

Amita Bhakta, Paula Morcillo de Amuedo and Mark Fletcher

Enhancing inclusion in climate-resilient urban sanitation services

A discussion paper supported by Arup

:



Contents

1.	Executive Summary	4
2.	Background	6
3.	Understanding Inclusive WASH	8
4.	Understanding the linkages between climate change and sanitation	13
4.1	How climate change impacts sanitation	13
4.2	How sanitation impacts climate change	14
5.	Opportunities to enhance inclusion through climate-resilient sanitation	16
5.1	Opportunity to increase focus on marginalised communities enhancing universal access to sanitation	16
5.2	Opportunity to develop solutions that could work in different contexts	16
5.3	Opportunity to professionalise services improving workers' conditions and public perception	17
5.4	Opportunity to design climate-resilient initiatives to address everyone's needs	19
5.5	Opportunity for new markets and job creation	20
6.	General best practices for inclusive climate-resilient WASH	22
6.1	Maximise existing systems performance during the management stage	25
7.	From opportunities to action: applying best practices to address gaps	26
8.	Conclusions	1
8.1	Overview	1
8.2	What is 'climate-resilient inclusive WASH'?	1
8.3	How can climate-resilient inclusive sanitation be achieved in the context of urban planning?	2
8.4	Areas for further research	2
9.	Recommendations	4
10.	Epilogue	6
2.	<u>Background</u>	6
3.	<u>Understanding Inclusive WASH</u>	8
4.	<u>Understanding the linkages between climate change and sanitation</u>	13
4.1	<u>How climate change impacts sanitation</u>	13
4.2	<u>How sanitation impacts climate change</u>	14
5.	<u>Opportunities to enhance inclusion through climate-resilient sanitation</u>	16
5.1	<u>Opportunity to increase focus on marginalised communities enhancing universal access to sanitation</u>	16
5.2	<u>Opportunity to develop solutions that could work in different contexts</u>	16
5.3	<u>Opportunity to professionalise services improving workers' conditions and public perception</u>	17
5.4	<u>Opportunity to design climate-resilient initiatives to address everyone's needs</u>	19

5.5	<u>Opportunity for new markets and job creation</u>	20	
6.	<u>General best practices for inclusive climate-resilient WASH</u>		22
6.1	<u>Maximise existing systems performance during the management stage</u>	25	
7.	<u>From opportunities to action: applying best practices to address gaps</u>		26
8.	<u>Conclusions</u>		1
8.1	<u>Overview</u>	1	
8.2	<u>What is ‘climate-resilient inclusive WASH’?</u>	1	
8.3	<u>How can climate-resilient inclusive sanitation be achieved in the context of urban planning?</u>	2	
8.4	<u>Areas for further research</u>	2	
9.	<u>Recommendations</u>		4
10.	<u>Epilogue</u>		6

Tables

Table 1: Inclusion gaps in delivering climate-resilient WASH	11
Table 2: Impacts of climate change on sanitation (adapted from Hyde-Smith et al, 2022)	14
Table 3: Impacts of the sanitation chain on climate change (Adapted from Johnson et al, 2022)	15
Table 4: Gaps in and opportunities for realising inclusion in climate-resilient sanitation	20
Table 5: Inclusive WASH principles (UNOPS, 2024)	22
Table 6: Applying best practices for inclusion in climate-resilient urban sanitation	2

Figures

Figure 1: A community toilet in Sinnar, Maharashtra (Photo © CWAS, CDRF, CEPT University)	10
Figure 2: Desludging truck used by women sanitation workers at a faecal sludge treatment plant in Cuttack, India (Photo © Amita Bhakta)	11
Figure 3: Sanitation chain (for sewer and non-sewer systems)	13
Figure 4: Emissions from the sanitation system in Kampala, to understand the key emissions areas (Johnson et al, 2022).	15
Figure 5: "Unplanned settlement in Cape Town (Kialitsha) (2937830300)" by SuSanA Secretariat is licensed under CC BY 2.0.	17
Figure 6: Women engaged in septic tank cleaning with access to adequate support through the professionalisation of the occupation under the Garima Scheme in Odisha, India (Photo: Jhunulata Naik)	18
Figure 7: Scheduled Desludging in Wai, Maharashtra, India. (Photo © CWAS, CEPT University)	19

At a glance

Purpose

To show how climate-resilient urban sanitation can enhance inclusion rather than deepen existing inequalities.

Core proposition

Inclusion should be a foundational design principle for WASH systems, policies, governance and finance, not a later-stage add-on.

Three shifts

Redefine inclusion to recognise sanitation workers; move from one-size-fits-all engineering to flexible and adaptive solutions; embed equity, accessibility and affordability from the outset.

Primary audiences

City leaders, urban planners, WASH practitioners, climate-resilience specialists, funders and delivery partners.

1. Executive Summary

As climate change intensifies in an increasingly urbanising world, the challenges of access to basic sanitation services remain for the growing populations of towns and cities across low- and middle-income countries. Sewered and non-sewered sanitation are impacted by climate change through increased precipitation and flooding, water shortages, sea level rise, higher temperatures, and increasingly frequent cyclones and storms, leading to various negative impacts on infrastructure functionality and the sanitation workers at the centre of service delivery.

Sanitation also drives the greenhouse gas emissions that are accelerating these impacts, both directly and indirectly along the sanitation service chain. At the same time, growth in urbanisation risks leaving behind the most marginalised communities, who are most exposed to the impacts of climate change, with much greater attention needed to ensure greater equity and inclusion for vulnerable urban populations.

This paper explores how ‘climate-resilient’ urban sanitation can be designed to enhance inclusion rather than exacerbate inequalities. It challenges existing debates around equity and inclusion and presents the provision of climate-resilient services as an opportunity to reassess ‘inclusion’ in WASH. This paper applies an understanding of ‘inclusive WASH’ as ‘WASH services which emphasise the rights of users as equal to those of service providers such as sanitation workers, and address the needs of all involved in providing and using WASH services, taking into account context-specific vulnerabilities and factors of social exclusion such as caste, religion, geography, and occupation, across all genders and abilities’.

It examines existing gaps and barriers for inclusive WASH and key opportunities to integrate equity, accessibility, and sustainability into WASH systems, ensuring that resilience-building efforts proactively address the needs of all communities, particularly the most vulnerable. By doing so, this paper explores how inclusion can become a ‘default’ rather than an ‘add-on’ in climate-resilient urban sanitation.

To guide this approach, we adopt the Bhakta definition of ‘climate-resilient inclusive WASH’:

"Water sanitation and hygiene (WASH) services that can adapt to climate stresses and survive climate shocks whilst continuing to serve everyone, embedding principles of inclusion as a default rather than an exception, and as a foundation rather than an afterthought, for the delivery of WASH infrastructure, policies, governance and financial mechanisms designed for all."

Reflecting on existing literature from around the world and utilising the case study of Cape Town, South Africa to illustrate practical application, this paper analyses how expanding access to climate-resilient urban sanitation can provide a route to enhancing inclusion.

Gaps remain in ensuring inclusion with a lack of consideration for different physical abilities in climate-resilient sanitation infrastructure, a lack of consideration for diverse user needs, behaviours, and practices in planning and implementing climate-resilient sanitation, a greater focus on sanitation users than the sanitation workers who are at the heart of service delivery and exposed to the impacts of climate change, and a lack of equitable access to sanitation due to affordability.

At the same time, ensuring inclusion in urban sanitation in the face of climate change presents opportunities to increase focus on marginalised communities to achieve universal access to sanitation, develop sanitation solutions that work in different contexts, professionalise sanitation services and improve the public perception of sanitation workers, design climate-resilient initiatives to meet everyone’s needs, and create new markets for and jobs within sanitation.

By addressing these critical systemic gaps and leveraging these emerging opportunities, we can chart a clear path forward for both global policy and municipal action.

Our main conclusions are:

1. The target group for inclusive sanitation must be redefined to look beyond service users and formally recognise sanitation workers as central, equal stakeholders whose safety, dignity, and occupational rights are core to inclusion;
2. The sector must shift away from rigid, 'one-size-fits-all' engineering towards flexible, context-specific, and adaptive solutions that remain physically accessible and safe for everyone during extreme climate events; and
3. Inclusion must be treated as a default, a foundational principle embedded from the outset across all sanitation infrastructure, policies, governance, and financial mechanisms, rather than as a retrospective, costly add-on.

Going forward we would recommend:

1. Universalising and operationalising the Bhakta definition of 'climate-resilient inclusive WASH' globally to ensure inclusion is integrated across global climate policies, and climate financing frameworks;
2. Institutionalising intersectional vulnerability mapping, participatory planning processes, and targeted financial models within city local governments to ensure infrastructure is co-designed and remains affordable for the most climate-vulnerable communities; and
3. Formally professionalising informal sanitation services to secure dignified, safe working conditions, while actively engaging, incentivising, and regulating private sector stakeholders to scale up resilient service chains.

2. Background

In an increasingly urban world shaped by a changing climate, access to basic infrastructure services in expanding towns and cities is essential. More people now live in urban areas than rural areas. In 2025, cities became home to 45 percent of the world's 8.5 billion people, reflecting a significant demographic shift in human history (UN, 2025). Yet safer urban development practices are unable to keep pace with unregulated urban expansion, as settlements emerge in hazard-prone areas such as flood plains. This affects already vulnerable communities, leaving residents exposed to a 'triple burden' of poverty, climate hazards, and low access to sanitation services (International Bank for Reconstruction and Development, 2025).

At the same time, the water, sanitation and hygiene (WASH) sector faces the immense challenge of delivering safe services to the 10 percent of the global population that still lacks access to at least one basic water, sanitation or hygiene service, with 22 percent having no access to basic sanitation (GWP and UNICEF, 2022a).

In the context of the changing climate and the associated uncertainty, particularly in the most climate-stressed regions of the world, this is set to directly affect water resources and the availability and quality of WASH services, which means progress towards Sustainable Development Goal 6 — ensuring access to water, sanitation and hygiene for all by 2030 — is under threat.

Water-related climate risks include too much water, causing flooding in communities; too little water, leading to water stress and drought; and too much pollution, reducing water quality and access to safe water supply. Sanitation services are equally under threat, yet limited attention has been paid to sanitation in current debates, despite the fact that sanitation is both impacted by and has an impact on climate change, and that expansion of access to sanitation services is lagging behind access to water, with 3.5 billion people still lacking access to basic sanitation (WHO and UNICEF, 2025).

In response, the WASH sector is increasingly shining a spotlight on the need for climate-resilient WASH, with various organisations giving increasing attention to defining it. According to WaterAid (2024: 3), climate-resilient WASH 'refers to WASH services and behaviours that continue to deliver benefits, or are appropriately restored, within a changing climate context and despite climate-induced hazards'. The Global Water Partnership and UNICEF (2022:5) suggest that achieving climate-resilient WASH requires a focus on:

1. Ensuring that WASH infrastructure and services are sustainable, safe and resilient to climate-related risks
2. Ensuring that resilient WASH systems contribute to helping build community resilience to the impacts of climate change, while reducing existing inequalities.
3. Working towards a low-carbon WASH sector by improving water and energy efficiency, improving sanitation practices (safe containment and transportation of faecal sludge) and, where possible, using renewable energy for water and sanitation services.

The current discussion around climate-resilient WASH, however, is gaining momentum after an era in the WASH sector that has been defined by a focus on equity and social inclusion. Whilst discussions around the inclusion of women in water supply began over 40 years ago in the 1970s (Fisher et al, 2017), inequalities in access to WASH across low- and middle-income countries persist, and will only be reinforced by climate change unless action is taken. Yet, specific attention to equity and inclusion in climate-resilient WASH discussions is largely lacking.

This 'forgotten consideration' is further exacerbated in an era where global international development is marked by political uncertainty, and a significant rollback of overseas development assistance by the largest economies in the world. Whilst debates have gathered pace on 'soft' approaches to enhance inclusion such as menstrual hygiene and health promotion programming, the delivery of inclusive sanitation infrastructure at a wider urban scale lags behind. A focus on mechanisms to expand access to sanitation in the face of a changing climate is a timely opportunity to rethink and reassess how 'inclusion' can truly be achieved as cities around the world continue to expand.

