

Water security beyond Covid-19

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Question

What can developing countries do over the mid-term horizon (next 5 years) to improve water security to prepare for a potential increase in disease outbreaks and pandemics such as Covid-19?

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1. Summary

Strengthening water security is essential for preventing and combatting future pandemics¹. Measures to suppress the Covid-19 pandemic, including hand-washing, self-isolating and lockdowns assume that societies, communities and households have sustainable access to acceptable amounts of adequate quality water. However, across developing countries, water insecurity is increasing, with the poorest and most vulnerable particularly at risk.

Water demand, stress and scarcity are increasing due to population growth, urbanisation, land use change, climate change and other drivers. Global water demand is increasing at approximately 1% per annum, whilst between 4.8 and 5.7 billion people are projected to live in areas that are potentially water scarce for one month per year by 2050 (UN-Water, 2019a). Climate change is altering the global water cycle and water availability is likely to become more variable and unpredictable. Ensuring sustainable access to adequate quality water for human health is challenging in this context.

Zoonotic disease outbreaks may increase due a number of drivers including deforestation and climate change, increasing the potential for future pandemics. Poor people are likely to be disproportionately affected by pandemics due to a lack of access to water, sanitation and hygiene (WASH), poorer underlying health and vulnerability to secondary health impacts, amongst other factors. Immediate water, sanitation and hygiene (WASH) responses to the Covid-19 pandemic will help to save lives, but in the medium term measures to strengthen water security will be needed. In addition to ensuring sustainable access to adequate quality water, medium term measures could help countries avoid some of the economic and human costs associated with pandemics.

The 2020 Covid-19 pandemic could increase developing countries and development partners' focus on water and WASH and trigger transformational change in some countries. The 2014-16 Ebola outbreak in West Africa increased the demand for safe water for prevention and treatment, and also increased development partners' attention to WASH at the household and healthcare levels both during and after the outbreak². As the Covid-19 pandemic is still unfolding, it is not clear what the impact on developing countries or their water security will be. Consequently, there is a need to monitor how the pandemic unfolds and assimilate lessons learned.

Interventions to strengthen water security should focus on four key areas:

- **Adequate water availability:** preventing or suppressing potential pandemics is likely to increase water demand for domestic and health uses. Supply and storage solutions are needed to ensure there is adequate water available and to manage trade-offs upstream (competing demands from other sectors) and downstream (wastewater production). In some ways ensuring water availability is the most obvious need, particularly in context of

¹ UN-Water define water security as “the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability” (UNESCO, UN-Water, 2020).

² See for example https://www.ilo.org/africa/countries-covered/liberia/WCMS_450479/lang--en/index.htm, and <https://www.msh.org/news-events/stories/after-ebola-ensuring-better-water-and-sanitation-for-health-in-liberia>

climate change, and increasing water scarcity, demand, and competition between sectors.

- **Acceptable water quality:** water quality is deteriorating across developing countries due to discharges from agriculture, industry, human waste, and wastewater. Both surface and groundwater are affected. Climate change will also negatively affect water quality.
- **Water resources management:** ensuring sustainable access to adequate amounts of acceptable quality water and resilience will require strengthening water resources management so that water is available where and when it is needed to suppress and prevent future pandemics.
- **Affordable access to WASH:** 2.2 million people globally lack access to safely managed drinking water (defined as drinking water from a source located on the premises, free from contamination and available when needed), and 4.2 billion people do not have access to safely managed sanitation services. This hampers efforts to suppress or prevent pandemics. Investments in extending access to WASH can have co-benefits, such as job creation and improved health³.

Medium term responses will involve moving beyond sectoral thinking to understanding and managing the links between upstream and downstream water resources and users, and the links between water resources and WASH. It will also be important to consider transboundary issues as many rivers, lakes and aquifers cross national borders. River basin planning processes and the co-management of surface and groundwater could lead to more resilient systems and increase a region's overall storage (UN-Water, 2019a; Rodriguez et al., 2020). Strengthening water security will have a number of positive benefits, beyond public and human health, including increasing resilience to climate change, supporting livelihoods, food security and economic productivity.

Possible medium term interventions

This paper largely focuses on technical interventions in four areas. However, it is important to remember that these interventions will depend on political will, building capacity, finance, data and information, and, accountability.

Adequate water availability

Nature based solutions (NBS) can improve water storage and supply, thereby increasing water availability and potentially reducing competition between different water users and uses. There is a small but growing body of evidence that NBS are cost-effective, efficient, and adaptable compared to gray infrastructure, and that they also offer co-benefits (Liquete et al., 2016; Seddon, 2018; Oral et al., 2020). This is important as international aid budgets may be reduced due to the economic effects of Covid-19.

NBS need to be applied in a context dependent manner as there are high degrees of variation in how ecosystems impact hydrology. Examples of possible interventions include:

³ See for example <https://washfunders.org/water-and-sanitation-investments-create-jobs/>

- **Watershed restoration and conservation** through improved land management can increase urban water security and benefit rural communities. The Upper Tana-Nairobi Water Fund, Kenya predicts a return of USD 21.5 million (against an investment of USD 10 million) derived from savings from water and wastewater treatment and other benefits.
- **Green infrastructure** such as rain gardens and wetlands in urban areas can reduce flood risks and improve water quality, whilst in rural areas, green infrastructure such as sand dams can increase water supply. Combining green and gray infrastructure can improve storage and supply, lower costs, produce more resilient services, enhance system performance and protect communities.
- **Managed groundwater and aquifer recharge** can reduce the risk of short-term water shortages by storing water for use in the dry season. Groundwater is an important resource but there are concerns about over-exploitation and depletion, so solutions should be context specific.

Wastewater treatment for reuse can provide an additional source of water. Resource recovery from wastewater could provide revenue for utilities and contribute to the sustainability of water supply and sanitation systems.

Acceptable water quality

NBS and combining green and gray infrastructure can also improve water quality and reduce water treatment costs. Examples of potential interventions include source water protection, constructed wetlands in urban areas for wastewater treatment, and, urban green infrastructure to manage and reduce pollution from storm water run-off.

