Development Bank.

Service Provision Under the Three Pandemic Phases

This paper is structured to present an overview of three phases of the COVID-19 pandemic: response, recovery, and rejuvenation. Although much of the COVID-19 literature makes reference to these three phases, there is no internationally accepted standard or definition to demarcate a clear distinction. It is quite possible for these phases to overlap, and where there is a resurgence of cases (a second or third wave) there is a rebound from recovery to response phase. Epidemiologists are expecting a multimodal pattern to emerge with repeated peaks and troughs in patient numbers over the next 3–5 years at least, not related to seasonality. Fakhruddin et al.¹ describe the cyclical nature of pandemic transitions to and from response and recovery (Figure 1). During these cycles, it is important to review which policies and approaches have been effective and which need to be revised to minimize consequences.

Figure 1: Cycles of Pandemic Response and Recovery Phase

Source: B. (SHM) Fakhruddin, K. Blanchard, and D. Ragupathy. 2020. *Are we there yet? The transition from response to recovery for the COVID-19 pandemic*. *Progress in Disaster Science*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7214278/>.

We refer to the response phase as the period that follows official (usually national) government pronouncement of community lockdown or quarantine measures that expressly signify the growing risk of COVID-19 transmission risk among the population. This reckoning period differs among countries, and indeed among cities within a country, as lockdown measures were announced or took effect at different times across Asia and the Pacific. The basis for lockdown pronouncements also differ: some governments may have imposed lockdown proactively to prevent widespread transmission, while some imposed lockdown in response to an already growing number

¹ B. (SHM) Fakhruddin, K. Blanchard, and D. Ragupathy. 2020. *Are we there yet? The transition from response to recovery for the COVID-19 pandemic*. *Progress in Disaster Science*. 7. p. 100102. Erratum regarding previous published articles (*Progress in Disaster Science* (2020) 5, (S2590061719300456), (10.1016/j.pdisas.2019.100045)). *Progress in Disaster Science*. 8.

of cases. This distinction is further blurred by the fact that countries acquired COVID-19 testing capabilities at varying times and expanded their capabilities at widely different paces. For example, the Republic of Korea rolled out mass testing in the early days of the pandemic even for people who did not show symptoms.² In any case, the overarching focus in the response phase is to decrease transmission and build up frontline healthcare capabilities for testing and treatment.

The recovery phase corresponds to a period of gradual return to “almost-normal” levels of business and social activity while maintaining cautionary measures and continuing to boost healthcare capability. This entails lifting of strict lockdown protocols which allows for a limited variety of commercial and social activities to resume, provided safety measures are observed such as wearing of masks, physical distancing, and, in some areas, curfews. The recovery phase may be triggered by the decreasing number of COVID-19 cases, an indication that the initial response measures have been effective in managing transmission. However, this is not always the case, as many countries and cities have lifted initial lockdowns despite having no reduction in cases. As such, the recovery phase may be motivated more by economic recovery or politics rather than recovery in the public health sense.

Compared to the response and recovery phases, the rejuvenation phase is clearly demarcated by the availability of a vaccine and widespread immunization that allows a “new normal” for social activities and business operations. During the H1N1 pandemic of 2009, the World Health Organization (WHO) monitored the prevalence of cases until the winter in the southern hemisphere to determine whether the virus had begun to behave like a seasonal influenza strain.³ In the postpandemic phase, there will still be cases and possibly widespread outbreaks of COVID-19. Governments can shift their focus to reviving and spurring economic and social activities, as well as preventing succeeding waves of COVID-19 cases. The availability of a COVID-19 vaccine is the precursor for the rejuvenation phase. Mass delivery of the vaccine and widespread immunization may even be considered the first step in the rejuvenation phase—a critical step toward the “new normal.”

Pandemic mitigation strategies depend on a number of highly localized factors. The most important factor is the effective containment of transmission, which in turn dictates the relaxation of quarantine measures in the area. The gradual lifting of mobility restrictions domestically and internationally can spur local economic activities such as tourism, agriculture, and trade. The pace of rebooting economic activities is capped by prevailing cautionary measures such as physical distancing or curfews. Firms will likely operate at less than full capacity, and many businesses will not be allowed to operate yet.

Some economies and cities that have transitioned to the recovery phase (or have started operating in a recovery “mode”) reverted to lockdowns after experiencing a new wave of increased COVID-19 cases. Many economies in Asia and the Pacific initially showed promising performance in terms of reported cases. The Australian state of Victoria reported zero new cases in early June, but a month later declared a state of disaster that imposed curfews, mobility restrictions, and border closure.⁴ In contrast, New Zealand and Taipei, China, have both ended local transmission, which paved the lifting of most restrictions, and have earned international praise and recognition as models of effective economywide pandemic suppression. Some economies have seen new

² World Health Organization. 2020. How countries in Asia and the Pacific are working towards universal health coverage and combating COVID-19. <https://www.who.int/westernpacific/news/feature-stories/detail/how-countries-in-asia-and-the-pacific-are-working-towards-universal-health-coverage-and-combating-covid-19>.

³ World Health Organization. 2010. What is post-pandemic? https://www.who.int/csr/disease/swineflu/frequently_asked_questions/post_pandemic/en/.

⁴ D. Normile. 2020. Once praised for taming the pandemic, Asian-Pacific nations worry about new onslaught. <https://www.sciencemag.org/news/2020/08/once-praised-taming-pandemic-asian-pacific-nations-worry-about-new-onslaught> doi:10.1126/science.abe1734.

waves of COVID-19 infections while many economies have not successfully recovered from their first wave. The key lesson, concludes Normile (footnote 4), is for governments to avoid cutting corners in COVID-19 countermeasures and avoid falling into a false sense of security until vaccines are available.

Whether short-lived or prolonged, transitioning into the recovery phase affects key drivers of the water sector such as volume of water demand and wastewater discharge. It is possible for service providers to project how these key drivers will turn out under best- to worst-case scenarios; this exercise is particularly useful for stress-testing their financial standing under a worst-case scenario (e.g., protracted lockdown due to multiple waves of COVID-19 cases). Exiting the “emergency mode” during the response phase allows service providers to begin shoring up their resources and efforts into recovery efforts.

Service providers’ priorities also shift during the three phases. In the response phase, the abrupt decline in commercial and industrial water demand and wastewater generation result in rapid operational adjustments, as described in Chapter 2. Service providers cautiously balance maintaining an adequate level of service while ensuring the safety of personnel. In the recovery phase, the gradual opening of commercial activity and increasing mobility eases the emergency protocols of service providers. However, the possibility of reversion into emergency mode puts service providers on high alert. Even as commercial activity picks up, the recovery phase does not represent prepandemic economic activities and service providers are likely to operate at less than full capacity. In the rejuvenation phase, service providers gradually return to normal or prepandemic levels of operation as business-as-usual ensues. This postpandemic period will see the emergence of a “new normal”—that is, how the lessons and experiences from the pandemic change the way we live, work, and play.

A boat owner sits by the lake during the COVID-19 lockdown in Pokhara (photo by Samir Jung Thapa/ADB).

2 Response Phase— How the Sector has Felt and Reacted to the Pandemic

This chapter summarizes the pandemic's impact on service providers' economic, technical, commercial, human resources, and customer dimensions. The key gaps and challenges in ensuring continuous service delivery are identified, and practical lessons and good practices are highlighted.

High-Level Appreciation of COVID-19 and Water Security

SARS-CoV-2 and the Water Cycle

SARS-CoV-2 is one of tens of viruses in the coronavirus family. It causes the disease COVID-19, and is one of seven coronaviruses that can infect humans. Other coronaviruses are estimated to cause 15%–30% of common colds, and the more serious coronaviruses include SARS (which caused the Severe acute respiratory syndrome outbreak in the early 2000s) and MERS (Middle East respiratory syndrome-related coronavirus).

Coronaviruses are generally not waterborne. This, unlike some other viruses (e.g., hepatitis A and E viruses and enteroviruses, including polioviruses), people are unlikely to catch COVID-19 from water. However, infectious SARS-CoV-2 virions (whole virus) and the ribonucleic acid (RNA) of the virus have both been detected in treated and untreated sewage and environmental waters (rivers and lakes) because people infected with SARS-CoV-2 shed the virus in exhaled breath, saliva, urine, and feces.

The presence of SARS-CoV-2 in raw sewage has been demonstrated in many countries affected by this pandemic by detecting the virus's RNA. But RNA does not indicate that the infective virions are present. In July 2020, the first data were published on the presence and infectivity of SARS-CoV-2 in wastewater and river water.⁵ Rimoldi et al. showed that wastewater and river water contained the viral RNA but not the infectious virus. This means that river water, even when contaminated with sewage, only poses a limited COVID-19 risk to public health. We should still treat sewage-contaminated water with caution, partly because there are only extremely limited data available and mainly because sewage can contain other, worse viruses than SARS-CoV-2.

The presence of waterborne viruses and bacteria has led to sewage worker protection protocols and water and wastewater treatment methods which, although not designed specifically for SARS-CoV-2, mitigate it very well. Bleach, ethanol, benzylalkonium chloride, povidone-iodine, and chloroxylenol destroy SARS-CoV-2.⁶ Wastewater and water disinfected with sodium hypochlorite (NaClO) alone, NaClO + ultraviolet (UV) disinfection lamps,⁷ high-intensity UV lamps (footnote 5), or peracetic acid (footnote 7) is safe for human contact. SARS-CoV-2 virions are 60–140 nm in diameter, therefore ultrafiltration, nanofiltration, and reverse osmosis membranes remove them from water.⁸ The guidelines for protecting water treatment plant personnel all state that no additional precautions are needed over and above normal good operational and hygiene practices. The most recently updated guide was published in August 2020.⁹

Environmental surveillance by the testing of wastewater for evidence of pathogens (called wastewater-based epidemiology, or WBE) has a long history of use in public health, particularly for poliovirus and more recently antimicrobial resistance (AMR). The presence of viral RNA in wastewater is now in widespread use (Figure 2) in WBE as a disease surveillance tool due to the RNA being detected in wastewater approximately 7–10 days before the first clinical cases present themselves,¹⁰ thereby providing an early warning system to prompt local lockdowns and emergency preparedness in local healthcare facilities.

Appendix B discusses in greater detail the current literature on the relationship of SARS-CoV-2 and the water cycle, and presents the relevant guidance to water service providers.

⁵ L. Guerrero-Latorre et al. 2020. SARS-CoV-2 in river water: implications in low sanitation countries. *Science of the Total Environment*. 743, pp. 0–4. S. G. Rimoldi et al. 2020. Presence and infectivity of SARS-CoV-2 virus in wastewaters and rivers. *Science of the Total Environment*. 744, p. 140911.

⁶ A. W. H. Chin and L. L. M. Poon. 2020. Stability of SARS-CoV-2 in different environmental conditions – Authors' reply. *The Lancet Microbe*. 1, p. e146.

⁷ W. Randazzo et al. 2020. SARS-CoV-2 RNA in wastewater anticipated COVID-19 occurrence in a low prevalence area. *Water Research*. 181, p. 115942.

⁸ H. N. Tran et al. 2020. SARS-CoV-2 coronavirus in water and wastewater: a critical review about presence and concern. *Environmental Research*. 193, p. 110265 doi:10.1016/j.envres.2020.110265.

⁹ Water Environment Federation. 2020. *The water professional's guide to COVID-19*. <https://www.wef.org/news-hub/wef-news/the-water-professionals-guide-to-the-2019-novel-coronavirus/>.

¹⁰ W. Ahmed et al. 2020. First confirmed detection of SARS-CoV-2 in untreated wastewater in Australia: A proof of concept for the wastewater surveillance of COVID-19 in the community. *Science of the Total Environment*. 728, p. 138764; W. Lodder and A. M. de Roda Husman. 2020. SARS-CoV-2 in wastewater: potential health risk, but also data source. *Lancet Gastroenterology and Hepatology*. 5, pp. 533–534; G. Medema. Wastewater Monitoring for COVID-19 Disease Surveillance. in (2020); G. Medema et al. 2020. Presence of SARS-Coronavirus-2 in sewage. *medRxiv*.doi.org/10.1101/2020.03.29.20045880; A. Nemudryi et al. 2020. Temporal detection and phylogenetic assessment of SARS-CoV-2 in municipal wastewater. *medRxiv*.doi.org/10.1101/2020.04.15.20066746; S. Wurtzer et al. 2020. Evaluation of lockdown impact on SARS-CoV-2 dynamics through viral genome quantification in Paris wastewaters. *medRxiv*.doi:10.1101/2020.04.12.20062679.

Figure 2: Global Status of Environmental Surveillance for SARS-CoV-2 Virus, 5 December 2020

Source: Isle Utilities, Water Action Platform.

COVID-19 and Water Security Risks

Water security is tied to COVID-19 risks through multiple pathways. To better understand the pathways connecting water security and COVID-19, Guthrie developed the COVID-19 Water Security Risk Index¹¹ to categorize countries' COVID-19 vulnerability into six temporal risk elements: (i) ability to stay alert, (ii) ability to delay the spark, (iii) ability to contain the spread, (iv) ability to treat those in need, (v) ability to immunize, and (vi) ability to recover. Each risk element is composed of risk factors, and of the six elements, five have water-related factors that contribute to COVID-19 risk. A total of 19 water-related risk factors (out of a total of 117) have been identified (Table 2).

Table 2: COVID-19 Water-Related Risk Factors

Temporal Risk Element	Water-Related Risk Factor	Rationale
(1) Ability to stay alert	Sewage surveillance capacity	Provide a signal of incident cases in the community to support COVID-19 testing
(2) Ability to delay the spark	Rate of deforestation	High rates of deforestation can increase the likelihood of zoonosis spillover events. Particularly relevant to the start of the COVID-19 pandemic
(3) Ability to contain the spread	Ability to isolate – access to water and sanitation at home	Isolation requires access to water services in the home
	Ability to isolate – risk communication ability, including health literacy	Public communication of health risks and advice is crucial to pandemic response
	Access to hand sanitizer	Handwashing is crucial to slow COVID-19 transmission

continued on next page

¹¹ International Water Centre. <http://www.watercentre.org/covid-19-water-security-risk-index/>.

Table 2 continued

Temporal Risk Element	Water-Related Risk Factor	Rationale
	Access to handwashing and cleaning	
	Access to handwashing at home	
	Degree of influence of climate on virus transmission	Although there is currently little evidence of major climatic influence on the spread of COVID-19, in other pandemics, temperature and rainfall can influence virus transmission
	Sewage surveillance capacity	Provide a signal of incident cases in the community to support COVID-19 testing
(4) Ability to Treat Those in Need	Medical – WASH in healthcare facilities	Functional medical systems require water, sanitation, and hygiene in healthcare facilities
	Natural disaster resilience	A concurrent natural disaster would make it more difficult to respond to a pandemic
	Water collection burden	Where women spend more time collecting water, there is an overall reduced capacity to care for ill family members in the home
(5) Ability to Immunize	(no water-related factor identified)	
(6) Ability to Recover	Economics – agricultural self-sufficiency	Self-sufficiency means more security if trade is impeded
	Economics – agricultural water security	Supports local or national food security
	Economics – aid dependence	Dependence on aid raises insecurity when funds are in short supply
	Economics – economic water security	Recovery requires secure water resources for economic uses
	Economics – energy self-sufficiency	Self-sufficiency means more security if trade is impeded
	Governance – environmental governance	Secure water resources require good governance
	Human resource capacity in water sector	A well-resourced water sector is more likely to have adequate capacity and redundancy
	Natural disaster resilience – drought, flood, storms	A concurrent natural disaster would make it more difficult to respond to a pandemic
	Resilience of supply chain for critical parts or equipment	Supply chain continuity is critical to utility operations
	Water utilities' ability to generate income	Revenue generation is critical to utility operations

Source: L. Guthrie and A. Roiko. 2020. *Asia Pacific COVID-19 Water Security Risk Index*.

Using this index, it is possible to develop a high-level mapping and ranking of countries based on their COVID-19 water security risks. Table 3 lists the countries with the highest and lowest overall COVID-19 water security risk ratings in Asia and the Pacific, and compares their ratings across the six temporal elements.

Table 3: Highest and Lowest Ranking Countries in Terms of COVID-19 Water Security Risk

Country and Ranking		Overall COVID-19 Water Security Risk Rating	Temporal Element Risk Ratings (5 = Highest Risk)					
			Ability to Stay Alert	Ability to Delay the Spark	Ability to Contain the Spread	Ability to Treat Those in Need	Ability to Immunize	Ability to Recover
Top 10 highest risk								
1	Afghanistan	23.3	1.0	4.7	4.8	5.0	5.0	4.7
2	Micronesia	19.3	1.0	3.6	4.9	4.7	5.0	3.8
3	Laos	18.8	1.0	5.0	3.9	3.7	5.0	3.9
4	Nepal	18.3	1.0	4.8	3.7	3.9	5.0	4.0
5	Pakistan	18.0	1.0	4.4	4.2	4.3	5.0	3.3
6	Cambodia	17.9	1.0	4.4	3.8	3.7	5.0	4.4
7	Myanmar	16.7	1.0	4.2	3.3	4.4	5.0	4.0
8	Timor-Leste	16.7	1.0	4.5	4.5	2.3	5.0	3.8
9	Papua New Guinea	16.0	1.0	2.8	4.6	4.1	5.0	3.9
10	Bangladesh	15.3	1.0	3.7	3.9	3.6	5.0	3.5
Top 10 lowest risk								
38	Cook Islands	8.1	1.0	1.0	3.0	3.1	5.0	3.9
39	Palau	7.9	1.0	2.7	2.0	2.4	5.0	2.5
40	Kazakhstan	6.8	1.0	3.3	1.1	2.5	5.0	1.8
41	Brunei Darussalam	6.7	1.0	3.6	1.5	1.7	5.0	1.2
42	People’s Republic of China	5.8	1.0	2.3	1.4	2.6	5.0	1.9
43	Japan	3.8	1.0	1.3	1.8	1.0	5.0	1.4
44	South Korea	3.8	1.0	2.1	1.1	1.1	5.0	1.0
45	New Zealand	3.3	1.0	1.5	1.0	1.5	5.0	1.2
46	Singapore	3.3	1.0	1.5	1.0	1.5	5.0	1.4
47	Australia	3.2	1.0	1.5	1.2	1.3	5.0	1.0

Source: L. Guthrie and A. Roiko. 2020. *Asia Pacific COVID-19 Water Security Risk Index*.

Because disease outbreaks are expected to increase with climate change and environmental degradation, it is important to understand where countries' vulnerabilities lie. The Index serves as a starting point for developing a more sophisticated framework for linking water security and pandemic risks. Currently, COVID-19 has hit almost every corner of the region and mass immunization is yet on the horizon, consequently the temporal elements requiring the most attention are ability to contain spread, ability to treat those in need, and ability to recover. Not surprisingly, these are also the temporal elements where water is a key factor or determinant of success or failure, as shown in Table 2.

Impacts to and Responses on Technical Operations

The next four sections will focus on water supply, sanitation, and wastewater service providers, due to the broader operational impacts experienced by these subsectors. The ADB survey results presented in sections are drawn from the questionnaire (Appendix A), which garnered a total of 25 responses. The final section of this chapter, will be dedicated to the impacts and responses on water resources, irrigation, and urban drainage and stormwater service providers.

Water Demand

Water consumption by commercial and industrial customers decreased, while household consumption increased. Because lockdown and quarantine measures halted normal business operations, the primary impact on water utilities was the decrease of commercial and industrial water demand, coupled by the increase in household water demand. In a survey of 44 utilities by the Global Water Leaders Group, an estimated 27% average reduction in industrial demand was observed as of May 2020.¹² The same survey reported that utilities around the world expect a reduction in revenues of 15% on average because of the pandemic. In comparison, the ADB survey revealed that 41% of respondents experienced a reduction in commercial and industrial water demand, 50% experienced an increase in household water demand, and 9% experienced changes in diurnal or nocturnal consumption patterns. Despite these changes, half of respondents did not change their total production level and only 32% decreased it. This means that, for some utilities, the decrease in commercial and industrial water demand is almost completely offset by the increase in household demand. It could also mean that production level remained constant because diverting more water delivered to households or residential districts increased physical losses in the form of leaks or pilferage. However, utilities with a significant proportion of large commercial and industrial customers will be more significantly affected.

The operational impact of sudden shifts in demand vary from utility to utility. This depends on factors such as customer mix, network configuration and capacity (e.g., strategically located reservoirs, interconnection of independent systems, and leak hotspots in certain neighborhoods), and availability of treated water supply. In various webinars (UNESCO, Malaysia International Water Convention, and the International Commission on Irrigation & Drainage), water supply service providers in Asian megacities reported their experiences as summarized below.

- ➡ Malaysia: household consumption increased by 7%–15%, while industrial and business consumption decreased by 10%–30%.
- ➡ Jakarta, Indonesia: industrial and commercial water consumption decreased by 43%. Water services were maintained normally. Water kiosk projects have been implemented alongside 170 handwashing stations in different areas of the city, especially in high-density and low-income communities.
- ➡ Karachi, Pakistan: increase in household demand by 20% occurred in the early months. With the economic reopening that followed, water supply became more challenging because even in normal circumstances, the city suffers from water shortage of about 45%. Peak demand strategies have to be implemented to manage scarce supplies.
- ➡ Mumbai, India: massive reduction in commercial demand to near-zero consumption benefited residential areas, which received better quantities of water. However, those living in high-density slum areas remained vulnerable due to their limited access to water services. Intermittent water supply and communal or shared water sources also posed health risks.

¹² G. Butler et al. 2020. *The Impact of COVID-19 on the Water and Sanitation Sector*.

- Shanghai, People's Republic of China (PRC): the problem of ageing infrastructure was noted as a challenge. Many people still live in old residential quarters where shared kitchens and toilets, in addition to pipe leaks and poor plumbing, can increase the risk of virus transmission.
- In India, due to the lockdown, a large number of urban dwellers went back to their hometowns in rural areas. This resulted in increased water demand in their hometowns, which some rural operators were not immediately ready to serve. Irrigation service providers were required to open canal gates to provide water for returning rural residents. This effect can be significant during the recovery phase when transport restrictions are eased and more people travel out of the city and stay in rural hometowns for the duration of the pandemic.

To cope with these changes in the water demand profile, service providers have adjusted their distribution operations. Network pressure management is the immediate response to efficiently allocate or reallocate supply across the system. In the ADB survey, 26% of respondents changed pressure management operations and 21% changed storage levels of tanks, impounding facilities, or reservoirs. Some utilities may not have interconnected systems that allow water supply reallocation, possibly resulting in service interruptions or reduced volume or pressure of water delivered to households. In the ADB survey, 16% have had to implement service interruptions to cope with water demand changes.

Wastewater Discharges

It is expected that wastewater discharges follow the changes in water consumption. Most utilities project or calculate wastewater discharge as a function of water consumption, although at less than a one-to-one ratio. Table 4 shows the range of impacts observed by the wastewater service providers that responded to the ADB survey. The most marked change is the decrease in discharge from commercial and industrial customers at 38% of respondents. Note that an equal number of respondents did not observe a change in domestic or household discharges, and only one-quarter of respondents observed an increase.

Table 4: Changes in Wastewater Discharge Observed by ADB Survey Respondents

	No Change	Increase	Decrease	No Observation	Total Responses
Domestic or Household Discharges	38%	25%	13%	25%	8
Commercial or Industrial Discharges	25%	13%	38%	25%	8

Source: Asian Development Bank.

Unlike water consumption, there is no direct measure for changes in wastewater discharges in the form of metering or volumetric monitoring. Hence, one-quarter of the ADB survey respondents did not capture these changes. Most utilities estimate wastewater discharge as a percentage of water consumption. Decentralized systems that cater to a specific neighborhood or zone are also more likely to capture or estimate the changes in customers' wastewater discharge profile. It is possible that wastewater treatment works (WWTW) are operating at the same capacity without understanding the change in the sources of the influent. Over 60% of ADB survey respondents reported no change in total wastewater load, and only one-quarter reported an increase in total wastewater load as measured at the treatment plants.