The effects of climate change on water and sanitation systems will reinforce existing inequalities in low- and middle-income countries (LMICs). Climate-resilient water supply and sanitation services are crucial to promoting sustainable and inclusive socioeconomic development. The lack of climate-resilient water and sanitation services can have impacts such as exacerbating gender inequality, social exclusion, displacement, and reduced access to opportunities for affected populations.

This paper explores how climate-resilient urban sanitation can be designed to enhance inclusion rather than exacerbate inequalities, seeking to disrupt and challenge existing debates around equity and inclusion and present the provision of climate-resilient services as an opportunity to reassess ‘inclusion’ in WASH.

It examines existing gaps and barriers for inclusive WASH and key opportunities to integrate equity, accessibility, and sustainability into WASH systems, ensuring that resilience-building efforts proactively address the needs of all communities, particularly the most vulnerable. By embedding these principles, we can move towards a future where climate resilience and inclusion are fundamental to all WASH services, rather than the exception, making “climate-resilient inclusive WASH” just “WASH” - with all these factors as a default.

The paper has a particular focus on sanitation, a sector often left behind and marked by significant inclusion gaps. Global good practices on climate-resilient WASH according to GWP and UNICEF (2022a) include undertaking risk analyses to look at the potential impacts of climate risks, designing reliable and resilient services that can be accessed throughout the year in all seasons and weather events, and having management and service delivery models that can cope with crises and ensure the long-term sustainability of infrastructure.

Climate-resilient sanitation interventions which are inclusive and leave no one behind should be evidence-based through climate risk assessments, grounded in national policies and approaches relating to nationally determined contributions (NDCs), and be innovative (GWP and UNICEF, 2022a).

Summary: Background

- Global urbanisation and unregulated expansion expose vulnerable communities to a "triple burden" of poverty, climate hazards, and inadequate sanitation access
- The growing focus on climate-resilient WASH centres on services that maintain benefits despite climate hazards, requiring action in three areas: resilient infrastructure, building community resilience while reducing inequalities, and moving towards a low-carbon sector
- Despite a long history of focus on equity and social inclusion, this specific attention is largely missing in current climate-resilient WASH discussions, which risks reinforcing existing inequalities.
- This paper explores how climate-resilient urban sanitation can enhance inclusion, not exacerbate inequalities.

3. Understanding Inclusive WASH

Whilst debates around the inclusion of women in WASH have been ongoing for over four decades, the recognition of the human right to water and sanitation has catalysed an intense focus through research and programming on various user groups. The sanitation needs of people with disabilities (Jones and Reed, 2005), the challenges faced in meeting menstrual hygiene needs among adolescent girls (Sommer and Sahin, 2013), including girls with disabilities (Wilbur et al, 2022), the priorities of people living with incontinence (Rosato-Scott et al, 2020), the hidden needs of perimenopausal women (Bhakta et al, 2021), and issues faced by transgender and non-binary sanitation users (Robinson et al, 2025; Boyce et al, 2019), have shaped a significant proportion of the WASH sector's focus over the last two decades.

In an era in which the WASH sector increasingly turns attention towards tackling the challenges of climate change, and in a time of deep political uncertainty and a rollback of overseas development funding from high income countries, it is timely to revisit what is meant by 'inclusive WASH' more broadly, and the extent to which current definitions are fit for purpose today to deliver 'climate-resilient' inclusive WASH.

Grey literature searches on the internet using the term 'inclusive WASH' narrow the focus of inclusive WASH on disability, with the very first result referring to it as aiming "to promote the equitable access to water and sanitation facilities for disabled people". People who are unfamiliar with this extensive field of work are directly guided towards a course which is about 'inclusive WASH' in the title, but with a description under the search result that it is a course on disability-inclusive WASH.

Further results listed fairly high up also focus on 'inclusive WASH and disability', and including people with disabilities in humanitarian WASH programmes. Yet, for people unfamiliar with WASH, these definitions do not reflect the vast amount of work done on the inclusion of people other than those with disabilities in the context of climate change, which poses threats to what is currently considered 'inclusive' within the WASH sector. More recent debates on 'gender equality and social inclusion' (GESI) in WASH begin to dig deeper below the surface. According to Soriano et al (2024), 'inclusive WASH' is now considered as WASH that 'provides all people (regardless of their personal circumstances or identity) with their human right to safe WASH'.

The most recent interpretations of inclusive WASH recognise gaps and inequalities in the ways in which infrastructure is designed, accessed and used, particularly for those who face multiple and intersecting forms of discrimination and are least likely to benefit. These interpretations also emphasise the need to ensure flexibility, accessibility and adaptability of options to suit diverse needs and contexts, and an ability to respond to future needs and challenges (Soriano et al, 2024). Whilst this definition begins to recognise the need for climate adaptation as part of inclusive WASH, this paper takes a closer examination into what this may mean in practice, with particular emphasis on climate-resilient inclusive sanitation.

Looking more closely, 'climate-resilient inclusive sanitation' appears to be blighted by a myriad of contradictions. For instance, from the lens of 'disability inclusion', climate-resilient sanitation infrastructure may be difficult to make accessible. Climate change is significantly increasing the risk of flooding, which poses a significant threat to sanitation services (Charles et al., 2009; Takamatsu et al., 2014; Goore et al., 2015; Dzikus et al., 2021; Nijhawan and Howard, 2022). In response, raised toilets above the ground have been constructed in places such as Bangladesh (WaterAid, 2020) on stilts, ensuring that rising floodwater can pass underneath them. The raising of the toilet superstructure may be a solution to ensure the continued functioning of the sanitation technology itself, as it physically could reduce the risk from flooding.

But, at what cost?

Sanitation becomes 'climate-resilient' but raised toilets are no longer physically accessible for people with disabilities. It may be challenging for many to climb any ladders or steps to reach the latrine, and well-known features of accessible toilets such as level access at the entrance and ramps are no longer as viable, due to the increased risk of flooding. Evidence from research with people with disabilities in Bangladesh (Nawaz et al, 2026) demonstrates the negative impacts on their access to sanitation after experiencing cyclones exacerbated by climate change. This study identified that among the sample, who mostly had access to basic sanitation, people with disabilities had a 28% higher risk of storms and flooding damaging their sanitation facilities than people without disabilities, and particularly among those with lower

socioeconomic status. After cyclones and flooding, paths to sanitation facilities became inaccessible, leading people with disabilities to depend on others for support to reach them due to higher risks of falling and injuring themselves. People with disabilities resorted to using alternative facilities in neighbours' homes, or continued to use their own damaged facilities due to fear of humiliation or challenges with the distance to the toilet. Some participants had to resort to open defecation, which was more challenging for women with disabilities due to challenges of privacy. People with disabilities experiencing incontinence often soiled their clothes because they could not reach a toilet in the cyclone and defecated at home in their rooms (Nawaz et al, 2026).

Meanwhile, in Srinagar in the valleys of Kashmir, India, fishermen and farmers living in informal 'kaccha' dwellings around the Dal Lake have been exposed to increased flooding. With kaccha dwellings located on the lake itself, research has identified that children and people with disabilities face particular challenges with access to sanitation, as 'hanging' latrines which are built to cope with flooding are unsafe and inaccessible (Satvi, 2023). Therefore, the uncertainties of climate change pose direct threats to physical accessibility and inclusion in sanitation infrastructure.

The challenges of achieving both 'inclusive' and 'climate-resilient' infrastructure are also evident in housing. Architects of eco-housing in the UK have been identified as consciously prioritising 'ecological' features to minimise environmental impact, and thereafter incorporating accessible features for people with disabilities further down the process as an 'additional' aspect, rather than considering disability inclusion from inception. Features such as triple-glazed windows may improve energy efficiency and insulation, for example, but may be too challenging for people with disabilities to open and close (Bhakta and Pickerill, 2016).

Gaps in infrastructural design of urban sanitation services begin to illustrate where significant cracks remain in ensuring climate-resilient infrastructure is inclusive from other user perspectives. For instance, taking a gender lens, Bhakta et al (2024) highlight that the 'need of the hour' in India is the provision of water supply in shared urban toilets for menstruating women, girls and transgender people to wash themselves and ensure provision of and be able to wash and use reusable menstrual products as and when they need to in community and public toilets. Yet, with 50% of India's population expected to be living in cities by 2030 (TERI University, 2017), addressing the lack of water supply in shared urban toilets is of increasing concern.

In Mumbai's slums, 78% of community toilets have no access to water (Koppikar, 2017) despite the expansion of access to toilet facilities through the Swachh Bharat Mission. This challenge arises against a backdrop of India already living through the realities of climate change which lead to both water excess and scarcity, facing severe risks with increasingly unpredictable monsoon seasons in the timing and quantity of rainfall causing flooding, and temperatures exceeding 50°C (Chateau et al, 2023).

Urban water security to support sanitation in cities is critical at a time when rapid urbanisation in addition to climate change is depleting water resources (Kumar et al, 2024). 'Climate-resilient inclusive sanitation' therefore should meet individual needs in a context of uncertainties in a changing climate, whilst also recognising interconnections to other services such as water.

Exploring the need for water to meet menstrual hygiene needs in shared toilets (Bhakta et al, 2024) demonstrates how climate-resilient sanitation should build on integrating user needs as per existing concepts of 'inclusion' into urban sanitation planning moving forward, whilst being sensitive to the realities of climate stresses on the ground. Looking at the need for water security as part of climate-resilient sanitation also brings opportunities to address user groups who are all too often overlooked. Access to water in sanitation is key to keeping services such as public and community toilets open for those who need to use them frequently, such as people of all ages and genders who live with incontinence (Rosato-Scott et al, 2020).



Figure 1: A community toilet in Sinnar, Maharashtra (Photo © CWAS, CDRF, CEPT University)

Yet, debates around sanitation have moved far beyond service users, with attention now increasingly also turning to service providers and sanitation workers, one of the key stakeholders in climate-resilient sanitation.

However, for sanitation workers, who empty septic tanks, pit latrines, sewers and drains, clean toilets, sweep streets, and collect and dispose of solid waste, there remain many blind spots in ensuring their inclusion (Bhakta et al, 2022). Sanitation workers are among the most marginalised groups in society, where in contexts such as India, Pakistan and Bangladesh, sanitation labour is deeply intertwined with low caste and religion, and people of Dalit caste backgrounds (Cawood et al, 2025; Dubey and Murphy, 2021) and religious minorities such as Christians (Aqeel and Gill, 2021) dominate the occupation.

Evidence from Bhubaneswar and Cuttack in Odisha, India, has identified that women sanitation workers face significant challenges with access to housing, often living in informal settlements with poor access to sanitation, leading them to practise open defecation and manage menstrual health needs in the open, on the banks of rivers (Bhakta et al, 2026). These challenges at home can be a detriment to the health of sanitation workers, due to inadequate access to WASH at home which can lead to open defecation, greater exposure to risk of illness, which in turn prevents them from working, and increases their financial precarity further. Yet, equity and inclusion debates in WASH have by and large overlooked their rights to support measures widely delivered for sanitation service users, with a stark absence of evidence on, for instance, sanitation workers' menstrual health needs, disability support and childcare needs (Bhakta et al, 2022).

These gaps remain in spite of the fact that climate-resilient sanitation services cannot be achieved without sanitation workers, who need to be part of discussions and programming as the stakeholders at the heart of service delivery. Climate change also brings additional factors to consider for the inclusion of sanitation workers. As temperatures rise, outdoor workers will be exposed to additional heat stress (Elliot et al, 2020), yet there is a gap in evidence on the impacts this will have on the health of sanitation workers and their ability to fulfil their roles. 'Climate-resilient inclusive sanitation' services therefore need to ensure that sanitation worker health, safety, wellbeing and inclusion (as per existing inclusion frameworks for users) remain core to programming. Moving forward, issues such as menstrual health and disability which dominate inclusion debates for sanitation users, need to be given equal priority for sanitation workers (Bhakta et al, 2022).



Figure 2: Desludging truck used by women sanitation workers at a faecal sludge treatment plant in Cuttack, India (Photo © Amita Bhakta)

The upgrade of WASH systems to be climate-resilient can also pose a significant challenge to their affordability by the user. The costs of implementing flood-resistant infrastructure can lead to higher service charges, disproportionately impacting low-income communities, and exacerbating existing inequalities if no measures are taken to ensure equitable access to climate-resilient services, such as targeted subsidies, progressive tariff structures, or financial support mechanisms.