Increasing access to affordable sanitation in urban areas can reduce contamination of water sources by human waste and wastewater and positively affect public health outcomes. Possible interventions include subsidising the cost of household sanitation, making the entire on-site sanitation service chain safe, reliable and affordable, and building regulatory capacity (Satterwaite et al., 2019). New infrastructure, such as waterless toilets, and new service delivery models, such as container based sanitation services should be considered. These new approaches may be more suitable for informal settlements than extending the piped sewer network (World Bank, 2019). Increasing access to sanitation can help to prevent and suppress future pandemics.

Water resources management

Climate resilient water management is needed to ensure that supply and storage solutions, institutions and decision-making are matched to a shifting climate and a dynamic and uncertain water cycle (Smith et al., 2019). Solutions need to be both robust (perform well across a range of possible future) and flexible (retain the ability to respond to unexpected climate shocks and stressors and long-term uncertainty) as there is uncertainty about future water resources availability due to climate change. New tools including Climate Risk Informed Decision Analysis, and approaches such as China's sponge cities, and source water protection (applied effectively in Rwanda) can ensure resilience in the face of changing water availability.

Good water governance will be needed to ensure an adequate supply of adequate quality water to fight and prevent future pandemics. Interventions could focus on strengthening the

policy, institutional and regulatory frameworks. For example, legislation in Peru requires water utilities to earmark revenue for water conservation. Stakeholder participation and multi-stakeholder platforms can support inclusive water management and strengthen resilience. For example, the Upper Tana-Nairobi Water Fund brings together a range of stakeholders to conserve water and soil upstream, reducing water treatment costs downstream and improving water supply, as well as supporting rural livelihoods. This also demonstrates the co-benefits that can be derived from NBS.

Knowledge and capacity building for institutions is needed to support good water governance and management. Weak systems and institutions pose a challenge for both water resources management and expanding access to WASH. Interventions to support capacity building and governance will need to take account of political economy factors.

The use of new data tools such as water accounting and urban water accounting can support decision-making and urban planning. Data gaps such as how many people live in informal settlements, access to WASH, trends in water supply and demand, and the amount of water entering and leaving cities can hamper decision-making and management.

Affordable access to WASH

Finance is a key challenge for extending access to services, with estimates ranging from USD 28.4 billion to USD 114 billion needed annually between 2015 and 2030 to meet the Sustainable Development Goal 6 targets for access to WASH.

In the long-term, cities should extend access to reliable and affordable piped water to the home or plot, with interim measures including supporting increased access to regulated water points and kiosks. Extending access to piped water involves addressing causes of intermittent water supply, diverse strategies to make water more affordable with special considerations for low income customers, and supporting informal settlement upgrading (Mitlin et al., 2019). It will also involve data for planning, increased investment in water infrastructure and maintenance and good governance. Interim measures such as low-income customer support units can increase access to utility water outside the home or plot.

Digital tools, such as smart meters can help to support service delivery and ensure sustainable water access for customers. Capacity building and the use of digital tools can increase the sustainability of service delivery organisations who often have problems with cost recovery, non-revenue water and low revenue collection.

Gender and social inclusion

Women and girls, poor households, marginalised groups and persons with disabilities often already experience inequalities in terms of access to WASH and water for livelihoods (UNESCO, UN-Water, 2020; World Bank, 2016). These inequalities may make it harder for these groups to take preventative measures during a pandemic and lead to greater exposure to infection. Medium term response measures need to ensure that barriers faced by these groups are considered and tackled in interventions.

Evidence base

This rapid literature draws on grey literature from leading water resources and WASH organisations including UN-Water, the World Health Organisation (WHO), and UNICEF, as well as working papers and commentary by experts and academics in the field. The report does not consider humanitarian settings and there is a slight emphasis on urban users (although rural users are considered) due to the time constraints of this review and concerns that pandemics may spread easier and quicker in urban areas. Hand washing is a key preventative measure to suppress transmission of Covid 19 and other infectious diseases. However, effectively changing handwashing behaviour is difficult and is more complex than the provision of hand-washing facilities and soap (Coates & de Albuquerque, 2020). Long-term investments are needed, and due to the large body of evidence, these are not considered within the scope of this report.

2. Pandemics and water

Outbreaks of zoonotic diseases may increase, with the potential for epidemics and pandemics. Covid-19 is a zoonotic disease (Anderson et al., 2020) with other recent outbreaks of zoonotic diseases including Ebola, Middle East respiratory syndrome (MERS), sudden acute respiratory syndrome (SARS), and Zika (UNEP, 2016). The richness of zoonotic diseases (the unique number of diseases) is increasing with approximately one new infectious disease appearing in humans every four months (Smith et al., 2014; UNEP, 2016).

A number of linked human drivers contribute to zoonotic disease emergence. These include: land-use changes, deforestation, intensified agriculture and livestock production, habitat destruction and biodiversity loss, rapid urbanisation and population growth, extractive activities, and the wildlife trade (UNEP, 2016; Redding et al., 2019; Lee, 2020). Human drivers can reduce the barriers between humans and host animals in both rural and urban areas. This driver disease transmission through increasing interactions between human and host animals, altering the distribution of zoonotic disease reservoirs and vectors, and increasing opportunities for diseases to pass from host animals or reservoirs to humans through livestock (UNEP, 2016).

There is growing evidence that climate change may lead to more frequent outbreaks and epidemics (UNEP, 2016). Climate change may increase the number of spill-over events from hosts to humans by increasing the landscape suitability for the host and human-host contact rates (Redding et al., 2016). It also likely to increase flooding, with failed sanitation and safe water contributing to conditions for disease spread (Lee et al., 2020).