In terms of septage collection and desludging operations, no significant changes in operations were noted by service providers. None of the ADB survey respondents changed their activities, or had experienced an increase or decrease of desludging activities specifically because of COVID-19. This is partly because desludging schedules are predictable and regular (e.g., every 5 years), and households have no reason to abruptly request desludging services during lockdowns.

Some service providers are also involved in solid waste management. In the ADB survey, three out of 25 respondents conduct solid waste operations: general garbage collection, transport, or processing (other than sludge generated from wastewater processing). One respondent indicated that they currently lack the capacity to handle hazardous and toxic solid waste.

Water Quality

To alleviate customer concerns of possible drinking water contamination, water quality became a key focus for service providers during the response phase. In Wuhan, PRC, additional water testing was conducted to determine adequate disinfectant levels delivered to customers. Wastewater released by two newly constructed hospitals was also tested to closely monitor whether the influent posed an additional risk in the wastewater treatment plant. The service provider in Istanbul, Turkey, also implemented a project to collect and analyze wastewater samples for COVID-19 monitoring, and detected inactive SARS-CoV-2 virus in sludge in a number of sites. In the ADB survey, about 30% increased both the frequency of water quality testing and the number of testing locations specifically because of COVID-19.

Disinfection processes in both water treatment works and WWTW, which have secondary or tertiary treatment stages, are being strengthened so as to protect public and environmental health. Barring significant adjustments in treatment technology, increasing chemical dosage, particularly disinfectants, is the immediate response. It is important to ensure adequate levels of free chlorine all the way until the customer's tap. In the ADB survey, 43% of respondents indicated that they changed chemical dosage in water treatment operations in response to COVID-19.

However, many middle- and low-income countries do not treat wastewater to tertiary standards, if there is wastewater treatment at all. Beginning to do so would demand considerable capital programs being created (as well the building capacity to operate and maintain facilities), and certainly not within the short span of time needed to implement them as part of immediate pandemic response. For example, a 2019 survey of 46 urban areas in India revealed that about 63% of sewage generated remains untreated.¹³

Labor

Labor challenges compound the difficulty of maintaining utility operations during the response phase. Many water and wastewater service providers rely on manual operations, with little to no capability for remote monitoring and control or automated operations. Ensuring adequate service provision without compromising the health and safety of operators is at the center of every utility's agenda during the response phase and beyond.

Skeleton workforces and shifting schedules of operators helped to maintain proper distancing protocols in critical sites such as treatment plants. Most utilities have adjusted staff scheduling to keep shift teams separate from each other, protect staff from having to use crowded public transport to go to work, and minimize the number of staff physically present at work. About 38% of respondents to our survey indicated changing their water

¹³ ENVIS Centre on Hygiene Sanitation Sewage Treatment Systems and Technology. 2019. National status of waste water generation & treatment. http://www.sulabhenvi.nic.in/Database/STST_wastewater_2090.aspx.

treatment operator shifting schedules to cope with lockdown and quarantine restrictions. The Water Action Platform,¹⁴ which was the COVID-19 Utilities Response Platform in March–July 2020, observed commonly implemented staff protection actions globally (Table 5).

Table 5: Staff Protection Actions Observed Globally

Utility Operational Areas	Actions and Allowed Activities
Offices and Operational Sites	<ul style="list-style-type: none"> ➔ Essential staff only at office and sites ➔ Site separation with physical distancing of staff on sites ➔ Staff to work from home using digital capability
Operation Activities Suspended	<ul style="list-style-type: none"> ➔ Maintenance practices (including meter renewals, leak detection, and water zone management and reinstatement) ➔ Planned wastewater overflow investigations and pipe cleaning ➔ Planned maintenance, connections, renewals work, and development services on networks ➔ Pump station maintenance and cleaning ➔ Maintenance of valves, hydrants, and equipment ➔ Reactive maintenance deferred unless there was an emergency
Developer Services	<ul style="list-style-type: none"> ➔ Compliance and inspections ➔ Connections of water meters to address outstanding connection applications ➔ Wastewater collection connections and drainlaying
Meter Reading, Billing, and Payment Collections	<ul style="list-style-type: none"> ➔ Reading cycles suspended; estimates used instead ➔ Meter issues remain unresolved ➔ Limited staff return to site if any telecommunications or Internet connectivity issues ➔ Staged return plan developed, where COVID protocols including physical distancing can be achieved

Source: Isle Utilities, Water Action Platform.

Construction

Construction work and the presence of large groups on project sites was suspended in all sectors under lockdown restrictions. This halted all construction activities upon lockdown enforcement. Where construction work is dependent on migrant laborers, travel restrictions capped available labor supply and added to the challenges of managing construction work during the lockdown or quarantine periods.

Aside from worker constraints, construction suspension has been common across all industries due to supply chain and logistics issues. This includes the disruption of supply chains for fuel, concrete, steel, soil, and other construction inputs.

Utilities vary in their experiences of securing government approval to proceed with construction work. Protocols on travel and gatherings for lengths of time vary from country to country, and even regionally within countries. This is the case for national policies that allowed for local government discretion on the appropriate quarantine level, as in the Philippines. Although many governments allowed most construction activities to proceed after easing of initial lockdowns (given precautionary measures such as physical distancing), the impact on construction timelines are considerable. The ADB survey revealed that close to 70% of respondents anticipate a delay in completion of ongoing construction, with over one-third of respondents expecting a delay of 3–6 months and more than 20% are uncertain on the impact on construction timelines (Figure 3).

¹⁴ Isle Utilities. www.wateractionplatform.com.

Figure 3: Anticipated Delay in Construction Completion Reported by ADB Survey Respondents

Source: Asian Development Bank.

Asset Management

COVID-19 also affected asset management operations, but not by much as service providers were able to adjust. Regular maintenance can typically be delayed by a few months without significant adverse effects to assets; however, careful attention must be given to critical or failing assets. The ADB survey revealed that while 30% of respondents postponed ongoing or planned maintenance work, 73% of respondents did not experience a significant delay in maintenance work. Typical adjustments in asset management include changing the regime or methodology for asset condition and performance monitoring (30% of respondents), and changes in product quality testing (26%).

Increase in nonrevenue water (NRW) levels has been attributed to both physical and commercial losses. Some utilities have reported challenges with NRW as the water demand profile changed. As described earlier, reallocating more water volume to leakage-prone areas leads to more physical water losses. The suspension of meter reading may also increase discrepancies between actual and billed consumption, leading to increased commercial water losses. About 32% of ADB survey respondents observed an increase in NRW levels. The increase range was 2%–8% and was attributed to increases in unbilled consumption (22% of respondents), metering and billing inaccuracies (24%), unauthorized consumption (17%), and pipe leakage or burst (15%). Not surprisingly, over one-third of respondents fast-tracked pipe repairs to cope with NRW increase and 86% of respondents did not suspend leak detection activities.

Digital Technologies

Digital technologies support remote working and operating with reduced onsite workers. Personnel absence due to illness and reduced onsite workers due to physical distancing measures are putting unusual pressure on workforces, and digital solutions can supplement lost worker-hours by accomplishing the same tasks remotely or with fewer worker-hour inputs. Because of COVID-19, the ADB survey respondents indicated that service providers have implemented or are planning to implement digital solutions in various areas of operations including wastewater treatment (50% of respondents), asset management (39%), sewer blockage management (38%), water treatment (24%), and distribution operations (21%). In general, digital solutions in these operational areas can reduce downtime and improve efficiency.

The uptake of digital technologies has been increasing, and COVID-19 has underlined the importance of strategically deployed digital solutions. Worldwide, Global Water Intelligence (GWI) estimates that there is a 7.8% growth from 2019 to 2020 on investments in digitization comprising automation and remote control for water and WWTW and irrigation scheme automation upgrades, digital metering, big data analysis, and remote monitoring (Figure 4).

Figure 4. Investment in Digitization Technologies by Global Utilities

(Figures in brackets indicate change from 2019 to 2020 estimates)

Source: R. Weaver. 2020. *Utility Digitisation under COVID-19*, published in Global Water Intelligence.

However, the uptake of digital technologies remains uneven due to the requisite telecommunications infrastructure. Remote asset and process monitoring and early warning technologies, leak detection technologies, electronic revenue technologies, and water and wastewater quantity and quality sensor technologies are being taken up much more quickly than in previous years, although the dependence on internet penetration means that the uptake is uneven. Japan, the PRC, Hong Kong, China, the Republic of Korea, and Australia are the most digitally ready countries of the ADB regional members.¹⁵ Large urban centers with good 4G or other internet coverage are accelerating their preexisting digitization programs. Rural utilities with little or no internet services still rely on personnel in vehicles to be able to attend to sites and equipment. Without remote technology capabilities, stay-at-home orders have forced these municipalities, irrigation boards, and other service providers to defer essential maintenance.

Impacts to and Responses on Commercial Operations

Customer Financial Assistance

Many governments around the world have intervened to ensure continuous service provision to households during the pandemic. Financial relief to customers has been extended by reducing tariffs (e.g., in Japan), providing free water service for certain groups (e.g., in Viet Nam and Indonesia), suspending billing or invoicing, or extension of discounts or payment plans. About 43% of the ADB survey respondents have implemented deferred payments schemes. Figure 5 shows the actions taken by respondents as part of COVID-19 financial relief measures for customers. Many governments also prohibited water rate rises and water supply cutoffs or disconnections during the lockdown period. In the ADB survey, disconnection was suspended for less than three months for 58% of the respondents.

¹⁵ Y. Shen. 2020. The Impact of COVID-19 in China; M. Hedlund. 2020. The Impact of COVID-19 in East Asia/Pacific (excluding China).

Figure 5: Pricing Schemes Implemented by ADB Survey Respondents

Source: Asian Development Bank.

Meter Reading, Billing, and Payment Collections

Due to lockdowns, utilities have suspended meter reading due to mobility restrictions and to protect field staff. Commercial operations in the DMC context are typically labor-intensive and require face-to-face or onsite interaction. For example, in Metro Manila, the Philippines, water utilities neither conducted meter reading nor billed their customers for three months as mandated by government. Maynilad Water did not charge interest on outstanding balances accumulated during the lockdown period; after the lockdown, the penalty-free receivables (based on consumption estimates) were added to customer bills on a staggered basis rather than as a single-time charge. Based on the ADB survey, Table 6 shows the various measures implemented by water supply, sanitation, and wastewater service providers in their customer billing process or system due to COVID-19.

Table 6: Changes in Billing Process or System by ADB Survey Respondents

Answer Choices	
Billing amount has been based on estimates	40%
Invoicing has been suspended	30%
Meter reading has been suspended	30%
Invoice has been sent electronically (mobile or e-mail)	20%
Digital solutions have been implemented or planned	30%
Other Changes	13%

Source: Asian Development Bank.

Electronic payment mechanisms have brought in some collections during the leanest months for some utilities. However, some utilities reported that customers still prefer payments in person to collect a printed official receipt or to discuss other concerns with a customer service representative. About 33% of the ADB survey respondents have created new electronic payment channels (mobile or online), and 19% improved their existing electronic channels. Box 1¹⁶ shares an example of a successful campaign for customer e-payment.

¹⁶ Asian Development Bank. 2020. *Ensuring Reliable Water Service in Viet Nam through Digital Technology*. <https://www.adb.org/news/videos/ensuring-reliable-water-service-viet-nam-through-digital-technology>.

BOX 1

Accelerating Digital Solutions for COVID-19 Response in Hue, Viet Nam

Recognizing the importance of continuous water services during the pandemic, the city of Hue in Viet Nam accelerated the adoption of smart digital solutions as part of its COVID-19 response. HueWACO, the water utility serving the city, produced four automatic disinfection chambers. The company also used posters to encourage customers to use mobile payments for payment of utility services. Electronic billing has been implemented by HueWACO since 2015; however, customer uptake was slow and reached only 22% by 2019. By campaigning to reduce direct interaction such as cash exchanges, HueWACO increased customer uptake of e-payment to 38% as of August 2020.

Source: Asian Development Bank.

Customer Service

To ensure both customer and staff safety, customer services have had to be provided remotely. In the early days of the pandemic, some utilities shifted their customer service operations from mostly face-to-face to virtual and telephone interactions. The ADB survey revealed that customer service through telephone was the most prevalent (95% of respondents), followed by front desk operations (62%), social media (57%), and e-mail (48%). As lockdown measures were eased, customer desks have been reopened but with safety measures such as required masks or face-shields when entering premises, plastic barriers, and physical distancing.

Customer concerns during the lockdowns pertained to safety, affordability, and reliability of water services. Among ADB survey respondents, the most critical customer concerns during the pandemic are water quality concerns (45% of respondents), increase in water bills (35%), and flow or pressure concerns (25%). Understandably, the work-from-home setup and reduced office personnel diminished the queuing capabilities of service providers. One-quarter of ADB survey respondents reported that customers also raised concerns about delays in addressing inquiries.

In terms of new water connections, some utilities reported an increase in new customer requests. This may be a result of the campaign for handwashing and hygiene to combat transmission as well as the mandate by some governments to reconnect previously cut-off accounts to support public health outcomes. In the ADB survey, 53% of service providers experienced an increase in or fast-tracked new service connections; despite this, the number of new service connections are still lower than prepandemic projections for 24% of respondents. There are also financial repercussions of reconnecting accounts that have been previously cut off due to payment delinquency; operating expenses increase, but payment collections remain low.

Financial Impacts

Revenues

Revenue decline is the single biggest financial impact to water service providers. This is due to the sharp decrease in commercial and industrial water consumption that may not be fully offset by the increase in household consumption. In fact, even with increased household consumption, some utilities have been unable to collect payments from residential customers in part due to customer relief efforts. Wastewater charges typically fall as well. The revenue toll is common to many utilities around the world, as estimated by GWI in Figure 6 which shows the largest dip in revenues for the first half of 2020, corresponding to the period of most (initial) lockdowns. The International Benchmarking Network for Water and Sanitation Utilities found that, as of June 2020, collection rates had fallen by 40% among utilities in its index. In comparison, publicly owned water utilities in the US reported a 10%–35% decrease in commercial water demand; they also reported 6% payment delinquencies in 2020 to date, compared with historic 0.5%–3.0% payment delinquency rates.¹⁷

Figure 6: Water Service Provider Revenue Loss in the Q1 and Q2 of 2020

Source: S. Lennox. 2020. *The Global Water Market Outlook: The Impact of COVID-19*.

The net change in revenues depends on customer mix and tariff structure. Utilities that employ cross-subsidies on water tariffs (that is, commercial and industrial customers are charged more per unit consumption than household customers) are expected to see large negative impacts in revenues. In a webinar by UNESCO, Jakarta's PAM JAYA reported reductions of over 30% in commercial and industrial demand, which resulted in a decline in overall revenues despite an 11% increase in household (residential) consumption. Table 7 shows the revenue impacts of COVID-19 to ADB survey respondents. Two-thirds of water supply service providers saw a decrease in commercial and industrial revenues, compared to 44% increase in domestic revenues. The impacts on sanitation and wastewater service providers are a little more spread out for commercial and industrial revenues: although most respondents (43%) experienced no change in revenues, a reduction was observed by 29% of respondents. Those survey respondents that indicated a net change in total revenues suffered net reductions of 10%–30%.

¹⁷ American Water Works Association & Association of Metropolitan Water Utilities. 2020. *The financial impact of the COVID-19 crisis on U.S. drinking water utilities*. https://www.awwa.org/Portals/0/AWWA/Communications/AWWA-AMWA-COVID-Report_2020-04.pdf.

Table 7: Revenue Impacts for ADB Survey Respondents

	No Change	Increase	Decrease	Total Responses
Water Supply				
Domestic or Household Revenues	39%	44%	17%	18
Commercial or Industrial Revenues	28%	6%	67%	18
Sanitation and Wastewater				
Domestic or Household Revenues	57%	14%	14%	6
Commercial or Industrial Revenues	43%	14%	29%	6

Source: Asian Development Bank.

Capital Expenditure

Overall utility capital expenditure declined across most of Asia and the Pacific from 2019 to 2020 (Figure 7); note that ADB and GWI regional classifications may differ. Capital spending is expected to bounce back in 2021 but the recovery will be uneven due to economic and financial losses, among other factors. To jumpstart capital spending, financial support from government is increasingly becoming the lifeline for service providers that have taken a hit in revenues and financial reserves. In this regard, service providers must jostle with other priorities for government funding, including frontline healthcare and vaccine distribution.

Figure 7: Growth in Utility Capex Estimates, 2017–2021

Source: S. Lennox. 2020. *The Global Water Market Outlook: The Impact of COVID-19*.

Ongoing capital programs have largely continued because budgets have been committed prior to the start of the pandemic. As such, it is the planned capital programs (i.e., planned for implementation or disbursement in the future) that have been deferred or delayed as a result of the pandemic. The ADB survey revealed that 50% of respondents did not change their ongoing capital spending as a result of COVID-19. An equal number of respondents (25% each) either experienced an increase or decrease in capital spending due to COVID-19. For the water supply service providers that changed their ongoing capital spending due to the pandemic, capital spending increased for treatment facilities (25%) and pipe network (19%), while some decreased their capital spending for pipe network (25%).

Governments vary in the financial assistance they extended to water service providers. The nature of the economic stimulus response and national politics affect how much and in what ways spending occurs in different countries. The South Korean government announced a Green New Deal that includes smart water management, water reuse, and desalination (footnote 15). New Zealand is ready to invest in large infrastructure water projects to spend stimulus money, and the PRC is encouraging the use of local government bonds to meet its preexisting 2020 water pollution prevention targets²¹. In contrast, full funding has not yet been secured for the Indian central government's ambitious drinking water program Jal Jeevan Mission, which aims to increase potable tap water connections to every rural household by 2024 (where at present the connectivity is only 18%).¹⁸ In the Philippines, the government's fiscal stimulus package was aimed at healthcare and lending for small businesses;¹⁹ utilities have not expected much financial support from government (footnote 15).

Operating Expenditure

Operating expenditure has remained mostly steady, as demand for safe water services during the pandemic is strengthened by the need for good personal hygiene. In some cases, operating costs have increased due to short-term supply fluctuations, transport disruptions, the need to ensure an adequate supply of personal protective equipment (PPE), increased cleaning activities, and new digital platforms. Table 8 shows the range of changes in operating expenditures experienced by the ADB survey respondents. Spending mostly decreased for power (47% of respondents) as the need for pumping large volumes to commercial and industrial customers have decreased. An equal number of respondents did not change or increased their spending for corporate social responsibility (CSR) programs (each 47%)—this refers to the various social programs to support customers and the general public, including provision of bottled water or hygiene kits. Some respondents (37%) increased spending for chemicals because heightened disinfection is observed in potable water systems.

Table 8: Changes in Operating Expenditures Among ADB Survey Respondents

	No change	Increase	Decrease	Total
Power	35%	12%	47%	16
Chemicals	53%	37%	11%	19
Staff Salaries	82%	6%	12%	17
Consultant Fees	71%	7%	14%	13
Community and CSR Programs	47%	47%	7%	15

Source: Asian Development Bank.

¹⁸ P. Jebaraj. 2020. Additional funds sought for Jal Jeevan Mission; A. Krishnamurthy. 2020. The Impacts of COVID-19 in India.

¹⁹ CNA. 2020. *Philippines' Duterte signs US\$3.4 billion COVID-19 pandemic stimulus package into law*. <https://www.channelnewsasia.com/news/asia/covid-19-stimulus-package-philippines-duterte-13104128>.

Liquidity and Contingency Funds

Many utilities, particularly smaller ones, have faced a steep decline in financial reserves. This is because of the falling-off in revenues from industrial and commercial customers, mandated customer relief schemes, and in some cases rising operating costs. Cost-cutting appears to be the first response among service providers. None of the ADB survey respondents have either deferred their payments to suppliers and contractors or have sought or are planning to seek financial relief from creditors and lenders. However, 27% of respondents have already drawn from their financial reserves (e.g., savings and contingency funds) to ensure short-term liquidity—a worrying prospect if revenue decline persists with the pandemic.

Utilities vary in their ability to access external contingency funds for temporary financial relief. This is primarily to shore up funds to cover operating costs as revenues continue to decline or plateau at levels below normal. Some utilities have received direct financial support from governments; for example, the water utility in Karachi, Pakistan, has received 60% subsidy of operating costs from the government as of June 2020. Other utilities, such as the private water concessionaires in Metro Manila, do not have the same recourse. Debt payment can also be a hard constraint: heavily leveraged utilities may be held hostage by nonnegotiable debt repayment obligations, or unable to take on additional loans which further adds to the liquidity pressure. Only 39% of ADB survey respondents indicated that they do not require external support for temporary financial relief; those who do have tapped or are planning to tap government sources (50% of respondents), international and multilateral agencies (17%), and/or commercial lenders (11%) for temporary financial relief.

Supply Chain

Water service providers were among the many that joined the urgent rush for PPE at the start of the pandemic. PPE such as masks, face shields, protective clothing, and gloves are standard for field and site operators, particularly those in water and wastewater treatment plants. However, providing a limited supply of PPEs for a larger number of staff, which during the pandemic includes office and other field staff, quickly depleted stocks. Many utilities have had to reuse PPE following WHO prescriptions on how to safely do so.

Most utilities maintain a buffer stock for chemicals and spare parts as part of their disaster response plans, allowing them to tide through the lockdown period. In Malaysia it is common for water utilities to maintain stocks of chlorine good for one month, and three months for other chemicals. However, with prolonged delivery constraints, cross-border prohibitions, and transport roadblocks, buffer stocks might not be enough for utilities that increased their chlorine dosage to ensure adequate disinfection at the farthest customer end-points. The ADB survey shows that respondents experienced delays in the delivery of spare parts (50% of respondents), PPEs (38%), and chemicals (25%).

Supply chain disruptions also caused delays in construction. Chinese international transport was suspended for two months, resulting in delays in export of Chinese goods and services, and resulting in increased prices of materials (e.g., steel) and components. In Malaysia, some water supply utilities used instant premix concrete to temporarily reinstate roads after repairing pipe bursts, until regular premix supplies were delivered after the first stage of the national Movement Control Order.

Unlike operational adjustments, which are mostly within the control of service providers, supply chain issues are more challenging to address or change abruptly because of the reliance on third-party suppliers. To cope with delays in the delivery of goods and services, 20% of ADB survey respondents changed suppliers or contractors, presumably favoring local suppliers that are able to quickly mobilize delivery logistics. One-quarter of respondents simplified, shortened, or streamlined their procurement processes—this relates to the findings in the asset management section where one-quarter of respondents changed their product quality testing methods. Close to one-half of respondents have implemented or plan to implement digital procurement solutions such as e-procurement, e-billing, and online meetings.

Human Resources

Water service providers have demonstrated the need to balance the delivery of critical public service while protecting the health and well-being of their employees. As in many other sectors, lockdowns forced staff to work from home except for a few critical operations staff. In Metro Manila, the Philippines, water treatment plant operators of the private utility Maynilad volunteered to stay in the plant premises for the duration of the three-month lockdown. Maynilad ensured they received an adequate supply of food, sleeping materials, and other necessities during this period. Providing for their needs required coordination with local governments and police to permit Maynilad vehicles to travel and conduct deliveries during the lockdown period.

Few service providers were prepared for the strict lockdown protocols. Lockdowns are highly unusual in most countries, sometimes setting off public alarm which manifests through panic buying and traffic congestion to leave cities. In complying with lockdown and quarantine measures in their areas of operation, 75% of ADB survey respondents indicated that they experienced challenges in preparing staff to work from home: 75% faced challenges in the mobility of staff, workers, or laborers; 65% faced challenges in implementing physical distancing among staff in the office or site; and 45% experienced challenges in sourcing PPE for their staff.