For example, in Jakarta (Prana et al, 2024), rising costs of flood-resilient sanitation have made access difficult for informal settlements. Similarly, in Cape Town (Brühl and Visser, 2021) water tariff increases following the Day Zero crisis placed a heavy burden on lower-income households. Without targeted subsidies, progressive tariff structures, or financial support mechanisms, the transition to climate-resilient WASH risks deepening existing inequalities rather than addressing them.

Current inclusion gaps in delivering climate-resilient infrastructures
Different physical abilities are not always considered in the design of climate-resilient WASH infrastructure.
Users' diverse needs, behaviours, and practices (e.g., gender, age, culture) are not always acknowledged in planning and implementation.
Efforts focus on users while overlooking marginalized service providers, who often work in unsafe conditions exacerbated by climate change impacts.
Lack of equitable access due to the affordability challenges of climate-resilient WASH systems.

Table 1: Inclusion gaps in delivering climate-resilient WASH

Summary: Understanding inclusive WASH

- Inclusive WASH has largely focused on user groups, and requires redefinition to include service providers such as sanitation workers and their needs, and facilitate climate-resilient inclusive WASH
- Inclusive WASH should recognise gaps and inequalities in infrastructure design, access and use, taking intersectional approaches to understand exclusion
- Flexibility, accessibility and adaptability of options to suit diverse needs and contexts, and an ability to respond to future needs and challenges are key to climate-resilient inclusive WASH
- The uncertainties of climate change in a world of cuts to international development aid pose a direct threat to existing ‘inclusive WASH’ solutions
- Climate-resilient inclusive sanitation should meet individual needs such as menstrual hygiene and incontinence through placing emphasis on interconnections to other services such as water supply, and paying attention to the need for water security in urban settings
- Climate resilient inclusive sanitation needs to: consider different physical abilities, diverse user needs, behaviours and practices, focus on the needs of sanitation workers who are exposed to unsafe working conditions exacerbated by climate change, and address affordability challenges for equitable access

4. Understanding the linkages between climate change and sanitation

In 2024, an alarming 3.5 billion people lacked access to safely managed sanitation, while 2 billion lacked even basic hygiene services (WHO and UNICEF, 2025). Despite these urgent needs, sanitation remains one of the most overlooked sectors in climate discussions.

While industries such as water, transport, and agriculture have made significant strides in understanding and addressing climate change, the sanitation sector lags behind. This is particularly concerning given the profound impact sanitation has on both climate change and human health. Yet, there is still a limited focus on how climate change affects sanitation systems.

As climate change threatens progress toward universal sanitation access, cities and countries have yet to sufficiently adapt their policies and planning to address its consequences. Efforts to mitigate sanitation's own contributions to climate change, through direct emissions of methane, carbon dioxide and nitrous oxide as part of the biological decomposition of human faeces, and indirect emissions through carbon dioxide produced through the burning of fossil fuels for the operation of the sanitation service chain (Johnson et al, 2022) are equally lacking.

Globally, only 9% of Nationally Determined Contribution (NDC) activities relate to Sustainable Development Goal (SDG) 6, with most of these efforts focused on water management. By mid-2020, a mere 2% of NDCs included commitments to sanitation access, and only 3% addressed wastewater management (Dickin et al, 2020). Without urgent action, the sanitation sector will continue to fall behind, jeopardizing not only public health but also efforts to combat climate change on a global scale.

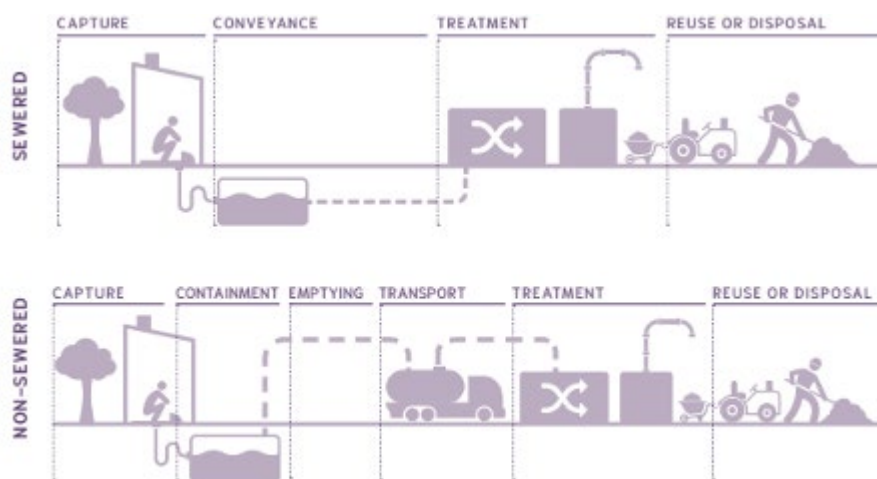


Figure 3: Sanitation chain (for sewer and non-sewered systems)

4.1 How climate change impacts sanitation

Climate change can damage sanitation infrastructure and disrupt services, leading to public health and environmental risks. Every element of the sanitation service chain can be negatively affected, from the usability of toilets to the capacity of treatment plants to treat wastewater or sludge. Both non-sewered and sewer systems are affected. The issues caused vary depending on which element of the sanitation chain is affected. Failures caused by climate change can range from pits overflowing because of rising groundwater levels or groundwater flooding, to corrosion of sewer systems.

In addition, sanitation systems can fail not only because of the direct effects of climate change on sanitation infrastructure, but also because they rely on people to operate services. For example, heat stress can affect operators' ability to work, causing disruption to sanitation services. It is also important to recognise sanitation systems' reliance on other systems, and how failures in those systems can disrupt sanitation services. For example, disruption to power supplies caused by cyclones can affect wastewater conveyance if pumps are unable to operate, as well as affecting treatment processes. Damage to roads can prevent faecal

sludge management services from accessing pit latrines when flooding occurs. This dependence and interdependence is an important consideration that is often lacking.

The different ways climate change can impact sanitation are summarised in Table 1 Table 2.

Flooding and increased precipitation	Public health risk of faecal matter from flooded pits, septic tanks and damaged wastewater treatment plants
Water shortages	Restricted functionality of water-based sanitation Corroded piped sewers Higher concentration of pollution in wastewater, reduced capacity of receiving waterbodies to dilute discharged wastewater
Sea level rise	Treatment plants in low lying or coastal areas subject to inundation, flooding, storm surge, erosion and saltwater intrusion, making treatment less effective
Higher temperatures	Can accelerate wastewater treatment, but can also corrode sewers and lead to increased evaporation/fermentation in faecal sludge treatment, creating bad odours and affecting performance Heat stress for sanitation workers, leaving them unable to work
Intense and frequent cyclones and storms	Damage to latrine superstructures, pipes, treatment plants, power supply

Table 2: Impacts of climate change on sanitation (adapted from Hyde-Smith et al, 2022)

4.2 How sanitation impacts climate change

The sanitation service chain contributes to GHG emissions with direct and indirect emissions (Table 3). Direct emissions are caused by direct emission from sewers, biological wastewater and faecal sludge treatment processes, and untreated or poorly treated wastewater and faecal sludge. Additionally, indirect emissions are caused by energy use in wastewater and faecal sludge processes and activities related with wastewater and faecal sludge transport e.g. pumping (GIZ, 2020).

Estimates of the impact of the sanitation sector on greenhouse gas emissions vary, from 50% of a city's total emissions in Kampala, to global estimates of degradation of organic matter during wastewater treatment contributing to ~1.57% of global GHG emissions and 5% of global non-carbon dioxide greenhouse-gas emissions (Johnson et al, 2022). Meanwhile in India, 4% of direct emissions were estimated to come from waste, with domestic wastewater comprising over half (55.7%) of direct waste emissions, alongside industrial wastewater (32.8%) and solid waste disposal (11.6%) in 2018, and indirect emissions coming from electricity consumption by India's WASH services (Jaiswal and Patil, 2024).

Direct emissions will always be produced but they can be reduced with adequate approaches, such as, for example, adequate wastewater and faecal sludge management through wastewater collection and treatment coverage, and formalised faecal sludge management for decentralised sanitation in informal settlements.

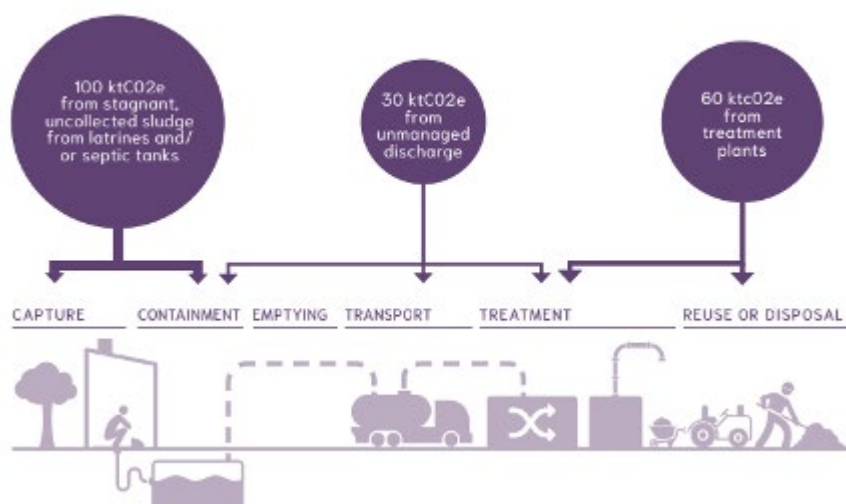


Figure 4: Emissions from the sanitation system in Kampala, to understand the key emissions areas (Johnson et al, 2022).

Direct emissions from the sanitation chain (via the decomposition of human faeces)	1. Methane 2. Carbon dioxide 3. Nitrous oxide
Indirect emissions from the sanitation chain (via operations)	1. Carbon dioxide

Table 3: Impacts of the sanitation chain on climate change (Adapted from Johnson et al, 2022)

Summary: Understanding climate resilient sanitation

- The sanitation sector lags behind in addressing issues relating to climate change, which in turn threatens progress made towards universal access to sanitation services.
- Climate change impacts both sewerage and non-sewerage sanitation systems, particularly through increased precipitation and flooding, water shortages, sea level rise, higher temperatures, and increased and frequent cyclones and storms.
- The issues created depend on the type of climate related impact, which component of the sanitation chain is affected, and the impact of climate change on key aspects needed for sanitation systems to operate, from the infrastructure through to the workers who maintain it.
- Sanitation systems also impact climate change through direct (sewers, biological wastewater and faecal sludge treatment processes, and untreated or poorly treated wastewater and faecal sludge) and indirect (energy use in wastewater and faecal sludge processes and activities related with wastewater and faecal sludge transport) greenhouse gas emissions

5. Opportunities to enhance inclusion through climate-resilient sanitation

Recent publications define climate-resilient sanitation as sanitation systems (both non-sewered and sewer), services and behaviours which can survive, function or quickly recover in the face of a range of climate-related shocks, chronic stresses and seasonal variabilities, ensuring that faecal matter is safely contained throughout the sanitation service chain and does not contaminate the environment, emit excessive GHGs or cause risk to public health (GWP and UNICEF, 2022).

This section explores the definition of climate-resilient sanitation through an inclusive lens, demonstrating how, even without explicitly addressing inclusion, it presents opportunities to enhance it, although it can also exacerbate inequalities if it is not done adequately. To illustrate this, we analyse insights from a recent study by Arup and WSUP for the World Bank, which examined efforts from cities worldwide to develop climate-resilient sanitation systems (World Bank, 2025). The study identified key approaches that strengthen resilience, and, from our perspective, also create opportunities to enhance inclusion in sanitation solutions.

The definition rightly refers to both types of sanitation systems, sewer and non-sewer systems, which is a good first step towards inclusion as non-sewer systems exist predominantly in low-income countries and informal contexts often left behind but usually most at risk of climate change impacts. Therefore, the aim to achieve climate-resilient sanitation brings a new focus to improve the sanitation systems and services (at times, even non-existent) in low-income neighbourhoods and informal settlements, moving away from just traditional sewer systems and looking for solutions that work in different contexts.