Zoonotic diseases are a significant threat to global human health and economies, disproportionately impacting poor communities (Redding et al., 2019). The 2013-16 Ebola outbreak was estimated to cost the three most affected countries USD 2.2 billion whilst the impact of the 2002 SARs outbreak was estimated at USD 41.5 billion (Redding et al., 2019; UNEP, 2016). The current Covid-19 pandemic has already had destabilising economic effects on developed countries economies and the global economy (IMF, 2020).

Water is key for pandemic suppression and prevention

The provision of safe water, sanitation and hygienic conditions is essential to protecting human health during all infectious disease outbreaks, including the Covid-19 pandemic (WHO, 2020: 1). However, across developing countries access to WASH is limited. For example,

3 billion people lack basic handwashing facilities (UNICEF & WHO, 2019). This creates a number of challenges for combatting transmission of Covid-19 and preventing/suppressing future potential pandemics. Underdeveloped water and waste management systems was one of the contributing factors to the spread of Ebola during the 2013-16 outbreak, and identified as an underlying factor in thousands of deaths during the outbreak (Kalra et al., 2014; ACAPS, 2015).

People living in informal settlements, the poorest and marginalised could be particularly vulnerable as they often rely on communal water points and toilets, private vendors and water tankers. **High water costs and limited access** could prohibit generous use of water for hand washing, whilst needing to leave home to access communal facilities and queuing for access in close proximity to others **makes self-isolation and social distancing difficult to implement** (SSHAP, 2020; Joshi & Nicol, 2020). **It also makes lockdowns impractical.** Limited household budgets may also mean that purchasing soap or hand sanitizer is not a household priority.

Immediate WASH responses should be followed by medium term measures to strengthen water security. Immediate water-related responses to the Covid-19 pandemic are focusing on setting up communal handwashing stations in informal settlements⁴; donor programmes, such as DFID's campaign with Unilever to target 1 billion with hand-washing campaigns and soap⁵; working with local government and public water utilities to connect households to water supplies, and ensuring supplies of water treatment chemicals⁶; and, scaling up access to WASH in healthcare settings⁷.

Preparing for future pandemics will require sustainable supplies of acceptable quality water. This will involve supporting storage, supply and treatment solutions, and, resilient water management as well as increasing affordable and sustainable access to WASH. There are enormous public health consequences if we do not address equitable water access (Joshi & Nicol, 2020). Access to WASH needs to be located in the wider context of increasing, potentially competing, water demands from a number of sectors due to a range of human drivers and climate change. Questions of where water is going to come from to support public health, how it should be managed to ensure sustainable supplies and adequate quality, and how to make it affordable need to be addressed.

3. Adequate water availability

Combatting and treating a pandemic requires water and it is likely that water demands for public health and human consumption will increase during a pandemic. For example, the

⁴ See for example, Shining Hope for Communities' work in the Kibera and Mathare informal settlements in Kenya: <https://www.shofco.org/covid-19/>

⁵ See for more information: <https://www.gov.uk/government/news/uk-aid-and-unilever-to-target-a-billion-people-in-global-handwashing-campaign>

⁶ See comments made by Kelly Ann Naylor, associate director of WASH at UNICEF, <https://www.devex.com/news/what-does-a-covid-19-response-look-like-with-limited-water-96834>

⁷ In 2016, only 55% of healthcare facilities in the least developed countries had access to basic water services, defined as water available from an improved source, such as a protected well, piped water, or packaged water, on the premises (WHO & UNICEF, 2019).

demand for clean water increased during the 2014 Ebola epidemic in West Africa⁸. Increased demand for domestic water and water for healthcare settings could lead to trade-offs both downstream (in wastewater production) and upstream (in competing demands for supplies from agriculture and other sectors) (Joshi & Nicol, 2020). Diverting water from agriculture for use in cities could affect food production, whilst maintaining water for agriculture could mean that cities do not have adequate supplies to combat pandemics.

This scenario would occur in a context where demand for water is already growing due to drivers including population growth, urbanisation, and changing consumption patterns (WWAP/UN-Water, 2018). Global demand for water is increasing at a rate of about 1% annually and will continue to grow significantly, with agriculture the largest overall user (WWAP/UN-Water, 2018). Africa's water towers, which replenish many of the continent's rivers, are under pressure from both climate change and deforestation and encroachment with implications for both water supply and quality⁹ (UNEP, 2016b).

Climate change is altering the global water cycle resulting in increased variability affecting water availability. This includes changing rainfall patterns, accelerated melting in glaciers, changing river flows and projected increases in both water scarcity and water stress (Smith et al., 2019).

Nature-based solutions

Nature based solutions (NBS) can improve water storage and supply, thereby increasing water availability for a range of human uses. NBS use or mimic natural processes to contribute to improved water management. Protecting, sustainably managing, restoring/rehabilitating and enhancing natural processes in both natural or modified and artificial ecosystems can improve the timing, location and quantity of water available (WWAP/UN-Water, 2018). Examples include protecting wetlands, improving soil moisture, watershed restoration, forest conservation, restoration of coastal mangrove forests, and enhancing groundwater recharge. Initial research on the Mau Forest complex in Kenya (a water tower) between 2012 and 2016 found that the forests supply clean water and also filter water from streams that come from agricultural land, as well as recharging the ground water table (Jacobs et al., 2016). In addition to positive effects for water storage and supply, NBS can contribute to flood and drought resilience (WWAP/UN-Water, 2018; Browder et al., 2019).

However, there is a high degree of variation in how ecosystems impact on hydrology, for example, trees can increase or decrease groundwater recharge depending on their type, density, location, size and age (WWAP/UN-Water, 2018). Therefore, it is important that how NBS are applied is context dependent.

NBS can also help with trade-offs between different water users. For example, conservation agriculture, rainwater harvesting, and enhancing aquifer storage can have positive benefits for water supply, potentially reducing competition between different users (WWAP/UN-Water, 2018;

⁸ For more information see <https://wwtonline.co.uk/news/opinion-water-s-role-in-beating-an-epidemic>

⁹ Water towers are forested mountains in East Africa that contain many springs and streams that are the sources of major rivers. For example, the Mau Forest Complex in Kenya is the source of 12 rivers that feed into lakes Victoria, Natron and Turkana and support the livelihoods of 3 million rural and up to 2 million people in urban areas. For more information see: <https://www.cifor.org/water-towers/>

Browder et al., 2019). The use of NBS in agriculture can also reduce downstream pollution, therefore having water quality benefits (WWAP/UN-Water, 2018).

