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RESEARCH ARTICLE

Advancing the evidence for water, sanitation, and hygiene (WASH) systems strengthening: A Delphi study to define research priorities

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Abstract

Despite significant progress in the provision of water, sanitation, and hygiene (WASH) services, 2.3 billion people still lack access to essential services, and many existing services fail to remain functional, reliable, and safe over time. Strengthening WASH systems is critical to ensure long-term service reliability, equity, and resilience. However, empirical evidence on WASH systems strengthening remains limited. This study employed a Delphi process to identify high-priority research questions to guide systems strengthening efforts, future investments, and policymaking. To collate questions on WASH system strengthening, the research team conducted a rapid scoping review of peer-reviewed and grey literature and extracted questions from international conferences. These questions were categorised, reviewed, and refined by the research leads, covering topics such as understanding the functioning of WASH systems, identifying pathways of change, and addressing systemic challenges of resilience, inclusion, sustainability, and governance. A diverse panel of WASH experts participated in a multi-round Delphi process, reaching consensus on key research priorities. The highest research priorities reflected all WASH system building blocks, with each question linked to at least three of the four domains. Five overarching themes emerged: 1) integrating climate resilience into systems strengthening, 2) enhancing gender, equity, and social inclusion in system approaches, 3) strengthening governance, financing, and accountability mechanisms, 4) improving monitoring, evaluation, and measurement of system change, and 5) understanding the political economy of WASH service delivery. This study highlights the growing

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recognition that WASH systems strengthening requires a broad approach, addressing dynamic linkages between building blocks, context, and actors. It also underscores the importance of improved knowledge sharing to bridge gaps between researchers, implementers, and policymakers and provides a guide to generate evidence that informs sectoral investments and interventions. By addressing key research priorities, it supports evidence-based decision-making to enhance the reliability, inclusion, and sustainability of WASH services.

Introduction

Over the past forty years, there have been substantial gains in access to water, sanitation and hygiene (WASH) services, however, 2.3 billion people still lack these essential services [1]. Beyond first-time access, sustainability is a challenge; trends show that WASH systems often fail to remain functional, reliable, or safe [2–5]. Globally, 1·4 (95% CI 1·3–1·5) million deaths and 74 (68–80) million disability-adjusted life-years (DALYs) could have been prevented by access to safe WASH services in 2019 [6], disproportionately this has affected rural, poor, and resource-limited communities. Ensuring WASH investments achieve their intended health benefits requires addressing these sustainability challenges.

"Systems thinking" gained attention among international development actors for WASH services in the mid-2010s [7,8]. Proponents of systems thinking recognised that conventional approaches, focused on hardware installation, maintenance, and community management, were insufficient to meet Sustainable Development Goal (SDG) #6: universal access to sustainable water and sanitation. Systems thinking was presented as an alternative to linear approaches that focused on a single weak link for the failure of services (e.g., a broken water point or lack of cost recovery). A "systems approach" gained traction [9–12], as a way of working that acknowledges the complex interplay of financial, institutional, environmental, technological, and social factors that influence sustainability [13–17].

Multiple frameworks, developed by UNICEF [16], Sanitation and Water for All (SWA) [18], Agenda for Change [19], IRC [7], and WaterAid [20], have identified core components- often termed "building blocks"- such as finance, institutional arrangements, monitoring, planning, regulation and water resources management as essential for sustainable WASH service delivery and system performance. Assessing the whole WASH system allows weak or even missing elements to be identified. Systems strengthening aims to improve the whole interlinked system rather than focusing on isolated actions in one building block. The World Bank's Water Supply and Sanitation Policies, Institutions, and Regulation (PIR) framework complements these efforts, emphasising robust public service governance, well-defined institutional roles, and effective coordination between regulation and service delivery [21]. Similarly, the Paris Declaration on Aid Effectiveness (2005) aligns with WASH systems strengthening principles by promoting local ownership, policy alignment between institutions, results-based approaches and mutual accountability [22]. Collectively, these

frameworks highlight the pivotal role of actors (both individuals and institutions) and the links among them in shaping how these building blocks operate. Consequently, effective WASH system strengthening initiatives must consider the dynamic interactions between actors and the building blocks in achieving long-term outcomes.

While these frameworks provide valuable insights into the essential building blocks of WASH systems, limited empirical evidence on how WASH systems function persists. There is a stated need for greater evidence regarding the relational dynamics between these building blocks, the context in which they exist, their inherent characteristics and the actors involved [10,23,24]. This includes the role of participation of local actors, end users, and local markets, whose engagement provides operational nuance that is vital for contextual relevance and sustainability of services [25,26]. In addition, the WASH system does not operate in isolation from other national-level systems or the wider political context, which may all influence the behaviour of the WASH system and the possibilities for scaling up and sustaining improvements. While it is often assumed that WASH services will be sustainable and inclusive when all building blocks of the system are strong, this assumption has not been demonstrated in the evidence [7]. Rather than focusing solely on strengthening individual building blocks, a broader systems perspective to engaging with complex service systems and their dynamic interactions is needed.

The inherent complexity of WASH systems, or any public service system, poses challenges in evaluating and understanding system-wide changes [4,9]. This complexity, characterised by numerous interconnected components and actors, makes it difficult to assess the effectiveness of systems approaches in addressing persistent issues of sustainability and equity within the sector. As it stands, the WASH systems strengthening evidence base and praxis is nascent. There is a wide body of theory and descriptive analysis about what the WASH system is and how it can be strengthened [16,18,20,27], but there is limited documentation of how strengthening the system corresponds to changes in service outcomes or if sustained improvements in service levels may reasonably be expected to reflect system outcomes [9]. Much of the existing research is generated from rural settings, and where research from urban contexts is present, it is often only loosely tied to WASH systems theory, making it difficult to generalise findings and insights.

Identifying evidence gaps in WASH system strengthening is crucial, as it enables practitioners and policymakers to develop informed strategies that effectively tackle the multifaceted challenges in WASH service delivery [24,28]. Documenting evidence gaps can inform future studies [29–31], while also ensuring that practitioners are aware of assumptions and limitations of existing theory before applying it in their programmes. This study aimed to identify priority research questions which can inform systems strengthening initiatives. By strengthening the evidence base that informs WASH system strengthening initiatives, the sector can move beyond anecdotal successes and implement scalable, context-specific solutions that ensure long-term benefits for all communities.