5.1 Opportunity to increase focus on marginalised communities enhancing universal access to sanitation

Marginalised communities tend to be more affected by climate change impacts because they often live in informal settlements in disaster-prone areas, such as flood plains, where they lack adequate water and sanitation infrastructure. The lack of climate-resilient services in these areas, which are heavily and repeatedly affected by climate change, poses significant risks to public health and the environment, urging key stakeholders to act and rethink adequately contextualised solutions for these often-forgotten communities. The need to prevent climate change impacts on public health and the environment can therefore help drive universal access to WASH services. Drawing attention to these communities also creates an opportunity to overhaul and redefine 'inclusion', so that it is decolonised and more relevant to Global South contexts, focusing on their priorities first and expanding existing understandings of inclusion.

We have seen positive efforts to serve these communities by the City of Cape Town. In their journey to avoid Day Zero and implement strategies to address water scarcity and flooding, the city restructured their Water and Sanitation department to become a customer-oriented and financially stable utility. As part of these changes, the Department created an Informal Settlement Basic Services branch recognising the complexity of providing services to these parts of the city, and the need of exploring less traditional approaches to serve them (World Bank, 2025).

5.2 Opportunity to develop solutions that could work in different contexts

The need for climate-resilient services requires stakeholders to move away from traditional approaches, commonly sewer systems, and explore a wider range of solutions, providing users with different sanitation options that are not only resilient but also adaptable to different contexts.

In the case of Cape Town, the new branch identified the informal settlements at risks of flooding and prioritised the use of resilient toilets. In these areas, where connection to the sewer system is not possible, they are providing alternative solutions to full flush toilets. The city provides three options of non-sewered sanitation: chemical toilets, container toilets and portable flush toilets. These toilets are above ground, sealable and regularly emptied, making them less vulnerable to flooding, and also less reliant on water availability. Chemical and container-based toilets were provided as communal toilets, whilst portable flush

toilets were installed in individual households and proved to be particularly useful for areas where residents were not feeling safe using shared facilities at night (Green Cape, 2021).

The use of container-based sanitation as a resilient solution to cover the lack of services in informal communities and low-income areas has been extensively seen in Nairobi, Kenya, with organisations like Fresh Life and Sanergy providing these services. The model used for these services incorporates the reuse of products for the agriculture and energy sector. Fresh Life and Sanergy collaborated with the national government to incorporate container-based sanitation into the Kenya Environmental Sanitation and Hygiene Policy, as it was recognised as a safe and cost-effective alternative to sewers and other on-site sanitation systems.



Figure 5: "Unplanned settlement in Cape Town (Kialitsha) (2937830300)" by SuSanA Secretariat is licensed under CC BY 2.0.

5.3 Opportunity to professionalise services improving workers' conditions and public perception

The definition of climate-resilient sanitation takes a holistic approach, emphasizing the entire sanitation chain, from safe containment to disposal and treatment, while specifically highlighting the resilience of services. This reflects the WASH sector's evolution from a narrow focus on toilets to an integrated approach where wastewater treatment and faecal sludge management are essential for sustainable sanitation systems that mitigate public health and environmental risks.

Climate-resilient sanitation needs to cover non-sewered sanitation, through the whole sanitation chain, from on-site sanitation to safe treatment and disposal or reuse of faecal sludge. The role of sanitation workers who provide emptying, collection and transportation services of sludge into treatment is key to completing the sanitation chain. But these workers are often marginalised and at times work under unsafe and unregulated conditions. Recognising their essential role presents an opportunity for city stakeholders to support the professionalisation of their services, improve their working conditions and change their marginalised status in the community. Lessons for the professionalisation of sanitation labour can be taken

for example from the Garima Scheme in Odisha, which has supported 9213 sanitation workers including sewer and septic tank cleaners, toilet cleaners, and faecal sludge treatment plant and sewage treatment plant operators to access personal protective equipment, formal identification, improved wages, welfare entitlements and health insurance (HUDD and UMC, 2025).



Figure 6: Women engaged in septic tank cleaning with access to adequate support through the professionalisation of the occupation under the Garima Scheme in Odisha, India (Photo: Jhunulata Naik)

The need to consider the whole sanitation system brings an opportunity to remove the focus purely on the user to a much wider approach where the wellbeing of the workers who are critical to delivering these services is considered to achieve resilience in sanitation systems. For example, we have seen in Table 2 how the resilience of a sanitation system can be affected in extreme heat weather due to the lack of sanitation workers who are unavailable to perform due to heat stress.

This could prompt measures to enhance the wellbeing of sanitation workers and improve their working conditions, which, as seen in previous sections, are often unsafe. It is important that the potential increase in the demand for sanitation services and workers is properly regulated and professionalised to avoid creating more risks in a sector already unsafe and marginalised in many contexts.

We can see an example where faecal sludge management services have gained relevance in Lusaka, where the Lusaka Water and Sanitation Company has integrated on-site sanitation and faecal sludge management into their business, which allows them to cover most peri-urban areas in the city that were relying on-site sanitation. The company established a Faecal Sludge Management unit to work with the private sector to manage faecal sludge. They also worked on improving on-site sanitation toilets to decrease the impact of flooding on them, with measures such as raising toilets above ground and designs that allow easier emptying operations. In Wai and Sinnar in Maharashtra, India (Mehta et al, 2019), the local governments introduced scheduled desludging as a municipal service for all residential and non-residential services and for all properties and across all income brackets.

These services were made possible through the construction of faecal sludge treatment plants and a public private partnership (PPP) arrangement. The PPP involved the provision of desludging services over a three-year cycle, with the city area divided into three zones, and each zone is covered in a year. The payment is

made to the private desludging service provider by the local government according to performance, the revenue for which is generated through a “sanitation tax” for each property tax bill in Wai and Sinnar. This was supplemented by a performance-based contract which released payments according to the number of septic tanks that were emptied and safe discharge at the treatment sites. The contract aimed to meet the interests of all parties, including citizens, city government, and the private sector, and helped the private sector providers to get a fixed source of income, whilst residents received good quality and regular desludging services (Mehta et al, 2019).



Figure 7: Scheduled Desludging in Wai, Maharashtra, India. (Photo © CWAS, CEPT University)

5.4 Opportunity to design climate-resilient initiatives to address everyone's needs

This definition extends beyond systems and services to acknowledge the importance of behaviours. These behaviours must either persist or be quickly restored in the face of disruption. However, to achieve truly resilient systems, we must recognise that sanitation users have diverse needs that drive different behaviours and practices.

For example, when emergency community toilets are installed after an extreme weather event, they must be designed with several factors in mind. This includes ensuring water availability for menstrual hygiene and choosing locations that feel safe for women and children. Furthermore, facilities should be convenient for those with reduced mobility, provide enough space for individuals requiring assistance, and be oriented to respect cultural beliefs.

If we return to Cape Town and its container-based toilets, we can see that, despite the positive progress made, the original designs were not adequate for all users, and not all service providers were meeting the required standards (Green Cape, 2021). A later assessment showed that, although these toilets were accepted overall, users were not fully satisfied because the designs did not meet their needs or adapt to everyone's circumstances. The toilets were imported from Europe and did not seem robust enough to accommodate heavier people. There was also only one type of design, with no adaptation options for different users such as children.

The assessment also highlighted differences in standards among the service providers responsible for managing communal toilets and emptying portable toilets, and the need for easier and more accessible reporting channels for communities to report service issues. To address these issues, the city is now

considering other toilet models for deployment and standards for service providers to follow. Such measures can help maintain service quality across suppliers and service providers while also fostering user confidence in the new services and encouraging adoption of the new toilet models. Although residents were engaged to understand how sanitation infrastructure and services could be improved, this example highlights the need to engage communities earlier in the process through a comprehensive intersectional approach to inclusion. While inclusion was considered, it was not implemented to its fullest extent.

5.5 Opportunity for new markets and job creation

The need to adapt sanitation services to climate change impacts can boost existing markets, as we have seen with container-based sanitation solutions or FSM services, and also drive the development of new markets. In water-scarce contexts, an increasing number of cities are exploring wastewater reuse for potable and non-potable uses. In Cape Town, thirteen of the city's seventeen treatment plants generate treated effluent that is sold for irrigation and industrial use. Additionally, the City of Cape Town is testing wastewater reuse for potable water through a 10-million-litre wastewater purification plant. In Chennai, not only are they reusing treated wastewater, but also they have established a market for energy recovery through biogas generation. There is also a growing market for materials recovery and sludge-based products (World Bank, 2025).

The development of new markets presents an opportunity for inclusive job creation, offering employment to diverse communities. However, there is also a risk that these markets and jobs may exclude vulnerable groups, reinforcing existing inequalities. To ensure equitable growth, policies and business models must be designed to prioritise accessibility, fair wages, and representation for marginalised populations.

As we can see, to achieve climate-resilient sanitation, default use of intersectional inclusion lenses needs to be applied to avoid the risk of failing to serve everyone and exacerbate existing inequalities. Climate-resilient sanitation does not mean a completely new approach to sanitation. It should take into account existing sanitation best practices and incorporate climate resilience, and that includes inclusive best practices. The issue is that in a sector where inclusive WASH is not fully understood and mainstreamed yet (as shown in the previous section), moving to the concept of climate-resilient WASH or more specifically sanitation without intentionally incorporating inclusion may mean that it may be forgotten.

Current inclusion gaps approaching climate-resilient infrastructures	Opportunities brought by climate-resilient sanitation
Different physical abilities are not considered in the design of climate-resilient water supply and sanitation infrastructure.	Increase focus on marginalised communities enhancing universal access to sanitation
Users' diverse needs, behaviours, and practices (e.g., gender, age, culture) are not acknowledged in planning and implementation.	Design climate-resilient initiatives to address everyone's needs.
Efforts focus on users while overlooking marginalised service providers, who often work in unsafe conditions exacerbated by climate change impacts.	Professionalise services improving workers' conditions and public perception
Lack of equitable access due to the affordability challenges of climate-resilient WASH systems.	Establish affordable services for all Enhance job creation for climate resilient WASH services within vulnerable communities

Table 4: Gaps in and opportunities for realising inclusion in climate-resilient sanitation

Summary: Opportunities to enhance inclusion through climate resilient sanitation

- There is scope to increase focus on communities who are too often left behind, and are most exposed to the risks of climate change, by taking an intersectional lens. In turn, this can drive a momentum towards contextualised solutions for forgotten communities, and propel progress on universal access to WASH to address public health concerns.
- Climate resilient inclusive sanitation can drive innovation in context-specific solutions that are sensitive to the needs of different users and service providers.
- Taking an holistic approach when focusing on climate-resilient inclusive sanitation has the potential to help to further professionalise the sanitation sector, by improving workers' working and living conditions and public opinion of sanitation workers, regulating the sector so that their health and wellbeing is prioritised. Improving the working conditions of sanitation workers is critical to ensuring the long-term sustainability of sanitation services in a changing climate, through measures such as breathable PPE, improved wages, formal identification, support to access welfare, and health insurance.
- Opportunities lie in the potential to deliver solutions to sanitation in a changing climate that meet everyone's needs, from service providers to different users, drawing on lessons from different models to ensure sustainable, good quality, accessible and inclusive services, embedded in placing community needs at the centre.
- Existing markets can be boosted, and job opportunities can be created through climate-resilient inclusive sanitation services through the expansion of innovations such as container-based solutions. Models which facilitate the inclusion of the most marginalised populations are key.

6. General best practices for inclusive climate-resilient WASH

There are multiple frameworks for inclusion that can be followed to ensure climate-resilient sanitation is implemented inclusively. UNOPS' recent guidelines for developing inclusive water, sanitation, and hygiene infrastructure (2024) characterise inclusive WASH infrastructure by five guiding principles (Table 5) that, in theory, can support the inclusion gaps highlighted in this paper.

Those principles are: equitable, accessible, affordable, do-no-harm and empowering.

Equitable	Provides fair and just access to WASH services that can address the diverse WASH needs of women and marginalized groups
Accessible	Provides user-centric solutions for diverse users to have access to WASH services in an easy, safe and dignified manner, without risk of accident or violence
Affordable	Increases opportunities for people of different economic means to access good quality, sustainable and resilient WASH services
Do-no-harm	Reduces the exposure of people and the environment to negative social, economic or physical impacts resulting from WASH infrastructure development
Empowering	Increases a person's ability to successfully exercise agency, make informed decisions and act on issues in their community through improved WASH

Table 5: Inclusive WASH principles (UNOPS, 2024)

To achieve this, the guidelines highlight four approaches to overcome implementation challenges:

Strengthen the enabling environment across the entire life cycle: Creating an environment that supports inclusive WASH infrastructure requires strong policy frameworks, legislation, and institutional capacity. Policymakers, regulators, and civil society organizations are central to this effort.