The unprecedented nature of the pandemic and strict lockdown protocols have raised various concerns among the workforce. ADB survey respondents reported that employees raised concerns about safety in the office or onsite (68% of respondents), constraints on commuting to and from work (59%), physical and mental well-being (55%), ability to accomplish tasks given the new work setup (36%), and financial concerns (18%). A small number of respondents (9%) reported that employees raised concerns about public stigma against water and sanitation field staff, which reflects popular misunderstanding and fears about COVID-19 infection in water and wastewater operations. Mental well-being has been a common concern among many industries during this time. To support Australian utilities with mental health awareness and preparedness, the Water Services Association of Australia (WSAA) recently relaunched its 2019 water industry mental health framework²⁰ to feature 15 case studies and to draw from recent workplace experiences during the pandemic.

Service providers have mostly retained their workforce. This is because water and wastewater services are critical during the pandemic. Most ADB survey respondents (73%) did not change the size of their workforce during the pandemic, and some even increased their workforce size (14%). Still, 14% of respondents decreased their workforce size, contributing to the increased unemployment across many economies during this time.

Socioeconomic Impacts

The pandemic has highlighted the unequal access to essential water and sanitation services. Proper handwashing is essential in preventing and controlling infection; however, this standard hygiene practice remains challenging in areas with no clean running water²¹ or when households are forced to prioritize the use of limited water supplies for drinking and cooking. Where potable piped water supply is unreliable or unavailable, methods have been promoted to ensure the safety of consuming unimproved water sources. The use of household water treatment devices or simple disinfection processes has been promoted as a way to ensure safe drinking and handwashing water. Examples of household devices and processes include the use of multimedia filters, chlorine tablets, and boiling. This is particularly useful for low-income homes that do not have access to the piped network or other formal or safely managed water services.

²⁰ WSAA. https://www.wsaa.asn.au/sites/default/files/publication/download/WSAA%20Water%20Industry%20Mental%20Health%20Framework%202019_0_0.pdf.

²¹ Organisation for Economic Co-operation and Development. 2019. Economic Outlook for Southeast Asia, China and India 2020: Rethinking Education for the Digital Era. vol. 53 (OECD).

Water sector response has been particularly difficult for urban slums. In Mumbai, India, slum areas were identified as highly vulnerable areas due to high population density and limited access to or intermittent water supply, as explained in Box 2.²² An estimated 80% of the 7 million residents of Dharavi, Mumbai—the largest slum in Asia—have no running water. With inadequate distancing measures, long queues at communal taps could present high transmission risk. Illegal settlers in Karachi, Pakistan, have no access to formal water services—this forces residents to obtain their supplies from water peddlers, which are not only unsafe but also more expensive. An estimated 34 million people in Pakistan who live in katchi abadis or urban informal settlements pay for tankered water at exorbitant prices, which leads households to scrimp on water use such as for handwashing.²³ Low-income households in Penjaringan, Jakarta, resort to buying water from their neighbors, which is 40–60 times more expensive than subsidized piped water supply; the financial burden of spending as much as 36% of household budget on water is aggravated by the logistical challenges of sourcing water during a pandemic scenario.²⁴ These situations highlight how the pandemic has exacerbated water inequality.

The pandemic's impact on the water sector has gender implications as well. Sadoff and Smith (2020) report that in many developing countries, women and girls are responsible for fetching water from communal sources or water vendors, potentially increasing their risk of exposure (cited by Neal). Shared and poorly maintained sanitation facilities put women, girls, and gender nonbinary persons at heightened risk of contracting COVID-19 as they manage their menstrual hygiene needs.²⁵

BOX 2

Mapping the Vulnerable for Early Response

Bhardwaj et al. (2020) modeled COVID-19 contagion risk hotspots in megacities such as New York and Mumbai, and found that population density alone is not a determinant of contagion risk. Rather, it is neighborhood income and economic characteristics that make a difference as these determine households' and communities' investments in housing, infrastructure, and amenities that can transform even overcrowded neighborhoods to livable places. Mapping the vulnerable requires looking at "economic geography" to help deliver targeted emergency response, including the provision of clean water. An example is Jakarta's retrofitting of informal *kampung* areas with low-cost public water containers and soap dispensers. Employing this methodology, the researchers predicted COVID-19 hotspots to help local governments with response planning in four developing country cities: in Kinshasa, Congo, 84% of the population is at risk of being infected even with limited social interaction; in Monrovia, Liberia, 55%; in Manila, the Philippines, 50%; and in Cairo, Egypt, 25%. To transform densely populated areas, Lall and Wahba (2020) recommend investing in infrastructure and service delivery for potable water and sanitation.

Source: G. Bhardwaj et al. 2020; World Bank. 2020.

²² G. Bhardwaj et al. 2020. Cities, crowding, and the coronavirus: predicting contagion risk hotspots. <http://documents1.worldbank.org/curated/en/206541587590439082/pdf/Cities-Crowding-and-the-Coronavirus-Predicting-Contagion-Risk-Hotspots.pdf>; World Bank. 2020. No urban myth: building inclusive and sustainable cities in the pandemic recovery. <https://www.worldbank.org/en/news/immersive-story/2020/06/18/no-urban-myth-building-inclusive-and-sustainable-cities-in-the-pandemic-recovery>.

²³ M. J. Neal. 2020. COVID-19 and water resources management: reframing our priorities as a water sector. *Water International*. 45, 435–440.

²⁴ D.A. McDonald et al. eds. 2020. *Public Water Dark Clouds and Silver Linings*. Kingston, Canada, Municipal Service Project; Amsterdam, the Netherlands: Transnational Institute; and Buenos Aires, Argentina: Latin American Council of Social Sciences (CLACSO), 2020, 458 pp., free e-book, ISBN 978-1-55339-666-6, no information for printed book, ISBN 978-1-55339-667-3.

²⁵ B. Yamakoshi. 2020. *Mitigating the Impacts of COVID-19 on Menstrual Health and Hygiene*. United Nations International Children's Emergency Fund.

During the pandemic, other vulnerable groups were identified for their high water insecurity and poor living conditions—but their vulnerability was not well understood before the pandemic. In Guangzhou, PRC, it was observed that migrant workers' poor living conditions increased their risk of contracting COVID-19, and because mobility restrictions prohibited them from going back to their hometowns. Homeless people who rely on unsafe sources (e.g., stormwater or untreated raw water) or unreliable sources (e.g., public water fountains) are similarly vulnerable to COVID-19, on top of their existing vulnerabilities to disease. The conditions in temporary settlements are likewise alarming, as in Cox's Bazar where COVID-19 cases have been reported.²⁶ However, few water and wastewater service providers have conducted thorough studies about the risks and impacts on vulnerable groups—perhaps due to the unprecedented and sudden nature of the pandemic but also partly due to the exclusion of vulnerable groups from their ambit of formal services. The ADB survey revealed that 61% of respondents did not conduct assessments for any vulnerable groups in their service area. Some have conducted assessments for poor households (33%), remote or rural areas (17%), and a number of other groups (Table 9). Across all types of service providers, no vulnerability assessments were conducted for temporary settlements (presumably because there are none in the respondents' service areas), women-headed households, and women and girls.

Table 9: Vulnerability Assessments Conducted by ADB Survey Respondents (Water Supply, Sanitation, and Wastewater)

Vulnerable Groups	Response Rate
Informal Settlements	11%
Homeless People	6%
Prisons	17%
Elderly	6%
Remote or Rural Communities	17%
Poor Households	33%
Women-Headed Households	0%
Women and Girls	0%
No Assessment Made	61%

Source: Asian Development Bank.

Many water service providers extended services to vulnerable groups as part of their COVID-19 response. This explains the increased spending on community and CSR programs reflected in Table 8. The most common response has been to deliver water through water tankers or in plastic bottles to areas without access to the piped network, free of charge. ADB survey respondents extended or directly engaged in CSR measures such as mobilizing water tankers (55% of respondents), hygiene promotion primarily by encouraging compliance with handwashing practices (50%), distribution of hygiene kits including soap and PPE (30%), establishing handwashing facilities in public areas (30%), and distribution of bottled water (20%). Reconnecting delinquent accounts (15%) and increasing access to unbilled consumption (10%) are also considered as CSR measures, while others have made donations (10%). McDonald et al.³⁶ cite other progressive actions taken by public water operators in response to the pandemic, summarized in Table 10, many of which benefited vulnerable groups.

²⁶ Oxfam. 2020. *Fears for spread of coronavirus in refugee camps as up to 250 people share one tap*. <http://oxfamapps.org/media/7pcxa>.

Table 10: Examples of Progressive Actions Taken by Public Water Operators

Objectives	Actions
Making Water Services Affordable	<ul style="list-style-type: none"> ➤ Payment deferrals ➤ Reduced rates ➤ Free allocations of water services ➤ Careful targeting of subsidies to those most in need
Keeping People Connected to Services	<ul style="list-style-type: none"> ➤ Moratoria on cutoffs ➤ Rapid reconnections from prior cutoffs ➤ Rapid repair of breakdowns or interruptions ➤ Ensuring 24/7 services
Closer or Safe Access Points	<ul style="list-style-type: none"> ➤ Installing home or yard taps ➤ Installing community taps ➤ Providing emergency water tankers
Emergency Services to Vulnerable Groups (e.g., Refugees and Informal Settlements)	<ul style="list-style-type: none"> ➤ Wash stations ➤ Water tankers ➤ Drinking fountains ➤ Cleaning services
Public Education	<ul style="list-style-type: none"> ➤ Importance and methods of handwashing ➤ Easing anxiety by assuring people that water services are safe, reliable, and affordable

Source: D.A. McDonald et al. eds. 2020. *Public Water Dark Clouds and Silver Linings*. Kingston, Canada, Municipal Service Project; Amsterdam, the Netherlands: Transnational Institute; and Buenos Aires, Argentina: Latin American Council of Social Sciences (CLACSO), 2020, 458 pp., free e-book, ISBN 978-1-55339-666-6, no information for printed book, ISBN 978-1-55339-667-3.

Service providers must be careful that their community outreach does not lead to unintended adverse consequences. A policy of free water provides temporary relief, but it may come at a significant cost and widespread inconvenience or harm, such as the reduction of available supply throughout the entire water network. Many governments in Africa announced free water at the start of the pandemic.²⁷ ONEA, a water utility in Burkina Faso, provided free water at standpipes from April to June 2020, which resulted in long queues that made physical distancing difficult. The announcement of the policy, which coincided with the country's dry season, was followed by massive consumption at standpipes and led to low water pressure that affected the entire water network. Due to high demand encouraged by free water and the low water pressure experienced across the network, it was reported that many standpipe operators and individual household connections had their taps open for 10 hours without a break. A similar policy in Ghana, the "Free Water Initiative," intensified intermittent water supply for weeks in Accra, making it difficult for households to enjoy water services altogether. The policy also imposed a huge operational and financial burden on Ghanaian utilities, adding to already excessive public sector arrears as the government of Ghana owes an average of \$2 million per month to Ghana Water Company Ltd.²⁸

Public communication was an essential part of pandemic response. Service providers employed different types of communication media—including letters to customers, mass SMS, social media, television, radio, and newspapers—to increase awareness on handwashing and hygiene; service interruptions; changes in billing, pricing, or payments; changes in customer service; and assurance of safety and continuity of services during the pandemic. Service providers' public communications that were consistent with public health authorities' messaging helped combat misinformation about COVID-19, for instance on the risks of viral transmission from the piped water network or environmental waters.

²⁷ D.A. McDonald et al. eds. 2020. *Public Water Dark Clouds and Silver Linings*. Kingston, Canada, Municipal Service Project; Amsterdam, the Netherlands: Transnational Institute; and Buenos Aires, Argentina: Latin American Council of Social Sciences (CLACSO), 2020, 458 pp., free e-book, ISBN 978-1-55339-666-6, no information for printed book, ISBN 978-1-55339-667-3.

²⁸ G. Amankwaa and E. F. Ampratwum. 2020. COVID-19 'free water' initiatives in the Global South: what does the Ghanaian case mean for equitable and sustainable water services? *Water International*. 45. pp. 722–729.

Impacts on and Responses in Water Resources, Irrigation, and Drainage

This section focuses on the subsectors for water resources, irrigation, and drainage and stormwater management. The ADB survey results presented in this section are drawn from a questionnaire, which garnered a total of 12 responses.

Labor and Operations

The largest labor impacts were seen among irrigation service providers. This is because many irrigation service providers depend on seasonal and migrant laborers who encountered mobility limitations.²⁹ Among the ADB survey respondents, four out of seven irrigation service providers reported a decrease in their workforce—in sharp contrast to water supply and wastewater service providers, who retained most of their workforce during the pandemic.

Most service providers did not experience significant changes in terms of volume of water managed as a result of COVID-19. Among ADB survey respondents, 70% did not experience significant changes in total water diversion or abstraction while 20%–30% did not make observations or measurements.

Nevertheless, some service providers made adjustments to their operations in light of COVID-19. Among ADB survey respondents, planned or maintenance works were postponed (40% of respondents), the regimes or methodologies for asset condition and performance monitoring were changed (50%), and proactive asset management measures were implemented (30%). Postponed maintenance works were delayed for up to 6 months for 89% of respondents. Half of respondents implemented service interruptions, while 43% decreased service interruptions in terms of number of service hours per day. Only one respondent reported increasing the frequency and number of testing locations for water quality as a result of COVID-19.

Delays during the pandemic have compounded to affect succeeding farming and irrigation cycles, reducing farmer incomes.³⁰ Initial lockdowns coincided with harvesting season in many countries; limited mobility of farm workers delayed crop harvest or resulted in food wastage. In addition, the exodus of migrant workers delayed sowing for monsoon crops. These combined delays affected water availability for monsoon sowing as farmers missed the opportunity to synchronize with the hydrological cycle. Irrigation water stored in reservoirs has been inadequate to provide sufficient water for off-cycle sowing.

Complying with lockdown protocols was challenging for many service providers. Among ADB survey respondents, top challenges include the mobility of staff, workers, or laborers (82% of respondents), preparing staff to work from home (64%), implementing physical distancing among staff in the office or plant (64%), and sourcing PPE (45%).

Commercial and customer service operations have benefited from the use of digital technologies. Among ADB survey respondents, 50% improved their existing electronic payment channels while 25% created new electronic payment channels. Customer relations methods moved offsite as well, with the use of telephone and mobile the most popular among ADB survey respondents (88%), followed by e-mail (63%) and social media (38%). A significant number (63%) maintained customer-facing front desks and office functions, provided that safety

²⁹ P. Waalewijnkarin et al. 2020. Examining the pandemic's impact on the irrigation and drainage sector and opportunities for recovery. World Bank Blogs. <https://blogs.worldbank.org/water/examining-pandemics-impact-irrigation-and-drainage-sector-and-opportunities-recovery>.

³⁰ International Commission on Irrigation and Drainage. 2020. News Update. *Journal of Perioperative Practice*. May.

protocols were observed. During this time, the critical concerns raised by customer in relation to COVID-19 were on water quality (50% of respondents), service or delivery concerns (50%), and inability to make payments (38%).

Construction, Project Preparation, and Implementation

Ongoing construction that was initially suspended in lockdown areas was eventually permitted to resume, provided adjustments were observed for worker safety. About 45% of ADB survey respondents indicated that ongoing construction was suspended for less than 3 months, causing delays in completion of 3–6 months (Figure 8).

Timelines for planned projects have been adversely affected. For planned construction, the biggest delays were in safeguard preparation (82% of respondents), procurement of goods and services (64%), feasibility and detailed design (64%), site surveys (45%), and land acquisition (45%). Safeguard preparation has been particularly difficult due to the inability to conduct site surveys and convene or gather stakeholders for meetings.

Financial Impacts

Because most water resources, irrigation, and drainage service providers rely on government transfers or payments, some service providers have seen declining revenues as the pandemic stretches government budgets. Other service providers, many being government agencies themselves, do not consider themselves as “revenue generating” and so reported no change in revenues. Among ADB survey respondents, 44% said they have not experienced impacts in revenues while 56% said they do not collect payment for their services.

Compared to their water supply and wastewater counterparts, water resources, irrigation, and drainage service providers did not experience severe financial losses. Essential maintenance and capital works may be compromised in the future as pandemic impacts cut further into government budgets; however, in the short term, capital and operational expenditures mostly remained constant. This is expected as there have been few COVID-related adjustments that would cause abrupt changes in spending. Only about one-third of ADB survey respondents reported an increase in capital spending, mostly for canals or conveyance systems (40% of respondents) and dam or weir structures (33%). For operating expenses, some service providers increased their spending for chemicals (29%) and materials (33%). Most service providers (60%) also do not require external support for temporary financial relief; those who do have tapped or are planning to tap government (30%) and international or multilateral agencies for financial support. Only one service provider reported deferring payments to suppliers or contractors, and sought financial relief from creditors or lenders. Another respondent reported having drawn from their financial reserves to ensure short-term liquidity.

Socioeconomic Impacts

Irrigation operations may have generally been insulated from pandemic impacts, but farmers experienced postfarm constraints that resulted in financial losses. Unsold goods were wasted as transport, distribution, and storage logistics have been limited by lockdown and quarantine measures. Reduced demand from exporters and bulk buyers, such as groceries or restaurants, also led to supply gluts. ADB survey respondents faced challenges with market access (18% of respondents) and processing of goods (18%) during the pandemic. Farmers' reduced income during the pandemic has lasting effects on their ability to finance succeeding planting cycles, as well as curtailing their ability to make loan repayments.

Some countries have faced or are facing compound crises during the COVID-19 pandemic, threatening both food and economic security. The western United States, southeastern Australia, Southeast Asia, and various regions of South America, Africa, and Europe experienced twin disasters of the COVID-19 pandemic and drought.³¹ In central Punjab, Pakistan, locust invasions caused crop damage.³² In these areas, farmers and agribusinesses have to contend with limited market access (due to mobility restrictions) for far lower yields, heightening the risks of bankruptcies and unemployment in the rural sector. Other countries like the Philippines were hit by strong typhoons that wiped out crops altogether, while forcing people into evacuation centers that are underequipped for a pandemic scenario. Other compounding natural disasters include floods, bushfires or wildfires, and heat waves.³³

Some service providers have proactively assessed COVID-19 impacts on vulnerable groups within their service respective areas. More than half of ADB survey respondents assessed the vulnerabilities of certain groups (Table 11). Service providers likewise participated in public support programs through CSR activities such as distribution of hygiene kits (67% of respondents), hygiene promotion (50%), and establishment of handwashing facilities in public areas (33%).

Table 11: Vulnerability Assessments Conducted by ADB Survey Respondents (Water Resources, Irrigation, and Drainage)

Answer Choices	Responses
Informal Settlements	9%
Homeless People	9%
Remote or Rural Communities	27%
Poor Households	27%
Women-Headed Households	36%
Women and Girls	9%
Seasonal Workers	9%
Share Croppers or Landless	0%
No Assessment Made	45%

Source: Asian Development Bank.

³¹ A. Mishra et al. 2021. Compound natural and human disasters: managing drought and COVID-19 to sustain global agriculture and food sectors. *Science of the Total Environment*. 754. p. 142210.

³² T. Yamano et al. 2020. *COVID-19 Impact on Farm Households in Punjab, Pakistan: Analysis of Data from a Cross-Sectional Survey*. ADB. doi:10.22617/BRF200225-2.

³³ R. van den Berg. 2020. Building climate-resilient and equitable cities during COVID-19. World Resources Institute Commentary. <https://www.wri.org/news/building-climate-resilient-and-equitable-cities-during-covid-19>.

Shazia Aziz, mother of 6-year-old Zahira Aziz, helping her daughter sanitize her hands to keep her safe during the COVID-19 lockdown in Pakistan (photo by Rahim Mirza/ADB).

3 Recovery Phase—Priorities for Pandemic Exit Strategy

In the recovery phase, the resumption of many, but not all, kinds of commercial and social activities is both an opportunity and a challenge to water service providers. The recovery phase is a transition period. Properly managed, the recovery phase can lead to improved economic and public health outcomes; executed carelessly, it can put more people at risk of COVID-19, resulting in a reversion to response or emergency mode. This chapter presents the priorities for water service providers during this transition period.

Public Health and Staff Safety

As in the response phase, the top priority is ensuring public safety through continuous service provision without compromising the safety of staff. Toward this end, workplace and work system adjustments have to be aligned with safety protocols. Customer-facing staff are at a higher risk of exposure. Hence, site disinfection and office redesign must be implemented to protect the employees, visitors, and customers. This includes provision of hand hygiene stations, control of foot traffic to enable physical distancing, and putting up plastic sheets to protect frontline staff interacting with customers. Temperature checks, foot baths, and contact tracing measures became mandatory for some offices. Table 12 summarizes the different measures implemented by ADB survey respondents (across all service provider types) to ensure staff safety during the pandemic.

Table 12: Safety Measures Implemented by ADB Survey Respondents

Answer Choices	Responses
Work-from-home arrangement for staff not required onsite	71%
Provide PPE and/or hygiene supplies	76%
Reminders (posters, emails) for handwashing and social distancing	85%
Staggered shifts to reduce number of people onsite/office	62%
Contact tracing for staff, customers, and visitors	50%
COVID-19 awareness training	53%
Limited travel or field work	74%
Digital solutions (e.g., online meetings)	47%

Source: Asian Development Bank.

In the interest of worker safety, as well as due to supply chain and logistical issues, deferred construction is inevitable. As ongoing construction work picks up in the recovery phase, service providers must ensure that their contractors embed precautionary measures in their ongoing activities. Site managers are encouraged to prepare a list of activities that can be deprioritized when the situation calls for reduced man-hours on site. Service providers can also ease the pressure on construction programs by granting time extensions to contractors.

WASH facilities in and services for public healthcare facilities must be assessed and urgently improved when found lacking. With the healthcare sector at the frontline of pandemic response and management, it is imperative that reliable and safe water and sanitation services are available. Globally, one in four healthcare facilities lack basic water services³⁴ and two out of five lack adequate hand hygiene facilities at the point of care.³⁵ A recent WaterAid study revealed that only 38% of 575 healthcare facilities surveyed in Cambodia are connected to a piped water service; those who are not connected have their own sources, which may or may not be safely managed.³⁶

Together with public health authorities and commercial establishments, service providers must promote constant messaging on hygiene promotion if this falls under their mandate. Many commercial establishments that have reopened have also put up posters and reminders to observe hand hygiene, wear masks, and physically distance within premises. In addition to handwashing, service providers need to provide guidance to building administrators about the dangers of reopening plumbing systems that were shut down, unused, or underutilized during the months-long lockdown period. Without adequate flushing and disinfection of their water system, low-occupancy buildings face the twin water-quality risks of heavy metals corrosion (e.g., iron, lead, or copper) and microbial growth (e.g., *Legionella*).³⁷ Service providers can promote guidance, such as the Centers for Disease Control and Prevention (CDC) guidance for reopening of buildings,³⁸ so that building managers can prepare prior to the return of building occupants and tenants.

³⁴ WHO and UNICEF. 2019. Progress on household drinking water, sanitation and hygiene 2000–2017 Special focus on inequalities. Launch version July 12 Main report Progress on Drinking Water, Sanitation and Hygiene.

³⁵ P. Nath and L. Gosling. 2020. Putting equality, inclusion and rights at the centre of a COVID-19 water, sanitation and hygiene response. WaterAid Blogs <https://washmatters.wateraid.org/blog/putting-equality-inclusion-and-rights-at-centre-of-covid-19-water-sanitation-and-hygiene-response>.

³⁶ A. C. Samol et al. 2020. Status of piped water connection to public healthcare facilities in Cambodia. http://cwa.org.kh/wpcontent/uploads/2020/09/Status-of-piped-water-connection-to-public-HCFs_v7-003.pdf.

³⁷ IWA. 2020. Learning the pandemic lessons for low-occupancy buildings. The Source.

³⁸ CDC. <https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html>.

