Mission-critical: Invest in water, sanitation and hygiene for a healthy and green economic recovery


WaterAid

Executive summary

The attainment of universal access to water, sanitation and hygiene (WASH) is fundamental to inclusive and sustainable development.

Inadequate access to WASH is responsible for as much as 10% of the global disease burden, contributing to 1.6 million preventable deaths each year, including 60% of all diarrhoeal deaths. A lack of basic WASH requires households to spend 1–2 hours per day on average collecting water, displacing time spent in employment or education. The incidence of these impacts on health and economic opportunity skews heavily towards women, meaning a lack of WASH is a critical barrier to female empowerment and gender equality.

Aspects of the case for investment in WASH are captured in benefit-cost ratio assessments, which consistently demonstrate strong value for money.

Benefit-cost ratios (BCRs) compare the socioeconomic gains from an investment against their costs, all measured in monetary terms, in order to assess value for money. Leading estimates have shown that universal WASH offers excellent value for money, with BCR ranges of 4–8 even where key societal impacts such as gender equality are not accounted for.

In the wake of COVID-19 and with increasing risks from climate change, it is timely to revisit the case for investment in WASH.

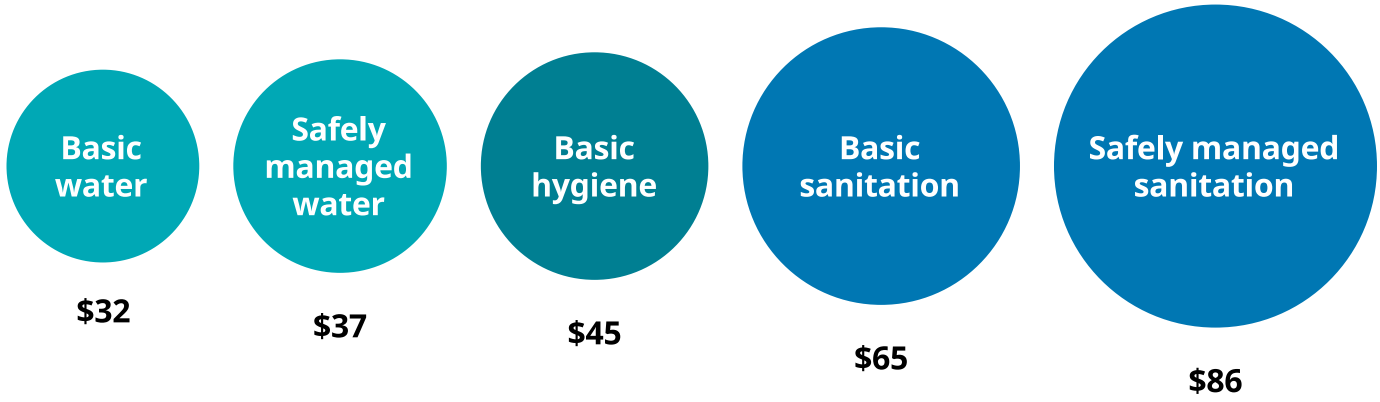
The pandemic has exposed the devastating economic and societal consequences of infectious disease – the risks of which are expected to increase significantly as a result of climate change. Yet the potential role of WASH in mitigating the risks of airborne infectious disease, which is significant for COVID-19, and in promoting climate resilience, has yet to be included in a BCR. At a time where many governments and donors are seeking to 'build back better' in the aftermath of COVID-19, the contribution of this study is to revisit the case for investment in universal WASH, updating previous estimates and accounting for its effects on resilience to climate change and respiratory disease.

Table 1: Global BCRs of achieving universal coverage by 2030, maintained through 2040

Service level	Water	Sanitation	Hygiene
Basic	14–18	4.4–5.5	15–21
Safely managed	1.5–1.9	2.2–2.9	–
Safely managed and climate resilient	1.6–1.9	2.2–3.0	–

Source: Vivid Economics

Figure 1: Annualised net benefits of achieving universal services 2021–2040 (USD billions)



Note: The area of each circle corresponds with the magnitude of net benefits from 2021–2040.
Source: Vivid Economics

Updated analysis confirms the value of universal WASH, which could unlock trillions of dollars of value over the next two decades (Table 1). It finds:

- Basic services can provide up to 21 times more value than expenditure, and are a necessary step towards universal safely managed services;
- Upgrading basic services to safely managed WASH infrastructure is a long-term investment that will yield net benefits of US $37–86 billion per year (Figure 1), avoiding up to 6 billion cases of diarrhoea and 12 billion cases of helminths between 2021 and 2040, with significant implications for child health and nutrition;
- Every dollar spent on strategic flood resilience upgrades could avoid at least US $62 in flood restoration costs. Flooding is the most prevalent climate change-related threat to global WASH infrastructure, with service disruptions expected for up to 13% of the population in the most vulnerable countries. Flood-resilience is a highly cost-effective investment for flood prone areas, with costs significantly lower than those of disruption and repair.

Investment in WASH can be an effective means of achieving transformative economic growth in the wake of COVID-19.

The BCR analysis presented in this report highlights how proximate benefits clearly outweigh costs of investment, but there are additional strategic dimensions to the decision. Over the short term, with many economies facing high unemployment as a result of the pandemic, WASH investments can be an effective form of stimulus spending, rapidly deployed and targeted towards job creation. Over the longer term, WASH can support healthier, more educated, more productive and resilient workforces, crowding in further private investment and sustaining more rapid and equitable economic growth.

Urgent actions required

WaterAid calls for governments, international organisations, donors and businesses to lead the way in providing substantially increased and sustained investments in WASH infrastructure and services in low income countries (LICs) and lower middle-income countries (LMICs) during 2021 and 2022. These investments are an essential public health response to COVID-19, a mission-critical fiscal stimulus for economic recovery and a core element of future pandemic preparedness plans.

- Governments, international organisations, donors and business should lead the way in financing the annual US $229 billion capital requirement for LICs and LMICs to restore progress and be on track to achieve SDG 6 by 2030.
- G20 governments must urgently phase out their US $580 billion annual subsidies to fossil fuels and redirect this to a healthy and sustainable COVID-19 recovery, including supporting investments in WASH services.
- Fiscal stimulus packages – supported by the international community – should include financing of the estimated US $6.5 billion[i] required to ensure every healthcare facility in Least Developed Countries (LDCs) has safe and sustainable WASH services.
- All high-income countries (HICs) should fulfil their responsibilities to provide new and additional climate finance, complementing increased Official Development Assistance (ODA), in line with the US $100 billion annual commitment to climate finance – with substantial increases in grant-based adaptation funding to WASH in LICs and LMICs.
- As part of meeting promises to spend 0.7% of gross national income (GNI) on ODA, high-income countries should lead a doubling of ODA for WASH in 2021 and 2022.
- Multilateral and bilateral donors and private sector investors should strengthen collaboration and create the enabling environments for increased water investments for the poorest, most vulnerable communities in climate change hotspots, in order to better align international climate finance with the highest needs in LICs and LMICs.
- G20 governments and private creditors must provide comprehensive debt cancellation to debt-distressed LICs and LMICs, including through the reallocation of Special Drawing Rights to enable investments in SDG 6 and Agenda 2030 as part of the fiscal stimulus for economic recovery from COVID-19.

[i] *Estimate based on WHO costing currently under peer review, as outlined in Gordon B, Montgomery M, Neira M (2021).* ***Opinion: How to ensure WASH services in all health care facilities.***

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1. Introduction

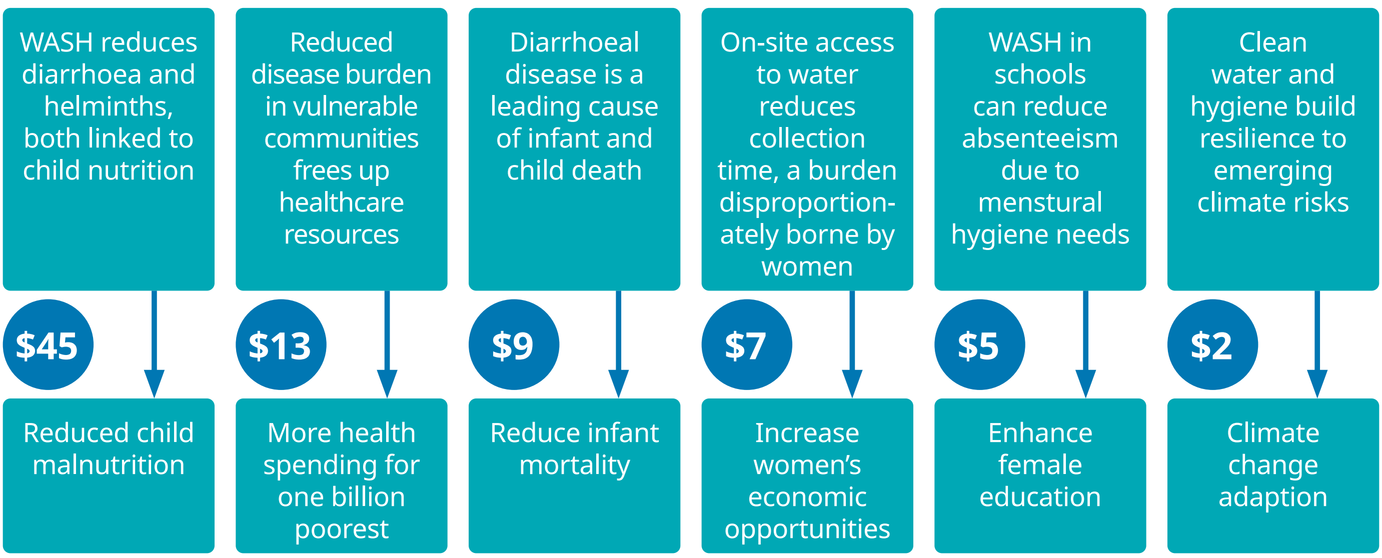
Achieving universal access to sustainable water, sanitation and hygiene (WASH) facilities underpins multiple Sustainable Development Goals (SDGs) and is an increasing challenge to achieve.

WASH is critical to reduce the spread of disease and adverse health effects,[1] particularly for individuals in LICs and LMICs. WASH is also a necessary condition for many linked SDGs, including poverty, health, education, gender equality and environmental health. In many countries, access to safely managed WASH services in both households and key community facilities such as schools and health centres is limited, and the need for sustainable WASH services will continue to increase with population growth.[2] Figure 2 shows the estimated benefit-cost ratios (BCRs) for related SDGs, and the role of WASH in achieving these outcomes.[3]

Recent decades have seen global progress against SDG 6 targets, while some countries have stagnated and face barriers to securing sufficient investments.

SDG 6 aims to ensure the availability and sustainable management of water and sanitation for the billions of people who currently lack access to safely managed services. In 2017, 73% of households worldwide had access to at least basic sanitation services, an improvement from 56%, in 2000. Over the same period, access to at least basic drinking water increased from 81% to 88%.[4] However, 9% of the global population still practises open defecation and the funding gap in providing WASH is still large, particularly countries with high needs and limited resources.[5]

Figure 2: WASH is directly linked to multiple cost-effective health, gender, economic and environmental SDGs



Note: Benefit cost ratios for SDGs estimated by Copenhagen Consensus 20163.
Source: Vivid Economics and Copenhagen Consensus 2016.[3]

LICs and LMICs face disproportionate challenges to attracting investment in scaling up WASH services.

The World Health Organization (WHO) estimates that less than 15% of countries have enough financing to meet their WASH needs.[6] Attracting private investment in the water and sanitation sector can be challenging, and some countries may face the added challenge of having less open markets. To achieve the SDG targets by 2030, investment in WASH services will need to be scaled up significantly.[1]

Previous research provides a strong economic argument for investing in WASH services.

Studies by the World Bank, UNICEF and others have estimated that the benefits of achieving basic water services can deliver up to US $66 billion in value per year. The annual cost of achieving this target is comparatively small, just US $14 billion per year. Accordingly, these investments can achieve good value for money, with the highest benefits per dollar spend in Latin America and Eastern Asia of 3.3 and 4 respectively.[7,ii] Overall, benefits consistently outweigh the costs across regions.

However, previous studies have failed to account for the benefits and costs of building resilience to climate change impacts.

More frequent climate disasters and slow on-set climate impacts on water availability increase the challenge of providing sustainable WASH services. Extreme climate events can disrupt access to WASH services, necessitating upgrades and investments in resilient infrastructure or risking severe damage costs. Simultaneously, access to WASH services will become increasingly important to build resilience to climate impacts, such as increasing temperatures and droughts. It is important that these costs and benefits are properly understood in order to appropriately prioritise and plan infrastructure, and to avoid locking in infrastructure that is ill-equipped to meet future climate needs.

WASH infrastructure underpins system-wide resilience in an economy, improving a country's ability to adapt and mitigate risks of both health emergencies and climate change.

Handwashing, drinking water and sanitation services are critical services during refugee, health and climate emergencies, helping a country respond and adapt. For example, hand hygiene is necessary for reducing the spread of upper respiratory illnesses and is the most effective physical intervention in reducing the transmission of diseases.[8] Improving infrastructure resilience, particularly in water and sanitation, can have economy-wide benefits through reducing the impact of high risk events.

1.1. Objectives and scope of the study

The objective of this report is to provide an updated investment case for WASH services, reflecting major global challenges: climate change, COVID-19 response and recovery, and building resilience.

The rest of the report is structured as follows:

- Section 2 outlines the role of WASH in achieving health, environment, socioeconomic and resilience outcomes;
- Section 3 details the findings from the benefit-cost analysis scenarios;
- Section 4 provides case studies of WaterAid projects in Ethiopia and Bangladesh that illustrate the role of WASH in building community resilience; and,
- Section 5 concludes with paths forward for financing WASH post-COVID-19.

[ii] BCRs will vary by country and region due to varying levels of capital required for outstanding infrastructure as well as income levels, disease incidence and mortality rates.

2. The role of WASH in economic development and resilience

Promoting safe and equitable access to WASH is recognised as a key sustainable development objective, both to serve basic needs and to deliver economic benefits. This section reviews existing evidence on the benefits of sustainable WASH services for economic and social development, which are subsequently valued in the next section. Economic benefits of WASH can be disaggregated into four categories:

- **Health** benefits include reductions in communicable and non-communicable disease incidence, and overall population wellbeing;
- **Environmental** benefits include reductions in environmental degradation and opportunities to improve resource efficiency;
- **Socioeconomic** benefits include increased economic, educational and leisure opportunities, particularly for marginalised and vulnerable groups; and,
- **Resilience** benefits include responsiveness, preparedness and recovery from health and climate-related emergencies.

2.1. Health

Inadequate access to WASH contributes to 1.6 million preventable disease deaths, disproportionately affecting children and vulnerable populations. Previous studies have estimated that achieving universal access to safely managed WASH systems could reduce the global disease burden by up to 10% annually.[9,iii] Table 2 shows that diarrhoeal disease and helminths incidence are particularly driven by inadequate WASH.[10] 2.8% of deaths annually can be attributed to inadequate WASH, including nearly 300,000 deaths of children under five from diarrhoeal disease.[9]

2.1.1. Communicable diseases

WASH can reduce spread of communicable diseases by preventing human contact with waterborne and airborne disease vectors, and faecal-oral transmission.

An estimated 60% of all diarrhoeal deaths can be attributed inadequate WASH facilities.[9] Access to clean drinking water and hygiene services are key interventions for diarrhoea prevention, which kills nearly one million people each year.[11] Studies have demonstrated that 20–47% of diarrhoeal cases can be reduced through handwashing with soap alone, and complementary cultural, technological and behavioural shifts for communities.[12] Basic drinking water can reduce diarrhoea incidence by 13% while safely managed household level access to drinking water can reduce diarrhoeal disease by up to 45%.

