Brief 3

Evidence priorities for climate-resilient urban sanitation

Technological innovation and systems change to address flooding in three country contexts

Key messages

1. **National and local governments are actively implementing sanitation initiatives that respond to climate risks**, including sealed or elevated systems, nature-based treatment plants, water recycling and prefabricated systems, tailored to local conditions and flood risks.
2. **Current initiatives reflect all three models of scale-up**: 'Keep optimising', 'Reach further' and 'Change the rules' each of which have corresponding evidence needs.
3. Focusing on **flooding as a common climate hazard**, the following evidence gaps persist:
    - Adequate performance data on new technologies, particularly on long term durability and resilience to flooding.
    - Synthesised experiences from pilots to guide policy and context specific design recommendations.
    - Mechanisms to improve coordination and communication for knowledge exchange between government departments, research and NGO to facilitate replication and scaling.
    - Operation and maintenance strategies and capacity building approaches, particularly for complex systems in flood prone contexts.
    - Better understanding of user acceptance of adapted technologies to support uptake.

Introduction

Purpose of brief

This brief aims to provide national and sub-national governments, and other sanitation professionals, with examples of technological innovation responses, scaling processes, and wider systems change used to address climate related sanitation challenges and identify related evidence priorities. The brief draws on experiences of government representatives and selected other stakeholders from Bangladesh, Fiji, and Vietnam and focuses on flooding. The initiatives shared were analysed with regards to: (i) how current initiatives towards building climate resilience and their approach to scaling, (ii) ongoing challenges to scaling, and (iii) key evidence gaps. While centred on flooding in these three country contexts, the insights are also relevant to broader climate hazards, and to other country contexts including in Africa.

Background of the brief

This work aims to drive increased access to climate-resilient sanitation across low- and middle-income countries by identifying critical evidence priorities to guide action. Building on a landscape study on the current state of thinking and action on urban sanitation and climate change (2022)[1] and wider efforts of the global Climate Resilient Sanitation Coalition for Action [2], this series of briefs have been developed with a specific focus on the intersection of technological innovations and wider social and systems change needed to accelerate progress. This brief is one of three documenting insights from six online participatory workshops in 2024 with global funders, global south researchers and national stakeholders in three countries. This work is funded by the New Ventures Fund/ Bill and Melinda Gates Foundation. The three briefs are:

- Models of scale-up linking technological innovation and systems change (Brief 1)
- How and why to invest in climate resilient sanitation research and relevant evidence priorities (Brief 2)
- Technological innovation and systems change to address flooding in three countries (Brief 3)

Climate hazards and urban sanitation

Sanitation systems are increasingly threatened by a wide range of climate hazards: Each climate hazard can compromise the functionality, safety, and sustainability of sanitation services. These hazards include more frequent and intense flooding, prolonged droughts, rising sea levels, extreme rainfall, and temperature fluctuations.[3] **Flooding** can lead to the overflow of latrines and septic tanks, contaminating water sources and surrounding environments. Meanwhile, **drought** reduces water availability for flushing and can cause clogging of systems that rely on water for operation. **Sea level rise and saltwater intrusion** pose additional risks, especially in low-lying coastal areas, by accelerating the corrosion of sanitation infrastructure and reducing treatment efficiency. These are just some hazards that highlight the urgent need for climate-resilient sanitation planning and implementation that accounts for the multiple and intersecting threats posed by climate change.

Flooding is a major concern across all three studied countries. In Bangladesh, Fiji, and Viet Nam, flooding is widespread, recurrent and severely impacts sanitation services and public health. While multiple climate hazards affect sanitation systems, to compare intervention approaches this brief focuses specifically on the impacts of flooding. Hence the focus of this brief, on how scaling models and associated evidence could advance progress.

Climate resilient sanitation: Definition

Climate-resilient sanitation services **anticipate, respond to, cope with, recover from, adapt to or transform** based on climate-related events, trends and disturbances, all while striving to achieve and maintain universal and equitable access to **safely managed services**, even in the face of an unstable and uncertain climate, where possible and appropriate, **minimising emissions**, and paying **special attention to the most exposed vulnerable groups**.