Methods

Ethics statement

Approval was granted by ethics boards at the London School of Hygiene and Tropical Medicine (LSHTM) (#29791). Before the survey, panellists received a participant information sheet and informed consent forms. All panellists were over 18 years of age. Survey responses were anonymous as no personal identifiers or information were required from participating individuals. However, panellists did take part in two online webinars, and as this is a small group, the individuals may be known to the wider development community. Written informed consent was taken from panellists.

Study design

This study was an observational study based on a Delphi process that aimed to reach consensus on research priorities to inform WASH systems strengthening initiatives (Fig 1). The study was conducted among a group of experts working on

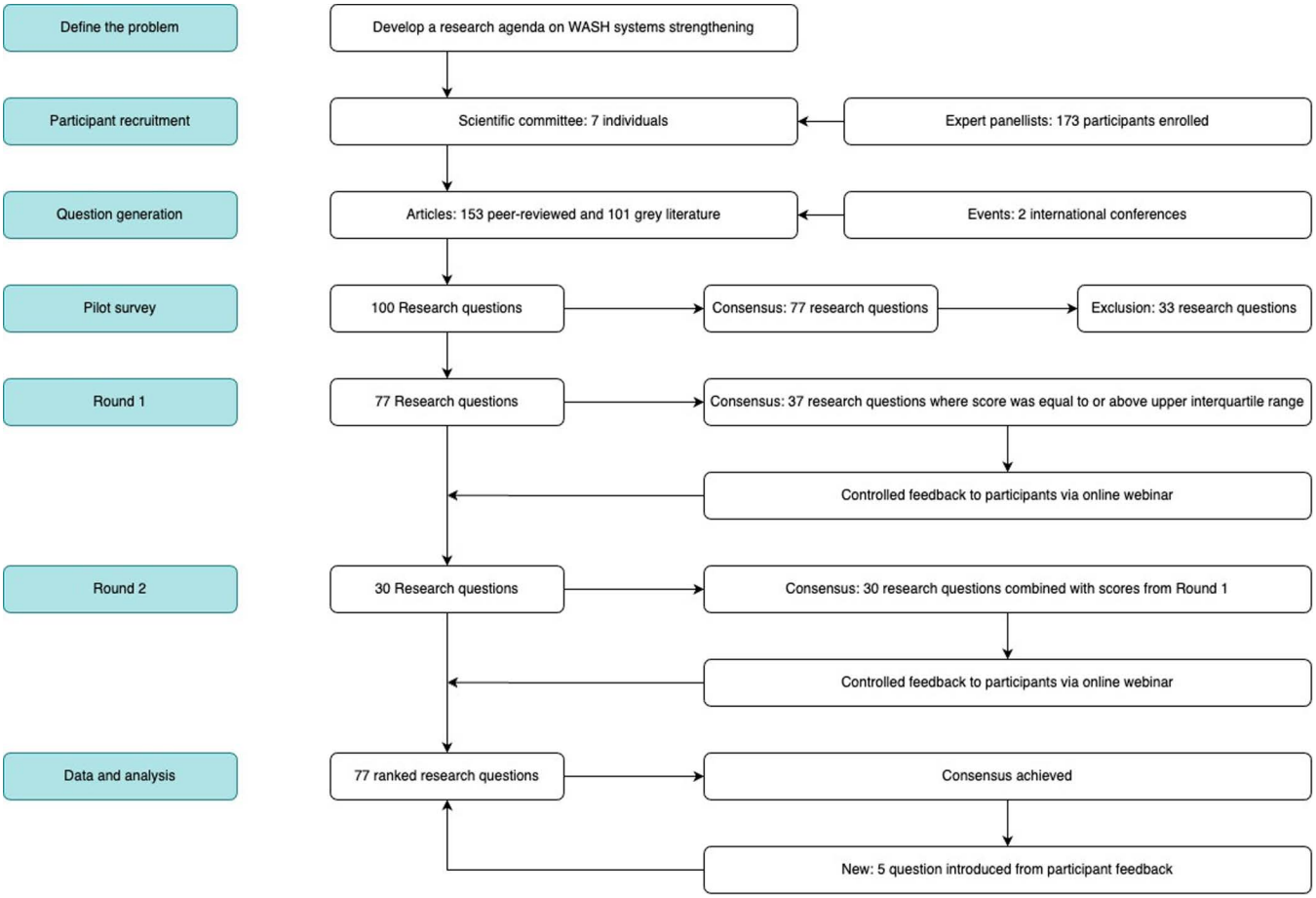

Fig 1. Flow chart of the Delphi process.

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water, sanitation, hygiene, and/or systems approaches. The study is reported according to the Guidance on Conducting and Reporting Delphi Studies (CREDES) (Table A in S1 Text).

Participants

This study involved two types of participants.

1.1. Scientific committee

The scientific committee consisted of a multidisciplinary group of seven individuals with experience in research and implementation of WASH from three institutions (IRC WASH, Netherlands; University of Leeds, UK; and the London School of Hygiene and Tropical Medicine (LSHTM), UK). The responsibilities of the scientific committee were defined at the start of the study and included: reviewing the study protocol and selected methods; generating research questions; question review; review of the survey created by the research team; and providing input into analysis and interpretation.

1.2. Expert panellists

Expert panellists were solicited from a group of WASH experts and provided their opinions on the items included in the Delphi process in an individual and anonymous manner. There is no standard sample size for the Delphi process, and

panel sizes vary in published studies [32]. We aimed to recruit at least 50 panellists. We aimed for a heterogeneous panel of experts [33]. We did not have a predefined criterion for the inclusion of panellists, and they could be from any region, organisation, discipline, or level of experience.

Advertisements were shared via the mailing list of Sanitation and Water for All (SWA). SWA is a partnership of over 300 stakeholders from over 70 countries whereby members coordinate high-level action, improve accountability and effective resource allocation and, implicitly, WASH systems strengthening. Membership includes key WASH stakeholders from governments, civil society, private sector companies, research and learning institutions, utilities and regulators, and external support agencies.

The study was primarily conducted electronically, which aimed to help with the representation of panellists as panellists were not required to be physically present.