Prioritise inclusive solutions during the planning stage: Inclusivity must be embedded early, during design and investment decisions. This requires cross-sector collaboration, feasibility studies, and participatory planning.

Deliver inclusive solutions well during the delivery stage: At the construction and implementation phase, inclusive infrastructure is realized through standards and codes that guide transparency, equity, and quality delivery.

Maximise existing systems performance during the management stage: Once built, WASH systems need to be maintained and improved to ensure inclusive services over the long-term. Capacity-building for service providers and ongoing investment are crucial (UNOPS, 2024).

These four approaches highlight the need to design and deliver inclusive, climate-resilient WASH holistically. This goes beyond just engineering the correct infrastructure. It requires a focus on service performance and the user needs and experience. Success must be sustained through timely early participatory planning, robust policy and regulation, and active stakeholder participation and capacity building. These elements are essential before, during, and after implementation to ensure long-term resilience.

Other studies also agree with UNOPS' approach, emphasising the importance of inclusive planning and participatory process to ensure actions delivered are long-term sustainable and will not exacerbate existing inequalities (C40 Cities and World Resources Institute, 2019; SNV et al, 2025).

The C40 Inclusive Planning Executive Guide (C40 Cities and World Resources Institute, 2019) provides guidance for cities to plan for inclusive climate actions, acknowledging that simultaneously addressing a climate change impact and growing inequalities needs careful planning. The guidelines include steps for designing and implementing fair and inclusive climate policies.

One of the key recommendations is for cities to do an Action Analysis, following the initial needs assessment. The goal of this analysis is to assess who benefits from the intervention and who may not, given existing inequalities. It looks at the benefits of the intervention in the domains of access and availability; prosperity and affordability; and spatial inclusion and place.

Research by Water for Women and UTS-ISF regarding the WASH-GEM (the Water, Sanitation and Hygiene-Gender Equality Measure) (MacArthur et al, 2024) not only highlights the importance of the holistic approach but goes beyond it, stating that the social process of community involvement and participation is a driver for empowerment and can shift power dynamics and social structures.

This research suggests there is a direct correlation between active involvement in WASH activities, such as planning committees and behaviour change campaigns, and higher individual scores for equality and climate resilience. Inclusive sanitation can create ripple effects beyond the sector, such as increased self-efficacy and improved household decision-making power for the most marginalised. However, as previously mentioned, it is important that the process is explicitly intersectional. Evidence from Nepal (Gonzalez et al, 2022) shows that empowerment gains can be uneven; for instance, men may report lower self-efficacy than women in the same community, highlighting the need for inclusive processes that address caste, disability, and gender simultaneously.

To illustrate the practical application of these holistic frameworks, we can apply the four UNOPS approaches to a fictional but representative case study. This exercise demonstrates a few representative actions required to bridge the gap between high-level inclusion principles and on-the-ground implementation.

Imagine an informal settlement in a low-income South Asian city.

The community currently lacks formal sanitation infrastructure and faces regular seasonal flooding, which poses a severe public health risk. To address this, the municipality is planning to establish flood-resilient, non-sewered sanitation systems for the residents.

Strengthen the enabling environment across the entire life cycle

At this stage, the city needs to build knowledge and understanding of the community's needs and develop an adequate institutional and legislative framework that enables action while prioritising the most marginalised.

The municipality should start by accessing disaggregated data based on age, gender, disability, as well as context specific markers of identity such as caste and religion to better understand the community context and unique social fabric.

It should conduct participatory consultation to identify different users' needs, particularly women and marginalised groups, across the sanitation chain from sanitation workers to other users who are more visible in the community, to understand key priorities that may not currently be addressed under existing equity and inclusion approaches.

When mapping key stakeholders for the project and establishing the engagement mechanism with them, it should make sure that women and marginalised groups are represented across the different organisations and that engagement is done in ways that everyone is allowed to participate, for example, at times where women do not have to take care of their household responsibilities, or when sanitation workers in South Asia who are often denied access to rights to their own toilets and housing on the basis of their caste are at home and able to discuss. Further, this means a greater focus is needed to reach the 'last mile' and focus

efforts on settlements where it may be harder to perform desludging with a truck, but where those who are most marginalised live and are at higher risk of exposure to the negative impacts of climate change.

The municipality may establish a legal framework that allows for public investment of non-permanent yet flood-resilient infrastructure in the informal settlement, ensuring that residents without formal land tenure are not excluded from essential services.

Community-wide awareness campaigns should also be launched to foster a sense of ownership in the new systems. By clearly communicating the health and dignity benefits, the project moves from being an external intervention to a community-led asset.

Prioritise inclusive solutions during the planning stage

When looking at the solutions for non-sewered toilets, different physical abilities need to be considered, as well as behaviours and practices. For example, raised toilets may not be the only option applied as people with reduced mobility may not be able to use them.

Community toilets could be explored, but checks should be made with women and girls to ensure they feel safe using them at night, and that key needs for water are met to support menstrual health needs, if not through piped supply, then through availability in buckets. The solutions prioritised should be those that reduce exclusion but are in line with the particular vulnerabilities certain groups face as a result of climate change.

Not only should users be accounted for when prioritising certain solutions; the health, dignity and wellbeing of workers should also be considered. For example, they should look at the design of the toilets and assess if the emptying operations would be safe and minimise the exposure of the worker to faecal matter. Solutions developed through co-design with all the stakeholders involved, and encouraging the participation of women and other marginalised groups, would be better.

Deliver inclusive solutions well during the delivery stage

Once a suitable climate-resilient and inclusive sanitation solution has been defined, delivery must be accountable and transparent to ensure the designs are accurately translated into reality.

Urban authorities should define codes, standards and guidelines to hold suppliers and contractors accountable for building toilets to agreed standards that guarantee a dignified level of service. To protect the community during this phase, procurement contracts should mandate strict social and environmental safeguards to prevent sexual abuse, harassment, exploitation, child labour and unfair labour practices.

Furthermore, if local contractors are not familiar with climate-resilient inclusive features, the municipality should provide capacity building and technical training before construction starts.

To ensure localised economic benefits, delivery should prioritise local materials, suppliers and workers so that economic benefits remain within the affected community. Measures should also be taken to ensure that any jobs or markets created through the construction of new toilets, formalised pit-emptying services or sludge-reuse enterprises are open to everyone, preventing dominant groups from monopolising new revenue streams and ensuring that market creation actively reduces, rather than reinforces, existing inequalities.

Professionalise inclusive sanitation services

Once the infrastructure is built, the professionalisation of inclusive sanitation services must be at the heart of managing and delivering climate-resilient sanitation. Too often, the individual needs of sanitation workers can get missed for a myriad of reasons.

Whilst the provision of PPE, breathable uniforms and machinery for cleaning makes a start, a fundamental challenge is a lack of formal identification for the workers in the first place. For instance, in India, sanitation workers are from low castes, tied into the occupation their parents and generations did due to discrimination, and denied access to formal national identity cards such as Aadhar cards on the basis of who they are and what they do.

Professionalising the service would pave the way to giving the workers more dignity, help to find routes to amplify the challenges they face and revolutionise the way in which inclusion is viewed within the sector. A

significant level of effort is needed to engage the already significant number of people in the WASH sector working on inclusion, to work with those who provide sanitation services as much as those who use them. This would help to find routes to address wider challenges faced by sanitation workers that remain too overlooked, such as access to housing through improved livelihoods which is less exposed to the risks that climate change brings with it.

6.1 Maximise existing systems performance during the management stage

Once the new toilets and services have been implemented, ensuring there is adequate local capacity to operate and maintain the system to the required quality is key to sustain long-term resilience. Robust monitoring and evaluation systems must be established, as well as accessible and confidential ways of collecting and addressing feedback and complaints, particularly from women and other marginalised groups.

Sustaining this over time requires continuous capacity building in inclusive and climate-resilient maintenance practices for both the service providers and the local community. To institutionalise this, establishing officially recognised community management committees run in partnership with local government, with mandated, diverse representation from women, elders, youth, and people with disabilities, represents an essential best practice for equitable oversight.

This management structure must be equipped with climate-adaptive operational protocols, such as ring-fenced emergency repair funds and rapid-response cleaning plans. This ensures that when seasonal flooding disrupts the system, services can be safely and quickly restored, preventing vulnerable residents from being forced back into unsafe practices. In turn, the health, dignity, and safety of the community can be preserved through every climate shock.

Realising climate-resilient inclusive sanitation in expanding cities across the world requires an array of practical actions to turn opportunities into action, and to address the gaps identified earlier in this paper.

7. From opportunities to action: applying best practices to address gaps

Realising climate-resilient inclusive sanitation in expanding cities across the world requires an array of practical actions to turn opportunities into action, and to address the gaps identified earlier in this paper.

In this section, we explore how we can apply existing best practices to ensuring climate-resilient urban sanitation can be 'inclusive'. Expanding access to inclusive sanitation that is resilient to the shocks that climate risks bring requires practical actions to engage and coordinate with different stakeholders in urban areas. Table 6 outlines the actions and recommendations to address gaps in delivering climate-resilient urban sanitation for all, through the application of best practices.

Current inclusion gaps approaching climate-resilient infrastructures	Opportunities to address current gaps through climate-resilient sanitation	Actions and Recommendations
Different physical abilities are not considered in the design of climate-resilient WASH infrastructure.	Increase focus on marginalised communities enhancing universal access to sanitation Design climate-resilient initiatives to address everyone's needs	Engage with people across all genders with different disabilities in marginalised communities in climate hazard prone areas through participatory methods to identify priorities for sanitation access and accessibility in the context of physical needs and vulnerabilities faced due to climate change. Methods may include participatory techniques (e.g. PhotoVoice, drawing, mapping, ranking exercises) as well as standard techniques such as surveys and interviews, which should be conducted in physically accessible locations and with accessibility measures such as sign language interpreters as needed Facilitate routes to innovative sanitation technologies through co-design processes in different contexts that are driven by and embedded within local contexts, involving: People with disabilities exposed to climate hazards Sanitation experts Inclusive design experts Climate change experts Behavioural experts
Users' diverse needs, behaviours, and practices (e.g., gender, age, culture) are not acknowledged in planning and implementation.	Increase focus on marginalised communities enhancing universal access to sanitation Design climate-resilient Initiatives to address everyone's needs	Use participatory approaches to engage with marginalised communities to understand what matters most within sanitation requirements and between sanitation and other priorities in urban contexts, to create targeted solutions that work for all in a changing climate Create evidence-based norms and urban planning guidance for climate-resilient inclusive sanitation which cater for diverse user needs, behaviours and practices across urban contexts, and factor in climate hazards and vulnerabilities that are specific to different geographies Integrate existing learnings on the infrastructural sanitation needs of particular groups that have already been established (e.g. people who menstruate, perimenopausal women, people with disabilities) where appropriate in climate resilient urban sanitation planning, design, and construction. Conduct institutional mapping to identify the key actors and organisations that should be involved in implementing norms for climate resilient inclusive sanitation Implement accessible and confidential mechanisms for collecting and addressing feedback and complaints, particularly from women and marginalised groups. Integrate subjective metrics (such as perceived mental stress, fear of violence, and loss of dignity during climate shocks) into formal WASH monitoring frameworks, moving beyond binary metrics of functional/non-functional infrastructure. Formalize community oversight through community committees with mandated, diverse representation (including women, older people, youth, and people with disabilities) to oversee service quality and equity