Economic and Financial Recovery

Economic contraction is projected for many countries for 2020. The GDPs of India and Afghanistan are projected to contract by 9% and 5%, respectively, in 2020. The GDP rebound in 2021 varies widely: October 2020 projections show that India is projected to grow by 8% (stronger than pre-COVID growth projection) and Afghanistan by 1.5% (weaker than pre-COVID growth projection). Meanwhile, the PRC's GDP is expected to grow moderately by 1.8% this year followed by 7.7% growth in 2021, following early recovery and containment of the pandemic. Despite this anticipated rebound, economic losses from the COVID-19 pandemic will have lasting long-term impacts. The loss in developing Asia including the PRC is forecast to range from \$721 billion to more than \$890 billion resulting from supply disruptions, interrupted remittances, and social and financial crises—these estimates exclude long-term impacts on healthcare and education.³⁹

As long as the pandemic persists, full financial recovery (i.e., returning to prepandemic levels of financial health) for many service providers may not be possible. The resumption of some economic activities has partially increased water demand and revenues for service providers, but many are still operating at a loss. Among ADB survey respondents, the total expected losses from the COVID-19 pandemic can be up to 30%. More than one-third of ADB survey respondents indicated that their financial situation will take anywhere between less than a year to 3 years to recover, while 17% are uncertain (Figure 9). For long-term financial recovery, respondents plan to implement cost-cutting measures (39%), take out new loans (30%), increase tariffs (30%), and apply for tax holidays (22%) or subsidies (22%).

Figure 9: Estimated Duration Before Overall Financial Situation Returns to Prepandemic Levels Among ADB Survey Respondents

Source: Asian Development Bank.

Governments' commitments and policies play an important role in the financial recovery of service providers. Some governments have included water sector spending as part of their economic recovery plans. In countries like India and Indonesia, government-funded capital projects to increase the number of household drinking water connections have accelerated as the public health dangers from lack of access to handwashing facilities become paramount. Direct transfers seem to be a more acceptable form of support than water rate hikes, which many governments are reluctant to approve in the near future as part of supporting the recovery of consumer finances. However, the mounting economic toll on government budgets may see funding allocations for water services diminish or totally disappear. Other than funding, local and central governments are also relied on for continuity of planned capital projects. While there has been no significant cancellations in ongoing capital projects in India,

³⁹ Asian Development Bank. 2020. *Outlook 2020*. https://globalfert.com.br/pdf/outlook_globalfert2020.pdf.

new government-funded projects are most at risk of delays and cancellations due to delays in the tender and procurement process (footnote 18).

In the meantime, water service providers need to find ways to mitigate their losses especially when there is no certainty about benefiting from government support. This includes cutting back on nonessential expenditures such as spending on noncore business operations and deferring planned capital works. A protracted recovery period will leave service providers with little room for resuming capital works or commencing new ones. The initial disruption to construction projects is expected to be followed by delays to the entire spending programs especially in middle-income countries, as governments and utilities need to reassess their priorities. This may also force utilities to pay more attention to addressing real water losses: reducing leaks (one of the cost-effective ways to increase water availability), reducing municipal costs, and increasing revenue collections.

Some service providers are seeking or plan to seek external sources of financial relief. The hardest hit service providers—those whose revenues fall severely short of covering operating costs—have to contend with protracted liquidity problems. Governments must work closely with their service providers to understand whether this is the case, and extend immediate financial support accordingly. Where funds are limited, these ailing service providers must be prioritized for financial relief as they are at risk of falling into a cycle of chronic financial emergency even long after the pandemic.

Protection of Vulnerable Sectors

The vulnerabilities of certain groups that came to light during the response phase must be addressed more systematically in the recovery phase. In the response phase, the most common action by service providers to provide essential water supply is to deliver water to vulnerable communities through water tankers or plastic bottles. These measures must continue in the recovery phase, and service providers must find ways to convert these ad hoc deliveries into a more formal service. Governments must continue to work with service providers to improve and expand WASH facilities and services in vulnerable areas and potential hotspots. This requires engaging with vulnerable groups in meaningful ways whereby bespoke solutions are cocreated (footnote 35), enabled by technological and financial innovation (Box 3⁴⁰ and Box 4⁴¹). A more exhaustive identification of at-risk groups—including often-overlooked populations such as ageing populations, persons with disabilities, prisoners, the homeless, refugees, undocumented migrants, and displaced people⁴²—and an examination of their vulnerabilities must be conducted.

⁴⁰ L. Denny. 2020. Innovations in combating the hand hygiene crisis: a lesson in getting creative. Global Handwashing Partnership Blog <https://globalhandwashing.org/innovations-in-combating-the-hand-hygiene-crisis-a-lesson-in-getting-creative/>.

⁴¹ Manila Water. 2019. Laguna Water and Calasiao Water partner with Water.Org. <https://www.manilawater.com/corporate/lagunawater/agos/2018-04-11/laguna-water-and-calasiao-water-partner-with-water-org>; Manila Water. 2018. Laguna Water continues to spread awareness about the importance of proper sanitation. <https://lagunawater.com.ph/news-and-updates/2018-05-15/laguna-water-continues-to-spread-awareness-about-the-importance-of-proper-sanitation>.

⁴² C. Staddon et al. 2020. Water insecurity compounds the global coronavirus crisis. *Water International*. 45, pp. 416–422.

BOX 3**Handwashing Technology for Cambodian Schools**

The “handwashing crisis” is a global problem with 3 billion people lacking proper hygiene facilities, notably a sink. Many schools and healthcare facilities in developing countries do not have sinks at critical sanitation spots such as beside toilets or at the point of care. HappyTap developed a portable mass-manufactured sink—consisting of water storage, tap, soap dish, and drainage—designed for low-income settings. HappyTap, which is marketed as Labobo in many countries, worked with UNICEF and the government of Cambodia to equip more than 3,000 schools across the country, enabling more than 70,000 students to practice proper handwashing. HappyTap is now expanding into Viet Nam, the Philippines, Bangladesh, India, Kenya, and the United Kingdom.

Source: L. Denny. 2020. *Innovations in Combating the Hand Hygiene Crisis: A Lesson in Getting Creative*. Global Handwashing Partnership Blog. <https://globalhandwashing.org/innovations-in-combating-the-hand-hygiene-crisis-a-lesson-in-getting-creative/>.

Poor communities and households may be at risk of water cutoffs as soon as government moratoria are lifted. The households that were added back into the network as part of the government mandate to reconnect as many households as possible are the first in line for being cut off if they cannot maintain their payments. To prevent this, water supply service providers can employ innovative commercial methods including flexible payment schemes.

The COVID-19 pandemic highlighted that the vulnerabilities in the agricultural value chain lie in postfarm marketing. To avoid wastage of farm produce, it is important to establish local storage facilities and basic processing technologies as part of the postfarm value chain. This can improve rural employment and increase the income of farmers. Governments should look further into the market and trade vulnerabilities made apparent by the pandemic to implement reforms in the agricultural sector. In the meantime, it is important to provide liquidity support to farmers, agribusinesses, and food processors under financial stress.

BOX 4**Mobilizing Microfinance for Water and Sanitation in the Philippines**

The WaterCredit and WaterConnect programs of Water.org have benefited almost 2 million people in the Philippines as of 2018. On the customer side, WaterCredit mobilizes local microfinancing institutions to extend small, easily repayable loans that enable households to access water and toilet solutions. On the utility side, WaterConnect is a partnership program with local water service providers to connect low-income households to the water network. Water.org has been working with three utilities in various parts of the country to help with planning network expansion, provide capacity building, and create instalment plans that align with households’ ability to pay (supported through WaterCredit). Laguna Water, one of the WaterConnect partners, has been exploring innovative sanitation solutions such as waterless toilets and portable toilet technologies and engaging the public through technology trials.

Source: Manila Water. 2018, 2019.

Enhancing Resilience

The lessons learned during the response phase must be reviewed and revisited to enhance the resilience of service providers. It is yet too early for service providers to lower their guard during the recovery phase, as many factors and risks contribute to the uncertainty around a country's full pandemic exit. Service providers must work closely with public health authorities to develop a holistic pandemic exit strategy that accounts for baseline, best-, and worst-case scenarios—including the possibility of reversion to lockdowns or a protracted recovery period as the number of cases rise or the mass distribution of COVID-19 vaccines is significantly delayed. In the recovery phase, service providers can turn their attention to normalizing the adjustments they made during the response phase to support continuous service delivery as we face the possibility of a prolonged pandemic. Some survey respondents indicated that they plan to institutionalize certain COVID-19 response measures as part of their postpandemic “new normal”: this includes flexible working arrangements (58% of respondents); use of digital technologies (46%); pricing or payment schemes (35%); continuing or additional support to vulnerable people through CSR (19%); and improving, diversifying, or localizing supply chains (19%).

Even with easing of lockdown restrictions, service providers continue to face challenges in complying with extended quarantine measures. Many survey respondents indicated that they are experiencing challenges in ensuring staff safety (64%) and billing or collection (52%). A key focus area during the recovery phase is addressing these challenges, for example by employing digital technologies that enable new ways of doing work. Another area of challenge for many service providers is staff testing for COVID-19 infection, made more difficult by the shortage of testing kits at the start of the pandemic. To overcome this, Maynilad partnered with a local hospital in Manila for COVID-19 screening of employees.

The pandemic is revealing the aspects of supply and value chains that are critical points of failure; these must be addressed as part of service providers' recovery strategies. These include supply chain disruptions (e.g., chlorine and spare parts) and asset failures (e.g., pump breakdown), but also downstream factors (e.g., value chain: postfarm marketing of produce). The OECD predicts that the COVID-19 pandemic will lead companies to rethink their supply and value chains in the medium to long term, possibly considering shortening supply chains where the risk of future disruptions is considerable.⁴³ Box 5⁴⁴ provides an example of a utility exercising a proactive, holistic, and systematic assessment of its supply chain. In terms of intangible business resources such as telecommunications tools and internet bandwidth, Accenture encourages utilities to stress-test their partners, suppliers, and providers as part of resiliency measures.⁴⁵

⁴³ OECD. 2020. *Investment promotion agencies in the time of COVID-19*. 1–12.

⁴⁴ L. Sawtell. 2020. Redefining Supply Chain Resilience – Lessons Learnt from COVID-19. Black Swan, Grey Rhinos, Which Will Impact You? (webinar); M. Zeilinga and S. Taylor. 2020. Black swan or grey rhino: A perspective on the impact of COVID-19 on Australia's supply chain. <https://watersource.awa.asn.au/business/assets-and-operations/a-perspective-on-the-impact-of-covid-19-on-australias-supply-chain/>.

⁴⁵ Accenture. 2020. *COVID-19: Strengthening Enterprise Resiliency in Utilities*.

BOX 5**Strengthening the Utility Supply Chain in Australia**

The 2019 business resilience and pandemic planning of Queensland Urban Utilities (QUU) was put to test almost immediately. As early as December 2019, QUU had conducting a global threat monitoring, and since January 2020 it has been on business alert. By February, a Supply Chain Resilience Working Group had been established. QUU invited their suppliers into early conversations to map out single points of failure and the criticality of supplies or commodities. Throughout the pandemic, there has been increased supplier engagement such as biweekly meetings with critical suppliers to manage the delivery pipeline. QUU interrogated the full supply chain to understand the origin of their suppliers' key inputs and raw materials, whether sourced intrastate or internationally. These insights helped improve QUU's supply resilience planning as restrictions and port congestion began to impact lead times. QUU was also able to explore alternate suppliers and products, focusing on locally available supply.

Source: L. Sawtell. 2020. Redefining Supply Chain Resilience—Lessons Learnt from COVID-19. *Black Swan, Grey Rhinos, Which Will Impact You?* (webinar); M. Zeilinga and S. Taylor. 2020. *Black Swan or Grey Rhino: A Perspective on the Impact of COVID-19 on Australia's Supply Chain*.

4 “New Normal” Phase— Building Back a Better Water Sector

Pandemics teach many lessons to modern civilization. UNDP describes how the cholera epidemic of 19th century England resulted in sweeping reforms in public health that included changes in water and sanitation service provision.⁴⁶ Many governments have learned valuable lessons from their experiences in overcoming past epidemics, such as the 2003 SARS crises in Hong Kong, China; and Taipei, China, and the 2015 MERS-CoV outbreak in the Republic of Korea. Indeed, a post-COVID world presents opportunities—as well as challenges—for change, as an internal survey by Isle Utilities among its global staff reveals (Figure 10).⁴⁷ The postpandemic “new normal” of the water sector will require a strong focus on preventing and responding to future health crises, accelerating universal access to water and sanitation, and adopting digital technologies. This chapter presents a vision of a postpandemic water sector that fulfills these objectives.

⁴⁶ United Nations Development Programme. 2006. Beyond Scarcity.

⁴⁷ Isle Utilities. Water Action Platform 20. <https://isle.andeye.com/wap20>.

Figure 10: Isle Survey Results on the Potential Changes in a Post-COVID-19 World

COVID-19 = coronavirus disease.

Source: Isle Utilities.

Preventing and Responding to Future Health Crises

The occurrence of disease outbreaks is expected to increase with rapid climate change, urbanization, and environmental imbalance that give rise to both emergence of novel pathogens and re-emergence of infections that were once controlled⁴⁸ unprecedented population growth with accelerated rates of antimicrobial resistance, have resulted in both the emergence of novel pathogenic organisms and the re-emergence of infections that were once controlled. The consequences have led to an increased vulnerability to infectious diseases globally. The ability to rapidly monitor the spread of diseases is key for prevention, intervention and control, however several limitations exist for current surveillance systems and the capacity to cope with the rapid population growth and environmental changes. Wastewater-Based Epidemiology (WBE). The water sector is crucial in preventing future outbreaks, as well as in responding effectively if they do happen. To ensure that water service providers are adequately prepared for this task, it is important to integrate WASH into the public health strategy, improve crisis preparedness and response management, and develop and employ WBE.

Integrate WASH into the Public Health Strategy

There needs to be more integrated thinking and planning between WASH service providers and public health managers. Water supply operators often plan service expansion without the lens of public health. Neighborhoods are connected to the piped system on the basis on what is immediately practical (e.g., proximity to main

⁴⁸ N. Sims and B. Kasprzyk-Hordern. 2020. Future perspectives of wastewater-based epidemiology: monitoring infectious disease spread and resistance to the community level. *Environment International*. 139. p. 105689.

transmission lines) rather than the urgency of addressing health concerns (e.g., urban poor or peri-urban communities with high incidence of waterborne diseases). These communities are bound to become disease hotspots without safely managed water access and sanitation services (Box 6).⁴⁹

BOX 6

Understanding Climate Impacts on Sanitation and Public Health in Africa

Three planning and modeling tools were combined to understand climate impacts on sanitation and public health outcomes in informal settlements of Kampala, Uganda, and Kisumu, Kenya. The first tool, Sanipath, uses stakeholder engagement and site data to identify areas of public health concern, fecal exposure pathways, and potential interventions. The second tool, K2P Safe Sanitation, uses information about existing sanitation systems to simulate surface water contamination by pathogens. The third tool, HyCRISTAL, builds scenarios to predict how flooding and infrastructure changes can impact health factors, such as the presence of human excreta in the environment. The pilot predicted the areas with the highest health hazard and identified measures – including technology, management, and behavioral interventions—to reduce public health risks and prevent future escalation due to climate change. These findings serve as bases for more robust planning and policy.

Source: UNC Water Institute. 2020.

The experience of megacities during the COVID-19 pandemic demonstrated that protecting the vulnerable is crucial to protecting everyone. This is a case for stepping up WASH investments in the poorest communities, but there are currently many barriers preventing these investments from being made. For example, many informal settlements are excluded from the coverage of service providers by making land title and other administrative qualifications a requirement for water supply connection. This policy has systematically cordoned off informal settlement communities from the piped network (Box 7).⁵⁰ Vulnerable sectors are also often regarded as having low ability to pay for water and sanitation services, despite various case studies showing that low-income communities are able to make good on their payment obligations for affordable water and sanitation, for example when cross-subsidies are in place⁵¹ or payment schemes (e.g., installments) are offered.⁵² This means that apart from investments by governments and service providers, demand-driven and market-based approaches are effective in expanding WASH services (Box 8).⁵³

⁴⁹ UNC Water Institute (Producer). 2020. Serving the urban poor: evidence to support decision-making in continuous supply and sanitation – 2 Case studies in Sub-Saharan Africa [webinar]. <https://waterandhealthconference.pathable.co/meetings/virtual/5XWPtX2R7Tc7ACvGQ>.

⁵⁰ A. Ho-Torres. 2019. Marrying CSR with business strategy. *Business Mirror*.

⁵¹ C. Acey et al. 2019. Cross-subsidies for improved sanitation in low income settlements: Assessing the willingness to pay of water utility customers in Kenyan cities. *World Development*. 115. pp. 160–177.

⁵² X. Leflaive and M. Hjort. 2020. Addressing the social consequences of tariffs for water supply and sanitation – *Environment Working Paper* No. 166. [https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP\(2020\)13&docLanguage=En](https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)13&docLanguage=En).

⁵³ WaterSHED. 2019. Estimating the economic benefits of market-based sanitation programs. <http://www.watershedasia.org/wpcontent/uploads/Economic-Benefits-of-Market-based-Sanitation.pdf>.

BOX 7

Expanding Water Services to the Urban Poor in Metro Manila, Philippines

In Metro Manila, Philippines, the water and wastewater service provider Maynilad has been able to work around land tenure requirements to serve urban poor communities using two mechanisms. With the *Samahang Tubig* Maynilad program, Maynilad organizes and enables community members to operate and maintain their own community waterworks using bulk water supplied by Maynilad at subsidized rates. The *Pag-asa sa Patubig* Partnership program differs in that Maynilad entrusts the management of the waterworks to a third-party operator. Through these programs, basic services are made available to otherwise waterless communities, thereby improving community health and livability.

Source: A. Ho-Torres. 2019.

BOX 8

Market-Based Sanitation Solutions for Rural Cambodia

Market-based solutions differ from most subsidy-based approaches in that the former relies on ability and willingness to pay of target beneficiaries (customers). To demonstrate the potential for market-based sanitation solutions, WaterSHED implemented the Hands-Off sanitation marketing program between 2011 and 2017 in the rural provinces of Cambodia. The program supported a network of small businesses to produce low-cost latrines that enable safely managed sanitation at the household level. The program both grew the rural sanitation market (increased latrine sales) and made it more efficient (reduced the price customers pay for a given amount of sanitation benefit). Over the seven-year period, the program's upstream and downstream market benefits were calculated at over \$166 million, compared to only \$50 million if the program had not been implemented. A key strength of the market-based approach is its ability to build and strengthen local markets that can provide affordable sanitation products over the long term, whereas subsidies typically benefit large producers from urban centers that crowd out local latrine producers.

Source: WaterSHED. 2019.

Improve Crisis Preparedness and Response Management

All water service providers must have a crisis response management and business continuity plans. Governments or regulators can include this as a performance indicator in water service obligations and standards. The “new normal” will see many more service providers developing robust business continuity plans that include a pandemic scenario. Moreover, these plans must be fully resourced so that WASH response (for whatever emergency) is mobilized and deployed quickly and efficiently.

There is a strong onus on water service providers to always be prepared for disaster risks and emergency responses. Water services are essential for life and continuous service provision is a key pillar of citywide resilience. As such, many utilities have prepared and adopted business continuity, crisis preparedness, and disaster response management plans. Most survey respondents indicated having plans, guidelines, or protocols

in place such as a water safety plan (64% of respondents), a sanitation safety plan (57%), a disaster risk management plan (50%), and a crisis management plan (43%). About 70% of respondents indicated that a pandemic scenario is part of their existing plan(s), but 37% indicated that they deviated from the plan during implementation and 30% said they did not follow their plan for pandemic response. This is understandable, since very few utilities have gone through a pandemic situation of this scale; any learnings from similar experiences (e.g., SARS and MERS-CoV outbreaks) are either theoretical or too limited in scale compared to the COVID-19 pandemic experience. Service providers must document their current experiences and incorporate key learnings into their existing plans. The experiences of Wuhan Water are worth considering (Box 9).⁵⁴

BOX 9

Wuhan Water’s “Safe Mode”

Wuhan Water made significant preparations prior to the city government’s announcement of the lockdown policy in late January 2020. The preparations were underpinned by three objectives: maintaining the water supply, meeting water quality standards, and protecting employees. The “Safe Mode” for water treatment plant operations applied a strict isolation protocol to cut off the risk of COVID-19 transmission among staff. The plan included step-by-step measures to limit contact between plant operations staff with the outside world, promoting “defense in depth” by deploying parallel working teams, and minimizing work tasks to only the essentials.

Source: Y. Wang, and W. Qu. 2020.

It is also imperative that water service providers are involved in multisectoral public health strategy coordination. More than half of ADB survey respondents (59%) reported that they have not been involved in any such a coordinated response or task force. The active involvement of service providers in coordinated response teams is necessary to ensure the continuity of essential water and sanitation services, for example by reducing the bureaucratic burden of permitting essential travel or prioritizing PPE access during lockdowns. Working closely with public health authorities can lead to early identification of transmission hotspots, allowing service providers to deploy support services or critical supplies more quickly and efficiently.

Wastewater-Based Epidemiology

WBE can augment disease surveillance and monitoring. Originally conceived and now widely used to evaluate the use of illicit drugs within a community, WBE has the potential to provide a snapshot of community-wide exposure to contaminants and pathogens, and identify likely sources of infections⁵⁵ WBE is expected to achieve more ambitious objectives such as establishing exposure to certain agents (pesticides, personal care products, persistent organic pollutants, and pathogens. Appendix B presents a full discussion on the mechanics of WBE. The CDC recently released updated guidance⁵⁶ on the use of WBE for detection and monitoring of SARS-CoV-2.

⁵⁴ Y. Wang and W. Qu. 2020. The “Safe Mode” of Water Treatment Plant Operation during the COVID-2019 pandemic by Wuhan Water Group Company 2. “Safe Mode” for water treatment plant operation. https://iwa-network.org/wp-content/uploads/2015/12/The-Safe-Mode-of-Wuhan-Water-Works-Company-during-COVID-epidemic_12_September_2020.pdf.

⁵⁵ M. Lorenzo and Y. Picó. 2019. Wastewater-based epidemiology: current status and future prospects. *Current Opinion in Environmental Science and Health*. 9, pp. 77–84.

⁵⁶ CDC. <https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/wastewater-surveillance/public-health-interpretation.html>.

WBE can complement current infectious disease surveillance systems and possibly act as an early warning system for disease outbreaks. Many of the current systems for assessing public health and infectious disease surveillance, such as clinical-based surveillance and hospital admission data, are passive and yield time-lagged indicators (footnote 48). WBE's advantage is in the ability to model spatial and temporal trends potentially in near real-time for some biomarkers. To improve the data capture and analysis methods for WBE, there is ongoing work on the selection of biomarkers, reduction of “noise” in the raw sewage data, and improving the time between data collection and analysis. This additional capability can add insights to public health planning and response. Indeed, WBE firmly places wastewater monitoring as part of a larger public health chain (Figure 11).

Figure 11: Graphical Representation of Wastewater-Based Epidemiology

Source: N. Sims and B. Kasprzyk-Hordern. 2020. Future perspectives of wastewater-based epidemiology: monitoring infectious disease spread and resistance to the community level. *Environment International*. 139. p. 105689.

WBE also has potential for detecting AMR, an important emerging public health concern. When left unmitigated, this may result in outbreaks of diseases that are difficult to treat using conventional treatment. AMR is accelerated by the misuse of antibiotic medication in humans and animals, and already a growing number of infections such as pneumonia, tuberculosis, gonorrhea, and salmonellosis are becoming harder to treat with conventional antibiotic regimens.⁵⁷ This risk has grown rapidly over the last two decades as shown by the risk map for ciprofloxacin (Figure 12) which is commonly used to treat a number of bacterial infections including respiratory and urinary tract infections. WBE—as part of the comprehensive monitoring of environmental waters—can provide a scientific basis for local policy and planning to avert potential public health crises arising from AMR.