Research question identification

1.3. Rapid scoping review

A rapid scoping review of published peer-reviewed and grey literature was conducted to identify articulated research gaps from the literature. Grey literature is defined here to include any type of credible and evidence-based literature from outside an academic journal. A search strategy was compiled by two experienced information specialists (JF and CD). The search strategy included strings of terms and synonyms to reflect the following concepts:

Concept 1: Systems strengthening

Concept 2: Water, sanitation, and hygiene

Concept 3: Contexts within which systems strengthening occurs

No limits were added to the search. Draft searches were adapted for each database to incorporate database-specific syntax and controlled vocabularies. Full details of the search strategy used for each academic database can be found at https://datacompass.lshtm.ac.uk/id/eprint/4670/.

All published peer-reviewed literature was imported into EndNote 20 software. Duplicates were removed, and titles and abstracts were screened for relevance to the key concepts. We retrieved 16,500 scientific articles and retained 153. For grey literature, we retrieved 101 documents from a variety of data sources, including non-governmental organisations (NGOs) websites and specialist WASH resource centres, such as the IRC Resources library (https://www.ircwash.org/resources) and the Rural Water Supply Network (RWSN) library (https://www.rural-water-supply.net/en/resources).

1.4. Conference participation

In parallel to the scoping review, two data sources for question generation were the All Systems Connect International Symposium in The Hague, Netherlands, May 2023 and the University of North Carolina Water and Health Conference: Where Science Meets Policy held in Chapel Hill, North Carolina, USA, October 2023. Both conferences explicitly target and engage with multiple stakeholders within the policy, practice, and research communities, including government partners, international and local NGOs, multi/bilateral aid organisations, and academic researchers. Both conferences presented an opportunity to capture articulated research and learning needs from actors who are less likely to publish academic or grey literature. To identify these research questions, a standard template was developed that required a team of students to qualitatively describe the research gaps and questions noted during events (See Acknowledgements).

1.5. Development of research questions

From the scoping review, research gaps and questions were collected and compiled from the conclusions and areas for further research sections of included articles and grey literature documents by researchers (BL, LDG, PH, CD, JB, AH).

From the international conferences, research gaps and questions were collated from the standardised reporting templates and reviewed by researchers (BL, LDG, PH). This led to an initial list of 710 research questions. After removing duplicate questions and any errors (LDG, PH), 569 research questions remained for review by the scientific committee.

All research questions were coded to the eight WASH system building blocks defined in Table 1, and questions could be linked to multiple building blocks to demonstrate linkages across the WASH system. To ensure that research questions also reflected the interactions with other national-level systems (e.g., health, education, environmental shifts, or concerns) or the wider political context, two other factors, including the "Health, Environmental and Education Systems" and the "Political Economy", were used to code research questions.

1.6. Review by the scientific committee

Four members of the scientific committee (BE, JB, JB, and RD) reviewed the list of 569 research questions and asked to rewrite, remove, and/or refine the research questions and consolidate overlapping or duplicative research questions. This process was conducted iteratively with discussions among researchers between stages. The purpose of this was to reduce the list of questions to a manageable level for assessment by panellists whilst keeping questions relevant to systems strengthening. The list was refined by the scientific committee to 100 research questions.

1.7. Survey design and piloting

Between January and February 2024, the list of 100 refined research questions was converted into an online survey using the Qualtrics (Qualtrics, SAP, Seattle, WA, US) platform. Survey participants were asked to rate the priority of each research question on a 5-point Likert-style scale (1: very low priority, 2: low priority, 3: neither high nor low priority, 4: high priority, 5: very high priority). Information on the demographics of participants was also collected. The survey was piloted and tested by the research team and colleagues, and questions were removed due to duplication or challenges with their understanding, resulting in a final list of 77 possible research questions for review.

Delphi process

The expert panellists were recruited via email between 7th November to 22 December 2023. Listed experts were sent via email an explanation of the study objectives, methodology, types of questions and criteria for selection, number of survey rounds, the approximate duration of the process and potential use of the collected information. An electronic link to the survey was included in the material sent to panellists. Panellists were provided with informed consent forms via email, and this was also embedded within the online survey.

The Delphi process was conducted in two rounds:

1.8. First survey round

The first survey round consisted of 77 questions. Two reminder emails were sent to registered expert panellists to complete the survey. The first round was completed in April 2024.

Results from each survey round were analysed to quantitatively identify areas of consensus on the priority of each research question included in the survey. Consensus was determined *a priori* as percent agreement in responses, according to previously published examples [32,35,36]. For each research question, percent agreement was calculated as the percentage of participants who rated the question as "4: somewhat high" or "5: very high" priority. The median and interquartile range (IQR) of percent agreement were then calculated across all research questions included in the survey. When a research question's specific percent agreement was greater than or equal to the upper interquartile range, the question was considered to demonstrate consensus among participants as a research priority. Questions, where the percent agreement was below the median, were also considered to have demonstrated consensus in that the question was not a research priority. Questions below the median percent agreement were dropped from subsequent survey rounds.

Table 1. Definitions of water, sanitation, and hygiene (WASH) building blocks and systems context used in the Delphi process.