Children are disproportionately vulnerable to diarrhoeal diseases, which can lead to long-term chronic health conditions.[14] Studies indicate that children living in areas with poor water quality suffer higher rates of diarrhoea, which is responsible for 9% of global child mortality.[15,16] In addition, diarrhoeal disease in childhood is linked to nutrition intake and poor health outcomes later in life,

Table 2: Disease burden driven by inadequate WASH results in nearly two million deaths per year

Disease	Deaths	DALYs (thousands)	% attributable to inadequate WASH
Soil-transmitted helminths infections	6,248	3,431	100
Diarrhoeal diseases	828,651	49,774	60
Acute respiratory infections	370,370	17,308	13
Malnutrition	28,194	2,995	16
Trachoma	<10	244	100
Lymphatic filariasis	<10	782	67
Schistosomiasis	10,405	1,096	43
Subtotal: WASH	1,243,868	75,630	
Malaria	354,924	29,708	80
Dengue	38,315	2,936	.95
Subtotal: water resource management	**393,239**	**32,644**	
Total	**1,637,107**	**108,274**	

Source: Prüss-Ustün A, et al. (2019) Figure 10 and WHO (2019) Table 1.

which can lead to stunting, poor cognitive development and obesity.[17] Improving the quality of service in the provision of water and sanitation further reduces the risk of diarrhoeal diseases, essential to improving children's long term physical health and cognitive development outcomes.

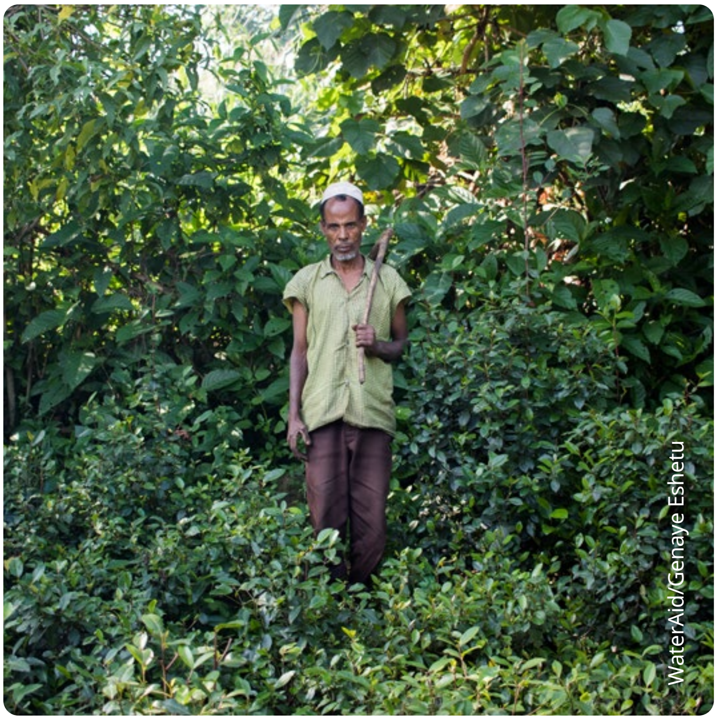
Cholera, a diarrhoeal disease contracted through ingesting contaminated foods and water, infects at least 1.3 million people each year where WASH services are disrupted or inaccessible.[18] Cholera is becoming an increasingly prevalent epidemic, with more than 300 cholera epidemic events between 2011 and 2017.[19] These events are typically observed following a disruption to WASH services,[20] for example in South India in 2012 following a cyclonic storm,[21] and in Yemen in 2017 as a result of increased conflict and displacement.[22] These outbreaks can be reduced through safely managed and reliable WASH services, which create barriers to oral-faecal contamination.[23,24] Cholera epidemics are likely to become even more frequent as climate-related hazards disrupt WASH services, increasing the urgency of investing in safely managed and resilient services.

[iii] *The global burden of disease, measured annual by WHO, is the impact of all diseases on the global population, measured by the number of years lost to the disease via disability-adjusted life years (DALYs). The WHO's global burden of diseases measures the estimated mortality across 100 diseases and injuries that result in loss of healthy years of life.*

Nearly all of the 1.5 billion annual cases of helminths could be reduced through improved access to hygiene and sanitation facilities.[25] Helminths, or parasitic worms, are spread through the excretion of infected individuals, where the eggs of helminths remain and are passed on to another individual who comes into contact with faecal matter.[26] Hookworm, one class of helminths disease, affects around 500 million individuals per year and results in an annual loss of four million disability-adjusted life years (DALYs).[27] More severe cases can cause chronic disability including diarrhoea, anaemia and undernutrition.[28] Previous studies have estimated that productivity losses from helminths cost as much US $20 billion per year.[29,30] Access to safely managed sanitation facilities can significantly decrease the likelihood of contracting helminths-classified infections, particularly compared to open defecation.[31]

Improved WASH services, particularly reducing open defecation practises, can help reduce the spread of waterborne antimicrobial resistance (AMR). Limited WASH access and open defecation in particular, can greatly exacerbate the feedback loop between antimicrobial consumption, excretion, contact and further consumption. Open defecation practices allow AMR to enter water bodies that are used by households for drinking and washing or by farmers for irrigation.[32] Where communities do not have access to handwashing facilities, this contact with waterborne AMR is much more likely to lead to its consumption.[33] Disease pathogens carried into water bodies from poor management of wastewater and sludge may also increase the need for antibiotic treatment, increasing the chance of AMR in humans and animals.[34]

Improved hand hygiene practices can reduce the incidence of upper respiratory tract infections and healthcare-associated infections (HAIs).[9,10,35,36] Hand hygiene is the first line



of defence against the spread of infectious diseases in healthcare facilities, including COVID-19, where current government guidelines recommend handwashing with soap.[10,37,38] This is particularly important for respiratory illness, which can be reduced by up to 21% when handwashing stations with soap and educational materials are provided.[35] Current estimates indicate that one-third of global healthcare facilities lack hand hygiene facilities at the point of care.[39] Increased infections and inadequate hygiene can lead to overreliance on antimicrobials, contributing to the growing threat of AMR and reducing the efficacy of healthcare services.[40]

Maternal and pre-natal health can be significantly improved through the implementation of WASH services in healthcare and hospital settings. A lack of available and safe WASH facilities during childbirths contribute to poor health outcomes for mothers and newborns.[41] Newborns in LICs are at a higher risk of morbidity and mortality from sepsis transmitting during childbirth.[42] Sepsis can be prevented by simple WASH interventions, averting up to 1.4 million maternal and natal deaths each year.[43,44]

2.1.2. Non-communicable diseases

Limited sanitation services can create situations that induce anxiety, shame or fear, affecting mental health. Populations forced to practise open defecation, using unimproved or communal sanitation facilities, or lacking access to personal hygiene services may face daily concerns surrounding dignity, personal safety and embarrassment.[45,46] There also may be physical fears that cause recurring stress events, such as insect bites or reptile attack.[47] Lack of sufficiently private facilities may place women in particular in vulnerable positions; in some cultures, bodily exposure may violate social norms, causing anxiety and exposing women to potential violence.[48]

Water insecurity can also reduce mental health and wellbeing through emotional and financial anxiety. Populations living in water insecure and informal settlements may face daily emotional distress over accessing sufficient water.[49] The high demand and scarcity allows vendors to price gouge, or significantly inflate prices. A study in Nigeria found that the price of buying water from vendors is 28–40 times the cost of an in-house connection.[50] Without safe access to alternative water sources, low-income households can face catastrophic expenditure, exacerbating financial anxiety.[47]

Safely managed water services can reduce contact with chemical pollutants and associated illnesses. Chemicals found in contaminated or untreated water include fluorides, nitrates, endocrine disrupting compounds (EDC) and microplastics. Humans are exposed to EDCs through untreated drinking water contaminated by wastewater, leeched chemicals from landfills or waste disposal effluent. Those who collect surface water or shallow groundwater are at higher risk of exposure to nitrates from agricultural run-off.[51] These chemicals have been linked to cancer, cardiovascular diseases and cognitive development.[10,52] Long term exposure to EDCs can induce immune effects, metabolic syndromes and reproductive health abnormalities.[53] Nitrate and nitrite in contaminated water can have negative health impacts, particularly for infants and pregnant women, even from short exposures.[54] As an emerging pollutant there is limited evidence on the health risk to humans of microplastics; however, the microbial pathogens and chemicals carried by these small particles have been noted as a concern for future research.[55]

2.2 Environment

Lack of wastewater treatment and open defecation can contaminate both land and aquatic ecosystems. Without WASH infrastructure that safely manages sewage effluents, wastewater and open defecation contribute to the overall nutrient load in the environment and can have harmful effects on sensitive ecosystems. It is estimated that currently, 80% of wastewater is disposed of directly into the environment without proper treatment.[56] Untreated sewage and wastewater is responsible for excessive nitrogen in freshwater systems, causing eutrophication that harms fish and wildlife.[57,58] Sewage effluents can also stress coral reef ecosystems through decreasing the salinity of coastal areas and causing diseases from pathogens present in the waste.[59] These impacts can cause significant biodiversity loss and reduce the functioning of ecosystems. For example, in Argentina, an excess of untreated urban wastewater in a coastal wetland led to an increase in bacterial productivity that reduced the estuary's natural seawater buffer mechanism and deteriorated habitat available for aquatic and land species.[60]

Environmental contamination can reduce recreational opportunities, particularly in rivers, lakes and other fresh water or coastal systems. Contamination from wastewater or the practise of open defecation make these areas unsuitable for safe recreation.[61] Children in cities are at an additional risk of disease where play areas are commonly used for open defecation.

WASH can be used in the circular economy, improving resource efficiency in the agriculture and energy sectors. Efficiently planned WASH services can create valuable materials for use in other productive processes, limiting resource extraction needs. In agriculture, treated wastewater can be used for fertilisation and aquaculture, while greywater systems from recycled piped water can meet local irrigation needs with minimal processing.[62,63] WASH systems can also create new energy sources. Heat from processed wastewater facilities can be used to heat homes or hot water. While this requires homes to have boilers or heat pumps and for wastewater facilities to be fully functional, the opportunity to use wastewater as a heat source is both feasible and improving in cost efficiency.[64]

Well-designed WASH facilities can improve the efficiency of resource use, reducing pressure on freshwater ecosystems. As demographic changes put pressure on surface water sources, well-designed WASH systems will be increasingly important for making more efficient use of natural resources. Well-designed WASH infrastructure can reduce unsustainable surface water abstractions and shift households towards an improved and centralised water source that can be regulated and managed efficiently.[65] Creating more locally-accessible water sources can also reduce waste during travel.[66]

2.3. Socioeconomic

Improving WASH infrastructure is key to improving socioeconomic outcomes, including greater workforce productivity, enhancing gender equality and increasing educational attainment.

The impact of WASH on population health is linked to economic growth, catalysing additional opportunities for development. Achieving development goals is often conditional on aggregate economic growth, which can improve the standard of living for populations in low- and middle-income countries.[67] Numerous studies have observed a relationship between population health and economic growth; countries that have seen a decline in key diseases such as malaria and malnutrition have also experienced an increase in GDP per capita growth.[68] Improved health outcomes from WASH can lead to economic opportunities through multiple channels, particularly by increasing educational outcomes and worker productivity.[69] This can have a multiplier effect on the economy, leading to increases in wages, consumption and creating additional economic opportunities.[70]

Improved WASH services can free up time for productive activities, education and recreation. Previous studies on the economic value of WASH have found that the majority of the value comes from increased economic opportunities. On average, having a piped water source saves a household 1–2 hours a day in water collection, increasing opportunities for income, education, childcare and building social capital.[7] Improved WASH services also provide economic opportunities by averting productivity losses from illness. This can result in averted absenteeism, reduced productivity from missed days of work, and presenteeism, reduced productivity from being ill or recovering while at work. Child illness can result in multiple losses; children who are sick miss school time, and adults may lose productive time as a carer.

Economic opportunities for women are substantially improved with the reduced time commitment for WASH activities. The burden of water collection and time costs are disproportionately borne by women.[71] Among 24 sub-Saharan countries, women undertake more than 50% of water collection activities in households without piped water.[72] Accordingly, providing on-site WASH services can be a tool for empowering women and reducing gender inequalities.

Safe and adequate WASH services can reduce gender-based violence.[73] There are three key sources of gender-based violence associated with WASH services. Firstly, women and girls are at risk of experiencing gender-based harassment and violence when practising open defecation, particularly in urban settings.[74] Secondly, in some cultures, a lack of adequate menstrual hygiene management (MHM) facilities can also risk bullying or violence.[75] Thirdly, women may suffer from domestic abuse related to providing household water supplies.[76]

WASH services in schools can improve educational attainment through reducing absenteeism from illness and MHM. Inadequate services can be a driver of diarrhoeal and helminths disease, leading to missed school days for students of all genders.[77] For menstruating girls in particular, WASH services in schools are necessary to accommodate safe MHM.[78] Survey data in Malawi shows that up to a third of school aged girls miss a day of school per menstrual cycle; in India, some girls have reported missing up to three days per cycle.[79,80] These lost educational opportunities can further gender inequalities, preventing girls from fully engaging in education and economic opportunities later in life.

2.4. Resilience

COVID-19 has highlighted the importance of building resilient social, economic and health systems that are able to respond and adapt to new threats. WASH services can be a source of resilience to emerging challenges stemming from both climate change and health emergencies.

2.4.1. Climate resilience

Environmental change is likely to increase infectious disease transmission, making WASH services increasingly important to reduce human contact with disease vectors.[81] Environmental change increases the risk of infectious diseases emerging through land-use change and climate-related hazards. Land-use change causes cross-species transmission by changing habitats, with more than 75% of human diseases traceable to wildlife or domestic animals.[82] Flood, heat and drought events also increase the risk of infection. In some areas, malaria and dengue risk has been linked to increasing temperatures, where vector populations have faster reproductive cycles in higher temperatures.[83]

Clean water can help reduce heat-related productivity loss, illness and deaths. Climate change is anticipated to lead to a global rise in average annual temperatures, with increasing long duration heatwaves in summer.[83] Temperature rise will lead to increased heat-related death particularly in urban areas and among vulnerable populations such as outdoor labourers, the elderly and those with underlying health conditions.[84] Improved access to clean water can reduce heat-related illness through two channels. Firstly, a readily available supply of water can reduce dehydration. Secondly, less time spent travelling to collect water means less physical activity in hot weather, reducing the risk of heatstroke and other health impacts.[85]

WaterAid/Basile Ouedraogo

Efficient WASH infrastructure can help build resilience to climate- and growth-driven water scarcity. Climate and demographic changes threaten the security of already limited water resources. 27% of the global population currently lives in potentially severely water-scarce areas. By 2050, the number of people living under severe water scarcity is predicted to be between 42% and 95%.[86] Upgrading WASH infrastructure to improve the efficiency can support the conservation of an increasingly scarce resource.[87]

2.4.2. Health resilience

In addition to the benefits of WASH for endemic diseases, access to WASH can build resilience to future health emergencies. As demonstrated by COVID-19, new infectious diseases can be devastating to both societies and economies. New diseases can be more challenging to treat and more difficult to control. WASH services are necessary to ensure health facilities can respond to new health threats. Sustainable WASH services in homes and communities can build resilience to future health risks through three channels:

1. **Reduced spread of disease:** WASH can reduce the risk and severity of health emergencies by limiting human contact with pathogens, preventing disease transmission.[88]
2. **Improved efficacy of healthcare systems:** In both clinics and hospitals, WASH services are a prerequisite to providing many services like maternal care and post-operational surgery care. WASH in healthcare facilities can also prevent HAIs, the spread of AMR and improve the overall quality of care.[39]
3. **Reduced vulnerabilities:** There is a disproportionate burden of disease faced by countries where WASH facilities are inadequate. Because of this, the baseline health of LICs and LMICs remains on average lower than HICs, creating additional vulnerabilities and co-morbidities in health emergencies.