Watersheds

Watershed restoration and protection through improved land management can increase urban water security and have benefits for rural communities. Urban water resilience often depends on watersheds upstream where there are already pre-existing local community users (UNESCO, UN-Water, 2020). Degradation due to human drivers including deforestation and land use change can negatively affect water quantity and quality downstream (WWAP/UN-Water, 2018). This can lead to reduced water availability for cities, aggravate urban flooding, and increase treatment and supply costs for urban water (WAP/UN-Water, 2018).

The Upper Tana-Nairobi Water Fund, launched in 2015, aims to secure Nairobi's water supplies while improving agricultural livelihoods¹⁰. The Fund brings together a range of stakeholders including water utilities, local government, and the forest service. It supports farmers in the watershed, through in-kind compensation mechanisms, to adopt water and soil conservation measures to improve water quality and supply downstream in Nairobi. The Fund predicts that a USD 10 million investment in its interventions could lead to a return of USD 21.5 million in economic benefits over a 30 year timeframe. This includes savings from water and wastewater treatment, increased power generation and increase yields for both smallholder farmers and larger producers.

Combining green and gray infrastructure

Combining green and gray infrastructure can improve storage and supply, lower costs, produce more resilient services, enhance system performance and better protect communities (Browder et al., 2019). For example, the lifespan of reservoirs increases with the use of green infrastructure to control erosion (Browder et al., 2019). Green infrastructure intentionally and strategically preserves, enhances, or restores elements of a natural system, such as forests, agricultural land, floodplains, and riparian areas (Browder et al., 2019). Integrating green and gray infrastructure (such as dams, canals, and treatment plants) recognises that gray infrastructure is embedded within watersheds, and the hydrological and environmental attributes of these watersheds affect infrastructure performance (Browder et al., 2019). It can also help with climate resilience (Browder et al., 2019).

Green infrastructure can be applied in both urban and rural areas. In urban areas, green infrastructure such as vegetated gardens can reduce flood risks and increase water quality. Sunken sand dams, amongst other water harvesting measures, in Kitui County, Kenya have helped to increase water supply, benefitting health and livelihoods and reducing the potential for competition between users (GWPEA, 2016). In rural Somalia and Somaliland, sand dams have been chosen over groundwater wells by two ongoing projects to increase water security (Browder et al., 2019). Reasons for this include they are easier to maintain and less expensive (Browder et al., 2019).

¹⁰ For more information see <https://www.nature.org/en-us/about-us/where-we-work/africa/stories-in-africa/nairobi-water-fund/>

Groundwater

Managed groundwater recharge can reduce the risk of short-term water shortages and increase water security (WWAP/UN-Water, 2018). Techniques intentionally enhance natural processes by building infrastructure and/or modifying the landscape. This can involve improving soil management to manage infiltration and rainwater capture, storing water in the soil for use in the dry season. UN-Water argue that approaches such as MAR (managed aquifer recharge) and UTFI (underground taming of floods for irrigation) are scalable, sustainable and cost-effective solutions (WWAP/UN-Water, 2018). Co-management of surface and groundwater could boost resilience to droughts and address water scarcity, making it possible to expand a region's overall water storage capacity (WWAP/UN-Water, 2018).

MAR is being implemented in the Windhoek aquifer, Namibia to combat climate change and drought, and supply water to the city (Murray et al., 2018). In India, UTFI involves facilitating aquifer recharge to store wet season high flows in catchments, mitigating the impact of flooding, and tackling drought by making additional groundwater available for a range of needs including irrigation (WWAP/UN-Water, 2018). The UTFI programme is also registered with the Mahatma Gandhi Rural Employment Scheme allowing communities to be remunerated for participating (WWAP/UN-Water, 2018).

Groundwater represents an important resource but there are concerns about over-exploitation and depletion. For example, in Lahore, Pakistan, which depends on groundwater abstraction, the water table is depleting at a rate of more than one metre per annum as urbanisation means groundwater recharge is minimal (Cooper, 2018). This could accelerate saline water intrusion (Cooper, 2018).

An initial priority is to substantially improve the information base regarding groundwater's extent and availability (UNEP, 2016b). For example, the FAO's Somalia Water and Land Information Management programme has re-established data collection networks to facilitate better monitoring and assessment of available groundwater resources, as well as rainfall, river flows, and land use, soil characteristics and land use suitability to enable effective land and water management¹¹. An accurate assessment of groundwater can inform discussions and decisions about water availability and use between different sectors, as well as inform planning.

Wastewater

Wastewater treatment for reuse can provide an additional source of water, whilst resource recovery from wastewater can contribute to the sustainability of water supply and sanitation systems and the water utilities operating them (Rodriguez et al., 2020). As cities in developing countries continue to grow development approaches are needed that minimise resource consumption and focus on resource recovery (Rodriguez et al., 2020). In addition to reusable water, energy, bio-solids and nutrients can be recovered from wastewater. These can provide financial returns to the utility to cover operations and maintenance costs either partially or fully (Rodriguez et al., 2020).

¹¹ For more information see: <http://www.faoswalim.org/about-us/who-we-are>

Adopting circular economy principles in wastewater management could lead to sanitation transforming from a costly service to one that is self-sustaining and adds value to the economy (Rodriguez et al., 2020). To achieve this facilities must be properly run, designed, planned, managed, and operated effectively and efficiently (Rodriguez et al., 2020).