Drawn from SWA (2024) Definition of climate-resilient water sanitation and hygiene services

[1] UTS-ISF (2022) Urban sanitation and climate change: A public service at risk – Landscape study. Prepared for BMGF by University of Technology Sydney - Institute for Sustainable Futures. Authors: J. Willetts, A. Kumar and F. Mills.
[2] See here: https://www.susana.org/community/themes/climate-resilient-sanitation-coalition.
[3] Kohlitz, J., Willetts, J., Gero, A., Lyons, S., Boisson, S., & Medlicott, K. (2019). Climate, sanitation and health: Discussion paper. World Health Organization.

Bangladesh

Bangladesh has been ranked as the world's seventh most climate risk-affected country.[4] Over the past two decades, the country has experienced 185 extreme weather events, which have resulted in 0.38 fatalities per 100,000 inhabitants.[5] At present, 27% of the population residing in coastal areas is vulnerable to a 100-year coastal flood event.[2] This figure is expected to rise to 35% with a half-metre increase in sea level. Flooding continues to represent the most economically damaging natural hazard in Bangladesh. The combination of increasing and changing rainfall patterns and many low-lying dense urban areas results in significant flood risk. This leads to significant challenges for sanitation infrastructure and related environmental and public health risks. In the context of escalating climate-related flood risks, urban sanitation systems in Bangladesh remain critically challenged, with only 39% of the population accessing safely managed sanitation services and an additional 22% relying on basic sanitation.[6]

Urban sanitation is managed through a multi-level institutional framework with national and city-scale actors, which has implications for sharing new knowledge and practices in climate resilience. At the national level, the Ministry of Local Government, Rural Development and Co-operatives holds overall responsibility for urban development, including sanitation. Under this ministry, two key departments provide technical support to local authorities, each of which has been involved in recent climate resilience activities: (i) The Local Government Engineering Department (LGED) offers technical and infrastructure development assistance to City Corporations, focusing on planning and construction support, and has been expanding programs including faecal sludge treatment plants. Meanwhile, the Department of Public Health Engineering (DPHE) contributes technical expertise for water treatment, drainage, and sanitation systems in both City Corporations and smaller municipalities. At the city scale, City Corporations in larger cities and municipalities in smaller towns are the primary implementers of sanitation services. These local bodies operate with a degree of autonomy but remain under the oversight of both LGED and DPHE to ensure technical standards and coordination are maintained, and hence the importance of these two departments in the scale-up of any technological innovations in climate resilient sanitation.

Flood risks and Bangladesh's urban sanitation context

- 27% population in coastal areas vulnerable to flooding, increasing to 35% with sea-level rise
- Only 39% of the population have safely managed sanitation services
- Two national departments (LGED and DPHE) support on technical standards and coordination across city corporations and municipalities responsible for urban sanitation

[4] Germanwatch. "2021. Global Climate Risk Index 2021." Bonn: Germanwatch.
[5] World Bank Group. (2022). Country Climate and Development Report: Bangladesh. World Bank.
[6] WHO and UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2023. Bangladesh. https://washdata.org/data

Initiatives, challenges and evidence needs for scaling climate resilient sanitation