Building Blocks*	
Finance	Identifying the costs of service delivery, the sources of funding, the roles of different actors in providing finance, effective mechanisms for long-term financial procurement and channels for getting the money to where it is needed.
Institutional Arrangements and Coordination	The formal organisational arrangements in a country across sectors for water and sanitation services, the capacity and resources that each organisation must perform its role, and the coordination mechanisms amongst the organisations.
Learning and Adaptation	The pace of change to maintain progress towards a vision. This presumes inclusive platforms for regular sharing of information and the use of data for critical analysis, with insights from multiple actors, including civil society. The actors then respond to the learning through adaptation, changing their policies and practices accordingly. They are willing to address failure and work with others to do things differently.
Monitoring	The capture, management and dissemination of the information required to effectively manage WASH services at all levels. Monitoring is the basis for the information feedback loops that ensure effectiveness and allow adaptive change. It should be both systematic and reliable so that it is accepted by different sector actors and can be used for decision-making.
Planning	The foundation for implementing policies to achieve universal access to sustainable services. Plans must include costs and details on financing and may involve multiple phases. WASH systems require three types of planning: strategic, annual, and project planning for infrastructure development.
Regulation and Accountability	Formal regulatory mechanisms, enforcement processes and other mechanisms to hold decision-makers, service providers and users to account and ensure that the interests of each group of actors are respected. Accountability goes beyond formal mechanisms to include the behaviour of different actors and their obligations in civil society. Governments are accountable for their formal commitments under their signed human rights accords, which include a process of systematic follow-up and review of implementation.
Service Delivery Infrastructure	The quality or standard of service, measured by criteria set by national standards and/or the norms for Sustainable Development Goal 6. The criteria for water include quantity, quality, reliability, and accessibility; for sanitation, they are accessibility, use, reliability, and environmental protection. The service provider is the entity responsible for the day-to-day management of WASH services, including operation and maintenance.
Water Resources Management	Refers to the coordination and control of how water is allocated to different sectors. A strong system includes methods or protocols for addressing conflicts and encouraging cooperation. Both the abstraction of freshwater and the disposal of wastewater should be controlled, managed, monitored, and enforced
System Context	
Health, Environmental and Education Systems**	The WASH system (and its building blocks) exists in a larger context that influences and conditions it. Strengthening and improving the building blocks should lead to improved services, but the WASH system is an open system: external factors influence its behaviours and the possibilities for scaling up and sustaining improvements. Major environmental shifts and public health outcomes may influence the WASH system, but are not considered building blocks of the WASH system
Political Economy**	The driving forces and power dynamics within which a system operates. The term emphasises the fundamental link between politics and economics in determining what is possible in each context. Of course, the political economy of a country is itself a system.

*Definitions taken from the WASH Glossary via Agenda for Change [34].

**Definitions adapted from Huston and Moriarty (2018) [7].

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Research questions where the percent agreement was between the median and upper interquartile range were defined as lacking clear consensus and were advanced to the second survey round.

An online webinar for expert panellists was held in May 2024 to share the results and responses from the first survey round. Summary statistics were shared of the initial ranking of questions, including the median and range of responses.

1.9. Second survey round

The expert panellists were invited to participate in a second survey round. An email was sent out in June 2024 with the second survey, along with detailed instructions similar to the first survey round. The second survey round consisted of 30

questions and was sent in June 2024. Additionally, panellists were able to add questions that they thought were missing from the list of questions.

Defining and reaching consensus followed the same approach as the first survey round. The results from both survey rounds were then collated, and questions were ranked based on their consensus scores (percent agreement of somewhat high or very high agreement). Questions were ranked in order from high to low. Similar analysis procedures were used to define questions that demonstrated consistency in the second round. In addition, the stability of the response was calculated for all questions. Stability was defined as agreement scores that remained above the median across the two survey rounds. After the second survey round, all research questions had either met criteria for priority or non-priority consensus; a third survey round was deemed not necessary. The consistency of responses was the stopping criterion of the Delphi rounds.

A second online webinar was held in July 2024 to share the results and stability of responses. Summary statistics were shared of the final ranking of questions, including ranked agreement scores for all 77 questions. Discussion and validation of the results were facilitated during this webinar.

1.10. Additional research questions from expert panellists

Alongside the included survey questions, the panellists were able to recall overlooked information, take account of the feedback from previous Delphi rounds, or draw on external sources of their knowledge. This new information took the form of additional research questions that could be considered as research priorities to support WASH system strengthening initiatives. Several panellists emphasised the importance of not reducing WASH systems to a single building block, in that it could lose the sense of an interactive system and inherent linkages across the system. Others noted that some questions were very broad and may have missed some aspects of how political economy underpins any questions on systems strengthening. These were shared with participants in the final webinar and included:

- What are the human resources and capacity needs to strengthen WASH systems?
- What facilitates actors to fulfil roles and responsibilities for sustainable WASH services?
- How does institutional leadership affect WASH provision and transformation of WASH services?
- What are the key drivers for progress towards better coverage and sustainability?
- What is the understanding of Sustainable Development Goal 6 among WASH service providers and other actors?

Results

Characteristics of expert panellists

In total, 173 individuals signed up to participate in the Delphi process. After which, 81 (47%) registered expert panellists consented and participated in Round 1 and 69 (40%) did so for Round 2. Table 2 provides the characteristics of the expert panellists from Rounds 1 and 2. There was a higher response from panellists working for NGOs and academic institutions, but panellists also represented government agencies, donors, and UN agencies. Panellists who indicated “Other” most often belonged to utilities and private sector companies, where indicated. Panellists were from 36 countries, and Fig 2 shows the geographical origin of panellists.

High-priority research questions

Questions were organised into a priority list in terms of the ranked percent agreement produced from this Delphi process. Here we present the top 25 priority research questions to inform WASH systems strengthening initiatives from the list of 77 (Table 3). All 77 research questions ordered by percent agreement can be found in Table B in S1 Text and Table 3.

Table 2. Characteristics of expert panellists.

		Round 1	Round 2
		n (%)	n (%)
Survey response			
	Signed up to participate	173	n/a
	Total participants (N)	81 (47)	69 (40)
	Range of responses	77-80 responses for each question	66-69 responses for each question
Gender			
	Female	25 (31)	20 (29)
	Male	55 (68)	48 (70)
	Prefer not to say	1 (1)	1 (1)
Type of organisation			
	NGO (international)	29 (36)	26 (38)
	Academic institution	13 (16)	17 (25)
	UN agency	3 (4)	5 (7)
	Government	5 (6)	5 (7)
	NGO (local)	13 (16)	2 (3)
	Other	17 (21)	14 (20)
	Donor government agency	1 (1)	0 (0)
Experience of panellists			
	Years of experience (average)	15	15
	Worked on WASH system strengthening	69 (85)	61 (88)

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When research questions were coded, each question was distributed across at least three or four building blocks and the system context, as illustrated in Table 3. Of these, *Learning Adaptation* and *Planning* were the most common building blocks referenced (n = 14, 56%), followed by *Monitoring* (n = 13, 52%) and *Service Delivery and Infrastructure* (n = 11, 44%). Whilst *Institutional Arrangements and Coordination* (n = 8, 32%), *Finance* (n = 7, 28%), *Water Resource Management* (n = 5, 20%), and *Regulation and Accountability* (n = 2, 8%) featured less frequently. Systems context was often considered by the priority research questions, including *Health, Environmental and Education Systems* (n = 7, 28%) and *Political Economy* (n = 4, 16%).