Moving from isolated wastewater treatment solutions (e.g. one treatment plant per municipality) to fully integrated river basin planning approaches can lead to more sustainable and resilient systems (Rodriguez et al., 2020). For example, this would allow for more efficient investments as effluent standards based on the specific contexts of particular water bodies and ecosystems could be developed, as opposed to uniform or arbitrary water pollution control standards (Rodriguez et al., 2020). Including wastewater in the hydrological system as a potential water source, allows for planning for its reuse, which can limit incidental and unplanned water reuse that can have negative health and environmental consequences (Rodriguez et al., 2020). Reusing wastewater can help to mitigate competition between water use sectors by providing additional water.

4. Adequate quality water

Treating and suppressing the spread of pandemics, such as the 2020 Covid-19 pandemic, will require an acceptable supply of adequate quality water. However, water quality is expected to further deteriorate over the next decades, increasing threats to human health (WWAP/UN-Water, 2018). Water pollution has worsened in almost all rivers in Africa, Asia and Latin America since the 1990s (WWAP/UN-Water, 2018). Causes of pollution and contamination in both surface and groundwater include discharges from agriculture, industry, human waste and sewerage. Pollution has rendered some water sources unsafe for human consumption, including the Nairobi River in Kenya¹². The greatest exposure to pollutants is expected to occur in low- and lower- middle income countries due to high population growth, economic growth and wastewater management systems (WWAP/UN-Water, 2018).

Climate change will also adversely affect water quality in a number of ways. This includes, but is not limited to, increasing organic matter, nitrate and phosphorous levels in river water; reducing the self-purifying capacity of freshwater; increasing sediment, nutrient and pollutant loadings from heavy rainfall; disruption of treatment facilities during floods; and groundwater deterioration due to saline intrusion in coastal areas (UNESCO, UN-Water, 2020).

Solid waste management is also a challenge in many developing countries. Estimates suggests only 40-50% of waste is collected across Africa (UNEP, 2016b). Dumpsites are largely uncontrolled or poorly managed, and in informal settlements waste in the streets poses a number of biohazard risks (UNEP, 2016b; SSHAP, 2020). The impact of medical and pharmaceutical chemical waste on water bodies is not well understood¹³.

Inadequate access to urban sanitation infrastructure and services negatively affects public health outcomes (Satterthwaite et al., 2019; Rodriguez et al., 2020). Leaks from piped sewerage systems, inadequate on-site sanitation management, poor-quality treatment

¹² For more information see: <https://watercentre.org/blog/the-sorry-state-of-kenyas-nairobi-river/>

¹³ For more information see <https://www.unenvironment.org/news-and-stories/story/drugged-waters-how-modern-medicine-turning-environmental-curse>

processes, open defecation and poor solid waste and wastewater disposal lead to contamination of surface and groundwater (Satterwaite et al., 2019). Analysis from 15 cities across the global south finds that on average 62% of sewerage and faecal sludge is unsafely managed¹⁴ (Satterwaite et al., 2019). In addition a lack of toilets in the household means that people are not able to self-isolate during a pandemic (SSHAP, 2020). This puts poor people at high risk of infection.

Nature based solutions

NBS can improve water quality and reduce water treatment costs (WWAP/UN-Water, 2018). This includes both natural and modified/artificial solutions. For example (WWAP/UN-Water, 2018; Browder et al., 2019; UNEP, 2006b):

- Source water protection can improve quality and reduce water treatment costs for urban suppliers, whilst in rural areas it can contribute to improved access to safe drinking water.
- Forests, wetlands and grasslands can help to regulate water quality by reducing sediment loading, capturing and retaining pollutants and recycling nutrients, reducing wastewater treatment requirements.
- Wetlands in urban areas can help to mitigate the impact of polluted storm water runoff and wastewater.
- Both natural and constructed wetlands can biodegrade or immobilise a range of emerging pollutants, including some pharmaceuticals.
- Constructed wetlands for wastewater treatment can provide effluent of adequate quality for non-potable uses including irrigation.

However, as with water supply solutions, for many polluted water sources, **a combination of green and gray infrastructure may be needed** (WWAP/UN-Water, 2018). Combining gray infrastructure components such as reservoirs, treatment plants and pipe networks, with watersheds and wetlands protection and conservation can lead to improved water quality and reduced costs (Browder et al., 2019).

Green infrastructure can manage and reduce pollution from urban run-off (WWAP/UN-Water, 2018). Examples include green walls, roof gardens, and vegetated infiltration or drainage basins to support wastewater treatment and reduce storm water run-off (WWAP/UN-Water, 2018).

NBS can also lead to water quality improvements in rural areas. Source water protection can contribute to improved access to safe drinking water in rural communities (WWAP/UN-Water, 2018). A series of measures in Lake Kako, Uganda, including catchment management and land restoration combined with promoting the adoption of solar cooking technology as an alternative to tree or vegetation cutting for cooking fuel, improved water quality (GWPEA, 2016). The Lake is the main source of drinking water, water for livestock and crop irrigation, for 18,000 people in

¹⁴ The 15 cities include Kampala, Uganda; Lagos, Nigeria; Maputo, Mozambique; Mzuzu, Malawi; Nairobi, Kenya; Bengaluru, India; Colombo, Sri Lanka; Dhaka, Bangladesh; Karachi, Pakistan; Mumbai, India; Caracas, Venezuela; Cochabamba, Bolivia; Rio de Janeiro, Brazil; São Paulo, Brazil; and Santiago de Cali, Colombia.

Mushumba Community and the deteriorating water quality had led to increased incidences of waterborne diseases (GWPEA, 2016).

Urban sanitation and sewers

Sanitation should be made affordable to help protect public health. Sanitation can pose high costs for low-income households. Pit latrines and private septic tanks can cost between 128%-759% of average household monthly incomes for those living in informal settlements (Satterwaite et al., 2019). Potential interventions include subsidising the capital costs of household sanitation (e.g. cost of toilets, septic tank construction); building communal and public toilets; subsidising the cost of household, communal and public toilet sewer connections; and subsidising the costs of safe on-site sanitation management including emptying, transporting, treatment, reuse and disposal (Satterwaite et al., 2019).