Climate-resilient sanitation initiatives participants shared	Persistent challenges	Evidence priorities
Khulna, a relatively flat region in the south-western part of Bangladesh, is currently undergoing a major transition in response to persistent flooding challenges. The city is **shifting from on-site sanitation systems to the centralised sewer network**, with the goal of expanding sewerage coverage to reach 70% of the city's area.  Aligned to 'Keep Optimising' model, since the initiative applies known centralised wastewater technologies with a focus on speeding up to rapidly increase coverage. Modifications to designs to address flood specific challenges and multi-stakeholder approaches to planning to enable scale up could also be implemented in other similar city settings.	Understanding and managing threats to sanitation infrastructure from heavy rainfall and inundation as well as the risks from contaminated floodwaters remains challenging. Beyond technology, operation and maintenance remains a major issue. **"Technology isn't the major challenge in Bangladesh — it's the operation and maintenance, especially in the face of frequent flooding."** (Government staff member)	Further research is required on how to ensure operation and maintenance practices are appropriate to manage a large, complex system, particularly in a flood-prone context, including necessary skills, capacities and financing to enable flexible, responsive operation.
Faecal sludge management (FSM) has been a significant challenge for urban areas in Bangladesh, particularly in flood-prone zones. **Faecal Sludge Treatment Plants** (**FSTPs**) construction was perceived as a critical step to increase climate resilience. A number of locally suitable technologies exist, such as unplanted drying bed and constructed wetland treatment in Khulna city and co-composting treatment in Kushtia municipality. Climate resilience design considerations included elevating treatment above flood levels, covering the drying beds and using locally available cocopeat filter media.  Aligned to Keep Optimising model, treatment plant designs and operation models have been optimised through collaborations between government, research and NGO partners. In Kushtia Municipality the engagement of private sector and reuse of treated sludge provides an example of a 'Change the rules' model that encourages diversification in operational models and a circular economy perspective.	While these low maintenance systems can be scaled up, in denser or built-up areas where land is scarce, innovative solutions that combined mechanised and nature-based solutions are needed. Yet at the same time, capacity and human resources within municipalities to manage FSM technologies are low. Despite technical success and environmental benefits in co-composting faecal sludge and solid waste, ongoing social stigma around reuse and generating market demand for the compost remains difficult. Similarly, there remains challenges with profitability when private sector are involved, and relying on municipality subsidies is not sustainable.	Given the high use of OSS across Bangladesh, greater evidence on the suitability of different technical or operation models to different contexts could inform replication. While evidence of financially sustainable models may be necessary for ongoing engagement of private sector or adequate budgeting of subsidies. Behaviour and market assessments could determine how to optimise economic and environmental benefits of reuse.

Climate-resilient sanitation initiatives participants shared	Persistent challenges	Evidence priorities
In low-lying, flood-prone areas, **plastic septic tanks** are being introduced as a technological solution to enhance flood resilience. This approach is planned for scale-up across ten additional towns. Alternatively, in Sylhet City, the City Corporation recommends that toilets and septic tanks are built above known flood levels.  These approaches align with the 'Reach Further' model, since the use of sealed prefabricated septic tanks is currently being spread, transferred and replicated across varied contexts in Bangladesh.	There remains uncertainty on the durability of plastics used in prefabricated tanks as some have degraded after 2 to 3 years use. User acceptance of raised toilets in rural areas has been a challenge.	To replicate in a wide variety of contexts, a review of existing experiences of flood resilient toilets in Bangladesh could give recommendations on context-specific solutions that account for flood risks, varying soil conditions, groundwater table depths, and other environmental and social factors to ensure long-term functionality and resilience.
In Bangladesh's urban sanitation sector, implementation is structured across multiple tiers—from national agencies to local-level implementers like City Corporations. As a variety of urban sanitation initiatives are being rolled out across these different groups (e.g. "61 cities program" to improve inclusive sanitation across 61 cities etc.) efforts to **share processes and practices, including on climate resilience**, has been identified as an enabler for better practice.  Given the cross-sector nature of sanitation services, alternative approaches to collaboration within and between different government departments aligns with a 'Change the Rules' model and can create an enabling environment for improved sharing and scaling of approaches.	Despite the intention of sharing through parallel implementation across multiple locations, in reality the mechanisms to share knowledge and experiences across different levels of government remains challenging.	Evidence to identify the key gaps in communication and mechanisms for knowledge exchange on climate resilient urban sanitation across departments, as well as ongoing strategies are needed to achieve this.
Local institutions, such as the Bangladesh University of Engineering and Technology (BUET) Khulna University of Engineering and technology (KUET), are leading research on innovative sanitation technologies, enabling local development and testing of climate resilient locally appropriate technologies, towards implementation at the local level carried out by City Corporations.  Aligned to 'Change the Rules' model to establish an enabling environment and strategic mechanisms that support effective collaboration between research institutions and local implementers.	There often remains a disconnect between research institutions and on-the-ground implementers, limiting the uptake and practical application of technological innovations.	Identifying or piloting effective approaches to translate climate-resilient sanitation innovations into practice, such as knowledge transfer, co-design processes or local level capacity building could improve coordination between innovators and the market.