Current inclusion gaps approaching climate-resilient infrastructures	Opportunities to address current gaps through climate-resilient sanitation	Actions and Recommendations
		Build capacity in the sanitation sector on best practices to ensure inclusion in sanitation services in the context of climate change
Efforts focus on users while overlooking marginalised service providers, who often work in unsafe conditions exacerbated by climate change impacts.	Professionalise services improving workers' conditions and public perception	Engage with sanitation workers from the outset of any programme on climate resilient inclusive sanitation at the same time as sanitation users, recognising them as equal stakeholders Highlight and promote the working conditions of different types of sanitation workers (e.g. sewer line workers, septic tank cleaners, toilet cleaners etc.) who are exposed to the impacts of climate change through their work. Gather evidence of the experiences of a variety of types of sanitation workers across different job roles, genders, ages, and in contexts facing different climate hazards (e.g. flood, drought, extreme heat) Professionalise sanitation work through provision of government-recognised identity documents, access to breathable and climate-friendly PPE, improved wages, access to welfare entitlements, and health insurance Integrate actions to mitigate the impacts of climate change on sanitation workers into climate and sanitation action plans at a national and municipal level according to context
Lack of equitable access due to the affordability challenges of climate-resilient WASH systems.	Establish affordable services for all Enhance job creation within vulnerable communities	Disseminate the Bhakta definition of 'climate resilient inclusive WASH' widely to align all parties around common understanding Position inclusive sanitation services as a critical adaptive measure to combat climate change and supporting vulnerable groups, to encourage financing of climate-resilient solutions that can be scaled up through climate financing, public-private partnerships, community-based funding initiatives, and data-driven storytelling for private sector investors. Proactively target vulnerable groups in the recruitment of workers to support the delivery of sanitation services in climate-hazard prone areas. To do this, provide training to municipalities on inclusive practices and diverse recruitment, and encourage recruitment drives to target the most vulnerable segments of society who are least likely to afford sanitation services. Create protocols that include ring-fenced emergency repair funds and rapid-response cleaning plans designed to equitably restore services by prioritizing the specific needs of women, people with disabilities, and marginalized groups, ensuring they are not forced back into unsafe practices during recovery after climate shocks like seasonal flooding. Structure sanitation-derived circular economy markets so that a percentage of profits is legally directed back into a community fund to subsidise household-level sanitation tariffs for the lowest-income bracket

Table 6: Applying best practices for inclusion in climate-resilient urban sanitation

8. Conclusions

8.1 Overview

We now live in an increasingly uncertain world. As we face the unpredictable challenges that climate change brings to the cities in which we live, we do so in an era shaped by political uncertainty, defined by limited funding for international development, and a narrative of inclusion being examined for its global relevance. At the same time, the most marginalised communities in expanding cities across low- and middle-income countries, who are often the most exposed to the impacts of climate change, continue to face the long-standing challenges in access to sanitation, which remain to be addressed.

As we move forward, it is critical that the whole sector's approach to inclusion is overhauled, expanding from a focus on individual user needs to one that considers the needs of people involved in the entire sanitation service chain from the outset, giving workers an equal platform in discussions on inclusion. Achieving this requires an approach which recognises perspectives of inclusion outside of the Global North, and one which considers diverse interpretations of what inclusion entails from the Global South.

Access to inclusive urban sanitation for all moving forward in the context of the multitude of challenges that climate change brings must recognise that the long-term legacy of colonialism continues to prevail, marked by, for example, the continued engagement of low-caste and marginalised populations in sanitation work which was assigned to them during the colonial era.

Climate change threatens to exacerbate the risks to the health of sanitation workers further through heat stress, in addition to occupational health and safety challenges that continue to go unmet. Urgent action is needed to give as much attention to the role and needs of professionals working along the sanitation service chain as the needs of users, if sanitation systems are to be sustained in a changing climate.

Our overarching conclusions are aimed at answering the following questions concisely:

- What is 'climate-resilient inclusive WASH'?
- How can 'climate-resilient inclusive sanitation' be achieved in the context of urban planning?
- Where are areas for further research?

8.2 What is 'climate-resilient inclusive WASH'?

To achieve 'climate-resilient inclusive WASH', a renewed definition of 'inclusive WASH' needs to be applied, which we propose as:

"WASH services which emphasise the rights of users as equal to those of service providers such as sanitation workers, and address the needs of all involved in providing and using WASH services, taking into account context-specific vulnerabilities and factors of social exclusion such as caste, religion, geography, and occupation, across all genders and abilities."

WASH services that are resilient to the impacts of climate change must be embedded into the fabric of urban (and rural) planning from the outset. Based on the discussions through this paper, we define climate-resilient inclusive WASH as:

"Water sanitation and hygiene (WASH) services that can adapt to climate stresses and survive climate shocks whilst continuing to serve everyone, embedding principles of inclusion as a default rather than

an exception, and as a foundation rather than an afterthought, for the delivery of WASH infrastructure, policies, governance and financial mechanisms designed for all.”

8.3 How can climate-resilient inclusive sanitation be achieved in the context of urban planning?

As we seek to address the challenge of access to sanitation across cities globally, urban planning, which is all too often overlooked in inclusive WASH discussions, needs to be viewed as a critical mechanism in delivering sanitation services across urban areas in the face of climate change. In the context of urban planning, action is needed to achieve climate-resilient inclusive sanitation to:

- Prioritise marginalised communities who are most exposed to the impacts of climate change by mapping risks across different parts of cities, sanitation access and the composition of communities
- Shift from ‘one-size-fits-all’ sanitation engineering to flexible, context-specific and adaptive solutions to urban sanitation provision
- Apply an intersectional lens from the outset as part of urban sanitation planning. Action is needed to understand how climate risks impact upon people according to their identities in the context of sanitation (e.g. gender, age, disability, caste etc.)
- The target group for inclusive urban sanitation needs to be redefined in line with a broader understanding of what ‘inclusive WASH’ entails. Sanitation workers must be treated as central stakeholders as part of this understanding, not invisible service providers.
- Design financial models that prevent the cost of resilient sanitation infrastructure from deepening inequalities.
- Institutionalise participatory processes that give marginalised communities and workers a formal, recognised role in decision-making.
- Formally regulate and professionalise sanitation services, ensuring health, safety, and welfare for workers
- Utilise disaggregated data to identify and reach the most climate-vulnerable communities by encouraging collaboration with urban local bodies and civil society organisations who hold information about them to create targeted, co-created, inclusive interventions
- Redress the balance of focus in climate action to ensure that sanitation systems are given as much attention as water systems. Sanitation must move from being overlooked in climate policy to a core pillar of climate action.
- Climate finance must specifically prioritise inclusive sanitation, moving beyond its current focus on water access.

8.4 Areas for further research

Based on the reflections shared in this paper, there are several blind spots in knowledge which can potentially be filled through research:

- Quantify the long-term, intersectional impacts of climate change specifically on marginalised groups and sanitation workers.
- Identify successful scalable, equitable financial models for flood-resilient infrastructure in informal settlements.
- Bridge the evidence gap between global climate policies and local sanitation service delivery realities.

- Expand evidence on the unique climate vulnerabilities of sanitation workers
- Explore the potential for inclusive job creation within new circular economy markets to ensure they do not replicate existing inequalities

9. Recommendations

This paper has explored how climate-resilient urban sanitation can be designed to enhance inclusion rather than exacerbate inequalities. Our analysis shows that delivering this in practice requires three core shifts:

- First, the target group for inclusive sanitation must be redefined. We must look beyond service users to formally recognise sanitation workers as central stakeholders, rather than invisible service providers, and address their safety, dignity, and inclusion as a core priority.
- Second, we must shift from a one-size-fits-all sanitation engineering mindset towards flexible, context-specific, and adaptive solutions. This ensures that sanitation infrastructure remains physically accessible and safe for everyone, even under severe climate stresses like seasonal flooding.
- Finally, inclusion must become a default rather than an add-on. Principles of equity and accessibility must be embedded from the outset as a foundation for all sanitation infrastructure, policies, governance, and financial mechanisms.
- To translate these conclusions into systemic change, we propose the following targeted recommendations for global implementation and city-level planning.

Recommendations for global implementation:

1. Adopt the Bhakta definition: Adopt the Bhakta definition of climate-resilient inclusive WASH globally. This ensures that inclusion is embedded as a default, foundational principle, rather than an afterthought or exception, across all global infrastructure, policies, governance, and financial mechanisms.
2. Redefine the global scope of inclusion to integrate sanitation workers: Overhaul the global sector's definition of 'inclusive WASH'. Move away from narrow, single-issue lenses (such as focusing solely on disability) to treat sanitation workers as central, equal stakeholders rather than invisible service providers.
3. Embrace inclusion programmes at all levels: Move beyond the confines of the water, sanitation, and hygiene sector to integrate inclusion initiatives across all global development and climate policy frameworks.
4. Elevate sanitation in climate action: Ensure sanitation systems receive as much attention as water systems in global climate policy, transforming sanitation from an overlooked area into a core pillar of climate action. Incorporate ambitious commitments for both sewered and non-sewered sanitation systems into Nationally Determined Contributions (NDCs), addressing both climate adaptation and the mitigation of greenhouse gas emissions along the entire service chain.
5. Prioritise inclusive sanitation in climate finance: Direct global climate finance to target inclusive sanitation specifically to scale up resilient solutions, using structures that ensure the cost of climate adaptation does not fall on the most marginalised.
6. Build capacity on inclusive climate-resilient sanitation: Establish sector-wide capacity building programmes to train global and national stakeholders on best practices for delivering intersectional, inclusive sanitation services under changing climate conditions

Recommendations for cities:

1. Apply an intersectional lens to mapping climate vulnerability and recovery: map city-wide climate hazards against community adaptive capacity. Utilise disaggregated details (such as age, gender, disability, caste, and religion) to identify which marginalised groups have the lowest resilience

and will take the longest to recover from climate shocks, ensuring municipal interventions proactively target and direct resources to the most climate-vulnerable communities.

2. Transition to flexible, context-specific solutions through pilots and community awareness: conduct local research and run pilots to test adaptive, non-sewered options that suit physical and social environments, backed by community awareness campaigns that highlight their dignity and health benefits so they are accepted as high-quality, resilient solutions rather than second-class sanitation compared to traditional sewer systems.
3. Formally professionalise and support sanitation workers: protect municipal and informal sanitation workers by formally regulating services and providing government-recognised identification, whilst defining clear municipal standards and policies that guarantee dignified working conditions, occupational safety, and welfare protections under changing climate conditions.
4. Institutionalise participatory community engagement in municipal processes: establish formal, permanent structures within municipal design, planning, and implementation processes that actively include community members (including the most marginalised such as women, youth, older people, and people with disabilities) as central stakeholders and co-designers of their own sanitation solutions.
5. Design equitable financial models: implement progressive tariff structures ensuring that the capital and operational expense of building or upgrading to flood-resilient infrastructure does not deepen urban inequalities or price out low-income residents.
6. Incentivise and regulate private sector participation: engage private stakeholders to support the city's inclusive, climate-resilient journey by designing municipal incentives and enforcing compliance frameworks that demonstrate the mutual value of public-private partnerships, leveraging private sector capacity and investment to scale up resilient sanitation services.

10. Epilogue

This paper was co-authored by an interdisciplinary team of three experts, who have wide-ranging experience and expertise on sustainable water management, climate change, urban planning, sanitation and inclusion.

How we came together

Mark bumped into Amita on the dancefloor at the ‘mingle’ for Stockholm World Water Week. They started talking and didn’t really stop. Issues around inclusion, climate change and sanitation flowed through the conversation and culminated in an idea to explore them further. Shortcomings in current thinking and definitions were painfully obvious where inclusion had been glossed over. Arup had recently been involved in key documents for UNOPS and the World Bank around water and sanitation, which Paula had helped to prepare, so it was a natural extension to involve Paula in the developing dialogue. We exchanged ideas via Teams and face-to-face sessions and assembled them in a coherent form for an online session at Stockholm World Water Week.

Framework of understanding

Our initial discussions were aimed at creating a simple-to-follow ‘framework of understanding’ that captured our main areas of concern from practical experience on the ground, contemporary papers and research. We wanted to draw on Amita’s research on inclusion from working on sanitation with urban communities in India, particularly minority and under-represented groups and their issues, such as sanitation workers. We also wanted to draw in recent practical guidance from Arup’s work with UNOPS and the World Bank, with which Paula was particularly familiar, alongside her extensive experience supporting cities on their climate-resilience journeys. Mark’s role was more of a check and challenge, bringing practical pragmatism to the team.

Co-authors’ experience

Dr. Amita Bhakta is a geographer specialising in urban infrastructure planning in India. Having spent over a decade exploring the different needs of sanitation user groups, Amita has a keen interest in how sanitation services can be embedded into urban planning, with a particular focus on the needs of sanitation workers involved in the handling of faecal waste. Amita’s work has highlighted the user needs of perimenopausal women in Ghana, the important interlinkages between water supply and shared urban toilets for menstrual health and hygiene across cities in India, and more recently, the invisible experiences of women sanitation workers engaged in toilet and septic tank cleaning in parts of urban Odisha in India. Amita is currently exploring how existing approaches to inclusion in the WASH sector can be decolonised, and the implications for this for urban sanitation.