Hand hygiene is an important infection control measure for any pathogen outbreak and has been a cornerstone of public health recommendations as a first line of defence for COVID-19.[89] The role of hand hygiene in controlling health emergencies depends on the disease and how it is transmitted; it is critical for waterborne infections, and to a lesser extent respiratory infections like COVID-19. As evidence on COVID-19 transmission is still emerging, the role of hand hygiene in slowing the spread in populations is not fully understood.[90] However, evidence from other coronavirus outbreaks such as SARS-Cov-2 highlights the importance of hand hygiene among health professionals in containing outbreaks and providing effective care.[91,92] While hand hygiene cannot substitute for other well-established preventative measures like mask wearing and social distancing, even modest impacts of hand hygiene on controlling infections can prevent health emergencies from exceeding the capacity of healthcare systems (Box 1).

Box 1: Case study: COVID-19 and hand hygiene

Indicative scenario modelling of a COVID-19-like epidemic in a sub-Saharan Africa urban setting shows that even modest effects of improved hand hygiene practices can slow the spread of infection. The analysis is based on a COVID-19 model developed by Siraj A, et al. (2020), to show indicatively the potential impacts of hand hygiene on a COVID-19-like epidemic outbreak. The scenario tested evaluates a 50-person outbreak in a city the size of Addis Ababa (population of five million) with a current hygiene access level of 59%. Based on evidence provided by the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) and Environmental and Modelling Group (EMG) for the Scientific Advisory Group for Emergencies (SAGE), the indicative scenario modelling assumes that having access to hygiene services reduces the likelihood of transmission given exposure by 3–6%.[90] The scenario modelling assumes no other preventative measures such as social distancing or mask wearing. From the indicative scenario modelling, two key impacts are observed:

1. **Even a modest impact of handwashing shows a significant reduction in infections over the first 75 days of the outbreak** (see Figure in the Appendix). Having full hygiene access and good hygiene practices can reduce hundreds of thousands of infections in absence of other interventions. Table 3 compares the cumulative infections across the hand hygiene scenarios at day 75 of the outbreak. Compared to the current level of access, having 100% access to hand hygiene could reduce cumulative infections by up to 20%. By helping to slow the spread early in the epidemic, hand hygiene provides time for healthcare systems to build capacity and invest in other interventions. Even small improvements from handwashing help save vital days as infections rise rapidly.
2. **Hand hygiene lowers peak illnesses during the initial outbreak.** A key indicator of pressure on the healthcare system is the number of people who are ill on any given day of the outbreak. Assuming that the illness lasts two weeks, hygiene access reduces the maximum number of people ill at any one time by 50,000. In a country with just 0.33 beds and 0.07 physicians per 1,000 people, every infection reduction helps reduce pressure on healthcare systems.[94]

Table 3: At day 75 of the outbreak, full access to hygiene services reduces cumulative infections by up to 20% compared to current levels of hygiene access

	Cumulative infections compared to current population access (59%)		
Handwashing scenario	**25% population access**	**75% population access**	**100% population access**
3% reduction	+4%	-2%	-8%
6% reduction	+9%	-10%	-20%

Note: Compared to the baseline of 59% of the population with access to hygiene services. Figures are indictive based on scenario assumptions described above; precise outputs will vary with model runs.

Source: Vivid Economics based on model developed by Siraj A, et al. (2020).

3. The value of investment in WASH services

This chapter details the findings of analysis conducted for this report, comparing the costs and benefits of achieving universal access to three levels of WASH services. Previous economic analysis has highlighted a strong investment case for achieving SDG 6 and the need for scaling up WASH financing. However, previous studies have failed to account for the benefits and costs of building resilience to climate change impacts. Extreme climate events can disrupt WASH services, necessitating upgrades and investments in resilient infrastructure or risking severe damage costs. The following analysis builds on the findings of previous studies, making use of more current data and considering a wider range of costs and benefits.

The analysis for this report finds that globally, WASH interventions represent good value for money even in the context of increasing costs of climate change (Table 4). Key findings include:

- Basic services are a no-regret investment across all three WASH categories, **providing up to 21 times more value than expenditure,** and are a necessary step towards universal safely managed services;
- Basic water services alone could save women **77 million working days** per year;
- Safely managed infrastructure is a higher upfront cost investment that will **yield benefits over a longer time** period, with relatively low maintenance costs;
- Safely managed sanitation services could avoid up to **6 billion cases of diarrhoea** and **12 billion cases of helminths** between 2021 and 2040, with significant implications for child health and nutrition (Figure 5); and,
- **Climate-resilient investments are cost-effective** and will become critical in countries with high exposure to flood impacts and damages.
- Every dollar invested in strategic flood resilience upgrades could **reduce repair costs by US $62–179.**

Table 4: Global benefit-cost ratios of achieving universal coverage by 2030, maintained through 2040

Service level	Water	Sanitation	Hygiene
Basic	14–18	4.4–5.5	15–21
Safely managed	1.5–1.9	2.2–2.9	–
Safely managed and climate resilient	1.6–1.9	2.2–3.0	–

Source: Vivid Economics

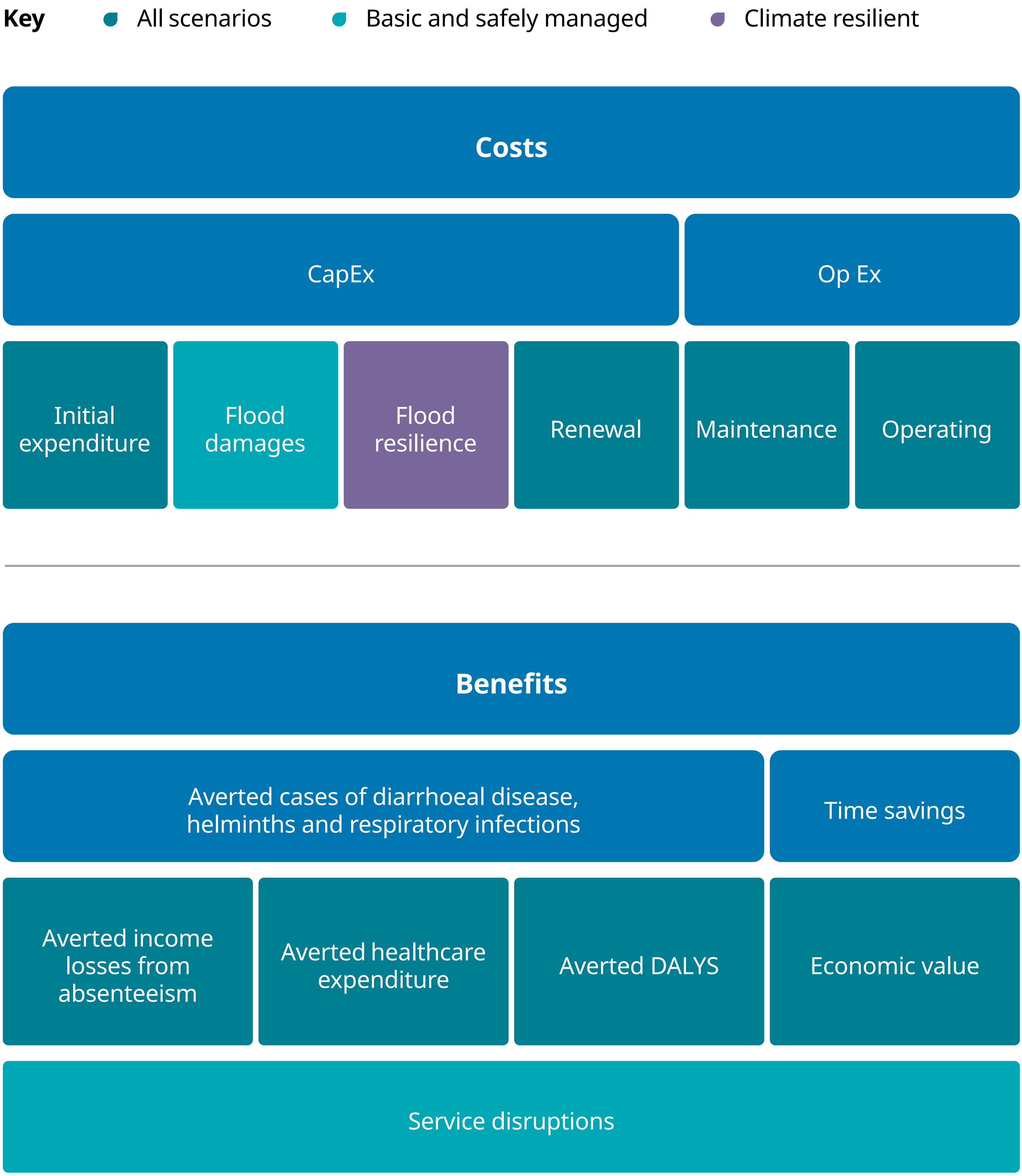
3.1. Overview of approach

The following sections describe findings from a benefit-cost analysis (BCA) of achieving universal access to WASH services. The objective of a BCA is to quantify the impacts of an investment or policy and provide an indication of whether it is an efficient use of resources. Often the costs of investments are well-defined, while the benefits, particularly when they relate to health or social outcomes, are more challenging to quantify. A BCA makes these benefits explicit and puts them into economic terms, allowing for comparison with other investment options.

The analysis assesses three scenarios of global WASH coverage. Each scenario assumes that the coverage level described is achieved by 2030 and is maintained through 2040. A more detailed description of the scenarios, data sources and key assumptions can be found in the methodology appendix.

1. **Basic service:** The first scenario assesses the costs and benefits of achieving universal access to at least basic services. Basic water technologies include boreholes and tube wells to provide drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip, including queuing. Basic sanitation technologies focuses on provisioning pit latrines facilities that are not shared with other households. Basic hygiene provides handwashing facilities available to each household.
2. **Safely managed service:** The second scenario assesses the costs and benefits of achieving universal access to safely managed services, a higher quality WASH service than the basic scenario. For water services, this means access to an improved water source which is located on the premises, available when needed and free from faecal and priority chemical contamination. The technology to achieve this is piped water supply. Safely managed sanitation requires the use of improved facilities which are not shared with other households and where excreta is safely disposed in situ or transported and treated off-site. The technologies build on the household-level provision of latrines achieved in the basic scenario to provide sewage systems, septic tanks and the management and treatment of faecal matter.
3. **Climate-resilient and safely managed service:** Multiple climate change-related hazards threaten the reliability of WASH services, including flooding, drought and sea-level rise. The analysis focuses on flooding as the most prevalent and damaging climate risk to WASH infrastructure. Severe flooding can render WASH services temporarily unusable and increase population exposure to waterborne diseases like cholera. A lack of WASH services also reduces local capacity to provide emergency services in the wake of a disaster. The third scenario assesses the costs of strategically upgrading safely managed service infrastructure to be flood-resilient in flood-prone areas, against the benefits of reducing flood service disruptions and flood damages to infrastructure. Although the climate-resilient scenario focuses on upgrading safely managed infrastructure, it is important to note that elements of basic service infrastructure can also be made more climate-resilient. The analysis focuses on increasing the resilience of safely managed infrastructure for two reasons: firstly, because achieving universal access to safely managed services is the target of SDG 6 and secondly, because the analysis relies on recent research on the costs of climate-resilient infrastructure, which also focuses on safely managed services.[95]

Figure 3: Benefits and costs included in the BCA



Note: See appendix for a full list of assumptions and data sources.

Source: Vivid Economics

Table 5: Population to receive upgraded service included in the analysis (billions)

	Water	Sanitation	Hygiene
Basic	0.9	2.2	2.0
Safely managed	3.0	3.5	-

Note: These figures will differ from figures reported by JMP and UNICEF due to a smaller number of countries covered in this analysis, and also accounting for population growth to 2040. A full list of countries covered in the analysis can be found in the methodology appendix.

Source: Vivid Economics


WaterAid/Genaye Eshetu

The methodology follows the structure of previous analyses conducted by UNICEF and others, with updated data sources and additional health and climate considerations.[5,7] The methodology appendix at the end of this report details the full approach, assumptions and data sources used in the analysis. Figure 3 provides an overview of the benefits and costs included in the analysis.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BCA is a useful analytical tool but has limitations. This analysis focuses on the economic benefits of health and social outcomes provided by WASH services. However, as discussed in the previous chapter, there are a much wider range of benefits provided by WASH services that cannot be quantified due to emerging or limited research. Moreover, a BCA cannot capture the society- and economy-wide transformations that improved human health and economic opportunities can achieve. Additionally, the structure of the BCA means that some of the inter-dependencies between the costs and benefits of achieving WASH services are not captured. Due to data limitations, each of the three WASH services are analysed in isolation, when in reality there are likely to be efficiency gains from investing multiple services simultaneously. As a result, the findings from this analysis should be considered a lower-bound estimate of the direct benefits of WASH.

3.2. Basic and safely managed services

The analysis finds that globally, both basic and safely managed service scenarios represent excellent value for money across all WASH interventions. Across all global scenarios, benefits exceed costs of achieving universal coverage by 2030 and maintaining access through 2040.

Basic services can be provided at a relatively low cost and are a necessary investment for achieving safely managed services in the long-term. Table 6 shows that the BCRs of achieving universal access to basic services from 2021–2040 is high across all regions, and particularly in Asia. The high value in East Asia is driven by China, where 13% of the rural population still lacks access to basic water services, equating to 77 million people. Basic water services in China alone could unlock over US $10 billion in value per year. Differences between the regions are be driven by a number of factors, including cost of investment, income levels and existing disease burden. In regions where there is a high burden of WASH-related disease, investing in WASH services will have a higher relative impact on reducing disease incidence. Additionally, in regions with higher income levels, the opportunity cost of travel time is higher, resulting in larger economic benefits. Countries in East Asia and Pacific have relatively higher income levels, while South Asia has relatively higher levels of WASH-related disease, driving the high BCRs for water and sanitation (Table 6).

Safely managed WASH services are a higher up-front investment, providing benefits over a longer period with relatively lower maintenance costs. The initial capital cost to install safely managed infrastructure is higher than basic interventions, but requires less frequent renewals. For example, safely managed pit latrines with faecal sludge management are expected to last 20 years before requiring further expenditure on renewal, compared to eight years for a basic pit latrine.

Table 6: Regional BCRs for basic services are highest in East Asia and Pacific, and in South Asia

	Water	Sanitation	Hygiene
East Asia and Pacific	26–27	10	14–17
Europe and Central Asia	6–7	4	40–47
Latin America and Caribbean	14–15	4	6–8
Middle East and North Africa	4–6	2–3	5–7
South Asia	13–18	6–7	14–19
sub-Saharan Africa	10–17	3–4	17–24

Note: See methodology appendix for a complete list of countries covered in the analysis by region.

Source: Vivid Economics

Investments higher up the WASH service ladder have lower marginal gains, but higher overall economic benefits. As shown in Table 4, the returns per dollar invested achieving basic services are significantly higher than for safely managed services. This is due to both the low cost of investing in basic services, and the high benefits in reducing the risk of WASH-related diseases and reducing travel time. For example, gaining access to basic water reduces the risk of diarrhoeal disease by 34%. Extending that access to safely managed water further reduces risk, but only by an additional 11%. Therefore, relative to the benefits achieved through basic access, the additional investment in safely managed service has lower marginal benefits. The same is true for the additional health benefits of other WASH-related disease, and also for time savings. The result is a larger total benefit for safely managed services (Figure 4), but a lower BCR. However, safely managed water and sanitation services provide a higher quality and more resilient level of service compared to basic services. Safely managed services have the potential to support wider societal transformations with larger impacts on health outcomes, economic opportunities and resilience.