⁵⁷ World Health Organization. 2020. Antibiotic Resistance. <https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance>.

Figure 12: Global Risk Maps for Antibiotic Ciprofloxacin, 1995 and 2015

Note: Maps show aquatic risks per ecoregion from ciprofloxacin in 1995 (top) and 2015 (bottom). Legend shows the ratio of predicted environmental concentrations in waterways to the no-effect concentration. Thus, values greater than 1 imply that predicted environmental concentrations are above the levels at which one would expect to start seeing effects.

Source: R. Damania et al. 2019. *Quality Unknown: The Invisible Water Crisis*. <https://openknowledge.worldbank.org/bitstream/handle/10986/32245/9781464814594.pdf>.

Accelerating Universal Access to Sustainable Water and Sanitation

Around the world, and particularly in the developing world, many countries are off-track in meeting SDG-6, which targets the provision of universal access to safely and sustainably managed water and sanitation.⁵⁸ Basic handwashing with soap and water remains difficult for many poor households around the world, as reported by a 2019 survey conducted by the Household Water Insecurity Experiences consortium (Figure 13 [footnote 42]). In Asia and the Pacific, the proportion of people without access to safe drinking water declined from 17.8% in 2000 to 6.3% in 2015, but water contamination and unequal access remain as critical issues.⁵⁹ During the same period, the proportion of people without access to safely managed sanitation declined from 48% to 35%, representing an additional 580 million people gaining access to safe sanitation. However, regional disparities are still apparent with as many as 59% of people in South and South-West Asia still exposed to poor sanitation.

There remain significant barriers to achieving universal access to sustainable water and sanitation. These include lack of financing, low technical capability, poor regulation and governance, and systematic discrimination of marginalized populations. Recognizing the need to fast-track SDG-6, UN Water developed the SDG-6 Global Acceleration Framework which aims to increase results during the 2020–2030 Decade of Action.⁶⁰ Underpinning this framework are the six fundamental principles: (i) prioritizing the vulnerable, (ii) inclusivity, (iii) conflict sensitivity, (iv) unleashing female and youth potential and reaching gender equality, (v) planning for resilience/sustainability, and (vi) making scientific evidence a prerequisite. Five “accelerators” are identified (Table 13). An example of purpose-driven application of the data and innovation accelerators in SDG target 6.4 (water use efficiency across all sectors) is shown in Figure 14.

Table 13: SDG-6 Accelerators

Accelerator	What Success Would Look Like
Financing	Costed plans related to delivery of SDG-6 are fully funded
Data and Information	High-quality information on SDG-6 indicators is shared and easily accessible by any decision maker
Capacity Development	Skilled staff enhance sustainable implementation of SDG-6
Innovation	Innovative practices and technologies for water and sanitation are leveraged at the country level
Governance	Efficient mandates for SDG-6 delivery in all sectors are established, institutions are strengthened to deliver, and intersectoral coordination mechanisms operate effectively

Source: United Nations. 2018. *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation*.

⁵⁸ United Nations. 2018. *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation*.

⁵⁹ UN ESCAP. 2020. *How Much do Asia-Pacific Countries invest in SDG-Related Priorities?* <https://www.unescap.org/blog/how-much-do-asia-pacific-countries-invest-sdg-related-priorities>.

⁶⁰ United Nations. 2020. *The Sustainable Development Goal 6 Global Acceleration Framework*. <https://www.unwater.org/publications/the-sdg-6-global-acceleration-framework/>.

**Figure 13: Proportion of Household Water Insecurity Experiences
Survey Respondents Reporting Inability to Wash Hands in the Last 30 Days**

Source: C. Staddon et al. 2020. Water insecurity compounds the global coronavirus crisis. *Water International*. 45. pp. 416–422.

**Figure 14: Example of Purpose-Driven Coordinated Actions
Using the Data and Innovation Accelerators**

6.4

Accelerator: Data

Example: Remote sensing for the water productivity. Agriculture is a key water user. A careful monitoring of water productivity in agriculture and exploring opportunity in increase it are required.

Example: Fit for purpose water monitoring system. Hydrological monitoring systems allow assessment of what is available to help manage distribution and demand.

Accelerator: Innovation

Example: In-site data for the verification of remote sensing data. The training and testing of machine learning models can facilitate and improve the verification process which is essential in the use of remote sensing data. Other examples include water cycle databases and pollution vulnerability mapping.

Source: UN. 2018. *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation*. United Nations.

In particular, governments and service providers must rethink sanitation service provision to accelerate sanitation access. There are 369 million people in Asia and the Pacific without access to basic sanitation services,⁶¹ and the sanitation burden is borne disproportionately by the poor and vulnerable. Designing safe, affordable, sustainable, culturally sensitive, and resilient sanitation services presents an investment opportunity not only for governments but also for the private sector. Conventional sewerage implemented by wastewater service providers is not only more expensive, but also impractical in many instances. Citywide Inclusive Sanitation is an urban sanitation paradigm that “aims to ensure that everyone has access to safely managed sanitation by promoting a range of solutions—both onsite and sewerage, centralized, or decentralized—tailored for the realities of the world’s burgeoning cities” World Bank (footnote 61). ADB’s Secondary Cities Environment Improvement Project is an example of a holistic assessment of sanitation opportunities: the project aims to improve wastewater treatment, sanitation, and drainage in conjunction with other urban environmental improvements such as riverbank embankment, coastal protection, public green spaces, and solid waste management in some of Viet Nam’s secondary cities.⁶² Going a notch further, the Toilet Board Coalition suggests that a robust sanitation economy must also be circular and smart.⁶³

The challenge is that the COVID-19 pandemic not only weakened economies, but also widened existing gaps in realizing water and sanitation development outcomes. The United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) SDG Progress Assessment⁶⁴ shows that Asia and the Pacific are not on track to meet the SDGs by 2030 (footnote 59). Zooming in on SDG-6, which combines targets for universal water and sanitation, five of the six indicators that have credible estimates (Figure 15) have barely reached the mid-point from the 2000 baseline. For the indicators not shown, data collection and progress monitoring in the Asia-Pacific is necessary.⁶⁵

⁶¹ World Bank. *Citywide Inclusive Sanitation (CWIS) Initiative*. <https://www.worldbank.org/en/topic/sanitation/brief/citywideinclusive-sanitation>.

⁶² Asian Development Bank. 2020. *A Sanitation Strategy for Secondary Cities Comes with Fecal Sludge Management*. Asian Development Bank. <https://www.adb.org/news/features/sanitation-strategy-secondary-cities-comes-fecalsludge-management>.

⁶³ Toilet Board Coalition and International Water Association. 2020. *Improving Public Health Through Smart Sanitation and Digital Water*. How data ecosystems and wastewater epidemiology can play a larger role.

⁶⁴ UNESCAP. <https://data.unescap.org/data-analysis/sdg-progress>.

⁶⁵ Ritchie et al. 2018. *Measuring Progress Towards the Sustainable Development Goals*. <https://sdg-tracker.org/water-and-sanitation>.

Figure 15: Asia-Pacific’s Progress in Meeting SDG-6 Targets

Source: UN ESCAP. 2020. How much do Asia-Pacific countries invest in SDG-related priorities? (ESCAP). <https://www.unescap.org/blog/how-much-do-asia-pacific-countries-invest-sdg-related-priorities>.

The “new normal” of the water sector must include a thorough understanding of the risks faced by vulnerable groups in society. Service providers must identify and assess the risks faced by marginalized and vulnerable groups within their ambit of service. This will help them understand the possible ways for extending critical services to presently unserved groups or areas, as well as prepare for more effective and efficient crisis response and management.

Extension of water supply services to the entire population entails employing both established and innovative solutions, including decentralization. There now exist technologies that work more efficiently and are cheaper at low-scale applications. This is in contrast to the large economies of scale that water service providers are typically configured for; in this way, decentralization offers the potential for equitable service provision. As the COVID-19 pandemic experience has shown, many centralized systems have excluded vulnerable communities such as the urban poor. The Cooperative Research Centre for Water Sensitive Cities argued that in the absence of centralized water supply and wastewater networks, urban informal settlements may be better provided with WASH services using alternative, decentralized approaches.⁶⁶ Decentralization allows the deployment of fit-for-purpose solutions that are not only more appropriate to the local constraints and opportunities, but also potentially more socially acceptable. Decentralization may also help speed up the implementation of suitable sanitation systems to achieve Citywide Inclusive Sanitation. WaterAid estimates that over \$1 billion in official development assistance is spent annually on large-scale sanitation systems, including sewerage and wastewater treatment plants, yet a review of these projects showed many are nonfunctioning, never commissioned, have stopped working, or are working poorly (e.g., due to underloading or overloading). In India, 54% of 44 wastewater plants were operating poorly, and in Viet Nam one-third of 17 wastewater plants were substantially underloaded.⁶⁷ To reduce the capex per connection for wastewater collection and treatment in a middle-income city from \$1,500 to \$500, conventional sewerage systems are not ideal; smart decentralized systems with localized reuse and resource recovery, particularly energy, are needed.⁶⁸

⁶⁶ T. Wong. 2018. Strengthening the delivery of WASH in urban informal settlements: addressing multiple exposure pathways in urban environments. www.watersensitivecities.org.au.

⁶⁷ WaterAid. 2020. *Troubled wastewaters A review of the functionality of wastewater treatment plants in low-and middle income countries*.

⁶⁸ C. Gasson. 2020. We need a new model to deliver sanitation for all. *Global Water Intelligence*. <https://www.globalwaterintel.com/news/2020/44/we-need-a-new-model-to-deliver-sanitation-for-all>.

Figure 16: Example Decentralization Strategies in the Typical Water Supply and Wastewater Value Chain

The diagram illustrates the typical water supply and wastewater value chain, showing how decentralization strategies can be implemented. The process is divided into two main paths: the water supply chain (green) and the wastewater chain (blue).

Water sources (top) feed into the **Water supply chain** (green) and the **Wastewater chain** (blue).

Water supply chain (green):

- Abstraction:** Connected to **Local water resources** (red box).
- Treatment and storage:**
- Distribution:** Connected to **Independent systems (can be interconnected)** (yellow box).

Wastewater chain (blue):

- Disposal or recovery:** Connected to **Community level resource recovery** (red box).
- Treatment:**
- Collection:** Connected to **On-site sanitation** (yellow box).

Customer services (bottom) are represented by icons for a faucet, a bill, and a call center agent.

Water services must be designed for sustainability and long-term resilience. Climate change is a major concern in the water sector because of its pronounced impacts on the water cycle, altering the operating parameters for many service providers in terms of water supply and quality. Legacy systems are already at risk of being a mismatch: countries that experience rapid climate change such as Nepal are seeing climate mismatches in infrastructures only a decade old. This does not bode well for DMCs that are intensifying investments in inflexible

⁷⁰ C. Kammeyer et al. 2020. How Distributed Water Infrastructure Can Boost Resilience in the Face of COVID-19 and Other Shocks. Pacific Institute. <https://pacinst.org/how-distributed-water-infrastructure-can-boost-resilience-in-the-face-of-covid-19-and-other-shocks/>.

gray infrastructures, such as the large multipurpose dams built or planned to be built along the transboundary Mekong River. Nature-based solutions (NBS) can support long-term sustainability by providing flexibility and adaptability to water service providers. For example, the PRC’s “sponge city” design approach—a suite of integrated NBS and “green and blue” infrastructures that aim to enhance urban water management in major cities such as Beijing, Tianjin, Wuhan, and Shenzhen—is envisioned to improve water retention (to avoid flooding and increase local water supply) and water quality (for reduced pollution and potential decentralized water sources).⁷¹ Safely managed sanitation is another area where NBS can deliver multiple benefits in terms of public health and community resilience. In low-income urban settlements, poor soil conditions and insufficient space make septic tanks impractical, and in many cases can exacerbate fecal contamination if wastewater effluent does not infiltrate the ground to a sufficient depth. Modular constructed wetland systems can promote sanitation and enable resource recovery for horticulture and agriculture production to support local economies (footnote 66). As rapid urbanization and population growth sweeps across Asia and the Pacific, service providers must consider NBS and green design as components of healthy, livable, and resilient cities.

As many legacy systems fall into disrepair, strategic asset management will be key in enhancing future resilience and ensure sustainable services. Utility services such as water and power are similar in that both are expected to minimize service downtime and restore services when outage is inevitable or unforeseen. In this regard, asset management for both water and energy utilities will move beyond scheduled maintenance and reactive fixes, toward “predictive, preventative, and prescriptive maintenance [that] best optimize[s] a utility’s asset (footnote 69).” This level of operational resilience can be achieved by proactive, strategic, and smart asset management that is enabled by digital technologies such as sensors and analytics.

Adopting Digital Technologies

Digital technologies have garnered significant attention during the pandemic as digitally ready service providers had better coping capability. This includes remote monitoring and control of operations supported by adequate and reliable digital and telecommunications infrastructure. Cloud computing and storage has freed service providers from office hardware, enabling flexible work-from-home schemes. Internet connectivity and speed are still key constraints in migrating to digital and online technologies, and this must be an area of future focus for telecommunications providers and government policy. Cybersecurity, data privacy, and system reliability are also growing concerns.

The pandemic has provided greater impetus for the digital transformation of many service providers. Already, service providers in both developed (Australia, Hong Kong, China, and Singapore) and developing markets (Indonesia, Pakistan, the Philippines, the PRC, and Viet Nam) are assessing how digital transformation can improve lifecycle management of assets and improve overall network management.⁷² Because of the pandemic, PAM JAYA in Jakarta, Indonesia saw the opportunity to upgrade and automate the water network, as well as digitalize the customer management and billing system, which will endure even after the pandemic.

Service providers vary in their readiness for digital transformation, and indeed differ in the value they can derive from going digital. The recommendation is not to indiscriminately apply digital technologies, but to understand which ones have the most impact to service providers’ ability to effectively meet their service obligations while considering constraints such as the organization’s telecommunications infrastructure and know-how, and

⁷¹ D. Gill. 2020. ‘Sponge cities’ could be the answer to China’s impending water crisis. <https://earth.org/sponge-cities-could-be-the-answer-to-impending-water-crisis-in-china/>.

⁷² Smart Energy International. 2020. Digital transformation reframes Asia Pacific’s water industry. <https://www.smart-energy.com/industry-sectors/digitalisation/digital-transformation-reframes-asia-pacifics-water-industry/>.

Figure 17: Digital Transformation Pyramid in the Water Sector

Source: M. Bennett and C. Villa. 2020. *Enabling Successful Water and Wastewater Projects through Technology Innovation*.

appropriateness of technology solutions to the operating context. Figure 17 shows the digital transformation levels for water service providers.⁷³ The foundation is data management: the collection, storage, and presentation of key information required for planning and decision-making, which are still conducted manually. This includes systems such as SCADA, asset management systems, and GIS, which are now common among many mature utilities. Basic sensor technologies also belong to this level. The second level is decision support: the analysis of big data that provides actionable insights and recommendations. Sensor technologies belong to this category when they offer data analytics (Box 10),⁷⁴ typically on a software-as-a-service or intelligence-as-a-service basis. For example, multiparameter water quality sensors that analyze large amounts of time series data can provide early warning to operators by predicting water quality events, which improves operator response time and reduces costly misadjustments in treatment dosing. At this level, planning, decision-making, and action are still conducted manually but are done faster and more efficiently. The final level of digital transformation is full automation: establishing a closed-loop system where machines learn and take action with minimal human intervention. For example, water quality analytics can be linked to automatic adjustment of treatment dosing and procurement of chemical stock. Only a number of utilities are currently able to implement full automation, and in most cases only in priority operational areas (Box 11).⁷⁵

⁷³ M. Bennett and C. Villa. 2020. *Enabling Successful Water and Wastewater Projects through Technology Innovation*.

⁷⁴ H. Taylor. 2020. *DASCOH Foundation uses continuous groundwater monitoring to improve water security*. <https://in-situ.com/en/blog/dascoh-foundation-uses-continuous-groundwater-monitoring-to-improve-water-security/>.

⁷⁵ Hiraya Water. 2019. *R-TAP in action*. <https://www.hirayawater.com/casestudies>.

BOX 10

Improving Water Security through Continuous Groundwater Monitoring in Bangladesh

In September 2020, the Bangladeshi NGO DASCOH Foundation switched from manual to continuous monitoring of groundwater resources in seven wells under its jurisdiction. Continuous monitoring is enabled by the deployment of smart data loggers that collect critical data on groundwater water level, pressure, and temperature that enable villagers to view hourly changes and fluctuations in groundwater characteristics. This robust data, together with manually collected historical data, will support full groundwater modeling, an important component of Integrated Water Resources Management and long-term planning. DASCOH aims to better understand water stress in the Barind Tract region as communities face a serious threat to water and food security.

Source: H. Taylor. 2020.

BOX 11

Smart Pressure Management to Combat Intermittent Water Supply in the Philippines

Intermittent water supply is common in developing countries, a result of a combination of factors including inadequate supply, poor distribution management, and high levels of nonrevenue water. Intermittent supply reduces the volume of available water for customers and increases utilities’ operating expenses (such as high pumping costs). Philippine startup Hiraya Water developed a low-cost intelligent pressure management system that controls manually operated valves. Trials with four local water districts resulted in savings in power consumption, higher billed volume, reduction in leakage, and optimized tank operations. As a result, many communities that depended on rationing have been served with more reliable water supply. Hiraya Water’s homegrown technology appeals to the price points of Philippine water districts, enabling “Water 4.0” without the prohibitive cost of hardware and software.

Source: Hiraya Water. 2019.

The ability to monitor and control facilities and equipment remotely is ideal for the COVID-19 pandemic or a similar disruption. A “digital twin” with remote control ability reduces the need for onsite or roving operators to conduct routine checks.⁷⁶ Even without remote control, a digital twin can provide advanced data management and decision support to promote network optimization, predictive maintenance, and streamlined capital investments. The Public Utilities Board, Singapore’s national water agency, recently announced the creation of

⁷⁶ Hiraya Water. 2020. *Guide for reshaping your business continuity plan amid the COVID-19 pandemic*.

its first digital twin for the Changi Water Reclamation Plant.⁷⁷ The project will enable whole-of-plant simulation using near real-time data feeds “whole-of-catchment” and predictive analytics, which will help test operational changes and improve operator training. The use of a digital twin also has the potential for making service providers more proactive in customer management as client and system information merge to better understand and preemptively respond to emerging customer needs.⁷⁸

On a larger scale, digital technologies can consolidate water sector data for improved resource management by multiple stakeholders. This can help achieve sector-wide resilience by enabling data sharing, coordination, and joint planning among service providers, government regulators, urban planners, and others. Open-access data is a powerful tool to support multiple stakeholders, as in the case of employing satellite analytics for “whole-of-catchment” monitoring and management (Box 12⁷⁹ estimated at 146 billion m³/year [Caparas, 2014 and Box 13⁸⁰]). Big data analytics can help service providers across the entire water cycle—from “ridge to reef”—gain a better understanding of water as a common pool resource impacted by multiple factors such as urbanization and climate change.

BOX 12

Satellite Analytics for Holistic Water Resources and Catchment Management in the Philippines

Metro Pacific Water trialed the use of satellite analytics to better understand the impacts of land use activities in the Laguna Bay catchment area. Using images from the National Aeronautics and Space Administration and the European Space Agency, machine learning algorithms classified the land use and land cover characteristics of the catchment. The imagery analyses were integrated with spatial datasets of topography, soil parameters, climate variables, and stream flow in a hydrologic model that showed the flow paths and estimated diffuse loadings of five key pollutants into Laguna Lake. The model indicated that water quality in the lake can be improved by optimizing land use management on residential and urban areas to the south-west, and agricultural areas along the southern edge of Laguna Lake.

Source: Rezatec. 2019.

⁷⁷ Jacobs. 2020. *Jacobs creating first digital twin of PUB's Changi Water Reclamation Plant in Singapore*. <https://www.prnewswire.com/news-releases/jacobs-creating-first-digital-twin-of-pubs-changi-water-reclamation-plant-in-singapore-301185525.html>.

⁷⁸ Idrica. 2020. *The 5 benefits of digital transformation for water utilities*. Idrica. <https://www.idrica.com/blog/benefits-of-digital-transformation-utilities/>.

⁷⁹ Rezatec. 2019. *A view from above: how satellites are changing the way water resources are managed in the Philippines*. www.rezatec.com.

⁸⁰ E. Quincieu. 2020. *How light detection technology for irrigation surveys could boost food security*. *Development Asia*. <https://development.asia/explainer/how-light-detection-technology-irrigation-surveys-could-boost-food-security>.

BOX 13

Using LIDAR for Irrigation Survey in Indonesia

The Integrated Participatory Development and Management of Irrigation Program, which is supported by the ADB, piloted the use of airborne bathymetric light detection and ranging (LIDAR) technology to survey irrigation networks in Indonesia. Covering an area of about 6,000 hectares, the project surveyed canal facilities (primary, secondary, and tertiary) to systematically check the status of irrigation assets. The project team obtained information such as dimension and conditions of soil and land, rivers, canals, and other related structures. The project was coupled with an upgrade of the irrigation asset management information system to include a spatial mapping capability and ability to capture field information through an Android-based platform. The project is the first of its kind in Indonesia and promises to bring substantial cost savings in operation and maintenance, efficiency in asset management, and time savings in conducting field work.

Source: E. Quincieu. 2020.

Digital technologies will continue to be developed for more bespoke use cases, particularly in developing country contexts. Already, many startups based in emerging economies are developing digital solutions that are not only cheaper but also potentially more appropriate for the local context. The Global Infrastructure Hub’s “infratech” library⁸¹ features smart digital technologies, many of which have used developing country case studies to demonstrate technical and commercial benefits. The rapid pace of innovation will drive down costs, allowing more service providers to adopt new technologies. In this regard, the development-oriented technology investments of ADB Ventures is a significant step in realizing technology-enabled development in Asia and the Pacific.

There remain significant barriers to digitization in the water sector. Sarni et al.⁸² identified the key barriers for digital technology as follows:

- ➔ Systems integration and interoperability: legacy systems, data siloes, and communications protocols that make integration difficult or impossible;
- ➔ Human resources impact: fears that digitization will displace workers, as well as the “fear of data and transparency;”
- ➔ Financing solutions without a clear value proposition: some digital technologies have well-defined value drivers (e.g., increased savings) while others do not (e.g., enhanced resilience); and
- ➔ Cybersecurity: maintaining customer and organization data privacy from potential attacks.

To overcome these barriers, digital adoption is now being accelerated by water sector regulations and public policy, data structuring solutions for legacy systems, the demographical shift (both customer and workforce) toward digital solutions, and various context-specific drivers (such as resource scarcity) that trigger utilities’ progress in their digital transformation. It is therefore important to foster partnership and collaboration between service providers and government regulators. In Australia, the Intelligent Water Network Programme—a partnership between the Victorian Government and VicWater, the peak body for the state’s

⁸¹ Global Infrastructure Hub. <https://cdn.gihub.org/umbraco/media/3060/the-global-infrastructure-hubs-reference-note-on-infratech-stocktakejuly-2020-revised.pdf>.

⁸² W. Sarni et al. 2019. *Digital Water: Industry leaders chart the transformation journey*.

water utilities—is aiming to investigate and accelerate the adoption of smart technologies (footnote 72). The proactive involvement of regulators in the innovation process helps to bridge the value gap between end-user and regulator, and can potentially speed up the creation of policies and institutional reforms to overcome innovation barriers.

Increasing the Resilience of Irrigation Systems

Improved Productivity, Market Connection, and Value Chain

Past improvements in agricultural productivity are likely to be eroded in the long-term because of COVID-19 impacts, if left unmitigated. In Central and West Asia, efforts such as land reform, agricultural diversification, and harmonization of trade policies brightened agricultural prospects, particularly in wheat production since 2016.⁸³ A prolonged pandemic and the possibility of reversion into lockdown will further weaken market demand, pushing many farms into a cycle of financial distress. To counter this, Sri Lanka has implemented a policy of import substitution, crop diversification and insurance that sought to increase domestic demand.

