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CO-BENEFITS
OF INVESTING IN
SAFE DRINKING
WATER, SANITATION
& HYGIENE
(WASH)

EXECUTIVE
SUMMARY

Investing in water, sanitation and hygiene (WASH) is one of the highest-return investments a government or funder can make. Access to WASH saves lives, cuts health costs, creates employment opportunities, unlock productivity and learning, reduce inequalities – especially for women and girls – and protects ecosystems, while strengthening climate resilience. Yet billions of people still lack safely managed services, and climate change, urbanization, fragility and under-investment are widening the gap.

This executive summary distils the best available evidence on WASH's added benefits across three domains – health, socioeconomic development and environment and climate – and translates it into clear suggestions for decision makers.

The message is straightforward: WASH is fundamental to protecting health, accelerating inclusive growth and meeting climate and environmental targets. Invest early, invest for resilience and invest systemically – because the returns multiply across sectors and across generations.



References: References used in this executive summary are included in the main report. United Nations Children's Fund, *Co-benefits of investing in safe drinking water, sanitation and hygiene (WASH)*, UNICEF and Swedish Environmental Research Institute (IVL), 2025. Available here: <https://knowledge.unicef.org/wash/resource/co-benefits-investing-safe-drinking-water-and-sanitation-wash>

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CO-BENEFITS OF INVESTING IN SAFE DRINKING WATER, SANITATION AND HYGIENE (WASH)



HUMAN HEALTH AND WELL-BEING CO-BENEFITS INCLUDE

1. **Cuts diarrhoea and infection risk** → 1.4 million deaths and 74 million DALYs¹ attributable annually to unsafe WASH; diarrhoea risk drops by up to 52 per cent with basic WASH improvements
2. **Delivers highly cost-effective hygiene prevention** → handwashing reduces diarrhoea by 30 per cent and could prevent 96 million cases of diarrhoea and 160 million respiratory infections annually
3. **Cuts cholera risk** → 2.86 million cases & 95,000 deaths annually (uncertainty: 1.3–4.0 million); safe water and sanitation remain the most effective long-term prevention
4. **Prevents child undernutrition** → unsafe WASH contributes to 10 per cent of global undernutrition; improved sanitation associated with a reduction in stunting of between 16–39 per cent
5. **Protects from neglected tropical diseases** → unsafe WASH drives soil-transmitted helminths (STH) infections,² affecting more than 1 billion people, and schistosomiasis³ causing 1.6 million DALYs annually, as well as trachoma which affects 1.9 million people annually, and puts 103 million at risk
6. **Strengthens epidemic and pandemic preparedness** → safe WASH is essential to control the spread of cholera, Ebola, COVID-19 and other infectious diseases; weak hygiene infrastructure accelerates viral transmission
7. **Reduces health care-associated infections and sepsis** → there are 48.9 million cases of sepsis annually, with 11 million deaths; up to half of health care-associated sepsis is preventable with reliable WASH and strong systems to prevent and control infection.



SOCIAL AND ECONOMIC CO-BENEFITS INCLUDE

8. **Boosting economic returns and productivity** → spending \$1 on sanitation brings a return of \$5.50; poor WASH costs 2–7 per cent of GDP in many low and middle-income countries (LMICs)
9. **Reducing poverty and inequity** → low-income households often pay much higher unit costs, sometimes by a factor of up to 30–40, for unsafe or vendor-supplied water
10. **Creating jobs and enterprises** → local businesses in construction, operations and maintenance, desludging; opportunities especially for women and young people
11. **Improving school attendance and learning** → reduces absenteeism by 20–50 per cent; menstrual hygiene can reduce between 27–41 per cent of missed days in some settings
12. **Strengthening women's safety, dignity and leadership** → safe, private sanitation reduces risks of harassment and violence; but women hold fewer than 18 per cent of WASH jobs and remain underrepresented in utility leadership
13. **Helping break time-poverty for women and girls** → women and girls spend 200 million hours daily collecting water – time lost from schooling, income and leadership opportunities, reinforcing gender inequality
14. **Preventing conflict and building peace** → children aged 5 and under in conflict zones are three times more likely to die from WASH-related disease than violence; inclusive WASH builds social cohesion and stabilization
15. **Strengthening community resilience** → resilient services prevent outbreaks post-disasters and restore livelihoods