Discussion

This Delphi process has identified a series of research gaps with tractable research questions that could usefully inform and have the potential to substantively enhance incremental improvement of accepted existing WASH systems. The research priorities reflected all WASH system building blocks, with each question linked to at least three of the four domains. Key research topics included understanding the functioning of WASH systems, identifying pathways of change, and addressing systemic challenges of resilience, inclusion, sustainability, and governance. Given the consensus among participants, these research priorities are highly relevant for guiding programme delivery, funding, policymaking, and future research.

Many questions were framed across a variety of WASH systems building blocks or systems context factors. However, whilst they address multiple building blocks and their interactions, there were very few system-wide research questions in the broader sense. This may reflect the structure of the study that encouraged a narrowing down of focus, or may reflect a tendency of the study participants to focus on more concrete technical aspects rather than more cross-cutting dynamics such as the whole system, role of politics, economic conditions, or social attitudes. Nonetheless, we view answering these research questions as informing system strengthening initiatives, rather than assuming that answering these questions

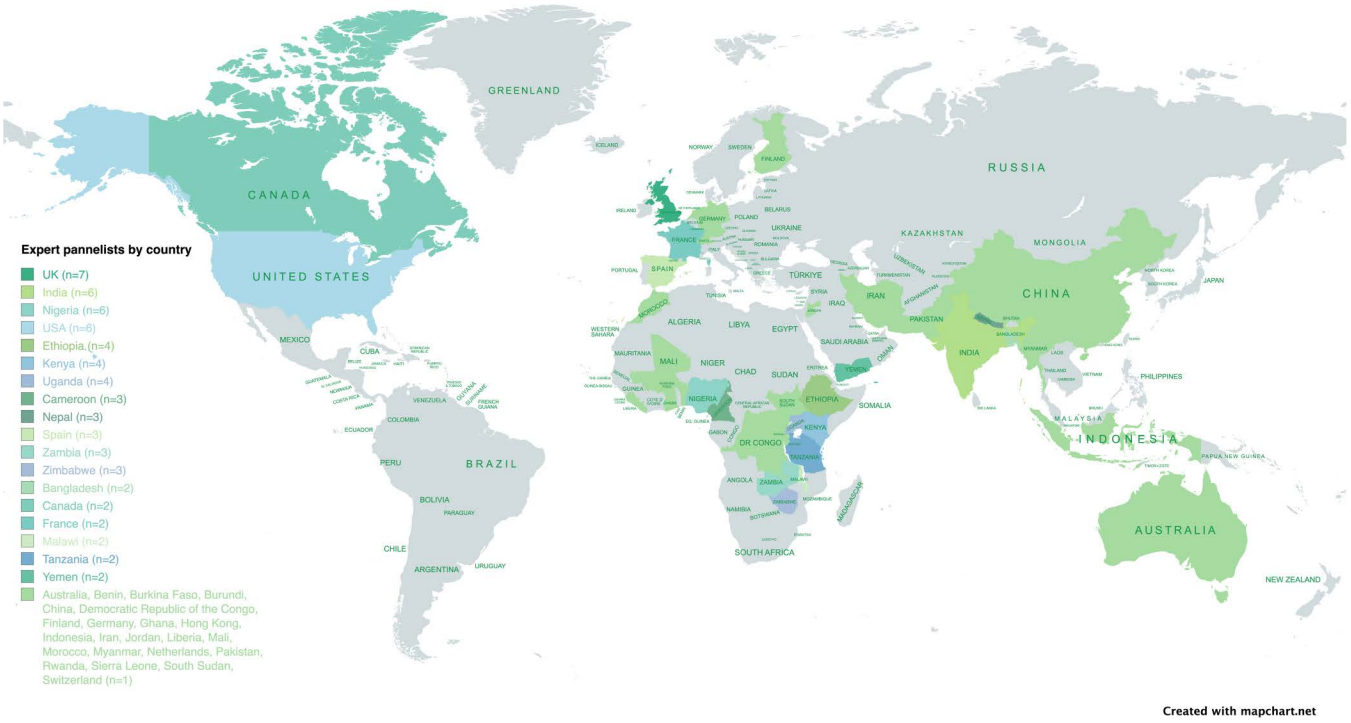

Fig 2. Country of origin among expert panellists across both survey rounds. Produced using https://www.mapchart.net/ and under a Creative Commons Attribution-ShareAlike 4.0 International License.

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would make the systems approach more effective or appropriate in a given context. Additionally, since it can be fundamentally difficult to link systems initiatives with long-term outcomes, such as service improvements or health, in a complex adaptive system in real settings, this study rather sets out to understand what evidence gaps and issues within systems strengthening are the most urgent knowledge priority for actors in a WASH system. Thus, the objective of the work was to identify research and evidence gaps to guide further work and highlight that there are many valuable opportunities for evidence generation on system strengthening.

Five overarching themes appear among the high-priority questions including integration of climate change resilience into WASH system strengthening efforts; enhancing principles of gender, equity and social inclusion (GESI) and human rights into initiatives; capacity development of actors for financial management, accountability frameworks and governance to build stronger systems; monitoring and measurement of systems change; and, a focus on the political economy that supports system strengthening. All of which could be answered through purposive and focused research.

Climate resilient systems

Climate resilience in WASH, the subject of the highest priority question as well as several others, is context-specific, defined by the interplay of local environmental conditions, public health needs, and system-level vulnerabilities. The 2022 UN-Water Global Analysis and Assessment of Sanitation and Drinking Water (GLASS) data shows that the majority of countries have not addressed climate risks or introduced climate resiliency into WASH policies and planning [37]. Understanding such issues as water security through a systems lens could enable researchers and practitioners to identify critical challenges and adapt interventions effectively. However, barriers to climate change adaptation, such as limited financial resources, governance constraints, and community engagement challenges, need to be understood. Evidence is

Table 3. High-priority research questions to support WASH system strengthening.