Paula Morcillo de Amuedo is a water professional specialised in climate resilience. As the manager of C40's Urban Flooding Network, she serves as the organization's global technical lead for urban flooding. With a background in Civil Engineering, Paula has delivered projects across Asia, Africa, and Latin America. She combines her water and sanitation knowledge with experience in stakeholder engagement, and Gender Equality and Social Inclusion. Paula's work has been focused on supporting international development clients and partners such as governments, NGOs, UN agencies, development banks to build climate-resilient communities and provide access to resilient water and sanitation services for everyone. Before C40, Paula worked in Arup as a senior Water consultant with a focus in International Development.



Mark Fletcher leads the Global Water Business of Arup. He is a Director and has been with Arup for 39 years. He is an international thought leader on sustainable water management, nature-based solutions and water resilience and has worked around the world. He gave the keynote lecture at the Edinburgh Science Festival in 2026 and also at Peking University in 2025. He is also on the Organising Committee for Singapore International Water Week and has led the initiative to include Young Water Professionals at Stockholm World Water Week for the last 10 years.



He is an Arup Fellow and Fellow of the Royal Academy of Engineering. He is an Honorary Fellow of the Society for the Environment and Chartered Institution of Water and Environmental Management, a Fellow of the Institution of Civil Engineers and received an Honorary Doctorate from Bradford University for his work on sustainable water management. He was a Royal Academy of Engineering Visiting Professor in Engineering Design for Sustainable Development since 2003. He was Faculty Leader for the Arup University - Massachusetts Institute of Technology (MIT) Sloan Management School Masters Programme on 'Resilience of Urban Systems' (2017-2021). He was formerly Chair of British Water and former Chair of the Water Industry Forum. He is also a Board Director at the Stockholm International Water Institute (SIWI) since 2025.

Acknowledgements

We would like to thank Aasim Mansuri, Center for Water and Sanitation, CRDF-CEPT University, India, and Lykke Leonardsen, C40 Cities, for their constructive feedback through peer review of this paper.

Glossary

Term	Definition	Source
Climate adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.	IPCC, (2022a)
Climate resilience	A climate resilient development integrates adaptation measures and their enabling conditions with mitigation to advance sustainable development for all. Climate resilient development involves questions of equity and system transitions in land, ocean and ecosystems; urban and infrastructure; energy; industry; and society and includes adaptations for human, ecosystem and planetary health. Pursuing climate resilient development focuses on both where people and ecosystems are co-located as well as the protection and maintenance of ecosystem function at the planetary scale.	IPCC, (2022b)
Climate resilient sanitation	Climate-resilient sanitation refers to sanitation systems (both non-sewered and sewerred), services and behaviours which can survive, function or quickly recover in the face of a range of climate-related shocks, chronic stresses and seasonal variabilities, ensuring that faecal matter is safely contained throughout the sanitation service chain and does not contaminate the environment, emit excessive GHGs or cause risk to public health.	GWP and UNICEF 2022b)
Climate shock	An acute natural event or phenomenon threatening major loss of life, damage to assets and ability to function and provide basic services, particularly for poor or vulnerable populations.	Adapted based on various sources (Rockefeller Foundation, UN-Habitat, UNISDR)
Climate stress	A chronic (ongoing or cyclical) natural event or phenomenon that renders infrastructure or systems less able to function and provide basic services, particularly for poor or vulnerable populations.	Adapted based on various sources (Rockefeller Foundation, UN-Habitat, UNISDR)
Disaster risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.	UNDRR (2017)
Exposure	The nature and degree to which a system is exposed to significant climatic variations.	IPCC (2018)
Green infrastructure	The strategically planned interconnected set of natural and constructed ecological systems, green spaces and other landscape features that can provide functions and services including air and water purification, temperature management, floodwater management and coastal defence often with co-benefits for human and ecological well-being. Green infrastructure includes planted and remnant native vegetation, soils, wetlands, parks and green open	IPCC (2022a)

Term	Definition	Source
	spaces, as well as building and street-level design interventions that incorporate vegetation.	
Hazards	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.	UNDRR (2017)
Causes of climate change (direct)	Broadly, examples of direct influences on greenhouse gas fluxes, might include the burning of fossil fuels and management actions such as reforestation, agricultural practices, and fire suppression. Concerning infrastructural systems such as sanitation, direct greenhouse gases emissions can be related to emissions along the service chain (e.g., nitrous, methane from waste) and related to its implementation (e.g., emissions associated to construction of assets).	Adapted based on Coppock and Johnson, (2004)
Causes of climate change (indirect)	Examples of indirect influences on greenhouse gas fluxes more generally might include CO ₂ fertilization, nitrogen deposition, acidic deposition, temperature and precipitation changes, invasive species, and tropospheric ozone. Regarding infrastructural systems such as sanitation, this might include emissions along the supply chain needed for the delivery of this service such as arising from energy and transport sectors operation.	Adapted based on Coppock and Johnson, (2004)
Mitigation (of climate change)	An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.	IPCC (2018)
Nature-based solutions	Nature-based solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature.	IUCN, 2016
Resilience	The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation.	Arctic Council (2016)
Sanitation failure mode	Failure Modes describe an analytic framework of scenarios along the sanitation service chain (both onsite and offsite), where the system fails to provide safely managed sanitation services. Specifically, the failure modes refer to FM1, faecal sludge (FS) not contained and not emptied; FM2, FS and/or supernatant (SN) not delivered to treatment; FM3, FS and/or SN not treated; FM4, wastewater (WW) not delivered to treatment; FM5, WW not treated.	Peal et al (2020)
Sanitation service chain	A context-specific series of technologies (or hardware), infrastructure and services for the management of human excreta and wastewater, for their collection, containment, transport (also referred to as conveyance), transformation (also referred to as treatment), utilisation (also referred to as reuse) or disposal.	Mikhael et al (2021)
Sanitation system	The combination of the sanitation service chain and its so-called enabling environment within which it operates. This includes for instance institutional arrangements and coordination, monitoring, planning, financing, regulation and accountability, environment, learning and adaptation, as well as the capacity of actors and their inter-relationships.	Mikhael et al (2021)

Term	Definition	Source
Sanitation worker	A sanitation worker is anyone – who is or is not employed- responsible for the cleaning, maintenance, operation, or emptying of a sanitation technology and includes toilet cleaners, pit latrine and septic tank cleaners, those handle faecal waste in other ways; sewer and manhole cleaners; and people who work at dedicated treatment plants	(Dalberg Advisors, 2017; WHO, 2018)
System sustainability	System sustainability within finance matters refers to the process of taking environmental, social and governance (ESG) considerations into account when making investment decisions in the financial sector, leading to more long-term investments in sustainable economic activities and projects.	Adapted from European Commission, (2023)
Urban climate resilience	The capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic climate stresses and acute shocks they experience.	Adapted from Mikhael et al (2021)
Urban resilience	The capacity of individuals, communities, institutions, business and systems within a city to survive, adapt and grow no matter what kinds of chronic stresses and acute shocks they experience.	Resilient Cities Network, 2026
Urban water resilience	The capacity of the urban water system, including human, social, political, economic, physical, and natural assets, to anticipate, adopt, respond to, and learn from shocks and stresses, in order to protect public health, wellbeing, and the natural environment, and minimize economic disruption.	Arup et al (2019)
Vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.	IPCC, 2018

Bibliography

Aqeel, A., and Gill, M. (2021). Shame and Stigma in sanitation: Competing Faiths and Compromised Dignity, Safety and Employment Security of Sanitation Workers in Pakistan- An Initial Assessment With Recommendations. Center for Law and Justice, Pakistan

Arctic Council (2016) Arctic Resilience Report M. Carson and G. Peterson (eds). Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm. <http://www.arctic-council.org/arrn>

Arup, SIWI, The Resilience Shift, Venturi Innovation, and OECD (2019) The City Water Resilience Approach London: Arup [The City Water Resilience Approach](#)

Bhakta A, Shah P, Parida, G, Patel R, Malhotra M, Baradi M and Jewitt S (2026) The unseen living conditions of women sanitation workers in Bhubaneswar and Cuttack, Odisha Poster at Global South Academic Conclave on WASH and Climate 6th-7th February 2026, CEPT University, Ahmedabad, India DOI: 10.13140/RG.2.2.20387.31525 [The unseen living conditions of women sanitation workers in Bhubaneswar and Cuttack, Odisha](#) 10.13140/RG.2.2.20387.31525

Bhakta, A., Mansuri, A., Jaiswal, J., and Iyer, M. (2024) ‘The need of the hour: Providing water in shared toilet facilities for menstrual hygiene management in urban India’ Journal of Water, Sanitation and Hygiene for Development 14 (2): 113-121 <https://doi.org/10.2166/washdev.2024.265>

Bhakta, A., Cawood, S., Zaqout, M. and Evans, B. (2022) ‘Sanitation work: realising equity and inclusion in WASH’ Frontiers in Water 4 doi.org/10.3389/frwa.2022.1022581

Bhakta A, Esseku H, Esseku Y, Fisher J and Reed BJ (2021) ‘The hidden WASH needs of perimenopausal women’ Journal of Water, Sanitation and Hygiene for Development 11 (6): 1016-1025 <https://doi.org/10.2166/washdev.2021.101>

Bhakta, A. and Pickerill, J. (2016) ‘Making space for disability in eco-housing and eco-communities’ The Geographical Journal 182 (4): 406-417 <https://doi.org/10.1111/geoj.12157>

Boyce, P., Brown, S., Cavill, S., Chaukekar, S., Chisenga, B., Dash, M., Dasgupta, R. K., De La Brosse, N., Dhall, P., Fisher, J., Gutierrez-Patterson, M., Hemabati, O., Hueso, A., Khan, S., Khurai, S., Patkar, A., Nath, P., Snel, M., and Thapa, K. (2019) Transgender-inclusive sanitation: insights from South Asia. Waterlines, 37(2): 102-117. doi: [10.3362/1756-3488.18-00004](https://doi.org/10.3362/1756-3488.18-00004)

Brühl, J. and Visser, M. (2021) ‘The Cape Town drought: A study of the combined effectiveness of measures implemented to prevent “Day Zero”’ Water Resources and Economics 34 (100177) doi: <https://doi.org/10.1016/j.wre.2021.100177>

C40 Cities and World Resources Institute (2019) [Inclusive Planning- Executive Guide- How to tackle climate change and inequality jointly: Practical resources and guidance for cities](#)

London: C40 Cities and WRI

Cawood, S., Farzana, M., and Naeem, KM. F. (2025). Nongra Kaj / ‘dirty work’: caste, colonialism and entrapment in Bangladesh. Contemporary South Asia, 33(4), 537-558. <https://doi.org/10.1080/09584935.2025.2575161>

Charles, K., Pond, K., Pedley, S., Hossain, R., and Jacot-Guillamod, F. (2009) Vision 2030 The Resilience of Water Supply and Sanitation in the Face of Climate Change: Technology Projection Study. Guildford: University of Surrey.