ENVIRONMENTAL AND CLIMATE CO-BENEFITS INCLUDE

16. **Protecting ecosystems from pollution** → approximately 58 per cent of coral reefs & 88 per cent of seagrass beds are exposed to wastewater nitrogen
17. **Driving a circular economy and resource recovery** → advanced treatment can recover up to 90 per cent of water and nutrients, producing reclaimed water, fertilizer and energy
18. **Nature-based solutions strengthening resilience** → the construction of wetlands, mangrove restoration and green infrastructure improve water quality, regulate floods and enhance ecosystem services; scaling-up requires stronger governance and investment
19. **Enhancing climate adaptation** → WASH is front-line defence against floods, droughts, heatwaves; protects health and livelihoods
20. **Reducing greenhouse gas emissions** → sanitation accounts for around 4.7 per cent of global methane; upgrades can cut these emissions by more than 50 per cent
21. **Improving energy efficiency and reducing costs** → water sector uses approximately 4 per cent of global electricity; NRW (non-revenue water) reduction can potentially cut greenhouse gases by more than 25 per cent
22. **Supporting nature-based and circular solutions** → wetlands, reuse, sludge-to-biogas increase biodiversity and carbon storage
23. **Bridging climate policy and finance gaps** → WASH is underrepresented in NDCs (nationally determined contributions) and NAPs (national adaptation plans); stronger metrics can unlock climate funding.

1 Disability-Adjusted Life Years (DALYs) are a public health metric used to quantify the burden of disease and evaluate the gap between a population's current health status and an ideal, healthy situation. One DALY represents one lost year of 'healthy' life.

2 Parasitic worm infections

3 Infection with the parasitic worm Schistosoma



1. HUMAN HEALTH AND WELL-BEING CO-BENEFITS

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Inadequate WASH is a leading cause of preventable mortality and disease. Access to water, sanitation and hygiene could prevent at least 1.4 million deaths and 74 million DALYs annually – equivalent to 2.5 per cent of all global deaths and 2.9 per cent of DALYs (WHO, 2023). Children under five are disproportionately affected, with unsafe WASH responsible for 7.6 per cent of deaths and 7.5 per cent of DALYs in this age group, making it one of the leading preventable causes of child mortality worldwide (WHO, 2023). Investing in WASH is among the most cost-effective public health strategies, critical for improving health, nutrition and resilience in low-resource settings (Prüss-Ustün et al., 2019; Hutton, 2012; Wolf et al., 2022).

SAFE WASH PREVENTS A WIDE RANGE OF INFECTIOUS DISEASES

■ Diarrhoeal disease remains the largest WASH-related burden.

In 2019, more than 1 million deaths and 55 million DALYs were attributed to unsafe water, sanitation and hygiene (WHO, 2023).

■ Basic WASH sharply reduces infection risks.

Systematic reviews show that moving from unimproved water sources to improved water supplies with higher water quality reduces diarrhoea risk by 52 per cent, point-of-use water treatment by 41 per cent (Wolf et al., 2022). Sanitation interventions reduce diarrhoea by 24 per cent, and sewer connections by 47 per cent (Wolf et al., 2023). Handwashing with soap reduces diarrhoea by 30 per cent (Wolf et al., 2023). However, hygiene promotion remains underfunded – even though it could prevent up to 96 million cases of diarrhoea and 160 million respiratory infections annually (Vivid Economics and WaterAid, 2021).



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■ **Cholera remains a major global threat, amplified by climate change and fragile WASH systems.**

Each year, an estimated 2.86 million cholera cases occur in endemic countries (range: 1.3–4.0 million) and cause around 95,000 deaths (uncertainty range: 21,000–143,000), with more than 1.3 billion people at risk. Epidemics continue to affect more than 30 countries annually (Ali et al., 2015; WHO, 2025). Safe water and sanitation remain the most effective long-term preventive measures, as outbreaks are increasingly driven by extreme weather and WASH failures (WHO, 2024; GTFCC, 2019; Nylander and Wilson-Jones, 2024).