Research Questions	Building Blocks and Systems Context	Finance	Institutional Arrangements and Coordination	Learning and Adaptation	Monitoring	Planning	Regulation and accountability	Service Delivery and Infrastructure	Water Resources Management	Health, Environmental and Education System	Political Economy	Agreement	Rank
How can climate change resilience and action be effectively integrated into national WASH programmes?						✓		✓	✓	✓		91%	1
What is the effect of approaches designed to achieve 'gender-responsive' WASH services?				✓	✓	✓						89%	2
How can a systems approach be used to integrate gender, equity, and social inclusion in WASH Systems Strengthening programmes?				✓	✓	✓						89%	3
What are the different principles and financing systems that can be employed to ensure sustainable and equitable financing of water management?		✓				✓			✓			88%	4
What are the best practices and strategies for building resilience in water and sanitation systems to protect against unforeseen events, such as pandemics or the effects of climate change?						✓		✓	✓	✓		87%	5
How do we define and monitor climate risk indicators for WASH services, and how do we integrate these into planning for WASH System Strengthening?					✓	✓			✓	✓		87%	6
How can financial and capacity gaps be closed to deliver on policies for WASH in health care settings?		✓	✓	✓						✓		87%	7
How effective are construction standards and accountability frameworks in enforcing quality standards for WASH contractors?			✓		✓	✓	✓	✓				87%	8
How is the climate resilience of WASH services defined in different contexts/systems, and what are the key influencing factors?					✓			✓	✓	✓		86%	9
How can you strengthen government-led WASH monitoring and evaluation systems to achieve strong, transparent, and data-driven decision-making?			✓		✓	✓						86%	10
What are innovative ways to finance and manage capital maintenance and replacement costs in rural water supply (and wider WASH), including pooled funding arrangements and insurance schemes?		✓	✓					✓				85%	11
What specific methods or indicators can effectively and usefully measure and report on the strength and efficacy of WASH service delivery models?		✓		✓				✓				85%	12
What are the key drivers and/or enabling factors in engaging high-level political actors in WASH Systems Strengthening?			✓	✓							✓	84%	13
How can the capacity and financial resources of local government be strengthened to better monitor, plan, and budget for WASH services?		✓		✓	✓	✓						83%	14
How can monitoring and evaluation systems for water supply and sanitation be improved to capture the quality, sustainability, and impact of services, as well as the inputs and outputs?				✓	✓			✓				83%	15
What ways are there to mobilise WASH resources and programmes specifically for vulnerable populations, and how do we monitor progress against targets within these groups?		✓		✓	✓							82%	16
What are effective management models for the operations and maintenance of WASH services in schools and HCFs?		✓					✓	✓				82%	17
What are effective approaches for integrating WASH service improvements with wider rural and urban development programmes?				✓		✓		✓		✓		80%	18

Table 3. (Continued)

Research Questions	Building Blocks and Systems Context	Finance	Institutional Arrangements and Coordination	Learning and Adaptation	Monitoring	Planning	Regulation and accountability	Service Delivery and Infrastructure	Water Resources Management	Health, Environmental and Education System	Political Economy	Agreement	Rank
How can human rights principles be better incorporated in WASH Systems Strengthening so that the poor and most excluded are not left behind?				✓	✓	✓						80%	19
Which are the best methods to measure WASH systems change?				✓	✓							80%	20
How do we move WASH service delivery from basic to safely managed services?				✓		✓		✓				79%	21
How can non-governmental actors in the WASH sector support systems strengthening approaches in practice?			✓							✓	✓	79%	22
What are effective mechanisms to improve (and measure) inclusion and empowerment outcomes in WASH Systems Strengthening programmes?				✓	✓	✓						79%	23
How does the political landscape influence the provision of water and sanitation services?			✓					✓			✓	79%	24
What are the capacity development requirements for WASH System Strengthening?			✓	✓		✓					✓	79%	25
Relative frequency of WASH systems strengthening building blocks and systems context		**7**	**8**	**14**	**13**	**14**	**2**	**11**	**5**	**7**	**4**		

HCFs: Health Care Facilities; WASH: water, sanitation, and hygiene.

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needed to show how climate-resilient WASH can enhance service delivery, ensure equity, and sustain long-term improvements within the WASH system while navigating the broader socio-environmental context [38].

Gender, equity, and social inclusion (GESI) in systems strengthening

Systems strengthening approaches tend to focus on the formal systems that are already in place, albeit weak, whereas exclusion in many cases may be the result of a flawed system that is exclusive by nature or blind to inequalities it creates [39]. The extensive focus on GESI across research priorities demonstrates that panellists are cognisant of this potential limitation and eager to generate more evidence on how systems strengthening can focus on reducing inequalities. While prioritising women, girls, and vulnerable groups is justified due to historical inequities that disproportionately affect them, a singular and unidirectional approach to systems strengthening may overlook broader structural inequalities. A more holistic and intersectional approach is necessary to ensure truly equitable and sustainable service delivery [40–42].

Capacity development for stronger systems

Research questions frequently asked for the implementation and evaluation of effective capacity development initiatives among actors [43,44], particularly to support planning approaches or the use of construction standards, with specific challenges such as the integration between rural and urban service delivery. The sustainability and potential for scaling financial solutions will require complementary investment in addressing basic foundational issues in the management of financial allocations and expenditures, mobilising funding to WASH services and the enabling environment to support effective financial management [45]. There are human dimensions of WASH governance and management, and efforts are needed to improve the capacity of the available and future human resources, particularly if the cornerstone of WASH system strengthening is empowering local governments to assume leadership in implementing reforms.

Measuring systems change

Producing evidence on the causal relationship between system strengthening activities and measurable changes in the WASH system and service delivery is challenging [46]. Research to measure systems change, and at what levels, and what methods are useful and effective for the measurement of systems change, was a common theme among questions. Data for global and regional monitoring of WASH systems is not readily available for many countries through robust national routine monitoring systems, nor can current indicators measure the extent of change, the scale at which these changes occurred, and the hopeful long-term resilience of such changes. In 2024, WHO and UNICEF have called for a "*government-led sector-wide approach to monitoring the strength of WASH systems using national monitoring systems is needed to enable decision-makers to accurately monitor progress and track system performance, assess current strengths and weaknesses, identify investment requirements, plan remedial courses of action, and ensure transparency and accountability*" [47]. Such a global call further amplifies the gap in monitoring information identified in this study. Research efforts are needed to strengthen data systems for effective management and planning of public services, including access to data, engagement of local actors in data collection and analysis, and how to scale monitoring systems to address measuring service delivery. More effort is needed to support the use of evidence within systems policies, foster innovation in areas requiring technological or policy advancements and create feedback loops for end users to address service inequalities and inefficiencies.