Postpandemic, the key focus should be placed on accelerating productivity and market access. This includes the development of irrigation systems (including micro-irrigation), farm-to-market roads, clean water supply, on- or near-farm processing infrastructure, and holistic agrologistics which should be designed for resilience, flexibility, and sustainability. Production closer to urban centers, including local urban production using greenhouses and vertical farming, must also be part of a comprehensive food security strategy. Table 14 shows the recommendations for accelerating productivity growth and market access in Central and West Asia, many of which are applicable for other regions in Asia and the Pacific.

Table 14: Proposed Interventions and Indicative Outcomes to Enhance Agricultural Productivity and Market Access in Central and West Asia

Proposed Measures	Indicative Outcomes
Accelerating productivity growth: <ul style="list-style-type: none"> ➤ Utilization of land zoning and soil conservation measures by agrosystem ➤ Establishment of intensive orchards and greenhouse using modern technologies (e.g., drip irrigation and other energy- and water-saving facilities) ➤ Employment of harvest and postharvest handling in horticulture crops ➤ Rehabilitation of irrigation systems ➤ Expansion of adaptive research to develop new, drought-tolerant varieties ➤ Application of remote sensing (for monitoring of agroecological conditions and productivity projections and/or interventions) 	<ul style="list-style-type: none"> ➤ Improved land management and soil fertility ➤ Improved crop productivity, quality-at-source, and value addition ➤ Increased import substitution and exports
Enhancing marketing and logistics: <ul style="list-style-type: none"> ➤ Development of agricultural marketing information systems ➤ Expansion of agrologistic infrastructure ➤ Enhancement of business development services for agribusiness ➤ Export promotion ➤ Formulation of strategy for medium- and long-term staple food reserves (e.g., buffer system for food security) 	<ul style="list-style-type: none"> ➤ Improved food availability ➤ Improved food quality ➤ Improved access to technical and marketing services across the value chain ➤ Increased exports

Source: B.M. Giap. 2020.

⁸³ B. M. Giap. 2020. COVID-19 pandemic impacts on food security in Central and West Asia. *Working Paper No. 9*.

Digital Technologies and Mechanization

Reduced field staff and workers triggered the introduction of mechanized and automated irrigation systems in some parts of the world. These technologies have the potential for improving labor productivity and water use efficiency. Coupled with technology-based storage facility management and cold chain systems, food losses can be reduced across the agricultural value chain.

Water-smart agriculture modernizes agricultural systems while promoting its green transition, as well as promoting resilience in the face of climate change. This is imperative as agriculture remains the largest consumer of water around the world, topping 80% of consumptive water use in some areas. Water resources allocation will therefore benefit from data-driven management made possible by remote sensing and big data analytics. ADB already uses remote sensing and satellite imaging for early identification of potential water shortages in Cambodia, India, Pakistan, and Viet Nam; these technologies improve irrigation infrastructure planning and crop area monitoring.⁸⁴

E-commerce Platforms

The pandemic has presented an opportunity for e-commerce and online platforms for agribusinesses. Online platforms can provide farmers and sellers direct access to consumers, both retail and wholesale, which reduces the need for brokerage, improves incomes, and reduces food wastage (Box 14).⁸⁵ In India, the regulatory framework has been adjusted to allow for e-commerce; however, internet connectivity especially in rural areas remains a major hindrance to its widespread adoption. There also needs to be technical capacity building and entrepreneurship support for small-scale farmers to enable them to take advantage of these opportunities.

BOX 14

Using Technology to Crowdsource Impact Investments for Small-Scale Filipino Farmers

Cropital is a social enterprise that manages a crowdfunding platform through which members can choose a Philippine farm to invest in. Once a farm is fully funded, the farmer-investees will be able to start farming. Cropital manages the investment fund for the farmers, ensuring that the resources are spent for productive use thereby minimizing investor risks. At the end of the farming cycle, investors receive a fixed return on investment depending on the success of the harvest. Cropital also offers farm-to-table services for members, ensuring low-cost delivery of fresh and quality produce from farmer-investees. FarmOn is another technology startup that offers investors the opportunity to invest in a crop, rather than a farm. Both companies are supporting farmers and rural workers who have traditionally been unbanked or have limited access to commercial credit to grow their business.

Source: Cropital; Oxford Business Group. 2020.

⁸⁴ K. Kim et al. 2020. Food security in Asia and the Pacific amid the COVID-19 pandemic. *ADB Briefs*. 6. pp. 1–15.

⁸⁵ Cropital. Cropital connects the farmers to the world. <https://www.cropital.com/learn/how-it-works>; Oxford Business Group. 2020. How state support and agritech solutions are enhancing the Philippines' food security during COVID-19. Oxford Business Group. <https://oxfordbusinessgroup.com/news/how-state-support-and-agritech-solutions-are-enhancing-philippines-food-security-during-covid>.

Staff at Beijing Gaobeidian Recycling Water Plant monitoring water quality. Beijing Drainage Group Co., Ltd. is strengthening its epidemic prevention and control in the treatment of reclaimed wastewater to ensure the safety of the water environment and supply of reclaimed water in Beijing (photo by Deng Jia).

5 Potential ADB Support and Way Forward

This concluding chapter proposes key mechanisms for ADB to support the long-term yet urgent need to “build back better” in the face of deep uncertainty and unprecedented development challenges in Asia and the Pacific water sector.

The characteristics of the “new normal” as outlined in Chapter 4 provide guidance not only to ADB but also to governments, service providers, and other water sector stakeholders. Table 15 shows some of the practical ways and immediate actions to support the adoption and progress of these objectives.

Table 15: Actions to Support the Realization of the “New Normal”

Characteristics of the “New Normal”	Sample Practical Actions to Support Their Realization
Early, comprehensive, and effective prevention and response to future health crises	<ul style="list-style-type: none"> ➔ Governments/regulators to include public health outcomes in water service providers' key performance indicators ➔ Service providers to use new planning tools to analyze future public health risks and scenarios (e.g., Sanipath, K2P Safe Sanitation, and HyCRISTAL) ➔ Governments and service providers to review local conditions that hinder poor communities from accessing safe and sustainable water and sanitation services (e.g., prohibitive legislation) ➔ Service providers to update existing business continuity and crisis management plans to include a pandemic scenario ➔ Governments to establish a standing multisectoral task force on disease monitoring and response that includes water service providers ➔ Researchers and service providers to study the application of wastewater-based epidemiology
Accelerated efforts to achieve universal access to sustainable water and sanitation	<ul style="list-style-type: none"> ➔ Governments, regulators, and service providers to include universal access as a strategic objective with measurable indicators ➔ Governments and funding institutions to ensure that adequate funding (capex and opex) is available for water service providers ➔ Service providers to craft a strategy to connect and service vulnerable and marginalized sectors ➔ Service providers to identify risks and opportunities for long-term resilience (e.g., climate change impact on legacy systems, supply chain disruptions) and promote resilience planning at all levels of operation and governance ➔ Service providers to explore new practices and technologies, including decentralization and nature-based solutions
Adoption of fit-for-purpose smart digital technologies	<ul style="list-style-type: none"> ➔ Researchers and service providers to evaluate the readiness and appropriateness of digitalization for each water service provider ➔ Service providers to explore and trial digital technologies that can deliver the desired operational and economic values ➔ Funding institutions and governments to support the development of bespoke digital solutions that can be deployed in context of developing member countries ➔ Governments to review legislation or regulatory guidelines that may hinder the adoption of smart practices and digital technologies, such as e-commerce or smart metering

Source: Asian Development Bank.

The succeeding sections discuss in more detail how ADB can support the above actions.

Lessons for ADB Crisis Response Support

ADB swiftly responded to support DMCs in the wake of the pandemic. As with many other multilateral development banks and international aid agencies, ADB's financial support aimed to provide fiscal stimulus for frontline healthcare measures, such as broadening COVID-19 testing capability and purchasing medical equipment. Nevertheless, some lessons can be gleaned from the COVID-19 experience that can improve ADB's crisis response support in the future.

Early identification of country risks and vulnerabilities is essential in crisis response preparedness and management. As such, a high-level mapping and identification of water sector risks for each DMC can be helpful. The International WaterCentre's COVID-19 Water Security Risk Index provides a baseline understanding of some of these risks. For example, by knowing that Timor-Leste has a relatively better ability to treat those in need than the ability to contain the spread of disease, funds and program support can be targeted toward improving

the latter. In contrast, Micronesia has better ability to delay pandemic spark and to recover postpandemic, but it has poor ability to contain the spread of disease and treat those in need. The support required by the two countries is therefore more nuanced, with funding for risk mitigation in some areas yielding more immediate benefits than others. Pre-identifying risks will make response times quicker and ADB's support can be made more targeted to country-specific needs. The objective should be to help governments address the most pressing risks that, if resolved, will enable them to move forward with resolving other risks. This is also the first step to designing effective coordination mechanisms between WASH and the health sector to systematically address risks faced by DMCs.

A high-level understanding of country risks can also help prepare against worst-case scenarios of multiple crises hitting DMCs at once. In October 2020, the Philippines was hit by a series of “super typhoons” that resulted in the influx of more than 345,000 people into dense and poorly serviced evacuation centers, posing significant risks in COVID-19 transmission. Disaster risk reduction and response under a pandemic scenario is made more challenging not only because of public health safety concerns, but also because local government resources are more thinly spread. The High-Level Experts and Leaders Panel on Water and Disasters (HELP) offers principles and practical guidance on addressing water-related disaster risk reduction under the COVID-19 pandemic.⁸⁶ Multiple crises are to be expected with climate change, at it is of vital importance to anticipate and understand the compounding risks.

Moreover, ADB must evaluate its internal processes and procedures to enable swift adjustments in all stages of project procurement, design, and implementation. Project preparation should consider potential risks and mitigations. Adopting digital technologies could add flexibility, such as by employing satellite imagery and analytics to replace site surveys. Finally, ADB may benchmark with other multilateral development banks to assess comparative advantages, niche areas of support and operations, and cooperation in times of worldwide crises.

Financing and Capacity Building

Delivering on ADB's Strategy 2030 and getting Asia and the Pacific back on track to achieving the SDGs, particularly SDG-6, will be a tall order, especially in DMCs where government budgets are spread thinly across many priorities. Hoy and Summer⁸⁷ further suggested that none of the best-case post-COVID-19 growth scenarios can pull off the “SDG hat-trick” of sustained economic growth, eliminating poverty, and significantly reducing inequality (footnote 87). They concluded that developing countries must pursue “historically unprecedented growth paths” to meet the poverty and inequality SDG targets. ADB suggested that green recovery strategies, including investments in water and sanitation, can deliver accelerated economic growth while protecting people and the planet.⁸⁸ The insights in this Guidance Note can be helpful in determining the priorities for the water sector, although each country or city must carefully assess their respective local contexts in crafting their respective strategies.

There is a need to step up investments to ensure that DMCs achieve universal access to quality water services, upgrade with digital technologies that enable smarter planning and operations, and enhance service providers' resilience. ADB survey respondents ranked the resumption of deferred capital works as the top priority that will

⁸⁶ HELP. <https://www.wateranddisaster.org/principles-to-address-water-related-disaster-risk-reduction-drr-under-the-covid-19-pandemic/>.

⁸⁷ C. Hoy and A. Summer. 2020. After COVID-19: how to pull off the SDG hat-trick? Center For Global Development. <https://www.cgdev.org/blog/after-covid-19-how-pull-sdg-hat-trick>.

⁸⁸ Asian Development Bank. 2020. *Green finance strategies for post-COVID-19 economic recovery in Southeast Asia: greening recoveries for people and planet*. doi:10.22617/TCS200267-2.

support their postpandemic and long-term recovery. Aside from providing funding through financial instruments such as loans, grants, and guarantees, ADB can help fill the investment gap by mobilizing private sector capital and other innovative financing strategies. In a new publication, ADB (2020) pushes for green recovery strategies in Southeast Asia which would require longer-term economic recovery packages (footnote 88). This includes a portfolio of measures that include government recovery packages, capital market instruments (e.g., green bonds), and catalytic mechanisms to de-risk green recovery projects. An example of an integrated plan for healthcare sector improvements, which include investments in water and sanitation, is shown in Figure 18.

As countries deal with pandemic recovery, ADB funding for holistic recovery that includes water sector financing and support remains critical. ADB's response has evolved since COVID-19 initially hit. For example, funding from the government of Japan enabled grant resources to deal with COVID-19 economic impacts which includes integrating WASH and health approaches at the regional level, addressing co-occurrence of natural disasters, and enabling behavior-centered design access to WASH. Sustainable and quality WASH services and sustained hygiene behaviors are fundamental toward building back better, even as ADB is ready to support countries in vaccine rollout.

Private sector investment is an important component of financing water sector recovery and rejuvenation through public-private partnerships (PPPs). Chronically underfunded service providers could explore PPPs, as in Japan's promotion of PPPs for rural municipalities and water utilities. However, countries with little or no prior experience with PPPs may not be as quick to adopt PPP arrangements to fund large-scale water and sanitation projects. Most governments have a supportive stance for some form of private sector participation in the

water sector,⁸⁹ which has led to experiments on hybrid and tailored PPP models and the growing importance of domestic companies as foreign players streamline and rationalize their international market participation. ADB must continue supporting private sector participation and investment in the water sector and co-leverage funds where applicable.

ADB's financing support must be coupled with capacity building at the subsector level. A number of the survey respondents indicated that capacity building is needed for planning future pandemic responses. ADB can support more robust planning for crisis preparedness, which must include pandemic scenarios, through capacity building of service providers.

BOX 15

Developing a Bespoke Innovation Framework for the Philippines and a Water Sector Roadmap for Australia and New Zealand

A bespoke innovation framework (shown below) was designed for the Philippine water and wastewater market by Metro Pacific Water, Maynilad Water Academy, and Isle Utilities, and implemented from 2015 to 2018 in partnership with the Philippine Water Association of Water Districts. The framework resulted in identification of 19 innovative technologies presented in four national summits. Four technologies were trialed addressing key market needs: holistic catchment monitoring, smart network pressure management, real-time online water quality monitoring, and innovative treatment. This process was supported by a capacity building forum where utility leaders acquired skills for planning and adopting technologies that are suited for their specific needs.

continued on next page

⁸⁹ O. Jensen. 2017. Public-private partnerships for water in Asia: a review of two decades of experience. *International Journal of Water Resources Development*. 33. pp. 4–30.

Box 15 continued

In November 2020, the Water Services Association of Australia in partnership with Isle Utilities and ThinkPlace launched the W-Lab Roadmap which presents the industry vision co-created with over 100 utilities. Four “Technology Showcase” areas were prioritized for piloting and business case development in the first year of the program. The W-Lab program will run until 2024 with an ambitious goal of trialing nine technologies per year.

Year 1 Showcase Areas

November 2020

Explore new markets
and recover value
from waste

March 2021

Limit our extraction
of freshwater
from the natural
environment

June 2021

Create insights from
data to inform our
decisions and share
with others

September 2021

Understand and
support the diverse
needs of our
customers

Sources: M. Bennett and C. Villa. 2020; Water Services Association of Australia. 2020.

Technology and Innovation

Service providers’ capabilities must be enhanced with the use of innovative, fit-for-purpose technologies. The specific needs of each country, city, and service provider will differ widely depending on context. The key to promoting technology adoption and innovation is to understand the bespoke needs of service providers to match them with value-adding technologies, or spur the development of new technologies that can deliver these values (Box 15 [footnote 73]).⁹⁰ Where the specific needs and integration opportunities are not well-defined, ADB can play an important role in helping service providers and other water-sector stakeholders craft bespoke roadmaps and strategies for technology innovation.

ADB already plays an important role in promoting technologies and de-risking innovation in the water sector. This includes open innovation competitions and startup support through ADB Ventures. These efforts have to be refined with our changing understanding of water sector needs and the rapid development of technology solutions. Investing in the right technological upgrades is key to navigating an increasingly uncertain future. For example, the ADB project to evaluate fit-for-purpose and appropriate asset management information system solutions for the United Water Supply Company of Georgia is a step toward sustainable and resilient asset management.

⁹⁰ Water Services Association of Australia. 2020. *W-Lab Technology Roadmap*.

Appendix A

Summary of Respondents to the ADB Survey

ADB administered two surveys to collect primary data from water service providers among DMCs. The service providers were grouped according to general similarities in technical and commercial operations. The first survey went out to water supply, sanitation, and wastewater service providers (WSSW survey). The second survey went out to water resources, irrigation, and drainage/stormwater management service providers (WRID survey).

A total of 25 responses were gathered for the WSSW survey. The various characteristics of the respondents are shown below.

Table A.1: Services Provided by WSSW Survey Respondents

Answer Choices (Can Choose More Than One)	Responses N = 25s	
Water supply: including treatment and distribution	96%	24
Sewerage and wastewater treatment	44%	11
Fecal sludge management: including sanitation services, desludging, septage collection and disposal or treatment	16%	4
Solid waste: General garbage collection, transport, and processing other than sludge generated from wastewater processing	12%	3

WSSW = water supply, sanitation, and wastewater service providers.

Source: Asian Development Bank.

Figure A.1: Population Served by WSSW Survey Respondents

WSSW = water supply, sanitation, and wastewater service providers.

Source: Asian Development Bank.

Figure A.2: Legal Nature of WSSW Survey Respondents

Source: Asian Development Bank.

Figure A.3: Geographic Areas of WSSW Survey Respondents

Source: Asian Development Bank.

A total of 12 responses were gathered for the WRID survey. The various characteristics of the respondents are shown in Table B.3. All respondents are government owned and operated (local/regional/national). Respondents manage a land area from 132 to 840 km².

Table A.2: Services Provided by WRID Survey Respondents

Answer Choices (Can Choose More Than One)	Responses N = 12	
Water resources or river basin management	58%	7
Irrigation and agricultural drainage	58%	7
Stormwater management and drainage	17%	2

WRID = water resources, irrigation, and drainage/stormwater management service providers.

Source: Asian Development Bank.

Figure A.4: Geographical Areas of WRID Survey Respondents

WRID = water resources, irrigation, and drainage/stormwater management service providers.

Source: Asian Development Bank.

Appendix B

Technical Note on SARS-CoV-2 and Water

This chapter discusses the nature of SARS-CoV-2, the virus that causes the COVID-19 disease, and its relationship with and persistence in water. Given this understanding, we also discuss various guidelines that inform the operational response measures of water service providers in terms of transmission prevention and containment.

A. Virological Background of SARS-CoV-2

In December 2019, the PRC reported an outbreak of pneumonia of unknown etiology in Wuhan, in Central PRC's Hubei Province to WHO.¹ Shotgun metagenomic sequencing of bronchoalveolar lavage samples indicated that this outbreak was associated with a novel coronavirus (nCoV).² The nCoV was confirmed to have 75%–80% nucleotide similarity to severe acute respiratory syndrome coronavirus (SARS-CoV) and was officially designated as SARS-CoV-2.³ Environmental monitoring has since shown that SARS-CoV-2 was already circulating in the human populations of Italy,⁴ the PRC, the USA,⁵ and Brazil⁶ in the second half of 2019.

SARS-CoV-2 belongs to the species *Severe acute respiratory syndrome-related coronavirus* in the subgenus *Sarbecovirus* of the family *Coronaviridae* that consists of a group of enveloped viruses with a single-stranded, positive-sense RNA genome. SARS-CoV (also called SARS-CoV-1) and SARS-CoV-2 are distantly related to Middle East Respiratory Syndrome coronavirus (MERS-CoV), which belongs to the species *Middle East respiratory syndrome-related coronavirus* within the genus *Betacoronavirus* (footnote 3). SARS-CoV-2 is also distantly related to “classical” human CoV strains (229E, OC43, NL63, and HKU1) belonging to the genus *Alphacoronavirus* or *Betacoronavirus* that have been studied since the 1960s and are estimated to cause 15%–30% of cases of common colds worldwide⁷ the respiratory epithelium is also composed of an elaborate network of dendritic cells (DCs. The older coronaviruses have emerged, caused epidemics, and then become endemic through a combination of humanity's response (learning how to prevent transmission of the viruses and treat the diseases they cause) and mutations in the viruses causing them to become less fatal. It is reasonable to expect SARS-CoV-2 to follow the same pattern and eventually become an endemic virus. It is not yet possible to predict how long it will take to achieve endemism, or whether or not it will become a seasonally affected virus.

¹ World Health Organization. 2020. Pneumonia of unknown cause – China. WHO. <https://www.who.int/csr/don/05-january-2020-pneumonia-of-unknown-cause-china/en/#.XvNdBy8Kebl.mendeley>.

² N. Zhu et al. 2020. A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*. 382. pp. 727–733.

³ A. E. Gorbalenya et al. 2020. The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nature Microbiology*. 5. pp. 536–544.

⁴ G. La Rosa et al. 2021. SARS-CoV-2 has been circulating in northern Italy since December 2019: evidence from environmental monitoring. *Science of the Total Environment*. 750. p. 141711.

⁵ Z. Du et al. 2020. Using the COVID-19 to influenza ratio to estimate early pandemic spread in Wuhan, China and Seattle, US. *EClinicalMedicine*. 26. p. 100479.

⁶ G. Fongaro et al. 2020. SARS-CoV-2 in human sewage in Santa Catalina, Brazil, November 2019. *medRxiv*. doi:10.1101/2020.06.26.20140731.

⁷ M. Mesel-Lemoine et al. 2012. A human coronavirus responsible for the common cold massively kills dendritic cells but not monocytes. *Journal of Virology*. 86. pp. 7577–7587.

The disease caused by SARS-CoV-2 is referred to as coronavirus disease 2019 (COVID-19). WHO declared the outbreak of COVID-19 a Public Health Emergency of International Concern on 31 January 2020.⁸ On 11 March 2020, WHO then declared the COVID-19 situation a global pandemic on the basis of “alarming levels of spread, severity, and inaction”.⁹

Both viable¹⁰ SARS-CoV-2 and viral RNA¹¹ are shed in bodily excreta, including saliva, sputum, and feces, which are often subsequently disposed of in wastewater and environmental waters. Thus SARS-CoV-2 enters the water cycle; treated and untreated wastewater is discharged via treatment works, septic systems, pit latrines, and open defecation into surface waters (rivers and lakes) and groundwater, which are the resources from which we abstract water for treatment to potable standards or for agricultural or recreational use (Figure B.1).

Although it is believed that the major transmission route of this virus is inhalation via person-to-person aerosol or droplet transmission, and fomite to hand contamination via droplets, untreated water and wastewater have a globally significant role as a potential source of epidemiological data, as demonstrated by its use in the monitoring and control of other viral diseases such as polio¹² and as a factor in public health risk. The viability of SARS-CoV-2 virions in surface water, wastewater, and groundwater has not yet been established with certainty, but Rimoldi et al. (footnote 5 of main text) virus presence and infectivity in treated wastewaters,

⁸ World Health Organization. 2020. Statement on the meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). [https://www.who.int/news-room/detail/23-01-2020-statement-on-the-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/23-01-2020-statement-on-the-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)).

⁹ J. Bedford et al. 2020. COVID-19: towards controlling of a pandemic. *Lancet*. 395, pp. 1015–1018.

¹⁰ Viable SARS-CoV-2 is virus that is capable of causing infection.

¹¹ The RNA of the virus. This simply indicates that SARS-CoV-2 is or was present, and does not tell you whether viable virus is in the water.