■ **Access to WASH also prevents other infectious diseases.**

Some 14 per cent of acute respiratory infections are attributable to poor hand-hygiene (WHO, 2023). STHs affect more than 1 billion people globally, and trachoma remains a major cause of blindness – both strongly linked to inadequate sanitation and hygiene (Prüss-Ustün et al., 2019). Trachoma is a public health problem in 30 countries and is responsible for the blindness or visual impairment of about 1.9 million people, with 103 million people living in areas where it is endemic, and who are at risk of trachoma blindness (WHO, 2025).

■ **Parasitic diseases thrive in poor WASH environments.**

Schistosomiasis remains a major public health challenge, causing an estimated 1.6 million DALYs in 2019, despite progress over the past two decades (Montresor et al., 2022). Transmission is closely linked to inadequate sanitation, unsafe water contact and environmental contamination. Households without a latrine have about 50 per cent higher chance of infection, and the lack of an improved latrine increases risk further; open defecation also elevates infection risk (Ismail et al., 2023). These findings highlight the critically important role of safe water, improved sanitation, and the elimination of open defecation in controlling and eradicating schistosomiasis (Prüss-Ustün et al., 2019; Roche et al., 2022).

■ Viral transmission is worsened by poor WASH.

Weak hand-hygiene and unreliable water and sanitation accelerate the spread of infectious viruses such as polio and Ebola. During the West Africa Ebola outbreak in 2014–2016, gaps in hand-hygiene infrastructure and supplies contributed to hospital-based transmission, prompting the large-scale distribution of chlorine-based disinfection kits and emergency infection-prevention measures (Tantum et al., 2021; Ali et al., 2020). Studies from Liberia and Nigeria show that limited supplies of water, soap and functioning hand-hygiene stations hindered the effective control of the outbreak and that hand-hygiene practices often declined once the crisis subsided (Martins and Osiyemi, 2017; Tantum et al., 2021).

WASH STRENGTHENS NUTRITION AND CHILD DEVELOPMENT

■ Inadequate WASH undermines nutrition.

Recurrent diarrhoea, parasitic infections and environmental enteropathy impair nutrient absorption, contributing to 10 per cent of global undernutrition in 132 LMICs – equivalent to 8,000 deaths and 825,000 DALYs annually (WHO, 2023).

■ Poor WASH perpetuates child undernutrition.

Children exposed to unsafe WASH are more likely to suffer stunting, wasting and impaired cognitive development, with long-term impacts on schooling and productivity (Victora et al., 2010; Andres et al., 2018). Observational studies show a reduction of between 16–39 per cent in stunting among children with improved access to sanitation (Rah et al., 2015).

■ Evidence linking WASH interventions to improved recovery from severe acute malnutrition remains limited and inconclusive.

While biological pathways are strong, current studies show no consistent effect, and more rigorous research is needed to determine whether WASH can reduce relapse after SAM treatment (MacLeod et al., 2024).

■ Basic WASH interventions alone are insufficient.

Large-scale trials in Bangladesh, Kenya and Zimbabwe found no effect on linear growth, and highlighted the need for transformative strategies – eliminating open defecation, achieving safely managed services and integrating WASH with nutrition, food security and health interventions (Luby et al., 2018; Null et al., 2018; Cumming et al., 2019).

■ Evidence remains mixed and context specific.

Reviews show access to sanitation reduces diarrhoea and child mortality, but links to stunting and wasting vary. Piped water and safely managed sanitation consistently show the strongest benefits (Headey and Palloni, 2018).



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WASH SAFEGUARDS HEALTH SYSTEMS AND PANDEMIC PREPAREDNESS

■ Maternal and newborn survival depends on WASH.

More than one million deaths each year are associated with unclean births, and infections account for 24 per cent of neonatal deaths and 11 per cent of maternal mortality globally (Cheng et al., 2012; WHO, 2020). Many health facilities still lack basic water, sanitation and hand-hygiene infrastructure, undermining safe childbirth. Evidence from Tanzania shows that only a minority of births occur in environments with safe access to water and sanitation, and that the absence of essential items such as soap, clean water and wash basins is one of the main reasons for maternal and newborn infections (Benova et al., 2014).

■ Inadequate WASH drives health care-associated infections and contributes to the global burden of sepsis.