Fiji

Fiji is among the most vulnerable nations worldwide to the impacts of climate change and associated disasters. The country is subject to a high level of exposure to tropical cyclones, which frequently result in flooding.[7] The Government of Fiji has suggested that the scale of flood risk is generally underreported due to the number of smaller-scale events that go unnoticed.[8] The increased risks of flooding and the impacts of climate change have a significant effect on sanitation in Fiji. In this country, only 43% of the urban population has access to safely managed sanitation, and 50% have basic coverage.[9]

Sanitation in Fiji is managed across national and city levels, hence efforts to address climate resilience are needed at both. Nationally, the Ministry of Public Works, Meteorological Services and Transport (MPWMST) leads sector strategy and oversight, supported by the Department of Water and Sewerage (DWS) for policy and FSM planning. The Ministry of Health and Medical Services (MoHMS) sets public health and septic design standards, while the Ministry of Local Government oversees municipal councils. At the city level, the Water Authority of Fiji (WAF) manages urban sewer systems, and municipal councils manage on-site sanitation systems, with increasing focus on climate resilience in addressing risks associated with flooding.

[7] Climate Risk Country Profile: Fiji (2021): The World Bank Group.
[8] Walsh, K., McBride, J., Klotzbach, P., Balachandran, S., Camargo, S., Holland, G., Knutson, T., Kossin, J., Lee, T., Sobel, A., Sugi, M. (2015) Tropical cyclones and climate change. WIREs Climate Change: 7: 65–89.
[9] WHO and UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2023. Fiji. https://washdata.org/data.

Initiatives, challenges and evidence needs for scaling climate resilient sanitation

Climate-resilient sanitation initiatives participants shared	Persistent challenges	Evidence priorities
Existing technology has been **adapted for context-specific sanitation and climate conditions** across various communities in Fiji. A range of sanitation facilities tailored to local needs and environmental conditions have been explored, including composting toilets in water-scarce regions and elevated septic systems in flood-prone areas. Aligned to 'Keep Optimising' model, since it focuses on modifying known technologies to address localised climate risks such as droughts and flooding.	Managing multiple climate hazards remains a significant challenge, with technology options needing to accommodate periods of limited water, flooding, cyclones and possible corrosion by seawater, while also protecting freshwater resources.	Evidence of technological solutions that reduce reliance on freshwater but can minimise corrosion issues from the salt/brackish water alternative. Evidence of approaches or technologies that increase resilience of toilet superstructures from cyclone damage, particularly in informal settlements.
Reusing reclaimed water offered a promising solution for sustainable sanitation and resource management in Fiji. In Denarau, a major tourist hub built largely on reclaimed land, recycled wastewater was used for irrigating golf courses and landscaped gardens. In drier periods, the reuse of wastewater both reduces environmental impact of wastewater discharge and reduces pressure on limited water supplies. Reuse systems align with 'Change the Rules' model as they often require new regulations, improved risk management and often political and social acceptance to reuse wastewater.	Although reclaimed water was reused effectively, the sewage system failed after more than 30 years of operation, primarily due to the absence of adequate monitoring and evaluation (M&E). **"I'm trying to draw attention that while you have got the technology to manage things, there has to be an M&E component to look into what the adverse impacts can be."** (International agency staff member)	Given wastewater treatment to enable reuse requires more advance technologies, operational and maintenance models are needed that can ensure long-term performance tracking or detect early signs of system failure. At the same time, opportunities to replicate wastewater reuse projects in this or other locations could be identified that can leverage the existing acceptance and regulations.
Fiji, with support from UNICEF and guidance from WHO, is in the process of **developing national WASH standards for healthcare facilities**, by adapting global guidelines to Fiji's specific context. Building from existing drinking water standards, these new standards will cover broader sanitation requirements, waste management, hygiene, water safety, and considerations for gender inclusion and disability access. Aligned to 'Keep Optimising' to set up national-scale standards that include climate-resilience.	A key challenge is the continued reliance on generalised international guidelines, which often do not align with the specific on-the-ground conditions. The absence of a nationally established sanitation standard in general further complicates efforts to ensure climate-resilient sanitation service delivery in healthcare facilities.	Research is needed to explore best practices for contextualising international guidelines to suit diverse environmental, social and institutional contexts and to assess their applicability and effectiveness in achieving climate-resilient sanitation.