Political economy to support system strengthening

Other questions asked for research on how to sustain services when faced with political and administrative changes, including effective institutional arrangements for water resources management in the face of climate change. There was an emphasis on how to keep political stakeholders accountable and how to build accountability and regulation as an

essential part of strong systems that protect both consumers and the environment and can support the long-term sustainability of services [48–51]. Challenges were raised on how to account for local governance failures, maintain political will and commitment to WASH service delivery, identify bottlenecks, and increase collaboration between actors.

Research methods for system strengthening

While the study did not ask about specific methods or types of data, it is clear from the broad spectrum of research questions identified in this Delphi process that systems strengthening research will require a diverse range of methodologies and study designs to effectively address complex challenges. Employing a combination of research designs and methods is necessary, all of which involve close collaboration between researchers and implementing partners, governments, and other stakeholders. Approaches may incorporate mixed-method research designs, leveraging systems theory analysis, such as to improve government-led WASH monitoring, transparency, and data-driven decision-making. Whilst in other instances, outcome evaluations may be applicable in limited cases, such as assessing the effectiveness of gender-responsive WASH interventions, however, many questions require alternative approaches. Additionally, financial and economic analyses will play a crucial role in exploring and testing mechanisms for financing management, capital infrastructure maintenance and replacement costs, particularly in rural water supply systems. Given the complexity and interdisciplinary nature of WASH systems strengthening, addressing these questions effectively will require a diverse set of methodological and theoretical skills, drawing from a range of research disciplines. Further, research may consider exploring practical, scalable interventions that translate these research priorities into actionable strategies towards sustainable WASH service improvements.

Implications of the current political and funding landscape

This research was developed over several years during a period of shifts in the political priorities and declining investment in global health and development, including notable reductions in bilateral aid and competing national priorities. These shifts directly shape the incentives, capacities, and institutional arrangements that underpin WASH system strengthening. As such, interpreting these research priorities requires us to understand power and resource flows and how they influence what evidence is generated and adopted. High-priority questions on governance, inclusion and measuring systems change demand more than technical solutions and require political commitment and institutional accountability, both of which are uncertain in the current time. At the same time, the evolving landscape may incentivise more targeted, cost-effective research that aligns with adaptive programming, strengthening local capacity and leveraging existing systems. By identifying tractable research questions with system-wide relevance, this work aims to support strategic decision-making amid funding uncertainty and political constraints. Recognising these dynamics is essential to ensure WASH systems research meaningfully informs policy and practice in a rapidly changing environment.

Limitations

The results of any Delphi process are shaped by the frame of data collection, who participates, and the analytical processes used. First, there is the challenge of how the research questions were captured. Harvesting of research questions may have missed relevant research questions found in interdisciplinary literature, particularly in areas where WASH system strengthening overlaps with other development sectors. Or that the systems approach ultimately shares similarities with collaborative principles of other public service governance systems or water resources systems [52]. We attempted to mitigate these limitations by explicitly adding a classification that allowed us to include research questions specific to this liminal space. We also attempted to move beyond peer-reviewed and grey literature to capture research priorities articulated in key international fora by the individuals directly engaged with system strengthening efforts but acknowledge that these efforts will not capture all possible research questions related to systems and specifically WASH systems

strengthening or may, in fact, only capture what is popular. Moreover, there may be an over-focus on the nodes or building blocks of a system rather than linkages, interactions, feedback loops and bottlenecks.

In addition, the depth and diversity of participants in this study may have affected the item generation and item review steps of the process [33]. The scientific committee, while selected to reflect diverse disciplinary expertise, was limited to institutions based in the Netherlands and the UK. This lack of geographical diversity may have introduced bias in how research questions were generated and reviewed, particularly in relation to perceptions of what constitutes useful or actionable research, issues inherently tied to broader political economy dynamics. The emphasis on topics such as climate change and GESI may reflect not only global priorities but also the institutional contexts and potential social desirability pressures influencing both the scientific committee and the panellists.

Regarding the panel, while roughly a third of panellists were from development organisations, other key actors, such as government representatives, multilateral agencies and private sector companies, including utilities, were underrepresented among panellists. This composition likely influenced which priorities were elevated. Notably, while practitioners are referenced throughout, the majority of panellists were not direct implementers (i.e., those providing services). The results should therefore be interpreted as what this specific panel group found most relevant, rather than necessarily representative of the wider WASH community. Additionally, we had neither sample size nor diversity to stratify by the type of stakeholder group, and no participation from Central and South America. The survey was also only in English, which may have further limited participation.

Lastly, this Delphi process was influenced by prevailing thinking on WASH system strengthening. We recognise that many of the identified research priorities may not necessarily represent gaps in evidence but rather gaps in knowledge about what evidence exists. While some of these topics may have been explored in existing research, limitations in the dissemination and uptake of evidence continue to hinder their practical application. The selection of priority research questions may therefore reflect the awareness and accessibility of existing evidence among panellists rather than highlighting truly under-researched areas. Addressing these identified knowledge gaps requires not only generating new evidence but also improving how existing knowledge is shared and used.

Conclusions

WASH is a critical global issue, with far-reaching social, health and economic consequences across all levels of development. To address this complexity, there has been a turn towards approaches that aim to strengthen the underlying systems that support service delivery, to ensure long-term efficiency, reliability, and safe services. Recognising this, our study set out to identify actionable research questions that could directly inform decision-making and drive meaningful improvements in systems strengthening efforts. Through a Delphi process, we selected priority research questions rated highly by panellists for their relevance and potential to inform systems strengthening initiatives. This process underscored both the appetite for incremental system improvements and the essential need for contextualising evidence so that non-researcher actors can effectively incorporate it into decision-making. With strong alignment between panellists' priorities, we confidently recommend these research questions and key findings to funders, policymakers, practitioners, and researchers. There is an urgent need for investment in research on measurement and monitoring of systems change, better capacity development for financial and management models, GESI principles, and climate resilience. By answering research priorities on systemic challenges, this study aims to facilitate evidence-based decision-making to improve the reliability, inclusion, and sustainability of WASH services.