In 2017, there were an estimated 48.9 million sepsis cases and 11 million sepsis-related deaths worldwide – many linked to inadequate prevention of infection, poor hand-hygiene and weak health care infrastructure (Rudd et al., 2020; WHO, 2020). Up to half of health care-associated sepsis cases are preventable through robust measures to infection prevention and control, including safe water, sanitation and hand-hygiene in health facilities (WHO, 2020; Hutton et al., 2024).

■ WASH is critical for containing outbreaks and pandemics.

Hand-hygiene and safe water are first-line defences against Ebola, COVID-19 and other emerging diseases. Countries with reliable WASH access were able to adopt and sustain protective behaviours, which is likely to have contributed to lower transmission during the COVID-19 pandemic (Bauza et al., 2021; Pakhtigian et al., 2022).

■ WASH helps combat antimicrobial resistance and zoonotic risks.⁴

Wastewater and poor sanitation act as reservoirs for resistant bacteria and zoonoses.⁵ Integrated WASH approaches reduce these risks and strengthen health system resilience (WHO, 2020b; LeDeunff, 2024).

⁴ A zoonotic infection is one that spreads naturally between animals and humans, caused by germs like viruses, bacteria, parasites or fungi, with common examples including rabies, salmonella, and COVID-19.

⁵ A zoonosis is a zoonotic disease.



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2. SOCIAL AND ECONOMIC CO-BENEFITS

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Safe water, sanitation and hygiene (WASH) are not only essential for keeping people healthy but are also powerful drivers of economic growth, gender equality and environmental protection. Inadequate WASH drains billions from economies each year, perpetuates poverty, limits women’s opportunities and damages fragile ecosystems (Hutton and Chase, 2016; Vivid Economics and WaterAid, 2021). By contrast, targeted investment in WASH generates high and durable returns, strengthens human capital and conserves natural resources – making it a foundation for inclusive and sustainable development (Macura et al., 2023).

 **WASH AS A DRIVER OF GROWTH AND POVERTY REDUCTION**

■ **High and durable economic returns**

global cost–benefit analyses confirm that every US\$1 invested in sanitation yields up to US\$5.50 in benefits (like lower health costs, increased productivity, saved time, fewer premature deaths), while investments in drinking water yield around US\$2. Modelling suggests that universal hygiene alone could prevent 96 million diarrhoeal and 160 million respiratory infections annually and save approximately US\$39 billion in lost workdays – returns unmatched by most other development investments (Hutton, 2012; Vivid Economics and WaterAid, 2021).



■ Job creation and local enterprise.

WASH generates livelihoods across construction, operation and maintenance, desludging and small-scale service provision – often employing women and young people. Yet barriers such as limited finance, weak regulation and poor technical support constrain this potential. Removing these bottlenecks can unlock entrepreneurship, stimulate microenterprise and improve service quality (Addisu, 2024; Abanyie et al., 2023; Hutchings et al., 2022; Bakker et al., 2021; Leahy et al., 2017).



WASH ADVANCES GENDER EQUALITY AND WOMEN'S EMPOWERMENT

■ Time-poverty.

Women and girls spend an estimated 200 million hours every day collecting water – 40 billion hours annually in Sub-Saharan Africa – time that could otherwise be used for education, income or leadership (UN Women, 2014; UNICEF, 2016).

■ Safety and dignity.

Women practising open defecation face a higher risk of sexual assault compared to those with private toilets (a 39 per cent higher risk was mentioned in a study in Kenya, based on a demographic and health survey). Lack of safe sanitation also drives psychosocial stress and daily anxiety over privacy, safety and dignity, particularly in informal settlements (Winter and Barchi, 2016; Hulland et al., 2015; Sahoo et al., 2015; Chi, 2023).

■ Costs of inaction.

Poor WASH can reduce GDP by 2–7 per cent in low- and middle-income countries, with sanitation-related losses alone exceeding 4 per cent in South Asia. Namibia, for example, loses 1.8 per cent of GDP annually due to inadequate WASH, mostly borne by rural households (Hutton and Chase, 2016; UNICEF, 2023).

■ Trapped in poverty.