Despite benefitting similar population sizes, the aggregate value of sanitation services is more than double the value of water services. Both water and sanitation services avert travel time and disease incidence. Time savings benefits represent nearly two-thirds of the value of achieving universal safely managed water services, providing US $342 billion between 2021 and 2040. Conversely, time savings represents less than one-third of the value of safely managed sanitation services due to the important role of sanitation in reducing diarrhoeal and helminths disease, and the resulting quality-of-life, healthcare and economic benefits. However, safely managed sanitation services still provide nearly double the time savings value of safely managed water services (US $660 billion) over the same time period. This is due to the fact that improved sanitation reduces travel time for all beneficiaries, while improved water services reduce travel time only for the person responsible for household water collection.[iv]

[iv] *See assumptions in methodology appendix.*

Figure 4: Annualised net benefits of achieving universal services 2021–2040 (USD billions)

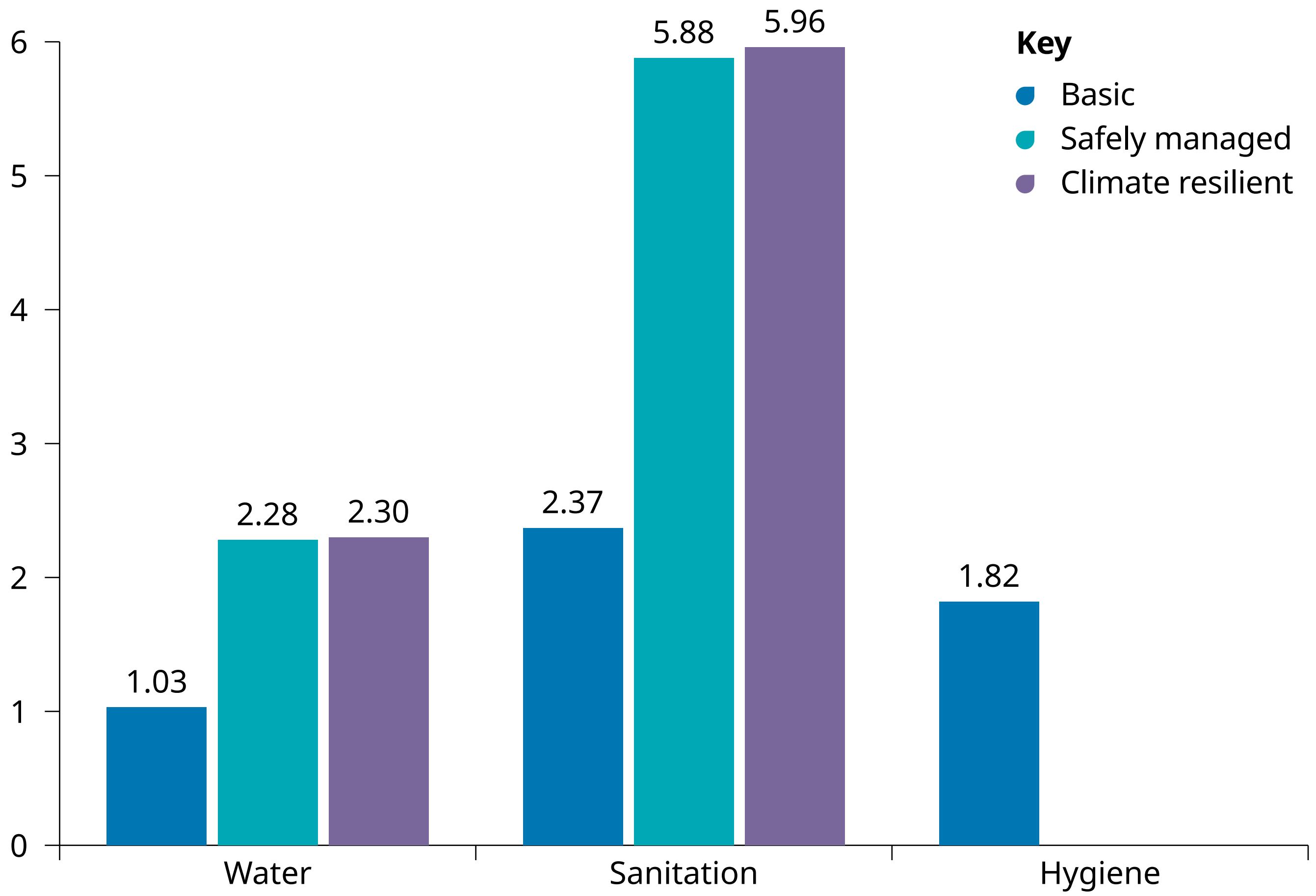
Note: The area of each circle corresponds with the magnitude of annualised net benefits from 2021–2040.
Source: Vivid Economics

3.2.1. Health benefits

The analysis values three key health outcomes linked with improved WASH services: diarrhoeal disease, helminths and respiratory infections. All three services can reduce diarrhoeal disease (Figure 5), sanitation can reduce helminths and hygiene can reduce respiratory infections.

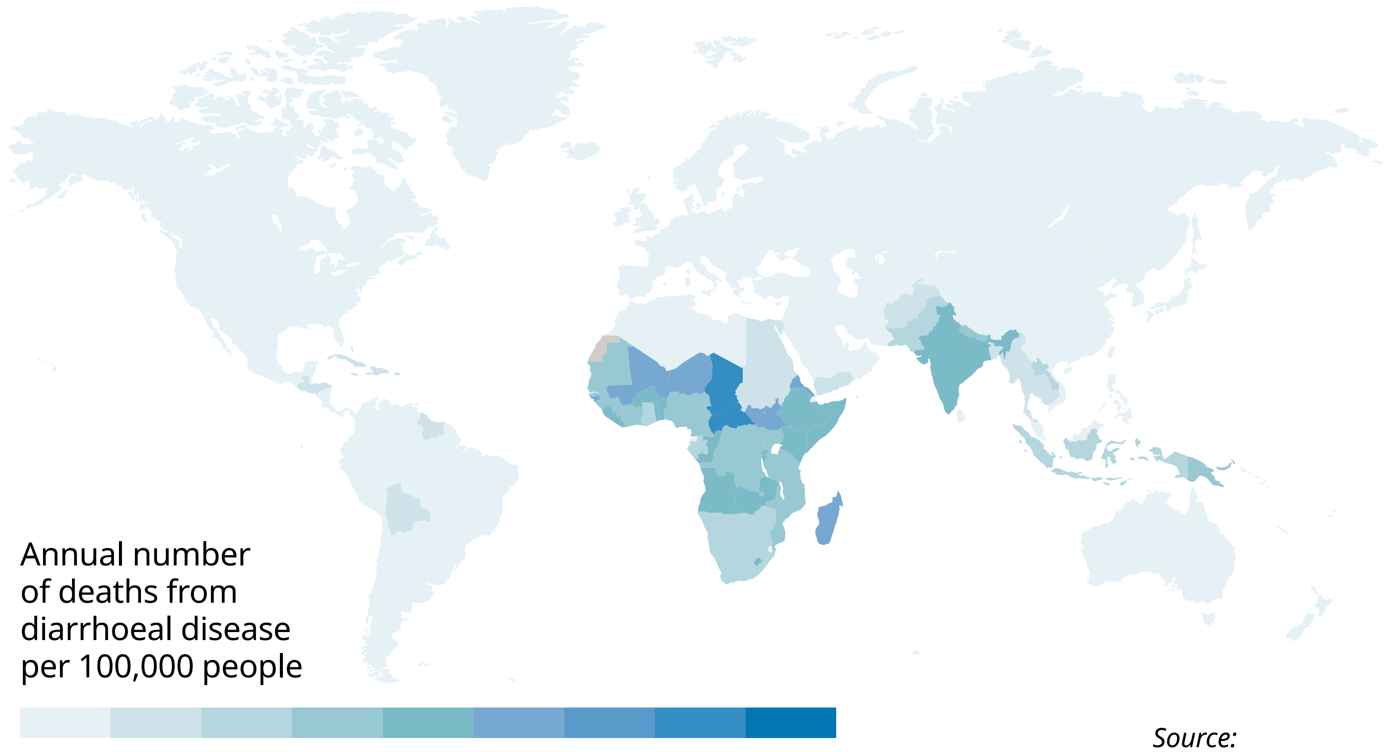
Safely managed services can more than double the health benefits of basic services. Basic sanitation services can make significant progress on eliminating preventable diarrhoea and helminths disease, averting 125 million and 300 million cases per year respectively. By comparison, safely managed sanitation services could avert 310 million cases of diarrhoeal disease and more than 600 million cases of helminths per year. Combined, safely managed sanitation could save more than US $2.6 trillion in health costs between 2021 and 2040. The health benefits of safely managed water are also more than double that of basic water, as shown in Figure 5.

Figure 5: Universal access to safely managed sanitation services could avert six billion cases of diarrhoeal disease between 2021 and 2040



Source: Vivid Economics

Figure 6: Diarrhoeal disease deaths are highest in sub-Saharan Africa and South East Asia



Source: Our World in Data[96]

Safely managed sanitation services reduce the likelihood of contact with faecal matter, and therefore can significantly reduce the transmission of diarrhoeal disease. The highest regional BCRs for safely managed sanitation can be achieved in the regions with the highest rates of diarrhoeal disease deaths (Table 6): East Asia and Pacific (BCR 3.2–3.4), South Asia (BCR 3.7–5.3) and sub-Saharan Africa (BCR 3.8–6.3). In India alone, where the incidence of diarrhoea each year is more than 22%[v] and the death rate is 85 per 100,000,[96] safely managed sanitation services could avert more than two billion cases of diarrhoeal disease and 25 million DALYs from 2021–2040.

Achieving universal access to safely managed sanitation could eliminate nearly all cases of helminths, with secondary impacts on child health, nutrition and education. Helminths disproportionately affect children and can lead to multiple weeks of school absence, inhibiting full engagement in educational opportunities and limiting productive time for carers.[97,98] Helminths are also a major contributing factor in malnutrition, reducing food intake and nutrient wastage.[99] As a result, malnutrition in childhood contributes to lifelong disability and impairs physical and cognitive development. Malnutrition in childhood therefore has long-term effects on human capital accumulation into adulthood. Safely managed sanitation services could avert more than 11 billion cases of helminths and 100 million DALYs, equivalent to US $220–420 billion. Using a conservative assumption that a case of helminths leads to five days of absenteeism, averting helminths could increase school and work attendance by three billion days each year, unlocking US $420 billion in productive value.

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[v] *Based on assessment of Global Burden of Disease 2019 data.*

Hygiene services can reduce both diarrhoeal and respiratory disease burden at low cost, improving quality of life, reducing healthcare expenditure and freeing up productive time. From 2021–2040, achieving universal access to hygiene services could avert 96 million cases of diarrhoeal disease and 160 million respiratory infections each year. This equates to less than US $10 spent to avoid each case. Assuming that each case of diarrhoeal disease results in one day of lost working time,[vi] and that each case of respiratory disease results in two days of lost working time, hygiene services could save up to US $39 billion in lost productive time. This productivity savings would be even higher including presenteeism (time spent working that is less productive due to illness).

3.2.2. Economic opportunities

Both water and sanitation services can provide significant time savings for households and individuals, freeing up productive time for work, education, childcare and leisure.

Safely managed water services could save households more than 50 billion hours in travel time between 2021 and 2040. Access to basic water saves rural households 40 minutes per trip, and urban households 20 minutes per trip, equivalent to 240–490 hours per year. Safely managed water services save an additional 60 hours per year. As discussed in the previous chapter, this burden disproportionately falls on women, making basic water services a powerful tool for addressing gender inequalities. If women are responsible for 60% of household water collection needs globally,[vii] achieving universal basic water services would free up more than 77 million working days for women each year between 2021–2040. Under the same assumptions, safely managed water would free up an additional 122 million working days each year for women.

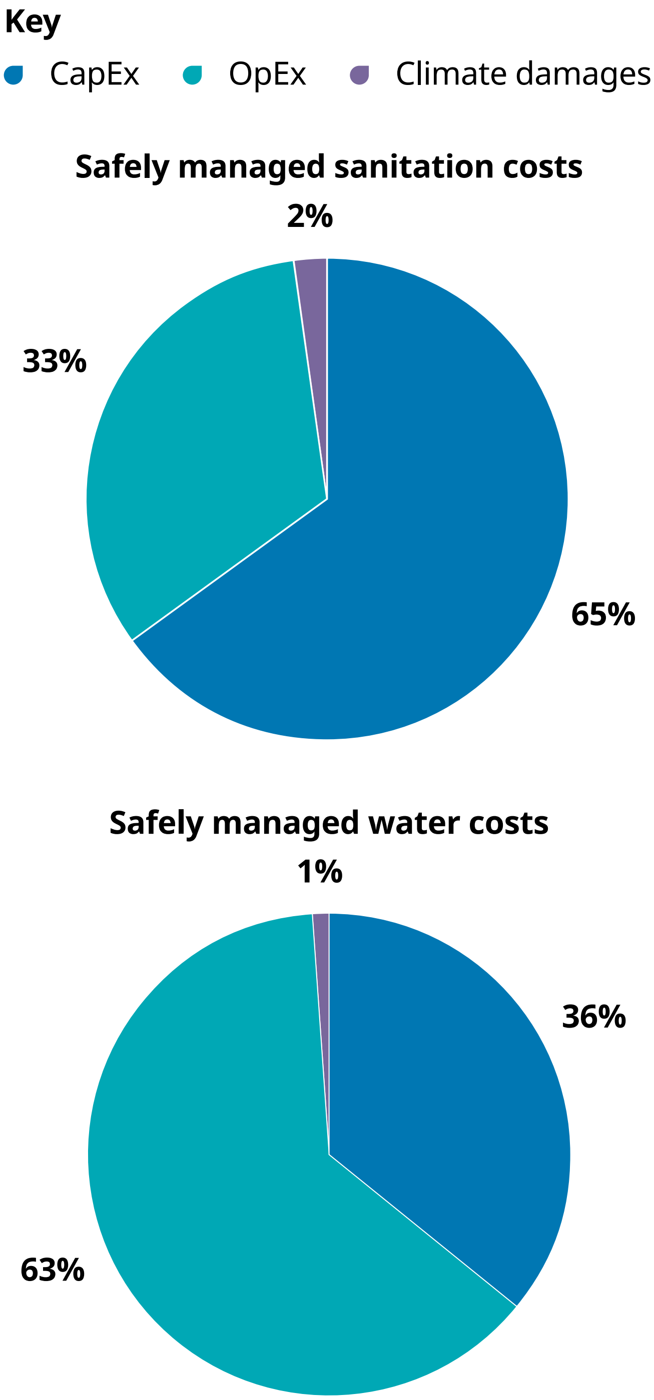
Basic and safely managed sanitation save less time per trip than water services, but provide benefits for more people. Basic and safely managed sanitation only save about 30 hours per year, but unlike water which only frees up time for the person responsible for household collection, sanitation can save time for all people with improved access. From 2021–2040, safely managed sanitation could save more than 43 billion hours, equivalent to US $35 billion per year in time savings value.

3.2.3. Costs and implications for financing

The costs of providing basic water and sanitation services are predominantly driven by capital costs. Across countries included in the analysis, basic water and hygiene services will cost less than US $3 billion per year.[viii] Providing universal basic sanitation is significantly more expensive and estimated to cost US $16 billion per year. Two-thirds of the costs of water and sanitation derive from the initial capital expenditure and capital renewal costs, and the remaining stemming from operations and maintenance costs. Conversely, basic hygiene costs are driven by operations and maintenance costs, with capital expenditure accounting for less than one-third of total costs.