¹² World Health Organization. 2003. Guidelines for environmental surveillance of poliovirus circulation. vol. 03.

but also in the receiving water bodies are still poorly investigated. In this study, raw and treated samples from three wastewater treatment plants, and three river samples within the Milano Metropolitan Area, Italy, were surveyed for SARS-CoV-2 RNA detection by means of real time RT-PCR and infectivity test on culture cells. SARS-CoV-2 RNA was detected in raw, but not in treated wastewaters (four and two samples, respectively, sampled in two dates demonstrated that viral RNA was detectable in the inflow but not the outflow of WWTW, and that although viral RNA was also present in rivers where uncontrolled sewage overflows or inefficient treatment works discharged, the SARS-CoV-2 infectivity was zero, both in treated and untreated wastewater and river water. The sample size is small and therefore a precautionary approach in the assessment of contagious risk is advocated until more data have been generated.

Until 2020, few researchers were working on respiratory viruses in water because the fecal–oral route has not previously been considered a significant route of transmission. Since March 2020 there has been an avalanche of academic research on SARS-CoV-2 in water (Figure B.2), a topic which is still only in its first stages of study.

The survival of other coronaviruses in water depends on a number of factors, including temperature, light exposure (solar or UV inactivation), organic matter (viruses can adsorb onto particles of organic matter, affecting settling behavior or light shielding), and the presence of antagonist microorganisms (increasing the extent of inactivation).

Figure B.2: A Pictorial History of Coronavirus Research in Water and Wastewater Environments

Note: Gray text indicates preprints, i.e., articles that have not yet been reviewed.

Source: M. Kitajima et al. 2020. SARS-CoV-2 in wastewater: state of the knowledge and research needs. *Science of the Total Environment*. 739. p. 139076.

B. SARS-CoV-2 and Related CoVs in Water Systems

Coronaviruses find their way into drinking water distribution systems when drinking water supplies are abstracted from virus-laden water resources and are either used without treatment or are treated in ineffective water treatment works, especially where a lower concentration of residual disinfectant (e.g., chlorine and other chemical oxidant disinfection) is detected in the system; their viral stability could be maintained by colonizing bacteria in biofilms in distribution systems and they could enter individual homes. There could be risks of aerosolization of coronavirus-containing droplets from shower heads when individuals take showers at home. This aerosol-human transmission pathway is believed to be important for human exposure to *Legionella pneumophila* from drinking water in residential homes.

Owing to concerns about SARS-CoV-2 water pollution, North Korea recently started to monitor surface water used as sources of drinking water, as recently announced in newspapers by the Korean government-funded news agency.¹³ However, preliminary knowledge published by Rimoldi et al. (footnote 5 of main text) suggests that this may be advisable rather than essential.

The disinfection steps in both drinking water treatment plants and WWTW and the associated regulatory requirements have been developed to inactivate a broad spectrum of pathogens, including coronaviruses. The recent COVID-19 outbreak highlights the importance of disinfection to protect public health. Currently available data on the survival of coronaviruses in water show that SARS-CoV-2 is deactivated by contact with soaps and many disinfectants in a matter of seconds. Because SARS-CoV-1 is more vulnerable to disinfectants than the standard indicator organism used to determine whether the disinfection of water has been successful (*Escherichia coli*), and since SARS-CoV-2 is an extremely closely related coronavirus, it is reasonable to expect that disinfection that removes *E. coli* also removes SARS-CoV-2. Overall, these results suggest that previous data on CoVs are likely to be useful for informing the environmental persistence of SARS-CoV-2, and that SARS-CoV-2 is likely rapidly inactivated under increased temperature (e.g., Pasteurization, autoclaving, or boiling) and by commonly used disinfectants. Multiple barriers used in drinking water treatment plants¹⁴ should remove SARS-CoV-2 to levels below the limit of detection (LOD). SARS-CoV-2 can be detected using culture techniques (where samples of water are taken and an attempt is made to grow the virus in a laboratory) or using molecular biology techniques to detect the RNA of the virus. Levels below the LOD simply mean there is either not enough culturable virus in the sample or not enough RNA. Levels below LOD do not guarantee there is no risk of transmission, but they do indicate that the risk is extremely low.

Chin et al. (footnote 6 of main text) NIH (USA) reported on the disinfection of SARS-CoV-2 and identified a high temperature dependence of the inactivation kinetics, and rapid removal of the virus using bleach, ethanol, benzylalkonium chloride, povidone-iodine, and chloroxylenol. A number of existing disinfectant products have been approved by the United States Environmental Protection Agency (USEPA) for use against SARS-CoV-2 on hands, fomites, and in water.¹⁵ The risk posed to human health by properly disinfected drinking water is negligible. As yet, the guidelines for protecting water treatment plant personnel all state that no additional precautions are needed over and above normal good practice.

¹³ K. N. Byung-joon. 2020. Korea to examine drinking water sources to ward off coronavirus. *Yonhap News Agency*.

¹⁴ The multibarrier approach to potable water treatment means the use of an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap to reduce risks to public health. The approach recognizes that while each individual barrier may not be able to completely remove or prevent contamination, the barriers work together to provide assurance that the water will be safe to drink over the long term.

¹⁵ USEPA. 2020. List N: Disinfectants for use against SARS-CoV-2 (COVID-19). <https://www.epa.gov/pesticide-registration/list-ndisinfectants-use-against-sars-cov-2-covid-19>.

C. SARS-CoV-2 and Related CoVs in Wastewater

Given the rapid emergence of SARS-CoV-2, previous studies on human CoVs, SARS-CoV, MERS-CoV, and surrogate viruses can help to inform predictions of the likely environmental fate and subsequent risks of SARS-CoV-2 while reliable data on SARS-CoV-2 itself are being generated.

Current knowledge on the presence of CoVs in wastewater is limited, due to the lack of previous environmental investigations focusing on CoVs (environmental investigations have historically focused on enteric viruses with proven fecal-oral transmission). Because CoVs are an enveloped virus that are thought to be primarily spread via person-to-person contact rather than the fecal-oral route (which has been postulated but not confirmed), their presence in feces requires careful interpretation.

Human CoVs are known to replicate in the gastrointestinal tract and cause gastrointestinal symptoms, including diarrhea, in 2%–10% of COVID-19 patients.¹⁶ The SARS-CoV RNA loads could be as high as 10^7 copies/mL in diarrhea and 2.5×10^4 copies/mL in urine.¹⁷ Positive isolation of RNA from feces persisted in 23% of COVID-19 patients even after it disappeared from the respiratory tract.¹⁸

Some clinical studies reported prolonged fecal shedding of SARS-CoV-2 RNA for up to seven weeks after first symptom onset¹⁹ and another study reported that viral RNA could be detected in the feces of ~82% of cases even with a negative throat swab result.²⁰

Recent reports implied that 17%–30% of infected individuals are asymptomatic,²¹ and SARS-CoV-2 RNA was detected in the feces of asymptomatic individuals as well.²²

Environmental surveillance by testing of wastewater for evidence of pathogens has a long history of use in public health, particularly for poliovirus and more recently AMR. In the context of the ongoing COVID-19 pandemic, it is being used for the detection of SARS-CoV-2 shed into wastewater from bodily excretions.

The presence of CoV RNA in wastewater is now in widespread use in WBE, i.e., as a disease surveillance tool (footnote 10 of main text) due to the RNA being detected in wastewater approximately 7–10 days before the first clinical cases present themselves (footnote 10 of main text) the etiologic agent of the ongoing COVID-19 pandemic, is accompanied by the shedding of the virus in stool. Therefore, the quantification of SARS-CoV-2 in wastewater affords the ability to monitor the prevalence of infections among the population via wastewater-

¹⁶ Q. Y. Gao et al. 2020. 2019 Novel coronavirus infection and gastrointestinal tract. *Journal of Digestive Diseases*. 21. pp. 125–126; J. Zhou et al. 2017. Human intestinal tract serves as an alternative infection route for Middle East respiratory syndrome coronavirus. *Science Advances*. 3. p. eaao4966; N. Chen et al. 2020. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 395. pp. 507–513; Y. Zhang et al. 2020. Isolation of 2019-nCoV from a stool specimen of a laboratory-confirmed case of the coronavirus disease 2019 (COVID-19). *China CDC Weekly*. 2. pp. 123–124; D. Wang et al. 2020. Detection of SARS-CoV-2 in different types of clinical specimens. *Journal of the American Medical Association*. 323. pp. 1061–1069.

¹⁷ I. F. N. Hung et al. 2004. Viral loads in clinical specimens and SARS manifestations. *Emerging Infectious Diseases*. 10. pp. 1550–1557.

¹⁸ F. Xiao et al. 2020. Evidence for gastrointestinal infection of SARS-CoV-2. *Gastroenterology*. 158. pp. 1831–1833.e3.

¹⁹ J. Cai et al. 2020. A case series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clinical Infectious Diseases*. 71. pp. 1547–1551. doi:10.1093/cid/ciaa198; Y. Wu et al. 2020. Prolonged presence of SARS-CoV-2 viral RNA in faecal samples. *Lancet Gastroenterology and Hepatology*. 5. pp. 434–435.

²⁰ Y. Ling et al. 2020. Persistence and clearance of viral RNA in 2019 novel coronavirus disease rehabilitation patients. *Chinese Medical Journal*. 133. pp. 1039–1043.

²¹ K. Mizumoto et al. 2020. Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. *Eurosurveillance*. 25. pp. 1–5; H. Nishiura et al. 2020. Estimation of the asymptomatic ratio of novel coronavirus infections (COVID-19). *International Journal of Infectious Diseases*. 94. pp. 154–155.

²² A. Tang et al. 2020. Detection of novel coronavirus by RT-PCR in stool specimen from asymptomatic child, China. *Emerging Infectious Diseases*. 26. pp. 1337–1339.

based epidemiology (WBE). These studies reported the detection of SARS-CoV-2 RNA in untreated wastewater with maximum concentrations over 1000 copies/mL.

At least one country, the Netherlands, plans to incorporate daily sewage surveillance into its national COVID-19 monitoring. A similar approach to using environmental surveillance as part of the routine COVID-19 surveillance package is being studied in Germany and has been initiated in Australia and New Zealand (footnote 10 of main text).

Scientists in the PRC, the Netherlands, and France have calculated the correlations between wastewater SARS-CoV-2 RNA concentrations and COVID-19 clinical case reports (i.e., the number of symptomatic COVID-19 patients that have presented themselves in healthcare facilities); however, the amounts of virus being detected in wastewater are much higher than expected from clinically confirmed cases and highly variable, therefore the correlations cannot yet be relied upon (footnote 10 of main text).

This is at least in part because the WBE reports have used four different virus concentration methods and seven different quantitative polymerase chain reaction (qPCR) assays, making the detection results difficult to compare between studies with confidence. Beyond these initial reports, continuous monitoring of SARS-CoV-2 in wastewater in multiple geographical regions is underway. Because the rising copies of RNA in wastewater precede the onset of symptoms by several days, it is intended that WBE can be used for localized, preemptive lockdowns and as an early warning system to allow local healthcare facilities some time to prepare. However, before these approaches can be perfected humankind needs to understand the relationship between numbers of copies of RNA and numbers of patients, which have not yet been established because of the effects of interacting variables such as rainwater dilution and sampling and analysis methods that are so new that they have not been standardized.

Laboratories with sufficient biosafety measures in place to be permitted to work with human pathogens are rare and expensive to maintain. Identifying a nonpathogenic virus which is a close model of the pathogen makes it possible for many more laboratories and universities to work on the problems posed by the pathogen, and advances humanity's knowledge much more quickly. Ahmed et al. published a paper in June 2020²³ that demonstrated that the murine hepatitis virus (MHV), which infects mice but not humans, is an accurate surrogate for SARS-CoV-2, and that out of seven virus concentration methods evaluated to recover CoV from wastewater (Figure 25), the most reliable and consistent two were adsorption-extraction with $MgCl_2$ pretreatment and adsorption-extraction without pretreatment. In August, the same researchers published work that showed that the decay rates of SARS-CoV-2 and MHV were similar enough in different water and wastewater matrices, temperatures, and other conditions to enable the use of MHV for WBE studies.²⁴

²³ W. Ahmed et al. 2020. Comparison of virus concentration methods for the RT-qPCR-based recovery of murine hepatitis virus, a surrogate for SARS-CoV-2 from untreated wastewater. *Science of the Total Environment*. 739. p. 139960.

²⁴ W. Ahmed et al. 2020. Decay of SARS-CoV-2 and surrogate murine hepatitis virus RNA in untreated wastewater to inform application in wastewater-based epidemiology. *Environmental Research*. 191. p. 110092.

Figure B.3: Seven Virus Concentration Methods Evaluated to Recover CoV from Wastewater

Note: Methods B and C had been the most reliable. They are now being adopted as the global standard methods.

Source: W. Ahmed et al. 2020. Comparison of virus concentration methods for the RT-qPCR-based recovery of murine hepatitis virus, a surrogate for SARS-CoV-2 from untreated wastewater. *Science of the Total Environment*. 739. p. 139960.

Although two studies demonstrated the presence of culturable SARS-CoV-2 in fecal samples from COVID-19 patients (footnote 16) a more recent study reported that culturable virus was not isolated from feces despite high viral RNA concentrations.²⁵ Initial outbreaks in China involved 13.8% of cases with severe courses, and 6.1% of cases with critical courses. This severe presentation may result from the virus using a virus receptor that is expressed predominantly in the lung; the same receptor tropism is thought to have determined the pathogenicity—but also aided in the control—of severe acute respiratory syndrome (SARS. This discrepancy could be due to differences in protocols for virus isolation from feces between laboratories, such as pretreatment method, cell lines, and number of blind passages, as viruses shed in feces are generally fastidious, meaning that they have complex or particular nutritional requirements and are therefore difficult to culture in the laboratory. The use of a recently reported engineered cell line that is highly susceptible to SARS-CoV-2 may enable enhanced virus isolation from feces.²⁶ Further research is needed to determine the concentrations of culturable virus particles, if any, in feces of presymptomatic, symptomatic, and asymptomatic individuals with SARS-CoV-2 infection.

A technical brief issued by WHO on 5 August 2020²⁷ that suggested that there is no evidence of survival of SARS-CoV-2 in wastewater includes the sentence “To date, no infectious SARS-CoV-2 virus has been recovered from untreated or treated sewage;” however, three studies have cultured live, infectious SARS-CoV-2 from stool

²⁵ R. Wölfel et al. 2020. Virological assessment of hospitalized patients with COVID-2019. *Nature*. 581. pp. 465–469.

²⁶ S. Matsuyama et al. 2020. Enhanced isolation of SARS-CoV-2 by TMPRSS2-expressing cells. *Proceedings of the National Academy of Sciences USA*. 117. pp. 7001–7003.

²⁷ World Health Organization. 2020. Status of environmental surveillance for SARS-CoV-2 virus. <https://www.who.int/publications/i/item/WHO-2019-nCoV-sci-brief-environmentalSampling-2020-1>.

specimens (footnote 18).²⁸ Regardless, it is likely that enveloped CoVs are less stable in the environment and are more susceptible to chlorine, pH, and temperature than nonenveloped enteric viruses,²⁹ and this hypothesis is supported by Rimoldi (footnote 5 of main text) who showed that no viable SARS-CoV-2 virions survived wastewater treatment processes nor could they be found in river water containing untreated sewage.

In WWTW, virions can be removed through physical, biological, and chemical processes (Figure 26). Wastewater first undergoes primary treatment where removal of viruses by sedimentation alone is low.³⁰ Secondary (biological) treatment combines aeration tanks with secondary sedimentation to retain the activated sludge. Virus sorption to organic particulates and removal by settling is thought to play an essential role in these secondary treatment steps.³¹ Treatment approaches that maximize retention and removal of solids (for example, membrane bioreactors) have been recommended as particularly effective means to remove viral loads from wastewater.³² Enveloped viruses are likely to be removed together with organic particles.³³ Additionally, extracellular enzymes such as hydrolases and proteases present in the concentrated bacterial consortia characteristic of secondary bioreactors are also likely to inactivate SARS-CoVs, similarly to other viruses (footnotes 31, 32, and 33).

Figure B.4: Secondary Biological Treatment Supports Enzymatic Degradation of Organic Material, Including Viruses

Notes: SARS-CoVs that were not removed by settling will likely aggregate with suspended organic material (OM) and be transported in primary and secondary effluent. Secondary effluent can be (a) directly discharged to surface waters or (b) disinfected prior to discharge. Alternatively, secondary effluent can be further treated with (c) advanced oxidation processes (AOP) such as ozone or ultraviolet (UV) light and (d) filtration via different membrane systems such as ultrafiltration (UF); for example, with UF or in a membrane bioreactor (MBR) for reuse applications¹⁰⁹.

Source: A. Bogler et al. 2020.

²⁸ F. Xiao et al. 2020. Infectious SARS-CoV-2 in feces of patient with severe COVID-19. *Emerging Infectious Diseases*. 26, 1920–1922.

²⁹ World Health Organization. 2020. Water, sanitation, hygiene and waste management for the COVID-19 virus.

³⁰ C. J. Hurst and C. P. Gerba. 1989. Fate of viruses during wastewater sludge treatment processes. *Critical Reviews in Environmental Science and Technology*. 18, pp. 317–343.

³¹ R. M. Chaudhry et al. 2015. Mechanisms of pathogenic virus removal in a full-scale membrane bioreactor. *Environmental Science and Technology*. 49, pp. 2815–2822.

³² W. Lv et al. 2006. Virus removal performance and mechanism of a submerged membrane bioreactor. *Process Biochemistry*. 41, pp. 299–304.

³³ Y. Ye et al. 2016. Survivability, partitioning, and recovery of enveloped viruses in untreated municipal wastewater. *Environmental Science and Technology*. 50, pp. 5077–5085; P. M. Gundy et al. 2009. Survival of coronaviruses in water and wastewater. *Food and Environmental Virology*. 1, pp. 10–14.

Therefore, conventional tertiary wastewater treatment processes inactivate SARS-CoV-2. Free chlorine is more effective in inactivating SARS-CoV than chlorine dioxide. Free residual chlorine of >0.5 mg/L or chlorine dioxide of 2.19 mg/L in wastewater is sufficient for the complete removal of SARS-CoV.³⁴ Wastewater treatment plant operators do not need to take additional precautions beyond normal biohazard good practice.

The formation of wastewater aerosols and droplets was confirmed as a key mechanism for fecal–droplet–respiration transmission during the SARS-CoV-1 outbreak, and is suspected in the current SARS-CoV-2 outbreak.³⁵ Aerosolized human CoV (HCoV 229E) has been found to be infective for up to 6 days at 25°C in 50% humidity, and is suspected to be infective for even longer periods at 6°C.³⁶ SARS-CoV-2 remains viable in aerosols for up to 16 hours with a median half-life of approximately 1 hour.³⁷ Although dispersal of larger droplets is limited, as they deposit close to the source, larger droplets cause local contamination of surfaces due to their enhanced capacity to carry pathogens, and are a vector for pathogen transmission, including SARS-CoV-2.³⁸

WWTW operators must follow standard practices to limit exposure to wastewater and contaminated surfaces, thus reducing the risk of exposure to pathogens, such as SARS-CoV-2.³⁹ Although no analysis of aerosolized SARS-CoV-2 within WWTW has been reported, aerosol formation during aerated treatment such as oxidation ditches and conventional activated sludge processes could pose a risk to WWTW operators and facilitate dissemination, especially for WWTW in densely populated areas. This pathway has been observed for other enteric viruses and bacteria.⁴⁰ Non-potable reuse of partially treated wastewater or graywater systems that generate aerosols (e.g., cooling towers and sprinklers) as well as decorative structures such as fountains must ensure sufficient treatment to avoid infection pathways beyond WWTW.

Concentrating SARS-CoVs in the sludge may pose the subsequent problem of sludge treatment and disposal (footnote 30), particularly when that sludge is applied to agricultural land.

D. SARS-CoV-2 and Related CoVs in Environmental Waters

Fecal contamination of water supplies has been historically recognized as a risk for human health: environmental water can provide a vehicle for pathogen spread, creating the conditions for outbreaks or sporadic cases of infection. Human pathogenic viruses and bacteria are often detected in water environments and are deemed responsible for a considerable proportion of waterborne diseases.

Survival of SARS-CoV-2 in environmental media including groundwater, canals, rivers, and lakes remains mostly unknown, since there has only been one study into viability of the virus in such media. Preceding CoVs

³⁴ X. W. Wang et al. 2005. Study on the resistance of severe acute respiratory syndrome-associated coronavirus. *Journal of Virological Methods*. 126, pp. 171–177.

³⁵ I. T. S. Yu et al. 2004. Evidence of airborne transmission of the Severe Acute Respiratory Syndrome Virus. *New England Journal of Medicine*. 350, pp. 1731–1739; M. Gormley et al. 2020. COVID-19: mitigating transmission via wastewater plumbing systems. *Lancet Global Health*. 8, p. e643; Z. Ding et al. 2020. Toilets dominate environmental detection of SARS-CoV-2 virus in a hospital. doi:10.1101/2020.04.03.20052175.

³⁶ M. K. Ijaz et al. 1985. Survival characteristics of airborne human coronavirus 229E. *Journal of General Virology*. 66, pp. 2743–2748.

³⁷ N. van Doremalen. 2010. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine*. 382, pp. 1564–1567; A. Fears et al. 2020. Comparative dynamic aerosol efficiencies of three emergent coronaviruses and the unusual persistence of SARS-CoV-2 in aerosol suspensions. *medRxiv*. doi: 10.1101/2020.04.13.20063784.

³⁸ J. Barker and M. V. Jones. 2005. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. *Journal of Applied Microbiology*. 99, pp. 339–347.

³⁹ J. W. Zabinski et al. 2018. A Bayesian belief network model assessing the risk to wastewater workers of contracting Ebola virus disease during an outbreak. *Risk Analysis*. 38, pp. 376–391.

⁴⁰ E. Brisebois et al. 2018. Human viral pathogens are pervasive in wastewater treatment center aerosols. *Journal of Environmental Sciences*. 67, pp. 45–53; K. Lin and L. C. Marr. 2017. Aerosolization of Ebola virus surrogates in wastewater systems. *Environmental Science and Technology*. 51, pp. 2669–2675.

have also been shown to occur in waters polluted by untreated wastewater.⁴¹ Older data suggest that other coronaviruses remain infectious in water environments for days to weeks, depending on temperature and other physico-chemical factors.⁴² Casanova et al.⁴³ determined the persistence of two surrogate CoVs, transmissible gastroenteritis virus, and MHV in lake water in North Carolina, USA. The persistence of SARS-CoV-2 needs to be determined in environmental waters for tropical, subtropical, and temperate climatic zones as it may be highly variable in different temperatures, as demonstrated in a recent study.⁴⁴ Ahmed et al. (footnote 24) investigated the decay of RNA from SARS CoV-2 and MHV in untreated wastewater, autoclaved wastewater, and dechlorinated tap water stored at 4, 15, 25, and 37°C. Temperature, then matrix type, most greatly influenced SARS CoV 2 RNA first-order decay rates (k). The average times required for 1 log₁₀ reduction for RNA of SARS-CoV-2 and MHV at comparable temperatures did not significantly differ, indicating that the earlier work by Casanova et al. (footnote 43) is relevant. However, it is important to note that the absolute data reported by Ahmed et al. (footnote 24) relate to RNA decay and offer no information on survival and viability of infectious virions. The persistence of SARS-CoV-2 in receiving water and inactivation mechanisms, such as predation, UV, and sunlight still need to be investigated.

In the meantime, it can be assumed that water bodies into which secondary or tertiary treated wastewater is discharged should not be at elevated risk, because standard sewage treatment processes, if operating effectively, destroy SARS-CoV-2 virions and only the noninfective RNA fragments remain in the wastewater. SARS-CoV in wastewater could be inactivated completely with chlorine (10 mg/L for 10 min; free residue chlorine 0.4 mg/L) or chlorine dioxide (40 mg/L for 30 min; free residue chlorine 2.19 mg/L) (footnote 34). This was discussed in the previous section. Environmental water polluted by untreated or primary treated sewage should be assumed to be a health risk.