Across many low-income urban areas, households without piped water pay far higher unit costs for small, irregular purchases from vendors. In Kano, Nigeria, local vendor water costs 28–40 times the utility tariff (Ahmad, 2017), and similar inequities are reported across Africa and Asia, where households without piped supply face disproportionately high prices for vendors' water (Bulled, 2017; Raina et al., 2020). These inequities deepen financial vulnerability and reinforce poverty traps for families relying on informal water markets.

■ Hidden risks of sextortion and gender-based violence.

Poor WASH access exposes women and girls to multiple forms of gender-based violence, including sextortion, where control over water points or sanitation facilities is abused to coerce women into sexual acts – as reported in Kenya, Bangladesh and other settings (Merkle et al., 2023; Pommells et al., 2018; Water Integrity Network, 2023). Evidence from East and southern Africa and South Asia also shows that harassment, assault and intimate partner violence are linked to distant or unsafe water points, inadequate privacy and the heavy domestic burden placed on women and girls (Pommells et al., 2018; Simavi, 2023). These risks underscore the need for gender-responsive WASH services, stronger accountability and safe, accessible water and sanitation infrastructure (UNDP-SIWI, 2017).

■ Leadership gaps.

In almost a quarter of countries, women hold less than 10 per cent of government WASH jobs (WHO, 2022), and World Bank data show women make up less than 20 per cent of workers and around 23 per cent of engineers and managers in sampled water utilities (World Bank, 2019). Across infrastructure sectors more broadly, women still occupy only around one in five senior roles, underscoring the need for gender-transformative approaches. Most WASH programmes stop at reducing women's time burdens rather than addressing structural inequalities, underscoring the need for gender-transformative approaches (Ram and Mrim, 2024; Macura et al., 2023).



WASH SUPPORTS EDUCATION AND HUMAN CAPITAL

■ Improved learning conditions.

Access to safe water and sanitation in schools reduces absenteeism, ranging from 20 per cent to more than 50 per cent in some trials, and contributes to lower child morbidity and mortality, especially by preventing diarrhoeal disease (McMichael, 2019). These improvements directly strengthen human capital and long-term economic growth (Hutton and Chase, 2016).



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■ Menstrual hygiene gaps hinder education.

Studies from countries such as Bangladesh and Ghana find that around 27–41 per cent of schoolgirls report that they miss school during menstruation, often for 2–3 days in each cycle, with some Ethiopian studies reporting even higher levels of absenteeism. Gender-responsive school WASH helps keep girls in school and improves participation (Adane et al., 2025; Shah et al., 2022).

■ Inclusion for children with disabilities.

Without accessible facilities, children with disabilities are almost twice as likely to suffer severe diarrhoea and be frequently excluded from school participation. Inclusive designs are critical for achieving universal education and equity (Wilbur et al., 2024; WHO and UNICEF, 2024).



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WASH, PEACE AND CONFLICT PREVENTION

■ In conflict settings, lack of WASH is deadlier than violence.

Children under the age of 15 are nearly 3 times more likely, and children under-5 more than 20 times more likely, to die from WASH-related disease than from direct violence. Attacks on systems exacerbate poverty, the problems of displacement and disease outbreaks. (UNICEF, 2019; 2022).

■ Conflict-sensitive WASH builds trust and reduces grievances.

Inclusive, participatory services restore livelihoods and strengthen cohesion when combined with institutional capacity and community leadership (as can be seen in Niger and Somalia). (Hayes and Fawcett, 2023; Mafuta et al., 2021; Grieve et al., 2023).

■ A neutral entry point for peacebuilding.

As part of the Humanitarian–Development–Peace Nexus, championed by the United Nations, WASH provides visible peace dividends and strengthens state–society relations. (UNICEF, 2023; OECD, 2025; Weinthal et al., 2011, 2014).



ENHANCING COMMUNITY RESILIENCE THROUGH WASH

■ Safe, inclusive WASH is a cornerstone of resilience.

It protects communities from escalating climate shocks, reduces the risks of conflict over scarce resources, and safeguards ecosystems that sustain water security (GWP and UNICEF, 2022; UNDP, SIWI and UNICEF, 2023; WaterAid, 2023a). Resilient services not only shield households from floods, droughts and disease, but also foster trust, social cohesion and recovery in fragile settings (WaterAid, 2022). By integrating nature-based solutions, clean energy and climate-smart sanitation, WASH can cut emissions, restore ecosystems and provide a practical entry point for both adaptation and peacebuilding (WaterAid, 2024; UNICEF, 2023).