Chateau, J., Dang, G., MacDonald, M., Spray, J., and Thube, S. (2023) A Framework for Climate Change Mitigation in India IMF Working Papers 2023, 218 (2023), <https://doi.org/10.5089/9798400247002.001> [Accessed: 11/12/2025] <https://doi.org/10.5089/9798400247002.001>

Coppock R. and Johnson S (2004) [Direct and Indirect Contributions to Terrestrial Carbon Fluxes](#) Washington DC: The National Academies Press

- Dalberg Advisors. (2017) Sanitation Worker Safety and Livelihoods in India: A Blueprint for Action—Phase 1: Understanding the Problem. Dalberg Advisors, New Delhi, India Dickin, S., Bayoumi, M., Giné, R., Andersson, K. and Jiménez, A. (2020). Sustainable sanitation and gaps in global climate policy and financing. *npj Clean Water*, 3(1). <https://doi.org/10.1038/s41545-020-0072-8>
- Dubey, S.Y. and Murphy, J.W., 2021. Manual scavenging in Mumbai: the systems of Oppression. *Humanity and Society*, 45(4); .533-555.
- Dzikus A., Pireh H., and Krhoda, G. (2021) Climate Proofing Toolkit for Basic Urban Infrastructure with a Focus on Water and Sanitation. Nairobi: UN-Habitat
- Elliot, Z., Kenner, A., and Sarao, M. (2020) ‘Dignity Over Dumping: The Fight for Climate Justice and a Just Transition for Sanitation Workers’ *Science For The People* 23 (2) <https://magazine.scienceforthepeople.org/vol23-2/green-new-deal-sanitation-transition-workers/>
- Fisher, J., Cavill, S., and Reed, B. (2017). Mainstreaming gender in the WASH sector: dilution or distillation? *Gender & Development*, 25(2), 185–204. <https://doi.org/10.1080/13552074.2017.1331541>
- Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2020) Stop Floating, Start Swimming: water and climate change - interlinkages and prospects for future action Bonn: GIZ <https://www.giz.de/en/downloads/giz2020-water-climate-report-2020.pdf> <https://www.giz.de/en/downloads/giz2020-water-climate-report-2020.pdf>
- Global Water Partnership and UNICEF (2022a) [Strategic Framework for WASH Climate Resilient Development](#) New York: GWP and UNICEF
- Global Water Partnership and UNICEF (2022b) WASH Climate-Resilient Development- Technical Brief: Climate-resilient sanitation in practice New York: UNICEF [WASH Climate-Resilient Development- Technical Brief: Climate resilient sanitation in practice](#)
- Gooré Bi, E., Monette, F., Gachon, P., Gaspéri, J. and Perrodin, Y. (2015) Quantitative and qualitative assessment of the impact of climate change on a combined sewer overflow and its receiving water body. *Environmental Science and Pollution Research*. 22(15): pp.11905-11921.
- Gonzalez, D., Abdel Sattar, R., Budhathoki, R., Carrard, N., Chase, R. P., Crawford, J., Halcrow, G., Kozole, T., MacArthur, J., Nicoletti, C., Touer, V., Basnet, M.P., Chhetri, A. Gurung, H., Yadav, A. Vourchnea, P. and Willetts, J. (2022). ‘A partnership approach to the design and use of a quantitative measure: Co-producing and piloting the WASH gender equality measure in Cambodia and Nepal.’ *Development Studies Research*, 9(1): 142–158. <https://doi.org/10.1080/21665095.2022.2073248>
- Green Cape (2021) [Opportunities for Container-based Sanitation in Cape Town](#) Cape Town: Green Cape
- Housing and Urban Development Department, Government of Odisha and Urban Management Centre (2025) [The Garima Story: Sanitation Work with Safety and Dignity](#) Bhubaneswar: HUDD
- Hyde-Smith, L., Zhan, Z. Roelich, K., Mdee, A., and Evans, B. (2022) ‘Climate Change Impacts on Urban Sanitation: A Systematic Review and Failure Mode Analysis’ *Environmental Science and Technology* 56 (9): 5306-5321 DOI: 10.1021/acs.est.1c07424
- Inclusive WASH and Disability <https://asksource.info/topics/cross-cutting-issues/inclusive-wash-and-disability> [Accessed: 11/12/2025]
- International Bank for Reconstruction and Development (2025) [The Global Sanitation Crisis: Pathways to Urgent Action](#) Washington: The World Bank
- Intergovernmental Panel on Climate Change (2022a) Annex II: Glossary [Möller, V., R. van Diemen, J.B.R. Matthews, C. Méndez, S. Semenov, J.S. Fuglestedt, A. Reisinger (eds.)]. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 2897–2930, doi:10.1017/9781009325844.029

Intergovernmental Panel on Climate Change (2022b) Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001

Intergovernmental Panel on Climate Change (2018) Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541–562, doi:10.1017/9781009157940.008. [10.1017/9781009157940.008](https://doi.org/10.1017/9781009157940.008)

International Union for Conservation of Nature (2016) ‘About IUCN’ <https://iucn.org/about-iucn> [Accessed 17/6/2026]

Investing in Inclusive WASH <https://www.elrha.org/researchdatabase/investing-in-inclusive-wash/> [Accessed: 11/12/2025]

Jaiswal, J., and Patil, K. (2024) ‘Evaluating GHG emissions across non-sewered sanitation chain’ Presentation at Global South Academic Conclave on WASH and Climate linkages, CEPT University, 2nd-4th February 2024, Ahmedabad

Johnson, J., Zakaria, F., Nkurunziza, A.G., Way, C., Camargo-Valero, M.A., and Evans, B. (2022) ‘Whole-system analysis reveals high greenhouse gas emissions from citywide sanitation in Kampala, Uganda’ Communications Earth & Environment 3, (1) 80 <https://doi.org/10.1038/s43247-022-00413-w>

Jones, H. and Reed R. (2005) Water and sanitation for disabled people and other vulnerable groups: Designing services to improve accessibility. Loughborough: Loughborough University. <https://hdl.handle.net/2134/30796> [Accessed: 16/6/2026] <https://hdl.handle.net/2134/30796>

Koppikar, S. (2017) ‘Death-trap toilets: The hidden dangers of Mumbai's poorest slums.’ The Guardian. <https://www.theguardian.com/global-development-professionals-network/2017/feb/27/death-trap-toilets-mumbai-india-slums> [Accessed 11/12/2025]

Kumar, S., Doshi, S. Mishra, G. and Iyer, M. (2023) Fostering water-sensitive urban planning in G20 cities T20 Policy Brief <https://www.global-solutions-initiative.org/publication/fostering-water-sensitive-urban-planning-in-g20-cities/> [Accessed: 11/12/2025]

MacArthur, J., Chase, R.P., Gonzalez, D., Kozole, T., Nicoletti, C., Toeur, V., and Willetts, J. (2024) ‘Investigating impacts of gender-transformative interventions in water, sanitation, and hygiene: Structural validity, internal reliability and measurement invariance of the water, sanitation, and hygiene–Gender equality measure (WASH-GEM).’ PLOS Water 3(10): e0000233. <https://doi.org/10.1371/journal.pwat.0000233> <https://doi.org/10.1371/journal.pwat.0000233>

Mehta, M., Mehta, D., and Yadav, U. (2019) ‘Citywide Inclusive Sanitation Through Scheduled Desludging Services: Emerging Experience From India’ Frontiers in Environmental Science. 7:188. doi: 10.3389/fenvs.2019.00188

Mikhael, G., Hyde-Smith, L., Twyman, B., Trancón, D. S., Jabagi, E., & Bamford, E. (2021). Climate Resilient Urban Sanitation Accelerating the Convergence of Sanitation and Climate Action Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Nawaz, S., Wilbur, J., Upoma, T.A., Tabassum, K.F., Goshami, A., Podder, B., Akter, J., Hasan, M., D’Mello-Guyett, L., Shoaib, D.M., Ruuska, D., Banks, L.M., Kovats, S., Chen, S., and Alam, M. (2026) ‘Extreme weather and sanitation in Bangladesh: a mixed-methods study of lived experiences of people with

disabilities' The Lancet Regional Health- Southeast Asia 47: 100744 DOI: 10.1016/j.lansea.2026.100744
[10.1016/j.lansea.2026.100744](https://doi.org/10.1016/j.lansea.2026.100744)

Nijhawan A, and Howard G. (2022) 'Associations between climate variables and water quality in low-and middle-income countries: A scoping review.' Water Research 2022, 210: 117996.

Peal, A., Evans, B., Ahilan, S., Ban, R., Blackett, I., Hawkins, P., Schoebitz, L., Scott, R., Sleight, A., Strande, L. and Veses, O. (2020) 'Estimating Safely Managed Sanitation in Urban Areas; Lessons Learned from a Global Implementation of Excreta-Flow Diagrams'. Frontiers in Environmental Science 8:1. doi: 10.3389/fenvs.2020.00001

Prana, A.M., Dionisio, R., Curl, A., Hart, D., Gomez, C., Apriyanto, H. and Prasetya, H. (2024) 'Informal adaptation to flooding in North Jakarta, Indonesia' Progress in Planning 186: 100851
<https://doi.org/10.1016/j.progress.2024.100851>

Resilient Cities Network (2026) 'What is Urban Resilience?' <https://resilientcitiesnetwork.org/what-is-urban-resilience/> [Accessed: 17/6/2026]

Robinson, H.J., Evans, B., Hutchings, P., Narayanaswamy, L., Bokam, R., and Barrington, D.J. (2025) "'Who gets to belong?'" Navigating appearance-based discrimination and transgender access to urban toilets in India' Health and Place 96 (103558) <https://doi.org/10.1016/j.healthplace.2025.103558>

Rosato-Scott, C., Barrington, D. J., Bhakta, A., House, S. J., Mactaggart, I. and Wilbur, J. (2020) '[Incontinence: We Need to Talk About Leaks](#)', Frontiers of Sanitation: Innovations and Insights 16, Brighton: Sanitation Learning Hub, Institute of Development Studies

Satvi, H. (2023) Accelerating the climate-resilient sanitation: A case of Dal dwellers, Srinagar Masters Directed Research Project, CEPT University. <https://portfolio.cept.ac.in/2023/S/fp/drp/ui4051-drp000586-spring-2023/pui21139-spring-2023-ui4051-pui21139> [Accessed: 11/12/2025]
<https://portfolio.cept.ac.in/2023/S/fp/drp/ui4051-drp000586-spring-2023/pui21139-spring-2023-ui4051-pui21139>

SNV, The University of Technology, Sydney - Institute for Sustainable Futures (UTS-ISF) and Water for Women (2025) [Measuring what matters: Gender equality changes, WASH and climate resilience](#) Webinar presentation, 20/01/2025

Sommer, M. and Sahin, M. (2013) 'Overcoming the taboo: advancing the global agenda for menstrual hygiene management for schoolgirls' American Journal of Public Health. 103(9):1556-9. doi: 10.2105/AJPH.2013.301374

Soriano A, Gaikwad S, Stratton-Short S, and Morgan G, (2024) Guidelines for developing inclusive water, sanitation and hygiene (WASH) infrastructure. UNOPS, Copenhagen, Denmark. [Guidelines for developing inclusive water, sanitation and hygiene \(WASH\) infrastructure](#)

Takamatsu, M., Nakazato, T., Fischer, R., Satoh, H., Bonaccorso, F. and Grey, G. (2014) Climatological disasters and their impact on wastewater treatment infrastructure - A comparison of Japan's tsunami and superstorm Sandy STP damage, response, and mitigation. In: 87th Annual Water Environment Federation Technical Exhibition and Conference, WEFTEC 2014, 2014, pp.1250-1261.

Taking action to achieve inclusive WASH <https://agora.unicef.org/course/info.php?id=40281> [Accessed: 11/12/2025]
<https://agora.unicef.org/course/info.php?id=40281>

TERI University (2017) State of Urban Water and Sanitation in India. TERI University, New Delhi.

United Nations (2025) [World Urbanization Prospects 2025: Summary of Results](#). UN DESA/POP/2025/TR/NO. 12. New York: United Nations.

United Nations Office for Disaster Risk Reduction (UNDRR). (2017) The Sendai Framework Terminology on Disaster Risk Reduction. "Disaster risk". Accessed 17 June 2026.
<https://www.undrr.org/terminology/disaster-risk>. <https://www.undrr.org/terminology/disaster-risk>

WaterAid (2024) [Climate-resilient WASH: An integrated solution for climate action, sustainable agriculture and biodiversity](#) London: WaterAid

WaterAid (2020) [Living in a fragile world: the impact of climate change on the sanitation crisis](#) London: WaterAid

Wilbur, J., Poilapa, R., & Morrison, C. (2022). Menstrual Health Experiences of People with Intellectual Disabilities and Their Caregivers during Vanuatu's Humanitarian Responses: A Qualitative Study. *International Journal of Environmental Research and Public Health*, 19(21), 14540. <https://doi.org/10.3390/ijerph192114540>

World Bank (2025) [The Global Sanitation Crisis - Rethinking Urban Sanitation - Circular Economy as a Climate Resilience Strategy - Background Paper](#) Washington, D.C. : World Bank Group

World Health Organisation (2018) *Guidelines on Sanitation and Health*. Switzerland: WHO.

World Health Organization and the United Nations Children's Fund (2025) [Progress on household drinking water, sanitation and hygiene 2000–2024: special focus on inequalities](#). Geneva: WHO and UNICEF