WaterAid/DRIK/Habibul Haque

Figure 7: Safely managed water and sanitation services will cost US $106 billion per year 2021–2040



Note: Cost methodology and data is based on approach developed by Hutton G, Varughese M. See methodology appendix for countries included and approach to estimating climate damages.[5]

Source: Vivid Economics

Safely managed services require scaling up existing financing sources to cover both up-front capital expenditure and recurring operating costs. For countries covered in the analysis, the cost of universal safely managed water and sanitation is US $50 billion per year and US $56 billion per year, respectively. The distribution of costs to achieve safely managed sanitation mirrors basic sanitation costs, while safely managed water service requires significantly higher operations and maintenance expenditure. Accordingly, maintaining universal safely managed water services requires a more stable and sustainable financing source.

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vi *See methodology appendix for a full list of assumptions and sources used in the modelling.*

vii *The burden of water collection by gender varies by country/location. While some research indicates that adult women disproportionately bear this burden, other studies have indicated that children in some areas bear the burden with roughly an equal gender divide. We've used a conservative assumption of 60% borne by women and girls to estimate productive days unlocked.*

viii *Although the approach to cost estimation draws on data from recent UNICEF reports and follows the methodological approach, these figures will differ due to differing country coverage and time frame.*

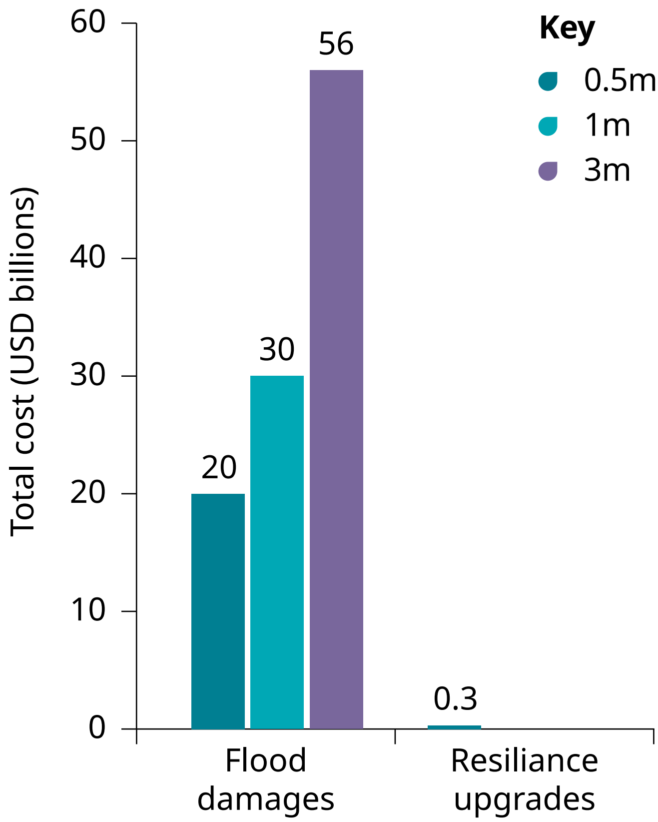
3.3. Climate resilient service

Defining resilience in WASH is an ongoing process given the varying technical interventions, capacity needs and climate hazards in different regions. In general, resilient infrastructure systems are planned, designed, built and operated in a way that anticipates, prepares for, and adapts to changing disaster risks. Ensuring climate resilience is a continual process throughout the life of the asset and should be integrated through a process of risk assessment. Climate resilience upgrades may involve both physical infrastructure upgrades and ongoing support.[100]

Flooding is the most prevalent climate change-related threat to global WASH infrastructure. From 1970 to 2008, flood events have affected more people than other climate-related hazards, including drought, extreme temperatures and storms, and are expected to increase globally.[101] Coastal flooding is also expected to rise due to climate change, putting all major infrastructure assets, including WASH assets, at risk of damage or permanent disruption. Coastal flooding may also contaminate freshwater sources through saline intrusion, runoff and microbial and pathogen contamination.[102]

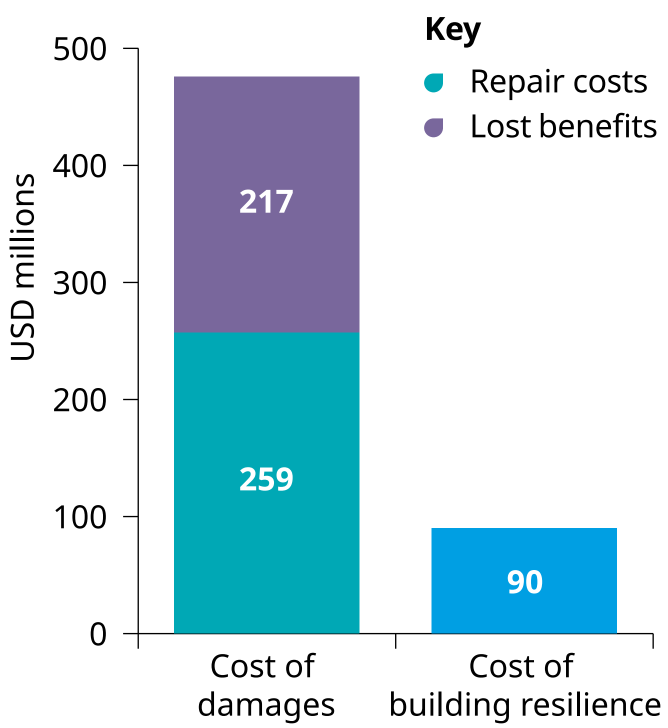
In flood-prone countries, up to 13% of the population may be at risk of flooding and WASH service disruptions.[103] India, Bangladesh and China are at highest risk of flood exposure, with a combined figure of more than 11 million people affected by flooding each year.[104] Affected populations are at risk of service disruptions and are also more exposed to waterborne diseases like cholera.[105] As a result, strategic flood resilience upgrades may be required to ensure the sustainability of WASH services and associated economic benefits.

Figure 8: The return per dollar on flood resilience upgrades is US $62–179



Source: Vivid Economics

Figure 9: The costs of inadequate infrastructure are significantly more than the cost of building resilience against flooding in Bangladesh



Source: Vivid Economics

Every dollar invested in strategic flood resilience upgrades could avoid up to US $96 in flood restoration costs.[ix] Flood service disruptions and damages are estimated based on average annual flood exposure. Even with conservative assumptions on flood depth and damage,[x] the cost of reconstruction and WASH service losses is significantly higher than the cost of strategic resilience upgrades (Figure 8). The cost of restoring WASH coverage due to flooding is estimated to cost US $30 billion over the period 2021–2040, compared to additional investment costs of climate resilient infrastructure of just US $0.3 billion. Accordingly, targeted climate-resilient upgrades remain a strong investment even at low levels of flood damages.

Without climate-resilient infrastructure, extreme flood events can trigger significant contingent liabilities for the public sector. In addition to average annual impacts, climate-safe infrastructure provides resilience to extreme events which can be cost saving for both households and the public sector. Flood disasters can damage public assets, creating fiscal risks. Vulnerable public assets include government buildings, healthcare facilities and education facilities, where WASH services can be significantly disrupted. In Ethiopia, annual flood damage to buildings alone costs US $200 million, including public health and education facilities.[106] Box 2 describes the public and private costs stemming from WASH service disruptions and damages in recent extreme flood events in Bangladesh.

Resilient infrastructure can provide additional adaptation benefits beyond flood protection. Water scarcity and increased heat events are also likely to increase as a result of climate change, increasing the urgency of providing sustainable and well-regulated groundwater sources. Some of the same countries at risk of flooding in Asia are also at high risk of water stress in the coming decades. World Resources Institute's Water Risk Atlas indicates that by 2040, water resources in India, Bangladesh and China will be under 'extremely high' water stress, even in an optimistic climate scenario.[103] Safely managed and resilient infrastructure can help ensure that water is efficiently allocated and can be linked with an effective integrated water resources management scheme to provide sustainable services.[107]

[ix] *See the methodology annex for assumptions on strategic flood resilience upgrades.*

[x] *BCRs are estimated based on a 1m average depth of flood exposure.*

Box 2: Case study: The value of targeted climate resilient investment in Bangladesh

Bangladesh is experiencing increasing frequency of severe and large-scale flood events. In the past three years, Bangladesh has been hit by the worst cyclone it has experienced in 50 years[108] the highest flood levels in 100 years[109] in the key river systems of Jamuna and Teesta. Most recently, monsoon flooding in 2020 affected 3.3 million people.[110] The consecutive nature of these disasters has severely hampered the recovery response, which is typically 3–5 years.

Flooding in 2020 severely reduced WASH service provision, compounding the impacts of the COVID-19 pandemic. A post disaster needs assessment (PDNA) published in July 2020 estimated that 82,000 toilets and 73,000 tube wells were damaged or destroyed. As a result, nearly half of the most affected districts ran out of safe drinking water and hygiene services were significantly disrupted. The PDNA found that 90% of affected regions reported water supply disruption and 93% reported sanitation service disruption. Women have been disproportionately affected by these events. The PDNA also found that 90% of regions reported water collection challenges, which are typically borne by women, and 68% of regions reported difficulty in maintaining personal and menstrual hygiene.

As a result of the service disruptions, the 2020 floods cost at least US $217 million in reduced WASH service benefits. The analysis in this report estimates WASH services in Bangladesh provide an annual benefit of US $28 per person for basic water services and US $49 per person for basic sanitation services. Nine months of WASH service disruption would lead to US $217 million in lost benefits.[xi,xii] Climate-resilient infrastructure can avoid these losses, in addition to avoiding the additional US $259 million cost of restoring basic WASH services, as summarised in Figure 9. The cost of restoring basic WASH services is US $86 per person, compared to the additional cost of climate-safe infrastructure of US $30 per person for water when installing safely managed infrastructure.

The severity of WASH service disruption from major flood events highlights the value and urgency of climate-resilient investments. Through annualising flood risk over multiple years, the acute impact of flood events can be diluted in longer term analysis. As highlighted in this case study, insufficient investment in climate-resilient WASH infrastructure creates a risk to life, results in a sharp decline in benefits and requires constant expenditure to maintain service provision. Despite a higher upfront cost, targeted investment in climate-resilient infrastructure can improve the disaster response for millions of people, providing extensive humanitarian and economic benefits, and reducing fiscal risks.

WaterAid/Abir Abdullah

[xi] Assuming all services lost are basic services; if safely managed services are disrupted this figure would be much higher.

[xii] Nine months of disruption is identified as the maximum time to respond with early recovery activities.

4. Building climate and community resilience

WASH services in institutions are critical in recovery from natural disasters or in humanitarian emergencies. Populations in humanitarian emergency are already vulnerable to health impacts, and without access to WASH may experience further physical and mental distress.[20] Institutional settings like schools, healthcare facilities and refugee camps are at a high risk of cholera outbreaks where WASH management is poor.[111] Ensuring healthcare facilities and community centres have running water for patients and hospital services is critical to ensuring health services can be delivered in response to natural disasters.[112]

The following case studies demonstrate the role of providing climate-resilient WASH in key community institutions.

4.1. Case study: Integrated and sustainable WASH in Burie, Ethiopia

A public-private partnership model in Burie, Ethiopia delivered sustainable WASH services in schools, health centres and communities to achieve access for more than 40,000 residents, particularly benefitting girls and women.

Ethiopia has limited access to WASH services in both households and institutions, contributing to a high burden of communicable diseases and child mortality. According to the most recent data from UNICEF, more than 22% of the population uses an unimproved drinking water source and nearly two-thirds use unimproved sanitation facilities. Schools and healthcare facilities are also severely lacking in WASH services; more than 75% of schools have no drinking water or hygiene services, and 64% of healthcare facilities lack basic waste management services. As a result, up to 80% of communicable diseases are attributed to inadequate WASH services, and diarrhoeal disease causes more than 70,000 child deaths each year.[22]

Ethiopia's vulnerability to climate disasters will create additional challenges in meeting WASH needs. Droughts and floods are the two most material climate risks that Ethiopia faces. Frequent and severe droughts exacerbate food insecurity and reduce livelihood opportunities. On average, 1.5 million people are exposed to drought annually.[106] Riverine (flash) flooding, particularly in the low-lying river basins, pose significant risks to human health, as well as resulting in displacement and crop and livestock losses. Flooding in 2019 affected more than 795,400 persons and caused severe damage to infrastructure (including schools, healthcare facilities and water supply schemes).[113] In addition, Ethiopia experiences regular earthquakes, volcanoes and landslides that cause less economic damage but still put a significant number of people at risk each year.[106] These hazards have the potential to reduce surface water supplies and damage WASH infrastructure, further disrupting services.

Ethiopia experiences regular cholera outbreaks due to limited progress on water and sanitation access and increased flood risk. An estimated 70 million people in Ethiopia are at risk of cholera, leading to more than 275,000 cases and 10,000 deaths each year. These outbreaks are most commonly reported in Addis Ababa, particularly during the rainy season.[114] According to EM-DAT, a database of international disasters, Ethiopia has had 28 epidemic events between 1970 and 2019, including outbreaks of dysentery, measles, meningococcal disease, poliovirus, yellow fever and others.[115] COVID-19 has shown that epidemics and pandemics can put untenable pressure on public health systems and devastate the economy, increasing the impetus for investing in sustainable and climate-resilient public services.

In 2016, WaterAid, the UK Department for International Development (DfID)[xiii] and a local government partnership provided WASH for communities in a vulnerable and underserved district. Burie is a district in the northeast of Ethiopia, with one of the lowest levels of access to WASH in the Amhara region.[116] Amhara is vulnerable to a wide range of climate hazards, including droughts, heavy storms, erratic rainfall and changes in the timing and duration of seasonal rains.[117] These risks threaten the sustainability of WASH services and create additional challenges in achieving universal access. The Deliver Life project in Burie aimed to improve WASH service delivery, improve sector performance and ensure the sustainability of WASH services through construction and rehabilitation of water and sanitation facilities in schools, healthcare facilities and selected communities. The US $2.3 million project was financed by a partnership between WaterAid, UK DfID, the Amhara regional government and the local community.

The Burie Project successfully delivered WASH in communities, exceeding project targets and extending access to more than 40,000 people and delivering significant value for money (Table 1). Using the same methodology developed for the global benefit-cost assessment, the Burie Project is estimated to deliver up to US $2.2, $2.1 and $4.3 million in benefits per year from WASH services respectively. This reflects the value of time savings and from reduced disease incidence as a result of improved WASH services. Key activities of the Deliver Life project included constructing and rehabilitating water and sanitation facilities in schools, healthcare facilities and selected communities. The project also included training on database management and building capacity for operating utilities, ensuring the sustainability of project outcomes. The project exceeded targets in community and school provision, leading to improved hygiene behaviours, benefits for women and students, and capacity building of local officials.

[xiii] *DfID is now the UK Foreign, Commonwealth and Development Office (FCDO).*

Table 7: Annual value of health benefits (USD millions)

Type	People	Time savings value	Health value	Total annual value
Water	43,696	0.3	1.0–1.9	1.3–2.2
Sanitation	41,630	0.2	1.0–1.9	1.3–2.1
Hygiene	58,053	-	2.3–4.3	2.3–4.3

Note: See methodology for assumptions used in the benefits calculation.

Source: Vivid Economics

Providing WASH in institutions and communities can deliver important benefits to women and girls. According to survey data collected in the community, in more than 90% of households, adult women are responsible for water collection. Reducing travel time to collect water can significantly reduce the burden on women, increasing time available for childcare, productive activities and increasing school attendance and performance. Access to improved sanitation facilities also has benefits for women by increasing privacy and dignity. Providing access to improved sanitation facilities in schools benefits adolescent girls in particular, who previously were absent from school during menstruation. WASH in healthcare facilities affects the quality of care for all community members, and especially in supporting safe birth conditions. Prior to the investments in healthcare facilities, expectant mothers in the community did not attend facilities for births due to safety concerns.