Climate-resilient sanitation initiatives participants shared	Persistent challenges	Evidence priorities
Fibreglass septic tanks are being implemented to increase durability compared to traditional metal drums that suffer from corrosion and leakage. This shift helps maintain the longevity of the septic systems. Such technologies require approval from both Department of Water and Sewerage and the Ministry of Health  Aligned to 'Reach Further' model, since the use of fibreglass septic tanks is currently being spread, transferred and replicated across varied contexts in Fiji.	A persistent challenge remains around the uncertainty of whether fibreglass tanks effectively contain faecal sludge, particularly during and after flooding events. Concerns have been raised about their structural integrity or floating in high groundwater and the potential for leakage, which could pose environmental and public health risks in flood-prone areas.	There is a lack of monitoring and performance testing of fibreglass septic tanks, particularly in terms of how well they are sealed and how they function under varying real-world conditions, including during flooding.
An example of a past financing approach in Fiji involved a **government-led cost-sharing mechanism** to support community water projects. Under this model, projects were implemented on a one-third, two-thirds basis—where one-third of the cost was contributed by the individual or community, and the remaining two-thirds was funded by the government.  Aligned to 'Change the Rules' model to develop finance mechanisms to support climate resilient sanitation	There is currently no equivalent, consistent mechanism in place to support sanitation infrastructure, highlighting a critical gap in financing options. In Fiji, like elsewhere, sanitation is predominantly managed at the household level, with minimal institutional support. A persistent challenge is the lack of financing mechanisms to assist households, particularly in low-income communities in accessing and maintaining adequate climate resilient sanitation facilities.	Evidence on suitable financing models that can support household-level climate resilient sanitation in low-income urban settings. Further research is needed to explore sustainable, context-specific funding mechanisms such as targeted subsidies, microfinance, or public-private partnerships that can enhance access, affordability, and long-term maintenance of sanitation facilities at the household level.

Vietnam

Vietnam is among the most flood-prone countries globally (jointly ranked 1st with Bangladesh). The country is susceptible to multiple forms of flooding, including riverine, flash, and coastal events.[10] Flooding constitutes the predominant natural hazard in Vietnam, accounting for an estimated 97% of average annual economic losses attributed to natural disasters.[7] Projections from a World Bank study indicate that approximately 33% of the population is currently exposed to flooding at a 1-in-25-year return period, with this proportion expected to increase to 38% under future scenarios.[11] These risks have significant implications for urban sanitation systems, where only 41% of the urban population has access to safely managed sanitation services.[12]

Urban sanitation in Vietnam is primarily managed by Ministry of Construction (MOC), in combination with local government authorities and the People's committee at provincial and city level. State-owned enterprises also operate at city level to provide wastewater services. Ministry of Health is responsible for approving certain technology types. The Ministry of Agriculture and Environment (formerly Ministry of Agriculture and Rural Development and Ministry of Natural Resources and Environment) also plays a role, with responsibilities for climate change and water resources.

[10] Climate Risk Country Profile: Vietnam (2020): The World Bank Group and the Asian Development Bank.
[11] Bangalore, M., Smith, A., & Veldkamp, T. (2016). Exposure to Floods, Climate Change, and Poverty in Vietnam. Policy Research Working Paper 7765, The World Bank.
[12] WHO and UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), 2023. Vietnam. https://washdata.org/data.