New sanitation infrastructure and approaches should also be considered including waterless toilets and container based sanitation services. Over 85,000 urine diversion dry toilets (UDDTs) have been effectively installed in rural and peri-urban areas of eThekweni municipality, South Africa that are not connected to the sewerage system and where households cannot afford to provide their own private septic tanks (Mkhize et al., 2017)¹⁵. Installation was subsidised by the national government and included hygiene and health education to promote acceptance of the toilets within the communities. Users have to maintain the toilets themselves. A study of user acceptance found lower levels of acceptance amongst the elderly and that some users aspired to flush toilets, seen as an indicator of household wealth (Mkhize et al., 2017).

Container based sanitation (CBS) services, including both household and shared/communal toilet options, can provide safe and affordable sanitation for the urban poor (World Bank, 2019). Service providers install a toilet with a sealed excreta container, and then empty (replacing it with a new clean container), transport and treat it safely (World Bank, 2019). CBS services are operating in Ghana, Kenya, Haiti and Peru with high customer satisfaction (World Bank, 2019). The World Bank (2019) argues that CBS is a potential solution for poor urban populations, informal settlements and flood prone areas where alternative on-site (latrines or septic tanks) or sewer-based sanitation services might not be appropriate. For example, due to population densities, water shortages, roads that are not large enough or suitable for sewer installation, lack of land tenure, proximity to water bodies and high water tables, and typography (World Bank, 2019). Challenges with CBS include: there is no management of household greywater; dependence on external funding and expertise, and lack of explicit regulation, service standards and interactions with local authorities (World Bank, 2019).

Cities will need to regulate on-site sanitation options and new approaches to protect public health. This could help to stop unsafe practices, such as pit latrines which are at risk of leaking, and households using self-provisioned drains to dump human waste and wastewater into storm drains and nearby waterways (Satterwaite et al., 2019). Capacity building may be needed to ensure this: many cities have weak or non-existent regulatory capacity (Satterwaite et al., 2019). The entire sanitation chain needs to be safe, reliable and affordable.

¹⁵ For a brief overview of the project see: <https://www.siwi.org/latest/ethekwini-chose-waterless-toilets/>

Where appropriate the sewer network could be extended to household, communal and public toilets. Sewer systems require large capital investments and daily supplies of water to work properly (Satterwaite et al., 2019). As such, extending sewer networks and building wastewater treatment plants may not be sufficient to deliver inclusive, citywide sanitation services for all, especially in informal settlements (World Bank, 2019).

Simplified sewerage systems may be more economical for high population density areas (Manga et al., 2020). A case study of lifecycle costs for providing sanitation in informal settlements in Soweto found that simplified sewerage (gravity flow into existing conventional sewers with treatment) was cheaper than waterless toilets and VIP latrines at population densities above 158 and 172 persons per hectare respectively (Manga et al., 2020). Sewers mean that households do not have to pay for costs such as emptying septic tanks. Although they do have to pay a monthly charge, which could be high in proportion to monthly incomes for low income groups, consequently, subsidies may be needed for the poorest (Satterwaite et al., 2019; Manga et al., 2020).

Gray infrastructure solutions are currently being supported in a number of cities across developing countries to improve waste and wastewater treatment. This includes faecal sludge treatment plants being constructed in Rwanda supported by the African Development Bank, and three wastewater treatment plants in Lahore, Pakistan supported by the Asian Infrastructure Investment Bank.

Ensuring the resilience of gray infrastructure will be important as climate change impacts come to be felt more strongly. For example, the functioning of the Iolanda water treatment plant, which supplies water to Lusaka, Zambia is vulnerable to climate change as drought affects hydropower production, the main electricity supply for the plant¹⁶.

5. Water resources management

Increasing water security will rely on water resources management. The solutions outlined above can increase the amount and quality of available water, but good water resources management is key to ensuring sustainability and resilience.

Climate resilient water management

Climate resilient water management is an integrated approach to building resilience for water-related decision-making to address the short and long term impacts of climate change by balancing robustness with flexibility (Smith et al., 2019). As there is uncertainty about future water resources availability due to climate change impacts, the best options for water management will be robust (perform well across a range of possible futures) and flexible (retain the ability to respond to unexpected climate shocks and stressors and long-term uncertainty) (Smith et al., 2019).

Institutions and infrastructure must be matched to a shifting climate and a dynamic, uncertain water cycle (Smith et al., 2019). Gray infrastructure solutions are a long-term investment and can lock countries into inefficient and unsustainable solutions as water

¹⁶ For more information see: <https://agwaguide.org/casestudies/zambia/>

availability and predictability changes. For example, there is a growing climate mismatch between the design parameters of Zambia's Kariba Dam and a non-static climate, consequently, the dam only produces electricity for a few hours per day with economic consequences for both Zambia and Zimbabwe (Smith et al., 2019).

Water resources planning, investments, agreements, regulations and gray infrastructure have traditionally been designed using an assumption of stationarity (that past water availability and weather patterns can predict the future) (Smith et al., 2019). Climate change is undermining this assumption creating challenges for decision-makers, planners and managers who are unable to distinguish between the likelihood of widely divergent scenarios and select appropriate solutions (Smith et al., 2019; Matthews et al., 2019).