Improving WASH in institutions can help build resilience to climate and humanitarian disasters. Providing WASH in community institutions can ensure that residents have access to key services in crises. During humanitarian and climate disasters, communities may be physically displaced from their homes for safety reasons, gathering in community centres for shelter, including government buildings and schools. If key institutions lack access to WASH, this can create conditions for disease transmission and lead to further morbidity and mortality during disasters. WASH in healthcare facilities can also be important during emergencies, as facilities may be forced to cope with an influx of patients. Overcrowded facilities without proper sanitation and hygiene can increase the incidence of hospital-acquired infections and reduce the effectiveness of treatment.

4.2. Case study: Promoting climate-resilient WASH in Shyamnagar, Bangladesh

WaterAid Bangladesh is implementing strategies to promote climate-resilient and inclusive WASH services in the salinity- and disaster-prone coastal belt of the country.

Climate risks and poverty in Bangladesh threaten maladapted infrastructure. Bangladesh experiences frequent storm surges that cause coastal flooding and flooding of major rivers. 20% of the country is affected by flooding each year and 45% of the country is exposed to the risk of extreme flooding.[118] The increased depth of coastal floods in the southwestern region contributes to groundwater salination and higher depths of inundation – rendering drinking water and sanitation services non-functional. Shyamnagar, a locality on the southwest coast of Bangladesh, has experienced two of the worst cyclones in Bangladesh in 2007 and 2009 that caused severe damage to regional infrastructure. It is estimated that Bangladesh will need to invest US $5.7 billion per year to make all infrastructure, including WASH, adapted to climate change by 2050.[119] Vulnerability to climate impacts is heightened in the region due to low GDP per capita and high poverty, particularly in Shyamnagar. GDP per capita in Bangladesh was less than US $2,000; the poverty headcount ratio was 24.3% (2016), whereas in Shyamnagar the ratio was 46% (2019).[120,121,122]

Saline intrusion from coastal flooding threatens the long-term supply of reliable and safe water. Upstream impacts include the loss of a functional water source, due to disruption by drought or salinity levels that reduce the safety and reliability of service.[123] Saline intrusion is linked with a higher concentration of iron present in local drinking water sources, a cause for safety and health. It is estimated about 20 million people in coastal areas of Bangladesh are affected by water salinity each year, leading to negative health outcomes.[124] Most households rely on pond sand filter (PSF) technologies for drinking water that are vulnerable to climate impacts and heavily dependent on natural fresh water sources. In the summer, the ponds become parched while during monsoons, the levels of saline in groundwater increases. It has also been reported that toilets in community clinics which are already in poor conditions are often submerged under water during flood events, rendering sanitation services temporarily inaccessible.

Bangladeshi WASH infrastructure services require significant upgrades for climate resilience and to meet the SDGs. Current rates of coverage for hygiene service in rural Bangladesh is very low, where only 25% of the population has access to basic hygiene, while 60% have limited access and 13% have no facility.[4] Rural populations have lower levels of access, and less than half (46%) of individuals have at least basic access (including safely managed) to sanitation services. In addition, Bangladesh has poorly adapted infrastructure, ranking 111 of 137 countries on overall infrastructure health.[125] Only 68.2% of water sources were found to be functional throughout the entire year in Shyamnagar, where WASH services were disrupted during floods and during the summer season.[126] Current WASH infrastructure is at risk of damages from climate change and requires both physical and system-wide upgrades to improve climate resilience.

In Shyamnagar, the climate-resilient WASH programme was designed to increase access to the WASH facilities for both households and at community-level sites. The US $500,000 project began in 2018 and is ongoing. Using the same methodology developed for the global benefit-cost assessment, the project is estimated to deliver up to US $127,000, $420,000 and $10,000 in benefits per year from WASH services respectively. This reflects the value of time savings and from reduced disease incidence as a result of improved WASH services. Key components of the project include:

- **WASH service delivery:** 26 latrines were installed and five were renovated at 14 local schools. Additionally, eight public handwashing stations were installed for the public at community and health centres, and 20 stations were installed at the household level.
- **Improvement of sector performance:** There are over 45,000 direct users annually as a result of the new community- and school-level facilities. Four campaigns and 65 separate hygiene promotion events were put on in the community to develop best hygiene practices at the community-level. New facilities were designed to be gender-inclusive to promote safe sanitation services for female students. Capital investments in service provision was to be accompanied by hygiene educational sessions to ensure support by school administration, parents and students for the fair use of services.
- **Sustainability of WASH service:** After building the WASH facilities, resources were mobilised as the final project component to support the ongoing operation and use of these facilities. Ongoing funds were set aside to support future operation and maintenance (O&M) cost, particularly in the face of increasing costs due to climate risks.
- **Learning, documenting and implementing:** Educational materials, training and allocation of resources and responsibility to the ongoing maintenance and upkeep of WASH facilities is necessary to ensure reliable service in the face of climate risks.

Table 8: Annual value of benefits (USD '000s)

Indicator	Number of interventions	Daily direct users	Time savings value	Health value	Total annual value
Hygiene facilities in schools	8	9,493	-	72–127	72–127
Sanitation facilities in schools	26	8,277	130	190–290	330–420
Water access (safely managed)	3	214	5.6	2.2–3.9	7.9–9.6

Note: The number of educational sessions held in schools is lower than anticipated due to social distancing guidelines imposed by COVID-19 during Phase III of the project. Therefore, targeted levels of engagement have been lower but are anticipated to meet project goals by the completion of the project. Additionally, Phase III is ongoing and daily direct users are lower than anticipated outcome. See the methodology sections for assumptions used in the benefits estimation.

Source: Vivid Economics based on reports provided by WaterAid Bangladesh 2021.

Investments in WASH facilities were designed to be inclusive of marginalised groups and support gender equality. Improved sanitation and hygiene facilities in schools and healthcare facilities were gender segregated and contained adequate MHM facilities, to provide female students with the safe sanitation services. Hygienic, private bathrooms with clean, running water, sinks and soap can help adolescent girls and female staff in schools and colleges manage menstruation safely and with dignity.[127] In Bangladesh, 40% of girls do not attend school during menstruation for an average of three days.[128] This can have long term implications, reducing their overall educational attainment and likely future earnings. In addition to the physical construction of the facilities, a total of 136 MHM educational workshops were conducted at schools, reaching 2,161 adolescent girls focusing on healthy behaviours and reducing stigma. The latrines in facilities were also equipped with on-ramps to make them accessible for persons with disabilities.

The project established several important lessons for building climate resilience in communities. Key findings include:

WaterAid/Sharbendu D

- **Coordination:** Planning for climate-resilient infrastructure requires additional coordination among local governments to prioritise the management and delivery of WASH to reduce system-wide risk. Currently, the Health ministry does not allocate any funding for O&M of WASH facilities at healthcare or community centres. WASH systems are therefore subject to the technical and financial capacity of the union parishads and may require more support from the national level.
- **Financing:** An O&M fund is a necessary risk reduction measure to ensure the reliability of WASH services under rising climate risks. A School Management Committee was formed at each of the fourteen schools, where the team and the school created an O&M budget ranged from 10 to 20% of the construction cost to be used for future maintenance and repair.
- **Capacity building:** Soft investments in the skill development of community members and authorities is required to plan for climate-resilient WASH as hazards and economic conditions continue to evolve. Sustaining WASH through creating a business model can improve economic outcomes for local residents and deliver on the benefits of improved WASH systems.
- **Co-benefits:** Investments in sustainable WASH infrastructure can deliver economic co-benefits. Two reverse osmosis plants were established to support financial health of WASH systems. These profitable systems can enable the provision of safe water and the future expansion of WASH services. Two female entrepreneurs formed a business and received capacity training to oversee the operations of the plants. Creating local knowledge on the long term financial and administration needs for building WASH can support the delivery of affordable water and the development of similar businesses with empowerment potential for women.

5. Financing WASH post-COVID-19

Mobilising sufficient resources to achieve WASH benefits will require increased ambition across public, private, development and blended finance sources. The analysis in this report demonstrates that providing universal access to WASH is a good economic investment for reducing endemic diseases, improving economic opportunities and building resilience to future climate and health risks. However, current financing does not cover the costs of even basic WASH service provision, despite its relatively low cost. In 2020, UNICEF reported that from 60 countries surveyed, the average WASH budget was just US $9 per capita. In 2019, ODA disbursements to the water and sanitation sector were only US $7.4 billion.[xiv]

Achieving this level of ambition will be challenging given the scale of funding increases required and budgetary constraints. The economic downturn and competing priorities stemming from the COVID-19 pandemic will put further pressure on already limited WASH resources. In this context, it is helpful to consider leveraging specific sources of finance: stimulus spending and climate finance.

- **Stimulus spending:** There is a time limited opportunity to achieve multiple objectives by investing in WASH infrastructure to help economies recover from the effects of COVID-19.
- **Climate finance:** Adaptation finance for WASH services and infrastructure can lead to transformative economic impacts and support adaptation priorities.

The following sections outline how stimulus spending and climate finance can mutually advance SDG 6 and achieve economic and climate ambitions.

5.1. Stimulus spending

Stimulus spending in response to the COVID-19 pandemic is the most ambitious low-carbon spending programme on a global scale. The recovery from the 2008–09 financial crisis included new, low-carbon spending programmes, but overall, the recovery was carbon-intensive.[129] In response to COVID-19, over US $4 trillion of the US $14.3 trillion spent globally on stimulus packages from 2020 is targeted towards environmentally relevant sectors. The objective of these recovery programmes is to both transform economic recovery towards low carbon development and to increase employment.[130]

Infrastructure investments can be an important stimulus measure to improve access to basic services, create job opportunities and improve social outcomes of vulnerable populations. Infrastructure investments can provide a short-term boost to aggregate demand

[xiv] *As referenced in the* ***OECD Creditor Reporting System, 2020.***

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as more people are employed and there is a spur on spending in the construction sector during an otherwise low period of economic activity.[131] Project-based infrastructure investments have a greater long-run multiplier than liquidity support for businesses, income tax cuts, business payments and worker retention schemes.[132] Public infrastructure investment as a fiscal policy for investment has consistently been shown to have a higher fiscal multiplier across countries.[133] Therefore, these investments can help achieve both the short-term objectives of economic stimulus and the long-term benefits of sustained access to safely managed WASH services.

Investment in WASH infrastructure meets the criteria for a strong 'green' stimulus investment. There are four key criteria for investments to be effective and environmentally sound stimulus measures:

- **Timely:** WASH infrastructure varies in size, some have lower capital cost (handwashing stations, wells), making them quick to deploy during economic recessions. When projects are 'shovel ready' and can be implemented immediately, the investment is not at risk of causing overexpansion and inflation.[134]
- **Temporary:** The investment in WASH infrastructure can be made temporary without major commitments in total funding. Investments that do not require long term commitments or permanent levels of funding are best suited for recovery. With WASH construction, small scale interventions can be undertaken until fiscal options are expended. The benefits do not depend on economies of scale, and any number of small-scale interventions funded results in the same level of realised benefits per capita. While financing sources for ongoing O&M is needed, capital cost is the largest component of WASH investment but remains lower than other infrastructure projects.[135]
- **Targeted:** Prioritisation of at-risk populations can be made to ensure the most vulnerable are recipients of economic benefits and employment opportunities. WASH infrastructure is not subject to offshoring and can deliver an immediate benefit.[132]
- **Transformational:** For recovery spending to be transformational, it must contribute to creating positive climate outcomes for a country. While there is no strict definition of transformational, the analysis in this report clearly demonstrates benefits of WASH for the environment and human health that can improve resilience and reduce vulnerabilities. Although WASH is not traditionally considered a 'green' investment, based on the co-benefits it delivers, WASH can support the transformation towards a more climate-resilient economy.

5.2. Climate finance

Climate finance flows have nearly doubled in volume over the past decade but fall short of adaptation needs. As of 2019, climate finance flows amounted to more than US $600 billion. Despite the increasing volume of available funds, just 7% of climate finance is dedicated to climate change adaptation. In 2017–18, only US $30 billion was made available for adaptation, compared to an estimated US $180 billion needed to adapt to the ongoing and future impacts of climate change.[136] There is an increasing recognition that resources for adaptation will need to be scaled significantly to meet growing needs.

The water sector is already a priority for adaptation-related climate finance, but there are opportunities to more strategically allocate resources. A recent WaterAid report on climate finance for the water sector and WASH highlighted that while the water sector is receiving as much as 43% of adaptation-related finance, these resources fail to align with critical needs. The report highlighted that five middle-income countries in Asia receive 30% of finances, and that these resources predominantly support large infrastructure investments. Given that millions of people, particularly in rural areas of lower-income countries, still have inadequate access to basic WASH, there is an urgent need to shift financing priorities to meet immediate needs.[137]

There is an opportunity to build a case for WASH as part of a new approach to transformational climate finance. The World Bank has recently outlined criteria to make the increasing flows of climate finance more effective and transformational.[138] This includes both scaling up the volume of investment and ensuring that climate finance is funnelled towards strategic priorities and supports transformational change. The analysis in this report has demonstrated that financing WASH meets the criteria for strategic transformational change, and there is a strong case for making more adaptation resources available for the sector:

- **Supports key adaptation priorities:** Improved and efficient WASH infrastructure can support adaptation priorities across multiple sectors, including efficiency in water resources use for agriculture and energy, sustainable water management systems and prioritising resilience.
- **Unlocks social dimensions of climate action:** WASH can provide co-benefits in addressing social and gender inequalities, increasing economic opportunities and improving quality of life.
- **Supports transformational change:** Safely managed and climate-resilient WASH supports many of the dimensions of transformational change, including changes in social and economic systems, scalable investments and sustainable impacts.[138]


WaterAid/Abir Abdullah

6. Recommendations

This timely research and analysis signals the need for a major international effort, including the public and private sectors and civil society, to mobilise substantial increases in investment in climate-resilient WASH infrastructure and services. This is mission-critical for economic recovery and sustainable development.

WaterAid calls for governments, international organisations, donors and businesses to lead the way in providing substantially increased and sustained investments in WASH infrastructure and services in low income countries (LICs) and lower middle-income countries (LMICs) during 2021 and 2022. These investments are an essential public health response to COVID-19, a mission-critical fiscal stimulus for economic recovery and a core element of future pandemic preparedness plans.

- Governments, international organisations, donors and business should lead the way in financing the annual US $229 billion capital requirement for LICs and LMICs to restore progress and be on track to achieve SDG 6 by 2030.
- G20 governments must urgently phase out their US $580 billion annual subsidies to fossil fuels and redirect this to a healthy and sustainable COVID-19 recovery, including supporting investments in WASH services.
- Fiscal stimulus packages – supported by the international community – should include financing of the estimated US $6.5 billion[xv] required to ensure every healthcare facility in LDCs has safe and sustainable WASH services.
- All HICs should fulfil their responsibilities to provide new and additional climate finance, complementing increased ODA, in line with the US $100 billion annual commitment to climate finance – with substantial increases in grant-based adaptation funding to WASH in LICs and LMICs.
- As part of meeting promises to spend 0.7% of GNI on ODA, high-income countries should lead a doubling of ODA for WASH in 2021 and 2022.
- Multilateral and bilateral donors and private sector investors should strengthen collaboration and create the enabling environments for increased water investments for the poorest, most vulnerable communities in climate change hotspots, in order to better align international climate finance with the highest needs in LICs and LMICs.
- G20 governments and private creditors must provide comprehensive debt cancellation to debt-distressed LICs and LMICs, including through the reallocation of Special Drawing Rights to enable investments in SDG 6 and Agenda 2030 as part of the fiscal stimulus for economic recovery from COVID-19.