Initiatives, challenges and evidence needs for scaling climate resilient sanitation

Climate-resilient sanitation initiatives participants shared	Persistent challenges	Evidence needs and priorities
In flood-prone areas of the Mekong Delta, communities have adapted to frequent flooding, which occurs every three months, by **constructing elevated toilets beyond the known flood level.** This design allows for continued access to sanitation facilities even during high water levels, demonstrating a locally driven, flood-resilient approach.  Aligned with 'Keep Optimising' comprising modifications made the existing technologies (elevated toilets).	While elevating the toilet enables access during flooding, a key challenge remains in ensuring public health protection as inundated septic tanks may not adequately contain pathogens which poses a risk of disease transmission in flood prone areas. In parallel a lack of current sanitation standards and poor acceptance of innovations in policy, remains a challenge for enforcing current or improved designs.	Further research is needed to evaluate alternative or adapted technologies and to develop context-specific strategies that not only consider user access but also protect health and environmental outcomes in urban flood-prone settings. There is a lack of national standards governing the design, construction, and regulation of septic tanks.
In areas of water shortage and groundwater depletion, lower quality surface water supplies have been used for toilet flushing.  Aligned with 'Keep Optimising' comprising modifications to change flush water for toilets	It remains challenging balancing the competing priorities of reducing open defecation, with reducing the impact of flush toilets on scarce water supplies. While use of surface water has potential benefits, given it is often saline, it corrodes infrastructure and shortens the lifespan of sanitation facilities.	More evidence is needed on sustainable sanitation technologies that can function effectively with saline surface water or during periods of low water availability. More examples are needed of approaches that enable a direct step from open defecation to climate resilient sanitation.
Effort have begun to examine approaches to integrated urban planning, wastewater and drainage management. With growing populations and increasing volumes of wastewater, integrate climate resilience into these "green city" planning approaches could allow a shift from pipe away and concrete urban areas, to more natural drainage or infiltration solutions (i.e. "retain and buffer"). Considering flood models in urban planning to predict potential impacts of climate change could be used by decision makers in urban planning and sanitation.  Aligned to 'change the rules' since it involves a more integrated and nature-based approach to urban planning and considering how future flood scenarios could impact urban sanitation.	Flood impacts on sanitation cannot be solved without considering urban planning, but more stakeholder cooperation is needed. Applying more natural solutions to stormwater or wastewater management may also be impeded if the policy landscape does not support innovation.	There is a need for simple approaches to model flood risks in urban areas that can potentially identify alternative solutions to integrate wastewater and drainage management, such as through nature-based solutions. Further research is needed to develop and apply such models to support evidence-based policymaking and to strengthen collaboration between decision-makers and researchers working on climate-resilient sanitation solutions.

Conclusion and looking forward

All three countries face challenges related to flooding and its impact on sanitation infrastructure and services, with growing demand for climate-resilient technologies and adaptive service models. The experiences shared by government representatives and selected other stakeholders from Bangladesh, Fiji, and Vietnam demonstrate a range of promising initiatives to develop and scale climate resilient sanitation. While the initiatives focus on flooding, using this consistent hazard allowed comparison of diverse technological, service delivery and policy initiatives across the three models of innovation scale-up and systems change and can inform efforts in other climate or country contexts.

Insights from scaling models

A number of current initiatives adapt and optimise existing technologies, modifying them to suit local climate challenges in alignment to the **Keep Optimising** model. This includes rapid scale up of centralised sewer systems in Khulna Bangladesh; elevated toilets in Fiji and Vietnam; and diverse nature-based faecal sludge treatment solutions in Bangladesh. While technological solutions now exist, persistent issues remain with operation and maintenance, limited capacity for managing complex solutions, and challenges sharing of knowledge. Research can consolidate piloted solutions and make recommendations how these can be adapted to different contexts to incorporate into policy, design standards to further stabilise and speed up the scaling of these initiatives.

The **Reach Further** model centres on the transfer and replication of resilient technologies, such as prefabricated septic tanks, which are being trialled and scaled across Bangladesh and Fiji. However, durability of these systems remains a challenge, particularly in flood conditions, and there may be resistance to adopting new designs into standards and policies. Further evidence is needed to prove the suitability and durability of new technologies, particularly during flooding, to enable government approval and encourage buy-in by stakeholders at different scales that could facilitate replication.

Various examples of circular economy, integrated urban planning, and applied research align with the **Change the Rules** model by transforming governance and institutional frameworks, and uptake of novel technological solutions. These initiatives highlight the potential for systemic change but face significant barriers, including fragmented governance, a lack of enabling policies, and challenges translating research into practice. Sharing evidence of successful policy changes, user acceptance or innovations, such as the wastewater reuse in Fiji, could be leveraged to facilitate replication and scaling.