Resilience depends on the performance of engineered infrastructure and functions of ecosystems, as well as institutions and decisions made locally and at higher levels (Smith et al., 2019). Examples of new approaches, tools and solutions include:

- **Climate Risk Informed Decision Analysis (CRIDA) and the World Bank's Decision Tree Framework** support climate resilient water management by looking at a particular system, understanding how it works, and considering both NBS and gray infrastructure jointly including source water resilience (Matthews et al., 2019).
- **China's 'sponge cities'**, which combine urban storm water engineering with flexible approaches to using green spaces to buffer flows of water during extreme events (Smith et al., 2019)¹⁷.
- **Source water protection in Rwanda:** wetlands degradation upstream of two hydropower plants in the Rugezi River exacerbated the effects of a mild drought in 2002, reducing river flows and power generation sparking a short-term crisis. Responses included wetlands restoration; legislation to protect national water resources and to ensure landless farmers had access to arable fields in less sensitive regions (this reduced pressure on national wetlands and riparian zones); and, energy diversification away from an overdependence on hydropower and diversified hydropower generation away from a single basin (Matthews et al., 2019).
- In the lower Save Catchment, Zimbabwe, **the DFID-supported Climate Resilient Infrastructure Development Facility (CRIDF)** developed water abstraction, pumping and irrigation infrastructure in two rural communities to increase food security, improve river health, and increase access to WASH. In response to poor harvests due to changing rainfall patterns farmers had shifted cultivation to riverbanks, negatively impacting the river's health. In turn, the communities partly relied on the river for drinking water. The project also included gender inclusive community management committees and a contract farming arrangement, which helped to increase some household incomes. One of the irrigation schemes is solar powered, which contributes to resilience as there are no electricity costs. As with many rural schemes there is a concern about ongoing operation and maintenance: in the Zimbabwe context the economic situation means sourcing parts can be difficult (CRIDF II, 2018).

¹⁷ For more information see: Wang, H., Mei, C., Liu, J.H., and Shao, W.W. (2018). A new strategy for integrated urban water management in China: Sponge city. *Science China Technological Sciences* 61(3). Doi: 10.1007/s11431-017-9170-5.

Governance

Good water governance will be needed to ensure an adequate supply of adequate quality water to fight and prevent future pandemics. However, in reality water governance is often fragmented. Interventions could include strengthening policy, institutional and regulatory frameworks. For example, a common barrier for the widespread adoption of green infrastructure is the lack of enabling policies, laws and regulations (Browder et al., 2019). Legislation in Peru requires water utilities to earmark revenue for water conservation and combatting climate change, with strategies considered in their budgeting and planning processes (Browder et al., 2019).

In response to Covid-19, policy responses are needed that address a more 'inclusive and holistic water security' (Joshi & Nicol, 2020). Solutions such as wastewater reuse will require institutional capacity to enforce environmental regulations such as water pollution control standards (Rodriguez et al., 2020). Although, interventions to strengthen water governance will need to recognise that it is shaped by political economy.

Stakeholder participation

Citizens and communities role in water management should be acknowledged and mechanisms put in place for them to have a say in decision-making. In Kenya, multi-stakeholder approaches are being piloted in Kajiado County to address water data gaps and knowledge sharing to enhance monitoring of water resource use and development. This will support decision-making and can help to ensure access to water¹⁸.

Green infrastructure/NBS have a strong social dimension and require cooperation among multiple institutions and stakeholders (Browder et al., 2019). As opposed to gray infrastructure which is owned and operated by companies or government entities, green infrastructure is operated by people and local communities (Browder et al., 2019). Local communities are responsible for implementing land stewardship practices and maintaining the project over the long-term (Browder et al., 2019). Consequently, local participation is extremely important, especially as NBS can operate at the landscape level and involve multiple groups (Browder et al., 2019). In order to be successful, green infrastructure needs to meet the needs and interests of local stakeholders and communities (Browder et al., 2019).

Systems and institutional strengthening

External support agencies are increasingly focusing on WASH systems strengthening (UN-Water, 2019b). Weak systems, including financial systems to support service delivery, and weak institutions are key challenges to increasing access to WASH (UN-Water, 2019b). For example, only 12% of 115 countries and territories surveyed for the UN and WHO's global analysis and assessment of sanitation and drinking water reported that urban drinking water surveillance was carried out at 100% of the required frequency (UN-Water, 2019b). A number of countries reported that they are seeking to make WASH services affordable through policy measures and financial schemes, mostly for urban water supply. However, systems to

¹⁸ For more information see <https://africa.wetlands.org/en/news/towards-sustainable-livelihoods-application-of-geo-data-in-water-resource-management-in-kajiado-county/>

monitor and finance these measures are not always in place, indicating that the level of implementation is insufficient (UN-Water, 2019b).

Strong formal and informal institutions and human resources are important for good water governance (WWAP/UN-Water, 2018). Lack of capacity and human resources, across all areas including agriculture, risk management, wastewater and sanitation, is constraining water resources development and management across regions including sub-Saharan Africa and South and South-east Asia (WWAP/UN-Water, 2018). For example, in Punjab and Khyber Pakhtunkhwa Provinces, Pakistan the formal institutions responsible for rural drinking water and urban water and sanitation lack qualified human resources and capacity to manage and expand water access (Cooper, 2018). **Long-term support for knowledge and capacity development is needed as it takes years to strengthen institutional capacity with a cadre of experienced and effective professionals and technicians** (WWAP/UN-Water, 2018).

Move beyond sectoral thinking

Moving beyond sectoral thinking which sees water resources, WASH, and public health as largely separate sectors will help countries to prepare for future threats. The COVID-19 pandemic illustrates that WASH activities should be considered as an essential public health intervention¹⁹, whilst upstream water resources management is essential for urban water supply. Understanding the links between these sectors and breaking down siloes will improve coherence and formulate coordinated responses to prepare for future pandemics. This will also involve taking account of any transboundary aspects as water resources often cross national borders.

Data and information

A lack of data can pose challenges for water management particularly in a context of climate change, water stress and scarcity, population growth and rapid urbanisation. For example, data is needed to monitor progress and to hold service providers, governments and development partners to account (WWAP/UN-Water, 2018). However, many countries lack the financial, institutional and human resources to acquire and analyse data to support governance (WWAP/UN-Water, 2018). Informal settlements pose a data challenge as there is often no reliable data about the number of people who live within them or their access to services (SSHAP, 2020).

The development of tools such as water accounting can help decision-makers, planners, and managers understand and resolve water problems (FAO & WWC, 2018). Defined as the systematic quantitative assessment of the status and trends in water supply, demand, distribution, accessibility and use in specified domains, water accounting can improve understanding of medium and long term changes in demand across all water users and inform water management decisions (FAO & WWC, 2018).