[xv] *Estimate based on WHO costing currently under peer review, as outlined in Gordon B, Montgomery M, Neira M (2021). **Opinion: How to ensure WASH services in all health care facilities.***

Methodology appendix

5.3. Key assumptions and data sources

Table 9: Key assumptions used in the analysis

Assumption	Value and unit where applicable	Note/Source
Relative risk of diarrhoeal disease – Unimproved hygiene compared to improved hygiene	1.39	Ejemot-Nwadiaro RI, et al. (2015)[139]
Relative risk of diarrhoeal disease – Unimproved sanitation compared to safely managed sanitation	3.23	Hutton G (2015)[7]
Relative risk of diarrhoeal disease – Basic sanitation compared to safely managed sanitation	2.32	
Relative risk of diarrhoeal disease – Unimproved water compared to safely managed water	1.82	
Relative risk of diarrhoeal disease – Basic water compared to safely managed water	1.2	
Relative risk of helminths disease – Safely managed sanitation compared to unimproved sanitation	0	
Relative risk of helminths disease – Basic sanitation compared to unimproved sanitation	0.5	
Relative risk of respiratory disease – Unimproved hygiene compared to improved hygiene	1.45	Warren-Gash C (2013)[36]
Value of time savings	30% of income	Hutton G (2015)[7]
The analysis assumes the value of time savings is equivalent for both adults and children		

Assumption	Value and unit where applicable	Note/Source
Discount rate	5%	The analysis uses a 5% annual discount rate to align with Hutton G, Varughese M (2016)[5] conservative analytical assumptions.
Value of a DALY (lower bound)	$6,284 in 2005 USD, increasing with growth of global GDP per capita	Brent R (2011)[140]
Value of a DALY (upper bound)	$11,871 in 2005 USD, increasing with growth of global GDP per capita	
Year in which SDG 6 is achieved for all countries	2030	Assumption
Initial year of analysis	2021	Assumption
Final year of analysis	2040	Assumption
Coverage of WASH access in 2021 is equivalent to the most recent year of JMP data collection		JMP indicators[4]
Socioeconomic scenario	SSP2	Assumption
Climate change scenario	RCP8.5	Assumption
Climate costs/damages cut off	Countries in the top 25% globally of WRI Aqueduct flood risk rankings	Assumption

Assumption	Value and unit where applicable	Note/Source
Travel time for households with unimproved water, urban	40 minute per trip per household, two trips per day	Hutton (2015)[7]
Travel time for households with unimproved water, rural	60 minute per trip per household, two trips per day	
Travel time for households with basic water, urban and rural	20 minute per trip per household, two trips per day	
Travel time for households with safely managed water, urban and rural	5 minute per trip per household, two trips per day	
Travel time for use of sanitation facilities, open defecation, urban	15 minute per trip per person, one trip per day	
Travel time for use of sanitation facilities, open defecation, rural	20 minute per trip per person, one trip per day	
Travel time for use of sanitation facilities, basic and safely managed facilities, urban and rural	5 minute per trip per person, one trip per day	
No time savings benefits for access to hygiene facilities		
Individuals that are exposed to flooding and do not have climate-resilient service, lose the benefits of having access to that service in the year of exposure. Individuals are dropped down one service level – e.g. someone with safely managed sanitation is not assumed to have no access to sanitation, but rather the benefits equivalent to a basic level of service. The actual impact of a flood will vary significantly by country and flood depth; this assumption is meant to capture several key aspects of non-climate resilient services, including: 1) safely managed services may not be entirely resilient to floods, but may still provide some level of resilience above basic services; 2) repairing disrupted services is likely to take a significant amount of time, depending on the severity of flood damage, individual incomes and public sector response times.		Assumption
Hourly wage is estimated at net national income per capita / 365 / 8, to capture the average daily or hourly value of an individual's productive time, irrespective of whether the person is actually employed or working.		Assumption

Assumption	Value and unit where applicable	Note/Source
Hourly wage grows at a rate equivalent to a country-specific predicted annual growth rate in GDP per capita from 2020–2026. From 2027–2040, the analysis assumes average annual GDP per capita growth is equivalent to the rate estimated in 2026.		Assumption
Population growth is estimated using a static average annual growth rate estimated for 2020–2030. This is applied to both urban and rural subpopulations, therefore the analysis does not capture shifts in urbanisation.		Assumption
Where incidence of disease data is unavailable, the analysis uses prevalence as a proxy.		Assumption
The analysis assumes that each case of disease requires one outpatient facility visit, using the lowest facility cost by country. This is likely a conservative assumption; while it's true that not every case will require a medical visit, there are also cases that will require more extensive inpatient/hospital care. The analysis does not include medical facility travel costs as they will be highly variable by country and within country.		Assumption
For countries with missing data for net national income per capita, the analysis imputes a regional average.		Assumption
The analysis assumes average household size is static over time.		Assumption
Flood exposure includes a combined riverine and coastal flooding exposure. This, however, does not account for coastal flooding salinisation impacts.		WRI Aqueduct[103]
Absenteeism from respiratory infections	2 days	Middeldorp M, et al. (2020)[141]
Absenteeism from helminths disease	10 days	Review of academic literature, RCTs and other sources
WASH unit cost inflation uplift	1.08	US Bureau of Labour Statistics[142]
Climate resilient cost uplift	2.2%	Hallegatte S, et al. (2019)[95]
For countries with missing costs or safely managed populations, the analysis imputes a regional average		Assumption

Source: Vivid Economics

Table 10: Data sources

Data	Source
Technology interventions for WASH scenarios	Hutton G, Varughese M (2016)[5]
WASH service coverage	JMP world coverage data[4]
Technology interventions unit costs	Hutton G, Varughese M (2016)[5]
Technology intervention lifespan	Hutton G, Varughese M (2016)[5]
Population at risk of flooding	WRI Aqueduct[103]
Flooding depth damage functions	JRC Technical Report (2017)[143]
Disease prevalence, incidence, and DALYs for diarrhoeal disease, helminths disease and respiratory disease	Global Burden of Disease Study 2019[144]
Outpatient care centre visit cost	WHO (2010)[145]
Net national income per capita	World Bank (2019)[146]
Population by country and growth	IIASA Shared Socioeconomic Pathways[147]
Household size	UN Department of Economic and Social Affairs (2019)[148]
GDP per capita growth projections	IMF World Economic Outlook Data Mapper[149]

Source: Vivid Economics


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5.4. Population coverage

The first step in the analysis is to define the number of people requiring service upgrades for each WASH category, in each service level scenario. This analysis defines WASH service levels using the JMP reported categorisations, and effort was made align our approach to categorisation levels with the approach employed by Hutton G, Varughese M (2016).[5] However, there will be discrepancies between the categorisations in this analysis and previous categorisations, given changes in JMP's methodology for assessing the service level coverages, which have been implemented in the intervening time period.

Table 11: Water service levels

Service level	Description
Insufficient	Individuals with less than basic access service are considered to have insufficient access to drinking water. In line with the United Nations' (UN) definition of universal basic access for drinking water under SDG 6, drinking water access should be equitable, safe and affordable. Therefore, individuals who fall into the JMP service levels of unimproved, limited or surface water users are assumed to have less than basic access to drinking water services. Surface water is directly from a river, dam, lake or another body of water. Because surface water availability can be dependent on rainfall and undergoes no treatment process, using surface water carries many of the same risks to human health and is incompatible with the UN's goal of equitable, safe and affordable drinking water. Unimproved access is access to an unprotected dug well or spring. Similarly to surface water, this drinking water source is not always accessible or safe, and may carry similar human health risks as no drinking water. Limited access is a water source that is more than 30 minutes away (including wait times). Limited access cannot be considered equitable or affordable given the demand on individual's time and the limits many individuals may have in accessing this source. For this analysis, the sum of the proportion of the population classified as using surface water, with unimproved access, or with limited access is used to estimate the proportion of the population in each country with insufficient water access.
Basic	Basic service level, defined in the JMP service ladder, is the share of the population with access to improved drinking water that is less than 30 minutes away roundtrip. The proportion of the population with access to basic water services is reported by JMP.
Safely managed	Safely managed service, defined in the JMP service ladder, is drinking water from an improved source available when needed and free of chemical or faecal contamination. Safely managed service includes water that is either accessible on the premises, available when needed and/or free from contamination. Safely managed water service can be either piped or non-piped. This is assumed to be the highest water service level. The proportion of the population with access to safely managed water services is reported by JMP.
Climate resilient	JMP does not define a service level that is climate resilient. The model assumes only safely managed services can be made climate resilient in line with resilience cost estimates developed by Hallegate S, et al. (2019).[95]

Source: Vivid Economics

Table 12: Sanitation service levels

Service level	Description
Insufficient	Individuals with less than basic access service are considered to have insufficient access to sanitation services. This corresponds with JMP service categorisation of open defecation, limited or unimproved sanitation services. The share of individuals categorised as practising open defecation – disposing of human faeces in an open space or with solid waste – lack a basic sanitation facility. Individuals with access to unimproved service used either pit latrines, slabs, hanging or bucket latrines, which is considered less than basic given risks to health from human to excreta contact still existing in these facilities. Limited was also included as individuals with limited access, who are either subject to communal facilities or the facilities were non-functional at the time of survey. Under the UN's SDG 6, access to sanitation facilities needs to be 'adequate and equitable' while also ending open defecation. These three levels of service do not meet the criteria for basic coverage. For this analysis, insufficient access is estimated as the sum of the proportion of the population classified under these three service levels by JMP.
Basic	Basic sanitation service is defined as the use of improved facilities that are not shared with other households. Households with basic service have access to functioning, non-shared facilities that are designed to maintain hygienic separation between excreta and human contact. To calculate the share of the population with basic services, the analysis uses the JMP service definition of 'at least basic service', subtracting out the share of the populations with a higher level of coverage.
Safely managed	Safely managed service, defined in the JMP service ladder, includes the share of individuals with access to improved facilities that either treat or dispose of excreta in situ, store and treat excreta off site or use a sewage transport system for treatment off site. This coverage level directly corresponds to the number of individuals with safely managed service used in our analysis.
Climate resilient	JMP does not define a service level that is climate resilient. The model assumes only safely managed services can be made climate resilient in line with resilience cost estimates developed by Hallegate S, et al. (2019).[95]

Source: Vivid Economics

Table 13: Hygiene service levels

Service level	Description
Insufficient	Insufficient access is the aggregation of both no facility and limited access service categories as defined by JMP service ladder. The percentage of individuals with no facility have no handwashing facility on their premises. The percentage of individuals with limited access have an available handwashing facility, but there is either no water or no soap available. Without both soap and water available at a handwashing facility, the health risk reductions from handwashing interventions cannot be realised. Therefore, both no facility and limited access are considered insufficient access to hygiene services. To get the number of individuals with insufficient access, the share of the population with no facility and limited access are summed-up for each country and the product of this share and the country's total population produces the number of individuals with insufficient access to handwashing facilities. Under universal basic coverage, all individuals in this service ladder move up to the basic service category.
Basic	Unlike water and sanitation access, hygiene access is only defined at two levels: insufficient and basic access. Basic access is defined as having a household handwashing facility available with both soap and water. JMP does not have a safely managed tier for access to hygiene services, given the presence of both soap and water are sufficient to reduce the health risks associated with a lack of hygiene facilities. Therefore, in our analysis, there are no added benefits resulting from hygiene interventions beyond the provision of basic access. JMP provides the proportion of the population with basic service access.
Climate resilient	This analysis assumes climate-resilient hygiene interventions are basic technologies that have been 'climate proofed'. Therefore, individuals move directly from basic to climate-resilient as the benefits from a safely managed service are assumed to be identical to the benefits from basic hygiene service level.

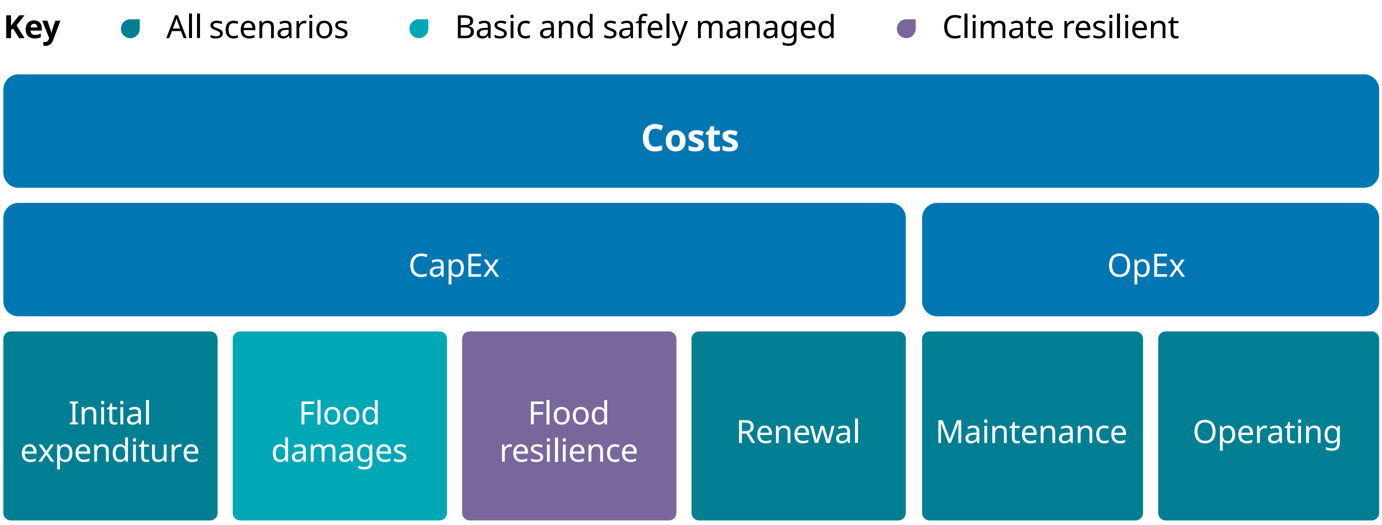
Source: Vivid Economics

For each WASH coverage level, the current population receiving each coverage level is estimated by country, split by rural and urban. For each scenario, the number of people to move out of either below basic (in the universal basic coverage scenario) or basic coverage (in the safely managed and climate safe scenarios) is calculated such that by 2030, universal coverage of the specified service level is achieved. For example, for universal basic water coverage, the population that have below basic coverage is reduced in a linear manner so that in the year 2030 the remaining population is zero, and they all now receive basic coverage. Population growth is assumed to occur over time to each WASH coverage subgroup in line with predicted national population growth.

The population coverage estimates directly feed in to both the cost and the benefits methodology. For the costs, population moving into a service category in a given year determines capital costs and the timing of capital renewal costs. Cumulative population that has been moved into a service category and population growth determine operations expenditure required to maintain service coverage, and the total benefits of maintaining service coverage.

5.5. Cost analysis methodology

Figure 10: Overview of costs included in the analysis



Source: Vivid Economics

The cost of achieving and maintaining access to services under each scenario includes three types of costs: capital expenditure, operating expenditure and costs associated with climate change (Figure 10). Costs calculated include the initial costs to improve coverage, and the subsequent costs required to maintain the improved WASH coverage over the timeframe considered. For example, if 100,000 people in 2023 are moved from unimproved to basic sanitation coverage in Angola, the costs associated with the initial capital and operations costs are calculated, along with the subsequent discounted operations, software, maintenance and renewal costs to maintain coverage over the timeframe considered are calculated. For future costs, each WASH coverage group is assumed to grow overtime in line with predicted national population growth.

The approach to costing the basic and safely managed scenarios is predominantly based on the approach and data provided by Hutton G, Varughese M (2016).[5] This research provides the technology interventions assumed for each scenario, and the associated unit costs. The unit costs include the capital, operations, maintenance, renewal and software costs for each country. The model employs the assumptions surrounding technologies used, life span of capital, and other costs as described by Hutton G, Varughese M (2016) (Figure 11). The analysis assumes that capital expenditure costs are applied to the initial size of the population receiving the technology upgrade, while annual operating costs grow in line with population growth.