E. SARS-CoV-2 and Related CoVs in Irrigated Agriculture

Recent evidence of SARS-CoV-2 RNA in wastewater (footnote 10 of main text) indicates possible risks associated with wastewater reuse for agriculture. Irrigation of fruit and vegetables with contaminated wastewater effluent may serve as an indirect transmission pathway for SARS-CoVs through handling or consumption of contaminated food.⁴⁵ This may be especially relevant for technologies that do not apply the water directly to the root zone (e.g., drip irrigation), such as surface or sprinkler irrigation. As stated above, aerosolized viruses may be generated and transported locally during irrigation and fertilization using partially treated wastewater (footnotes 35, 40, and 45).⁴⁶

Although foodborne transmission of SARS-CoV-2 has not been documented, similar viruses are known to be transmitted by foodborne pathways following irrigation with treated wastewater.⁴⁷ Bovine CoV, which is very similar to SARS-CoVs, remains infective on lettuce leaves for the entire shelf-life of the lettuce (at least 14 days) (footnote 47) and human CoV 229E on lettuce only declined by 0.2 log₁₀ after two days of storage at 4°C

⁴¹ K. R. Wigginton et al. 2015. Emerging investigators series: The source and fate of pandemic viruses in the urban water cycle. *Environmental Science: Water Research and Technology*. 1. pp. 735–746.

⁴² A. Pratelli. 2008. Canine coronavirus inactivation with physical and chemical agents. *Veterinary Journal*. 177. pp. 71–79.

⁴³ L. Casanova et al. 2009. Survival of surrogate coronaviruses in water. *Water Research*. 43. pp. 1893–1898.

⁴⁴ O. E. Hart and R. U. Halden. 2020. Computational analysis of SARS-CoV-2/COVID-19 surveillance by wastewater-based epidemiology locally and globally: Feasibility, economy, opportunities and challenges. *Science of the Total Environment*. 730. p. 138875.

⁴⁵ A. A. Adegoke et al. 2018. Epidemiological evidence and health risks associated with agricultural reuse of partially treated and untreated wastewater: a review. *Frontiers in Public Health*. 6. pp. 1–20; S. K. Dickin et al. 2016. A review of health risks and pathways for exposure to wastewater use in agriculture. *Environmental Health Perspectives*. 124. pp. 900–909.

⁴⁶ D. Courault et al. 2017. Assessment and risk modeling of airborne enteric viruses emitted from wastewater reused for irrigation. *Science of the Total Environment*. 592. pp. 512–526.

⁴⁷ L. Mullis et al. 2012. Stability of bovine coronavirus on lettuce surfaces under household refrigeration conditions. *Food Microbiology*. 30. pp. 180–186; M. S. Yépez-Gómez et al. 2013. Survival of respiratory viruses on fresh produce. *Food and Environmental Virology*. 5. pp. 150–156.

(footnote 47). Moreover, washing produce does not completely eliminate virions (footnote 47). Thus, especially during a large SARS-CoV-2 outbreak in areas without adequate sanitation, the connection of fecal–waterborne–foodborne transmission through irrigation with wastewater can be an important dissemination pathway. Additionally, sprinkler irrigation with wastewater and fertilization with wastewater solids generates considerable aerosols. These aerosols are often dispersed at regional scales (footnote 45), which is especially important for farm workers and potentially relevant where agricultural and populated areas are in relatively close proximity. Transmission of SARS-CoV-2 via waterborne–foodborne or waterborne–aerosolized pathways during an outbreak can be minimized by disinfection prior to wastewater reuse, emphasizing the importance of standards for safe wastewater reuse.

F. Guidelines for Water Sector Organizations

This section summarizes the mainstream guidance published for the water sector, including the issuing organization and the date of issue.

Protection of Personnel Working with Untreated Water

Only a small number of publications have addressed this topic, because of preexisting guidelines for protection of staff from other viruses, including other pathogenic coronaviruses and enteric (waterborne) viruses which are more dangerous than SARS-CoV-2. The Water Environment Federation updated their guidance in August 2020 to add SARS-CoV-2 to the list of pathogens encompassed by the advice provided.

Table B.1: Guidelines for Protection of Workers Exposed to Raw Water and Wastewater

Title	Publisher	Date	Ref.
Protecting Wastewater Workers from Disease Risks: Personal Protective Equipment Guidelines	Water Environment Federation	Apr 2019	159 ^a
COVID-19 Control and Prevention	US Occupational Safety and Health Administration	Apr 2020	160 ^b
Getting Your Workplace Ready for COVID-19	WHO	Mar 2020	161 ^c
Protecting Wastewater Professionals From COVID-19 and Other Biological Hazards	Water Environment Federation	Aug 2020	162 ^d

^a M. W. LeChevallier et al. 2020. Protecting wastewater workers from disease risks: Personal protective equipment guidelines. *Water Environment Research*. 92. pp. 524–533.

^b Occupational Safety and Health Administration USA. 2020. COVID-19 Control and Prevention. <https://www.osha.gov/SLTC/covid-19/controlprevention.html#solidwaste>.

^c World Health Organization. 2020. Getting your workplace ready for COVID-19. World Health Organization. <https://www.who.int/docs/default-source/coronaviruse/getting-workplace-ready-for-covid-19.pdf>.

^d Water Environment Federation. 2020. Protecting Wastewater Professionals from COVID-19 and other Biological Hazards. Water Environment Federation.

Source: Asian Development Bank.

The Department of Health of the Philippines and the CDC in the USA both stated in conversation in the Isle Utilities COVID-19 Response Platform in April 2020 that no additional measures are required for personnel at risk of infection from raw water or wastewater beyond the previously recommended occupational hygiene for their operational conditions. The US Occupational Safety and Health Administration expressed the same advice and also stated “there is no evidence to suggest that additional, COVID-19-specific protections are needed for employees involved in wastewater management operations, including those at wastewater treatment facilities (footnote b).

In addition, general operating guidelines have been published, such as the USEPA's web page, Water Utility Resources for the COVID-19 Pandemic,⁴⁸ and the Water Environment Federation's page, Current Priority: Coronavirus,⁴⁹ which cover the following topics:

- ➔ System operations
- ➔ Laboratory capacity
- ➔ Funding and financing
- ➔ Pandemic incident action checklist

Information on maintaining or restoring water quality in buildings with low or no use.

Water, Sanitation, and Hygiene Guidelines

Guidance for the broader population on WASH and water-related risk in managing COVID-19 has been provided by numerous organizations (Table A.2).

There are other, more general guides and advice pieces available such as the US Department of Homeland Security Science and Technology Directorate's Master Question List for COVID-19 (caused by SARS-CoV-2)⁵⁰, which is updated weekly⁵¹ and summarizes what is known and what information is needed to answer questions like "How long does the virus persist in the environment?".

Sanitation and Water for All have also produced a collection of resources on their web page Resources on COVID-19 and WASH⁵², where they have also provided public education and communications tools for WASH service providers to use freely.

Table B.2: Summary of WASH-Related Guides Published Since the Beginning of the Pandemic

Title	Publisher	Date	Ref.
Water, Sanitation, Hygiene, and Waste Management for SARS-CoV-2, the Virus That Causes COVID-19. Interim Guidance	World Health Organization (WHO)	29 Jul 2020	166 ^a
Coronavirus and Drinking Water and Wastewater	United States Environmental Protection Agency (USEPA)	9 Jun 2020	167 ^b
List N: Disinfectants for Use Against SARS-CoV-2 (COVID-19)	USEPA	Apr 2020, updated 20 Aug 2020	113 ^c
Scientific Brief on the Status of Environmental Surveillance for SARS-CoV-2 Virus	WHO	5 Aug 2020	131 ^d
Water, Sanitation, Hygiene, and Waste Management for the COVID-19 Virus	WHO	23 Apr 2020	133 ^e
Fact Sheet: Safe Management of Water Supplies During COVID-19 Outbreak	Water Research Commission (WRC)	27 Mar 2020	168 ^f

continued on next page

⁴⁸ USEPA. 2020. Water Utility Resources for the COVID-19 Pandemic. <https://www.epa.gov/coronavirus/water-utility-resources/covid-19-pandemic>.

⁴⁹ Water Environment Federation. 2020. Current Priority: Coronavirus. <https://www.wef.org/news-hub/current-priorities/coronavirus/#watersector>.

⁵⁰ US DHS. <https://www.dhs.gov/publication/st-master-question-list-covid-19>.

⁵¹ US Department of Homeland Security – Science and Technology Directorate. 2020. Master Question List for COVID-19 (caused by SARS-CoV-2). <https://www.dhs.gov/publication/st-master-question-list-covid-19>.

⁵² SWA. <https://sanitationandwaterforall.org/about/about-us/water-sanitation-hygiene/covid-19-and-wash>.

Table B.2 continued

Title	Publisher	Date	Ref.
COVID-19 Precautionary Measures	WRC	27 Mar 2020	169 ^g
COVID-19 and Sanitation: What Do We Know and Measures to Limit Disease Transmission	WRC	27 Mar 2020	170 ^h
Coronaviruses in Water and Risk of Infection	WRC	27 Mar 2020	171 ⁱ
Waterborne Diseases – Managing Risks of Infection and Responses to Outbreaks	WRC	27 Mar 2020	172 ^j
COVID-19 Fact Sheet	Water Services Association of Australia (WSAA)	2 Apr 2020	173 ^k
Fact Sheet: COVID-19 and Wastewater	WSAA	15 Apr 2020	174 ^l
Fact Sheet: The COVID-19 Virus – Water, Sanitation and Wastewater Management	Global Water Research Coalition	26 May 2020	175 ^m

^a World Health Organization. 2020. Water, sanitation, hygiene, and waste management for SARS-CoV-2, the virus that causes COVID-19. Interim guidance. 11.

^b USEPA. 2020. Coronavirus and drinking water and wastewater. <https://www.epa.gov/coronavirus/coronavirus-and-drinkingwater-and-wastewater>.

^c Asian Development Bank. 2020. Ensuring reliable water service in Viet Nam through digital technology. <https://www.adb.org/news/videos/ensuring-reliable-water-service-viet-nam-through-digital-technology>.

^d Public Water and COVID-19: Dark Clouds and Silver Linings. (Municipal Service Project (Kingston), Transnational Institute (Amsterdam) and Latin American Council of Social Sciences (CLACSO) (Buenos Aires), 2020).

^e P. Waalewijnkarin et al. 2020. Examining the pandemic's impact on the irrigation and drainage sector and opportunities for recovery. World Bank Blogs <https://blogs.worldbank.org/water/examining-pandemics-impact-irrigation-and-drainage-sector-and-opportunities-recovery>.

^f N. Kalebaila. 2020. Safe management of water supplies during COVID-19 outbreak.

^g T. G. Barnard. 2020. COVID-19 precautionary measures.

^h S. Pillay. COVID-19 & sanitation what do we know & measures to limit disease transmission.

ⁱ N. Potgieter. 2020. Coronaviruses in water and risk of infection Introduction to speaker : Prof Natasha Potgieter.

^j N. Page. 2020. Waterborne diseases – managing risks of infection and responses to outbreaks. doi:10.4135/9781412974592.n150.

^k Water Services Association of Australia. 2020. Fact sheet: COVID-19. https://www.wsaa.asn.au/sites/default/files/publication/download/COVID-19_Fact_Sheet_02042020.pdf.

^l Water Services Association of Australia. 2020. COVID-19 and wastewater. https://www.wsaa.asn.au/sites/default/files/publication/download/Factsheet_COVID-19_and_wastewater_15042020_1.pdf.

^m Global Water Research Coalition. 2020. The COVID-19 virus – water, sanitation and wastewater management. http://www.globalwaterresearchcoalition.net/_r4285/media/system/attrib/file/826/GWRC_Factsheet_COVID-19_Virus_25May2020.pdf.

Source: Asian Development Bank.

Guidance on Operations

Once again, more general guides and resources are available in addition to the documents listed in Table B.1. One example is the Canadian Water and Wastewater Association's web page which provides links and resources,⁵³ including a link to their Water Sector Pandemic Action Plan,⁵⁴ the USEPA Water Utility Resources for the COVID-19 Pandemic,⁵⁵ and the Water Environment Federation's field guide, the Water Professional's Guide to COVID-19.⁵⁶ The International Water Association also compiled its open-access resources on COVID-19.⁵⁷

⁵³ CWWA. <https://cwwa.ca/covid-19-links-and-resources/#technical>.

⁵⁴ I. McIlwham and G. Solecki. 2020. CWWA Water Sector Pandemic Action Plan. <https://cwwa.ca/wp-content/uploads/2020/03/CWWApandemicAction.pdf>.

⁵⁵ EPA. <https://www.epa.gov/coronavirus/water-utility-resources-covid-19-pandemic>.

⁵⁶ WEF. <https://www.wef.org/news-hub/wef-news/the-water-professionals-guide-to-the-2019-novel-coronavirus/>.

⁵⁷ IWA. <https://iwa-network.org/news/information-resources-on-water-and-covid-19/>.

Table B.3: Operational Guidance for Water and Sanitation Service Providers

Title	Publisher	Date	Ref.
COVID-19 Manual Urgente para Operadores de Gestión Urbana de Agua (Español)	IWA Publishing	Apr 2020	177 ^a
COVID-19 Guia para reduzir riscos à saúde de operadores de estações de tratamento de esgoto e redes de esgoto (Português)	IWA Publishing	25 Mar 2020	178 ^b
COVID-19 Guía para reducir los riesgos para la salud de los operadores de plantas de tratamiento de aguas residuales y redes de alcantarillado (Español)	IWA Publishing	25 Mar 2020	179 ^c
COVID-19 Response: Water Sector Preparation, Vigilance Crucial	American Water Works Association (AWWA)	12 Mar 2020	180 ^d
The Financial Impact of the COVID-19 Crisis on US Drinking Water Utilities	AWWA and Association of Metropolitan Water Utilities	14 Apr 2020	24 ^e
Water Sector Pandemic Action Plan	Canadian Water and Wastewater Association	2020	176 ^f
COVID-19 Control and Prevention, Including Interim Guidance for Solid Waste and Wastewater Management Workers and Employers	US Department of Labor Occupational Safety and Health Administration	2020	160 ^g
Incident Action Checklist – Pandemic Incidents	United States Environmental Protection Agency	Apr 2020	181 ^h
What Water and Sanitation Operators Can do in the Fight Against COVID-19	Global Water Operators' Partnerships Alliance	13 Mar 2020	182 ⁱ
The “Safe Mode” of Water Treatment Plant Operation during the COVID-2019 Pandemic by Wuhan Water Group Company Limited, China	IWA COVID-19 Task Force Case Study	12 Sep 2020	64 ^j

^a L. Babiano. 2020. COVID-19 Manual Urgente para Operadores de Gestión Urbana de Agua. (IWA Publishing).

^b D. A. Nolasco. 2020. COVID-19 Guia para reduzir riscos à saúde de operadores de estações de tratamento de esgoto e redes de esgoto.

^c D. A. Nolasco. 2020. COVID-19 Guía para reducir los riesgos para la salud de los operadores de plantas de tratamiento de aguas residuales y redes de alcantarillado (Español). <https://iwa-network.org/wp-content/uploads/2020/03/COVID-19-Gu%C3%ADa-para-reducir-riesgos-para-la-salud-de-operadores-de-PTARs-y-redes-de-alcantarillado-NOLASCO-31mar2020-v3.pdf>.

^d American Water Works Association. 2020. COVID-19 response: water sector preparation, vigilance crucial. <https://www.awwa.org/AWWA-Articles/covid-19-response-water-sector-preparation-vigilance-crucial>.

^e American Water Works Association & Association of Metropolitan Water Utilities. 2020. The financial impact of the COVID-19 crisis on U.S. drinking water utilities. https://www.awwa.org/Portals/0/AWWA/Communications/AWWA-AMWA-COVID-Report_2020-04.pdf.

^f WaterAid. 2020. Troubled wastewaters A review of the functionality of wastewater treatment plants in low-and middle income countries.

^g UNC Water Institute (Producer). 2020. Serving the urban poor: evidence to support decision-making in continuous supply and sanitation – 2 Case studies in Sub-Saharan Africa [webinar]. <https://waterandhealthconference.pathable.co/meetings/virtual/5XWPtX2R7Tc7ACvGQ>.

^h USEPA. 2020. Incident Action Checklist – Pandemic Incidents. https://www.epa.gov/sites/production/files/2020-03/documents/pandemic_iac_final_032620_508_fillable_o.pdf.

ⁱ Global Water Operators' Partnerships Alliance. 2020. What water and sanitation operators can do in the fight against COVID-19. <https://gwopa.org/what-water-and-sanitation-operators-can-do-in-the-fight-against-covid-19/>.

^j Y. Wang and W. Qu. 2020. The “Safe Mode” of Water Treatment Plant Operation during the COVID-2019 pandemic by Wuhan Water Group Company 2. “Safe Mode” for water treatment plant operation. https://iwa-network.org/wp-content/uploads/2015/12/The-Safe-Mode-of-Wuhan-Water-Works-Company-during-COVID-epidemic_12_September_2020.pdf.

Source: Asian Development Bank.

The American Water Works Association and Association of Metropolitan Water Utilities report *The Financial Impact of the COVID-19 Crisis on US Drinking Water Utilities*⁵⁸ has been included here because it provides recommendations on how to mitigate financial risks.

Areas of Overlap

As can be expected in a global medical emergency, critical health information including what is known about the emerging pathogen and actions to reduce risk has been published by numerous governments, national departments of health, and international health agencies. The primary source of information has been WHO. Their main COVID-19 web page⁵⁹ lists several links to more specialized web pages in the WHO site, such as advice for the public on protecting themselves and traveling,⁶⁰ country-specific advice,⁶¹ technical advice, and regularly updated situation reports.⁶² This means that national guidance has been repetitive to a very great extent, but this is useful in terms of a unified response. Where countries have differed in their advice it has been due to ideological differences, or decision-making in which political considerations have been deemed more pressing than scientific considerations. There is also more general advice available, such as the KWR's Guiding Principles for Effective Communication During a Public Health Crisis,⁶³ which are relevant during other types of crisis.

Guides provided by the technical or professional associations have converged on the nature of the microbiological risk presented by SARS-CoV-2 and the best ways to mitigate that risk.

Among the members of the Water Action Platform, some confusion has arisen and frustration has been expressed in regard to the rapidly changing science on SARS-CoV-2. A good example was the long-running scientific debate about whether COVID-19 is an airborne disease. Early evidence in March 2020 suggested that the primary route of transmission was respiratory droplets that fall to the ground relatively quickly after exhalation, and that keeping 2 meters distance from other people would be enough protection. This was the advice provided in the WHO guidelines on 29 March 2020. However, over the following few weeks evidence accumulated to show that transmission is via a combination of droplets and aerosols, and that a safe social distance is 9.5 meters. It is difficult for members of the general public to understand when advice changes because our knowledge has been enlarged and updated, and when advice changes for the sake of political expediency.

Gaps in the Guidance

The technical advice regarding the fate and behavior of SARS-CoV-2 in water, air, and soil will change in line with our increasing understanding of the virus. This can be considered a gap in the available guidance; however, because it arises from gaps in humankind's understanding of the fundamental microbiology of the disease, we can only fill in these gaps when we have generated and tested new knowledge.

The organization advice that is most lacking is to guide water sector organizations on how to prepare for the duration of the pandemic—including coping and recovery strategies for a protracted pandemic scenario—and how to budget accordingly. This gap is difficult to fill, mainly because we do not know how long the presence of COVID-19 will be uncontrolled but also because we do not know how to rise to the challenge of the unprecedented levels of uncertainty. Utilities find it impossible to create a scenario in which the virus does not

⁵⁸ American Water Works Association & Association of Metropolitan Water Utilities. 2020. The financial impact of the COVID-19 crisis on U.S. drinking water utilities. https://www.awwa.org/Portals/0/AWWA/Communications/AWWA-AMWA-COVID-Report_2020-04.pdf.

⁵⁹ WHO. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.

⁶⁰ WHO. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public>.

⁶¹ WHO. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance>.

⁶² WHO. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports/>.

⁶³ KWR. <https://library.kwrwater.nl/publication/61298615/>.

dissipate and yet the organization will survive, and yet SARS-CoV-2 is here to stay. It is likely to continue to mutate as it has done since it emerged, and the probable 100-year projection is that it will be similar to the other six coronaviruses that infect humans—responsible for 15%–30% of common colds—and monitored so we can produce seasonal vaccines as we do currently for influenza.

Comment on Expected Regulatory Positions

At the time of writing, environmental protection agencies around the world expect regulated businesses to make their best endeavors to meet their environmental obligations and are helping regulated businesses to adjust and adapt, recognizing that resources and capacities are severely constrained. Some of them published time-limited COVID-19 regulatory position statements to minimize the risks to the environment and human health where, for reasons beyond companies' control, compliance with normal regulatory requirements may not be possible temporarily. For example, the Environment Agency of England and Wales published a regulatory position statement which enables water companies to reduce regulatory sampling carried out in accordance with their permits in relation to operator self-monitoring and the Urban Waste Water Treatment Regulations 1994 monitoring.⁶⁴ It applies to monitoring of discharges of treated sewage effluent from WWTW and trade effluent from water treatment works. It only applies if the sample collection or analysis is affected by staff shortages due to COVID-19 or restricted access caused by people or places being infected or potentially infected with COVID-19.

Some regulatory agencies have temporarily relaxed regulatory enforcement during the crisis, although examples of this can only be found in Europe (the Environment Agency of England and Wales)(footnote 64), and the USA (USEPA).

The long-term regulatory positions (e.g., implementation of public health programs, vaccination campaigns, or rendering COVID-19 a notifiable disease) on the detection, monitoring, and control of SARS-CoV-2 around the world are expected to build on each country's current positions regarding other similar viruses, such as SARS and MERS, and be informed by international scientific and technical evidence.

WBE is already used to control and manage poliovirus, providing evidence for the absence of virus circulation in unvaccinated populations and early warnings of outbreaks, as well as “herd monitoring”.⁶⁵ Sewage surveillance for adenovirus, norovirus, rotavirus, parechovirus, enterovirus, astrovirus, and hepatitis A and E viruses is routinely used to provide early warnings of outbreaks, warnings of virus circulation in populations, and for influenza information on the virus genotypes that are circulating in populations, which is used to inform annual vaccine design.⁶⁶

It is expected that long-term positions will be informed by the outcomes of the research on the fate and behavior of infective SARS-CoV-2 in water and the aquatic environment, as well as the regulations that govern WBE programs used to monitor and control other viruses. In most cases, the regulations dictate that reporting of positive laboratory results from environmental surveillance to the relevant ministry of health and WHO should follow the guidelines of reporting for clinical surveillance with respect to the need for regular reporting of activities and findings as well as immediate reporting of wild virus isolation (footnote 12).

⁶⁴ Environment Agency. 2020. Water and sewerage company OSM and UWWTR sampling affected by COVID-19: RPS C3. <https://www.gov.uk/government/publications/water-and-sewerage-company-osm-and-uwwtr-sampling-affected-by-covid-19-rps-c3>.

⁶⁵ T. Hovi. 2006. Surveillance for polioviruses. *Biologicals*. 34. pp. 123–126.

⁶⁶ M. Hellmér et al. 2014. Detection of pathogenic viruses in sewage provided early warnings of hepatitis A virus and norovirus outbreaks. *Applied Environmental Microbiology*. 80. pp. 6771–6781.

Covid-19 and Water in Asia and the Pacific

Guidance Note

The coronavirus disease (COVID-19) pandemic has had a wide-ranging and substantial impact on the water sector in Asia and the Pacific. This guidance note focuses on how service providers—particular those involved in supply, sanitation, and wastewater treatment—have been affected and the response measures they have undertaken. It also identifies potential pathways to shape a post-pandemic recovery for the sector and the role of the Asian Development Bank (ADB) in supporting this. The guidance note is one of a series produced by ADB for key sectors and thematic areas.

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