■ Resilience depends on inclusive and adaptive services.

Inequities shape vulnerability; participatory governance, gender-sensitive design and ecosystem protection strengthen adaptive capacity. (Crozier et al., 2024; WaterAid, 2022, 2023b; ICIMOD, 2022; UNEP, 2022).

■ Resilient WASH services are designed to local risks and dynamics.

Flood-resilient sanitation, redundancy across water sources and animal-inclusive WASH reduce failures and zoonotic risks, while locally led adaptation blends traditional knowledge with flexible tech. (Howard et al., 2016; Abrams et al., 2021; Sentamu et al., 2023; Sharma et al., 2025; Gero et al., 2024).

■ Resilient WASH is front-line adaptation.

Inclusive, reliable services reduce post-disaster disease surges, support recovery and safeguard livelihoods. (UNICEF, 2017; Dickin et al., 2020; Prasad et al., 2023).



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3. ENVIRONMENTAL AND CLIMATE CO-BENEFITS

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Water, sanitation and hygiene (WASH) play a critical role in protecting ecosystems, strengthening water security and addressing climate change. Poorly managed sanitation and wastewater are major sources of pollution, contributing to freshwater and coastal ecosystem degradation, biodiversity loss and greenhouse gas emissions (Tuholske et al., 2021; WaterAid, 2024).

By contrast, safely managed and climate-resilient WASH systems reduce pollution, conserve water resources and enhance resilience to floods, droughts and heatwaves, while enabling water reuse, nutrient recovery and renewable energy generation (UN, 2017; Joseph et al., 2023; Sharma et al., 2022). Despite this evidence, WASH remains underrepresented in climate policy and finance, underscoring the need for stronger data, metrics and climate integration to align SDG 6 with biodiversity and climate goals (Prasad et al., 2023; Dickin et al., 2020).

WASH PROTECTS ECOSYSTEMS AND WATER RESOURCES

■ Untreated wastewater fuels ecological decline.

Human sewage contributes 6.2 teragrams of nitrogen annually to coastal waters, with modelled plumes indicating that about 58 per cent of coral reefs and 88 per cent of seagrass beds are exposed to eutrophication⁶ and biodiversity loss (Tuholske et al., 2021).

■ Multiple contaminants affect wildlife and human health.

Wastewater can also carry pathogens, microplastics and a wide range of pharmaceuticals and other micropollutants, which affect aquatic organisms, alter ecosystem processes and, through contaminated water and food chains, create feedbacks that can ultimately undermine human health (De Guzmán et al., 2023).

⁶ Eutrophication is the over-enrichment of lakes, rivers, oceans with nutrients like nitrogen and phosphorus, usually from fertilizers, sewage, and runoff, causing excessive growth of algae that block sunlight, die, and decompose, leading to oxygen depletion (hypoxia) and creating 'dead zones' where fish and other aquatic life suffocate, damaging ecosystems and impacting human health through toxins and contaminated shellfish.

■ Turning waste into resources supports circular economies and reduces pressure on fresh water.

With proper treatment and routine maintenance (e.g., desludging before rainy seasons), wastewater and sludge can be transformed into reclaimed water, biofertilizers and renewable energy. Advanced systems can recover up to 90 per cent of water and nutrients, cutting pollution, easing fresh water demand and creating new value chains for agriculture and energy, although performance varies widely (Lebu et al., 2024; Habanyama et al., 2024; Ji, 2021; Chojnacka et al., 2022; Joseph et al., 2023; Sharma et al., 2022).

■ Maintaining ecosystems can reduce pressure on water treatment.

Healthy forests, wetlands and soils filter pollutants, protect fresh water biodiversity and reduce pressures on water treatment systems (WaterAid, 2024). While more evidence is needed to demonstrate their cost-effectiveness across diverse contexts (Glass and Burgess, 2025), the experience of New York City – avoiding a multi-billion-dollar filtration plant and saving around US\$110 million annually through watershed protection – illustrates the potential for well-managed catchments to lower treatment and capital costs (McDonald and Shemie, 2014).