Figure 11: Assumptions made by Hutton G, Varughese M (2016)[5] and applied in the costing approach

Table D.1: Technology options modelled under baseline and in sensitivity analysis by service

Service	Baseline technology assumption	Sensitivity analysis	
		Low-cost	High-cost
Basic water	• 50% protected community borehole/tube well • 50% protected dug well	100% protected dug well	100% protected community borehole or tube well
Safely managed water	• Piped water supply on-plot		Increased bulk water supply costs
Open defecation-free rural	• Simple or traditional latrines		
Basic sanitation, urban	• 50% flush toilet to septic tank • 50% any type of pit latrine	100% any type pit latrine	100% flush toilet to septic tank
Basic sanitation, rural	• 50% pour-flush pit latrine • 50% dry pit latrine	100% dry pit latrine	100% pour-flush pit latrine
Safely managed sanitation	• 50% sewerage with treatment • 50% FSM with treatment	100% FSM with treatment	100% sewerage with treatment
Handwashing	• 100% with mix of hand washing basin options (varying by region)		

Note: FSM: Faecal sludge management.

Source: Hutton G, Varughese M (2016)[5]

The costs of flood damage are calculated in the non-resilient scenarios. The objective of the flood damage estimate is to provide a high-level indication of the costs of failing to adequately 'climate proof' WASH infrastructure in key areas. Without climate-resilient infrastructure, water and sanitation services are at risk of flood damages and associated repair costs. Flood damage costs are estimated for countries with estimated future annual flood exposure in the upper 25th percentile according to WRI's Aqueduct Flood Risk Rankings. In each year, the model estimates the number of people that had been upgraded to an improved service level but lose coverage from flood damages. Exposure is based on WRI's Aqueduct database, based on a high emissions climate scenario (RCP8.5).[xvi] The costs associated with restoring coverage and the associated benefits is assumed to be proportional to the full capital cost of the

Figure 11: Assumptions made by Hutton G, Varughese M (2016)[5] and applied in the costing approach

Table D.2: Assumptions used to fill gaps in cost data available by WASH service

Service	Lifespan of capital items (years)	Time until capital maintenance (years)	Software (as % of hardware)	Capital maintenance (as % of initial capital)	Operating costs (as % of initial capital)
Water supply					
Safe household piped	20	10	10	30	NR
Basic household piped	20	10	5	30	NR
Borehole or tube well	20	10	5	30	NR
Dug well	10	5	5	30	NR
Sanitation Septic tank, sewerage, treatment facilities	20	10	10	30	NR
Urban basic pit latrine	8	4	10	30	5
Rural basic pit latrine	8	4	10	30	5
Rural traditional pit latrine (for ODF)	2		5% of cost of a basic pit latrine	0	5% of cost of a basic pit latrine
Hygiene					
Handwashing	1–5*	Half life span	Estimates separately	30	NR

Note: WASH = Water, sanitation and hygiene; NR = No assumption required because data are largely available on these items; ODF = open defecation-free.

**Variable, depending on type of hardware*

Source: Hutton G, Varughese M (2016)[5]

[xvi] *The analysis does not estimate damage costs or losses for populations that already had access to WASH services.*

related intervention. The level of damage, and therefore the level of repair costs required, is estimated using a range of flood depth-damage functions to estimate cost sensitivity to flood depth. Floods are highly variable in nature, and the depth of flooding will depend on the severity of the flood and the location, and will vary spatially within a flood zone. The model uses a range of constant depth-damage functions to estimate a range of flood damage costs. The model applies regional depth damage functions developed by JRC; the central flood depth estimate is 1m, with sensitivities of 0.5m and 1.5m also reported.

The costs of flood resilience are calculated for the climate-resilient scenario. The climate resilience costs aim to provide a high-level indication of the investment required to reduce the likely impact of climate-related hazards. Based on a review of the literature, flooding was identified as the most prevalent and threatening climate change hazard to WASH services. This cost methodology does not capture the full costs of making WASH services resilient to all climate-related hazards. Costs will vary regionally and spatially, depending on specific hazards, technologies and other location-specific needs, and the research on the global costs of achieving climate resilience is still nascent. The approach in this report relies on estimates developed by Hallegate S, et al. (2019)[95] on the costs of achieving climate resilience across multiple sectors and to multiple climate hazards. For the water and sanitation sector, the paper estimates the cost increases required to make water and sanitation systems more resilient, assuming universal access to safe water and sanitation is achieved in LICs and LMICs at the current resilience level. The paper finds that a 1.1–2.2% increase in capital expenditure is needed to make all water assets more resilient to floods. As a conservative assumption, the model uses the upper bound of 2.2% to estimate the additional cost of capital required for resilience. In the resilient scenario, these costs are estimated based on the level of flood exposure in a given year. The implicit assumption is that certain areas in a country are more likely to be flood prone, and therefore only 'strategic' resilience upgrades are needed, in proportion with the percentage of the population with the greatest flood exposure in the year. The model uses an additional 10% buffer to the population exposure level to account for variation in households exposed. For example, in Bangladesh around 13% of the population will be exposed annually by 2040. The model applies the additional cost of resilience upgrades to 14.3% of the population, to account for both the exposure level and a buffer, as representative of the magnitude of strategically applied resilience upgrades. Exposure is based on WRI's Aqueduct database, based on a high emissions climate scenario (RCP8.5). These costs are only applied in countries with estimated future annual flood exposure in the upper 25th percentile according to WRI's Aqueduct Flood Risk Rankings.

5.6. Benefits analysis methodology

The benefits methodology follows the structure of the approach applied by Hutton G (2012), with updated data sources, assumptions and additional benefits included. In addition, the non-climate resilient scenarios account for service disruptions resulting from flood exposure. Figure 10 provides an overview of the types of benefits included in the benefits estimation. For the non-climate resilient scenarios, benefits lost from service disruptions are subtracted from total benefits as described in the assumptions table (Table 9).

5.6.1. Health benefits

The first step in the health benefits analysis is to estimate the averted cases of disease associated with a service upgrade. The analysis estimates averted cases of disease for three key diseases associated with WASH service access: diarrhoeal disease (all), helminths disease (sanitation) and upper respiratory diseases (hygiene). Averted cases of disease depends on the subpopulation risk before and after receiving a service upgrade. For each disease and each WASH service, the analysis estimates the risk of disease based on the observed disease rate among the population (GBD data), the proportion of the population with access to each WASH service level (JMP data), and the relative risk of disease at each WASH service level (see assumptions table). The model first derives a risk level for each population group with access to different levels of WASH service, per country. Then, the model estimates the reduced number of cases among the population sub-group as the product of the population size and the difference between the initial and final risk levels.

For each reduced case of disease, the analysis estimates three types of benefits: averted harm to quality of life or loss of life, averted productivity losses and averted healthcare expenditure. Averted harm to quality of life or loss of life is estimated based on DALYs per case of disease. DALYs are calculated within the Global Burden of Disease data and include both years of life lost due to premature mortality (YLL) and years lived with disability (YLD).[xvii] DALYs per case will vary by both disease and by country; countries with lower healthcare system capacity or other resource constraints may have higher mortality rates. The analysis estimates the reduced DALYs as the product of averted cases and DALYs per case by country. In addition, each case of disease may lead to lost economic output or earnings from presenteeism (lower productivity while at work due to illness) and absenteeism (missed work due to illness). The estimate of averted productivity losses are based on absenteeism. Based on academic literature (see Table 9), the analysis assumes that on average, each case of disease is associated with a fixed number of days of missed work. This is agnostic to whether the disease is experienced by an adult or a child; the implicit assumption is that if a child

Figure 12: Overview of approach to benefits valuation

Benefit	Population	Valuation approach
Averted harm to quality of life or loss of life.	Individuals who avoid getting the diseases.	Estimate disease burden reduction, associated DALYs and value of DALY.
Averted productivity losses.	Individuals who avoid missing work due to illness OR parents who avoid missing work due to child illness.	Estimate disease burden reduction, associated absenteeism and income gains.
Averted healthcare expenditure.	Individuals who avoid getting the disease.	Estimate disease burden reduction and averted outpatient healthcare expenditure.
Time savings.	Individuals who avoid spending additional time collecting water or travelling for sanitation.	Estimate travel time savings and associated gain in economic opportunities.

Benefits of WASH services

Source: Vivid Economics

[xvii] *See an explanation of the DALY concept here:* ***who.int/data/gho/indicator-metadata-registry/imr-details/158.***

falls ill, this will result in lost productive time from carers. This is also agnostic to whether the disease is experienced by an employed person; the implicit assumption is that productive time lost is valuable even when a person is not employed. Thirdly, illness can result in healthcare expenditure. As a conservative estimate, this analysis assumes that each case of disease results in one outpatient healthcare facility visit.

Finally, the model translates the three health benefits into economic terms. DALYs are valued based on Brent R (2011), which estimates the implicit price of a DALY for use in cost-benefit analysis. The research estimates the price of a DALY to be US $6,300–11,900 in 2005. The model applies the global growth in GDP per capita to estimate a DALY value in 2019 USD of $9,200–17,400. For productivity gains, the analysis uses the daily equivalent of national net income per capita as a proxy for the value of a lost productive day. For healthcare costs, the analysis uses WHO data on the cost of outpatient care visits by country. As a conservative assumption, for each country, the analysis uses the lowest reported centre cost. For countries with missing data, a regional average is imputed.

5.6.2. Time savings value

The time savings value approach follows the structure and assumptions used in Hutton (2012). The assumptions table shows the specific time savings for urban and rural beneficiaries; the model applies these time savings at the household level for subpopulations gaining improved access to water services, and at the individual level for subpopulations gaining improved access to sanitation services. In line with Hutton G (2012), the analysis does not estimate any time savings benefits for access to hand hygiene services. Time savings are estimated in hours per year, and monetised based on the hourly value of productive time (as above, based on net national income per capita). In line with Hutton G (2012), the model assumes that time savings are valued at 30% of the value of productive time.

5.7. Indicative COVID-19 scenario modelling

The model developed by Siraj A, et al. (2020), published early during the pandemic, provided initial estimates of COVID-19 infections in small, medium and large population clusters, specifically calibrated to sub-Saharan Africa. The model is a process-based model with parameters obtained from early studies of COVID-19 dynamics and taking into account local context. The objective of the paper was the model the spread of COVID-19 in differently sized population clusters, under different policy and behavioural conditions. The model tests the effectiveness and coverage of social distancing, contact tracing and usage of cloth face masks. The model also tests the importance of timing of implementation; the study found that implementing early contact tracing, face masks and social distancing can bring the epidemic to manageable levels.

The indicative COVID-19 scenario modelling adapts the model developed by Siraj A, et al. (2020)[93] to test scenarios representative of the impact of hand hygiene on COVID-19 transmission and provide the model data and accompanying code via GitHub; this analysis uses adjusted scenarios and accompanying code to run the analysis. The scenarios tested are described by the parameters in Table 14. The key parameters tested were the efficacy of hand hygiene and the coverage of hand hygiene. The model tested two impacts of hand hygiene, based on emerging research by NERVTAG/EMG on the role of hand hygiene in preventing the transmission of COVID-19.[90] The model also tests a range of hand hygiene coverage levels; just under 60% of the urban population in Ethiopia have access to hand hygiene.[xviii] Figure 13 shows the modelled trajectories of infection spread under these conditions over the first 100 days of the outbreak, under the higher hand hygiene efficacy scenario.

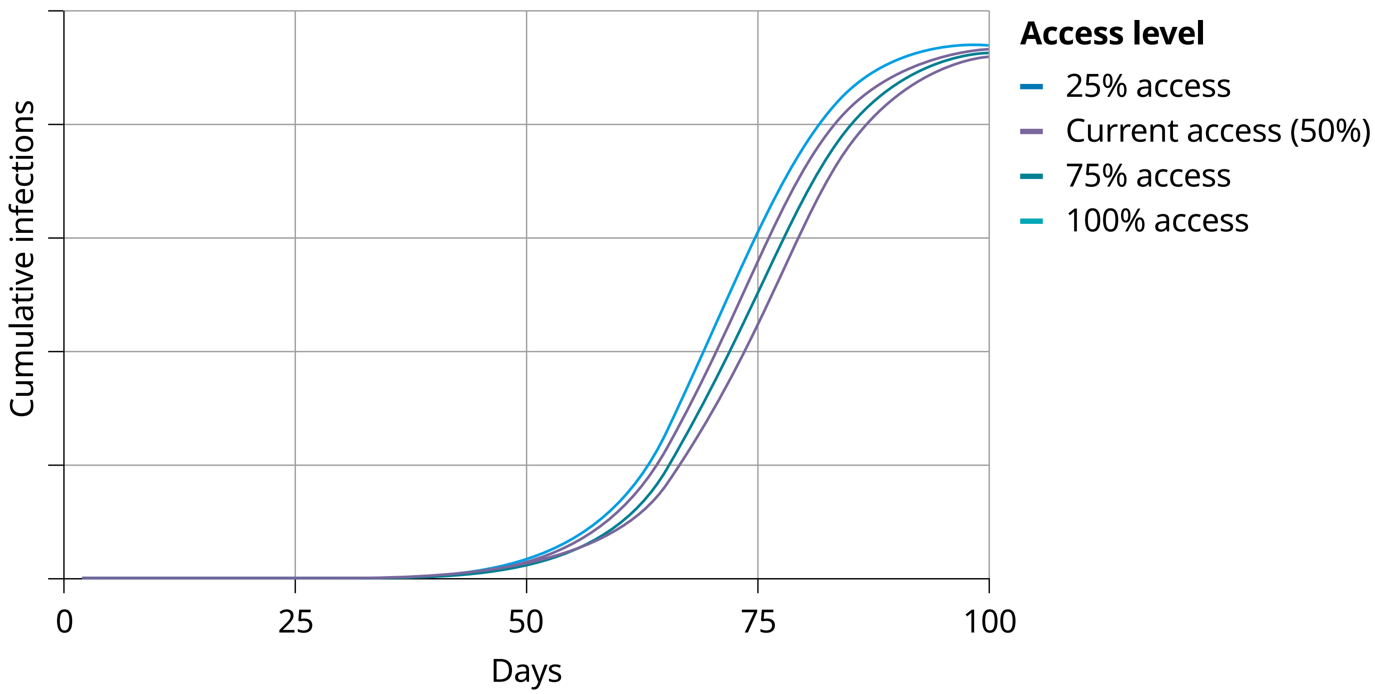
Table 14: Model calibration to test indicative implications of hand hygiene for COVID-19

Location	Large urban
Population	5 million (approximate size of Addis Ababa)
Initial cases	50
Social distancing	NONE
Contact tracing	NONE
Hand hygiene effect	3%, 6% reduction in spread given exposure[90]
Hand hygiene coverage	59.5%, 75%, 100%
Urban	YES

Note: Hand hygiene effect and coverage are implemented in the model by Siraj A, et al. (2020) as face mask efficacy and coverage. All permutations of the scenario parameters listed in the table were modelled.

Source: Vivid Economics

Figure 13: An indicative trajectory of a COVID-19-like epidemic in a city the size of Addis Ababa shows that hand hygiene can help flatten the curve in absence of other interventions



Source: Vivid Economics based on model developed by Siraj A, et al. (2020)[93]

[xviii] *Based on the most recent estimates from JMP.*

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WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation. Only by tackling these three essentials in ways that last can people change their lives for good.

This report draws on multiple sources, including economic analysis and case study research from Vivid Economics. WaterAid is responsible for the conclusions and recommendations of the research.

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