Resilience to flooding across contexts

All three countries face issues of flooding, however the nature and impact of flooding varied, as did the influence of other compounding climate hazards.

In **Bangladesh**, climate-resilient sanitation initiatives are advancing through adapting existing on- and off-site sanitation technologies and piloting circular models through sludge reuse and private sector engagement. However, operational capacity remains low, knowledge-sharing mechanisms are underdeveloped, and market demand for reuse products is limited. Further, while the technology exists, the maintenance of sanitation systems in flood-prone areas continues to pose a serious public health risk.

Fiji has demonstrated innovation through adaptation of technologies to address flood as well as drought conditions, yet further solutions are needed that can address multiple hazards. While innovation exists, inadequate national sanitation standards, limited monitoring and evaluation, and infrastructure durability issues present major challenges.

In **Vietnam**, communities have adopted locally developed flood-resilient sanitation solutions such as elevated toilets. While these modifications have enabled access during regular flooding, concerns remain regarding the integrity of containment systems and public health risks. In addition, challenges with policy acceptance, weak enforcement of standards, and the need for more integrated planning approaches may limit broader scaling up of climate-resilient solutions.

Contextual relevance for Africa

Experiences from Bangladesh, Fiji, and Vietnam provide valuable lessons for other regions like Africa, facing similar flood-related sanitation challenges. Many African cities suffer from seasonal and extreme flooding, which often leads to infrastructure failure, water contamination, and heightened public health risks.[13] African countries can draw valuable lessons from Bangladesh's rapid expansion of faecal sludge treatment plants and Vietnam's adoption of elevated toilets, both of which address resilience in flood-prone urban areas. Similarly, the transfer of successful sanitation technologies, such as prefabricated septic tanks adapted in Fiji, could help mitigate durability concerns under extreme flood conditions. Strengthening institutional frameworks is a critical need across both Africa and the studied countries, with the need to evolve sanitation standards and governance models.

Remaining evidence gaps

Across the three scaling models, significant evidence gaps remained in the three country contexts, across infrastructure, operation and service provision, institutional and policy, and user behaviours.

Infrastructure: Evidence on the long-term performance of newer technologies or adaptations, including their resilience in flood-prone or saline environments. Compilation of options and experiences from numerous pilots conducted in a country to develop locally relevant design adaptations and policy recommendations. Ongoing innovations to identify solutions resilient to multiple hazards (e.g. floods, droughts and cyclones), particularly for low-income or informal areas.

Operation and service provision: An overarching priority was to improve capacity and practice in operation and maintenance, particularly for complex systems or flood-prone environments. Innovative approaches to private sector involvement and circular economy were valuable, improved financial models and understanding of market demand are needed.

Policy and institutional: There are knowledge gaps on how to improve coordination between national and local institutions and align policy frameworks with climate-resilient sanitation goals. More research is needed on effective institutional arrangements, integration of sanitation into broader urban and climate adaptation planning. Mechanisms to facilitate greater knowledge sharing and collaboration between government, research and NGOs can improve translation of new technologies to field and scale up.

User behaviour: Evidence is needed on user behaviours, preferences, and the social acceptability of innovative sanitation technologies, particularly those introduced in response to climate hazards (e.g. raised toilets, reuse systems). Understanding these aspects is essential for the successful scaling and sustained use of context-specific sanitation solutions. Evidence on the acceptance or barrier to use and uptake of adapted technologies.

When addressing evidence gaps, **connecting local questions to levers for wider systems change** is essential to achieve climate resilient sanitation. The value of the examples presented in this brief is to demonstrate approaches that can be used more broadly, and to reflect on different approaches to scale-up technological innovations that address specific local climate hazards. Each has implications for the required evidence base that can best inform targeted action.

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[13] Islamic Development Bank (IsDB), Knowledge brief on urban flooding and climate adaptation action in Sub-Saharan Africa, Climate Change and Environment Division, Islamic Development Bank. 2024.