Accelerating urbanisation is exacerbating water management challenges for a large number of cities across most regions (WWAP/UN-Water, 2018). Urban water accounting, combining data from a range of sources including hydrological modelling, field measurements and remote sensing, can improve understanding of the urban water cycle and can help to

¹⁹ Bruce Gordon, Head of WASH, WHO, quoted in: <https://www.devex.com/news/what-does-a-covid-19-response-look-like-with-limited-water-96834>

address urban water challenges²⁰. This includes quantifying the amount of water entering and leaving a city, assessing the impact of green infrastructure, and optimising urban rainfall harvesting techniques.

6. Affordable WASH services

Affordable access to WASH services is essential for combatting future pandemics. It could also help to mitigate the economic costs of future pandemics as access to WASH can help to suppress infection, reducing healthcare and other costs. The poorest are often hardest hit by pandemics as they are unable to socially distance, self-isolate in their homes, or conform to lockdowns for a number of reasons including needing to leave their homes to access water and toilets. Long-term responses to Covid-19 should include a focus on extending access to services to poor communities, particularly in urban areas. Investments should support sustainable access and resilient services.

Finance

Finance is a key challenge for extending access to services. This includes both finance for infrastructure and finance for the systems, plans, policies, institutions, and capacity to ensure sustainable services (UN-Water, 2019b; Coates & de Albuquerque, 2020). In some cases large funding gaps remain between what is needed to reach WASH targets and the funding that is available (UN-Water, 2019b).

Estimates of the level of financing needed to extend access to WASH services and meet the SDG 6 targets range from USD 28.4 billion to USD 114 billion annually between 2015 and 2030 depending on the pathway for scaling up services (Hutton & Vargughese, 2016). Extending safely managed services will require three times the historical financial trend (Hutton & Varughese, 2016). Urban areas account for 70% of the needed capital expenditure to achieve universal access to WASH due to the shifts in population to urban areas and the commonly higher service costs in towns and cities (Hutton & Varughese, 2016).

Extending urban services

Access to piped water is the least expensive water service for most urban households (Mitlin et al., 2019). However, analysis of 15 cities across developing countries found that almost half of households lack access to piped water and self-provide through a number of mechanisms including tanker water (Mitlin et al., 2019)²¹. Self-provision mechanisms can be up to 50 times the cost of piped water (GSMA, 2020).

Extending urban access to reliable and affordable piped water requires action across four areas (Mitlin et al., 2019):

- Extending the formal piped network with the goal of achieving universal access to piped water to the home or plot.

²⁰ For more information see: <https://www.un-ihe.org/urban-water-accounting>

²¹ There were also geographical variations in access to piped water, with cities in sub-Saharan Africa having the lowest proportion of piped water to a dwelling and Latin America the highest (Mitlin et al., 2019).

- Addressing context-specific causes of intermittent water supply including revenue aspects (through the use of water meters to improve billing systems), using technology to detect leaks, and improving regular infrastructure maintenance to reduce leaks.
- Pursuing diverse strategies to make water affordable with special considerations for low-income consumers including subsidised water, cross-subsidies, incremental block tariffs and spatially targeted subsidies. Flexible payments arrangements for water and water connections should also be promoted.
- Supporting informal settlement upgrading to improve water access. This involves city-wide participatory, in situ, informal settlement upgrading as a means to improve water access and quality of service. There is evidence that that government and community-led informal settlement upgrading schemes are successful at improving access to water, sanitation and drainage.

Extending access to piped water will require data for coordinated urban planning, increased investment in water infrastructure and maintenance and good governance (Mitlin et al., 2019). Data about informal settlements is often lacking, as mentioned above, and global urban water data can lead policy-makers to overestimate urban water access (Mitlin et al., 2019). Intermittent water supply can often be related to inadequate water and energy supplies, pipe breaks and leaks, and a lack of financial investment as well as local politics (Mitlin et al., 2019). Extending access to piped water will require sustained political commitment and state regulation of the water service sector (Mitlin et al., 2019).

In urban areas approaches such as low-income customer support units can increase access to water as a mid-term measure, although care must be taken to ensure they do not heighten vulnerability. Cases studies from cities in Bangladesh, Kenya, Malawi, Uganda and Zambia demonstrate that low-income customer support units can lead to win-win situations for both utilities and the urban poor (Wateraid, 2016). For example, in Lilongwe, Malawi, extensive non-payment for water sold at kiosks promoted the utility to work with stakeholders to come up with new modalities to avoid wide-scale disconnections (Wateraid, 2016). The utility worked with community-based organisations to establish and outsource the management of a system of pre-paid water kiosks to Water User Associations, under a Kiosk Management Unit based in the Lilongwe Water board (Wateraid, 2016).

Connecting poor people to utility water supplies through kiosks and other measures can reduce the price they pay for water (Wateraid, 2016). However, steps should be taken to ensure these access modalities do not increase vulnerability. For example, pre-paid kiosks are not necessarily accessible to the poorest people, and there is a risk small-scale sellers can inflate prices when selling to people without access to regulated water points (Wateraid, 2016). As such social safety nets are required to ensure they can also access water services (Wateraid, 2016). Kiosks also involve people queuing for water, and pandemic preparedness measures would need to include the availability of hand-washing stations and soap.

Digital tools can help to support service delivery in urban areas. In Niamey, Niger a collaboration between CityTaps (a social enterprise), SEEN (the water utility) and Orange Niger (mobile phone company) combines smart, prepaid water meters, billing software and a pay-as-you-go mobile model resulting in users experiencing lower bills, uninterrupted water supplies, and users spending less time collecting and paying for water (GSMA, 2020).

In addition to digital tools, interventions to support capacity building for utilities can support sustainable service delivery. Cost recovery, non-revenue water and low revenue collection are problems for utilities across developing countries (Rodriguez et al., 2020; Wateraid, 2016). These pose challenges for capital investment and future expansion (Rodriguez et al., 2020). Tackling these challenges are important to ensure that water shut-offs do not occur and households have access to water during pandemics, particularly if asked to self-isolate.

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