■ Promoting nature-based solutions (NBS).

Constructing wetlands, restoring mangroves and introducing urban green infrastructure improve water quality, regulate floods and strengthen ecosystem services while delivering social and economic co-benefits. Evidence from Bangladesh, Brazil and the Philippines demonstrate their effectiveness, but scaling up these improvements requires stronger governance and investment (Acreman et al., 2021; Smith et al., 2021; Boongaling et al., 2024).



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IMPROVED WATER SECURITY

■ Climate-resilient water supplies are crucial.

More than 1.4 billion people, including 450 million children, live in high water vulnerability, a combination of a low coverage of drinking water services and high physical water scarcity risks. Investing in climate-resilient and safely managed water supply is the most effective way to reduce water insecurity (UNICEF, 2021).

■ Ecosystems and diversified sources buffer shocks when well-managed.

Protecting wetlands, mangroves and coral reefs alongside expanding safe reuse, groundwater management, rainwater harvesting and greywater reuse increases reliability and water quality during extremes. (Vymazal, 2010; GWP and UNICEF, 2022; WaterAid, 2024; Rodrigues et al., 2023).

■ Efficiency and monitoring are essential.

Greywater reuse can increase local availability by up to 60 per cent. Functionality tracking, affordability and responsive operations and management sustain long-term access (Anthonj et al., 2018; Murray et al., 2024; Tseole et al., 2022; Van De Walle et al., 2023).



CLIMATE MITIGATION THROUGH WASH

■ Sanitation is a large and under-counted methane source.

Non-sewered sanitation systems are a significant and under-counted source of methane, with recent estimates suggesting they may account for around 4–5 per cent of methane gas globally released into the atmosphere due to human activities emissions (about 377 million tons of carbon dioxide equivalent annually). Pit latrines are a major contributor to this, though their precise global share remains uncertain and depends on limited data (Cheng et al., 2022; Shaw et al., 2021; WHO, 2019; van Eekert et al., 2019; Manga and Muoghalu, 2024).

■ Treatment plants also emit—but upgrades work.

Wastewater treatment plants are estimated to contribute around 1.3–1.6 per cent of global GHG emissions and about 3–4 per cent of electricity use. Energy-efficient processes and biogas capture can reduce methane emissions by more than half in many plants, and targeted process optimization can significantly lower emissions of nitrous oxide, a powerful greenhouse gas, though the exact reduction varies by technology and operating conditions. (Lu et al., 2018; Crippa et al., 2019; EEA, 2021; He et al., 2023).

■ Scaling up adequate sanitation adds modest emissions.

Current estimates suggest that meeting SDG 6.2 would add only about 0.2 per cent of global greenhouse gas emissions – well below earlier projections (Shaw et al., 2021).

■ Energy efficiency is high leverage.

The water sector uses roughly 4 per cent of global electricity, water and wastewater services often accounting for 30–50 per cent of municipal electricity bills, making a powerful argument for greater efficiency. In Antalya, Turkey, for example, measures including non-revenue water reduction and energy efficiency were modelled to cut greenhouse gas emissions by about 28 per cent and energy use by around 16 per cent. (IEA, 2018; Muhammetoglu et al., 2022; Lam et al., 2017).



CLIMATE ADAPTATION THROUGH WASH

■ Climate hazards already disrupt WASH.

Risks from floods, droughts, and heatwaves rise with every degree of warming (IPCC, 2014; 2022).

■ Practical and scalable solutions exist.

Point-of-use treatment, solar disinfection, constructing wetlands, rainwater harvesting and regular desludging reduce risks and improve resilience – especially in fragile areas. (Pooi and Ng, 2018; Chu et al., 2019; ; Vymazal, 2010; WHO, 2023).

■ Policy and finance lag behind evidence.

Despite strong evidence of WASH–climate links, water, sanitation and hygiene are still often weakly reflected in NDCs, NAPs and climate-finance portfolios. Strengthening the climate rationale for WASH – through better metrics, risk analysis and costings for operation and management – is increasingly recognized as essential to unlocking climate funding (Prasad et al., 2023; Dickin et al., 2020; Shaw et al., 2021).





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