Supporting information

S1 Text. Table A: CREDES Checklist. Table B: All 77 research questions, and scores. Table C: Agreement scores between Delphi rounds.
(DOCX)

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References

1. WHO/UNICEF. Joint Monitoring Programme (JMP) for water supply, sanitation and hygiene. https://washdata.org/monitoring
2. Marks SJ, Kumpel E, Guo J, Bartram J, Davis J. Pathways to sustainability: a fuzzy-set qualitative comparative analysis of rural water supply programs. J Clean Product. 2018;205:789–98. https://doi.org/10.1016/j.jclepro.2018.09.029
3. Hutchings P, Chan MY, Cuadrado L, Ezbakhe F, Mesa B, Tamekawa C, et al. A systematic review of success factors in the community management of rural water supplies over the past 30 years. Water Policy. 2015;17(5):963–83. https://doi.org/10.2166/wp.2015.128
4. de Wit S, Luseka E, Bradley D, Brown J, Bhagwan J, Evans B, et al. Water, sanitation and hygiene (WASH): the evolution of a global health and development sector. BMJ Glob Health. 2024;9(10):e015367. https://doi.org/10.1136/bmjgh-2024-015367 PMID: 39366708
5. Barrington DJ, Sindall RC, Chinyama A, Morse T, Sule MN, Beale J, et al. The persistence of failure in water, sanitation and hygiene programming: a qualitative study. BMJ Glob Health. 2025;10(2):e016354. https://doi.org/10.1136/bmjgh-2024-016354 PMID: 40000060
6. Wolf J, Johnston RB, Ambelu A, Arnold BF, Bain R, Brauer M, et al. Burden of disease attributable to unsafe drinking water, sanitation, and hygiene in domestic settings: a global analysis for selected adverse health outcomes. Lancet. 2023;401(10393):2060–71. https://doi.org/10.1016/S0140-6736(23)00458-0 PMID: 37290458
7. Huston A, Moriarty P. Understanding the WASH system and its building blocks. The Hague, Netherlands: IRC; 2018.
8. Johannessen Å, Rosemarin A, Thomalla F, Gerger Swartling Å, Axel Stenström T, Vulturius G. Strategies for building resilience to hazards in water, sanitation and hygiene (WASH) systems: the role of public private partnerships. Int J Disaster Risk Reduction. 2014;10:102–15. https://doi.org/10.1016/j.ijdrr.2014.07.002
9. Valcourt N, Javernick-Will A, Walters J, Linden K. System approaches to water, sanitation, and hygiene: A systematic literature review. Int J Environ Res Public Health. 2020;17(3).
10. Valcourt NR. Understanding the complexities of water, sanitation & hygiene systems through local stakeholder perspectives. Colorado, United States: University of Colorado at Boulder; 2019.
11. Willetts PJ, Carrard DrN, Al'Afghani DrMM. Editorial: systems strengthening and human rights as entry points for WASH. H2Open J. 2022;5(4):686–90. https://doi.org/10.2166/h2oj.2022.104

12. Gensh R, Tillet W. Strengthening sanitation and hygiene in the WASH systems conceptual framework. German Toilet Organization; AguaConsult; Welthungerhilfe; 2019.
13. de Savigny D, Taghreed A. Systems thinking for health systems strengthening. World Health Organization; 2009.
14. Clarkson J, Dean J, Ward J, Komashie A, Bashford T. A systems approach to healthcare: from thinking to -practice. Future Healthc J. 2018;5(3):151–5. https://doi.org/10.7861/futurehosp.5-3-151 PMID: 31098557
15. Witter S, Palmer N, Balabanova D, Mounier-Jack S, Martineau T, Klicpera A, et al. Health system strengthening-Reflections on its meaning, assessment, and our state of knowledge. Int J Health Plann Manag. 2019;34(4):e1980–9. https://doi.org/10.1002/hpm.2882 PMID: 31386232
16. UNICEF. UNICEF WASH systems strengthening: framework 2024. UNICEF; 2024. https://knowledge.unicef.org/wash/resource/unicef-wash-systems-strengthening-framework
17. Jackson M. Systems approaches to management. USA: Springer; 2000.
18. Sanitation and Water for All. Building Blocks and Collaborative Behaviours. [Accessed 2023 October 1]. https://www.sanitationandwaterforall.org/about/our-work/priority-areas
19. Agenda for Change. 2015. https://washagendaforchange.org/strong-wash-systems/
20. WaterAid. 2024.
21. World Bank. Water supply and sanitation policies, institutions, and regulation: adapting to a changing world. 2022.
22. OECD. Paris declaration on aid effectiveness. Paris, France: OECD Publishing; 2005.
23. Walters J, Valcourt N, Linden K, Javernick-Will A, Lockwood H. Challenges and solutions to rural water service sustainability in East African countries: a 'systems scaffolding' perspective. Environ Sci Policy. 2022;136:564–74. https://doi.org/10.1016/j.envsci.2022.07.023
24. Walters JP, Valcourt N, Javernick-Will A, Linden K. Sector perspectives on the attributes of system approaches to water, sanitation, and hygiene service delivery. J Environ Eng. 2022;148(6). https://doi.org/10.1061/(asce)ee.1943-7870.0002010
25. Kimbugwe C, Davis T, Goff F, Greggio E, Chanthet S, Kiap B. Strengthening country-led water and sanitation services monitoring and data use for decision-making: lessons from WaterAid experience in four countries. H2Open J. 2022;5(2):348–64. https://doi.org/10.2166/h2oj.2022.028
26. Dickin S, Syed A, Qowamuna N, Njoroge G, Liera C, Al'Afghani MM, et al. Assessing mutual accountability to strengthen national WASH systems and achieve the SDG targets for water and sanitation. H2Open J. 2022;5(2):166–79. https://doi.org/10.2166/h2oj.2022.032
27. Agenda for Change. Six conditions for institutionalising WASH systems strengthening. 2023.
28. Pugel K, Javernick-Will A, Peabody S, Nyaga C, Mussa M, Mekonta L, et al. Pathways for collaboratively strengthening water and sanitation systems. Sci Total Environ. 2022;802:149854. https://doi.org/10.1016/j.scitotenv.2021.149854 PMID: 34525723
29. Nyanchoka L, Tudur-Smith C, Porcher R, Hren D. Key stakeholders' perspectives and experiences with defining, identifying and displaying gaps in health research: a qualitative study. BMJ Open. 2020;10(11):e039932. https://doi.org/10.1136/bmjopen-2020-039932 PMID: 33172944
30. Garcia-Basteiro AL, Abimbola S. The challenges of defining global health research. BMJ Glob Health. 2021;6(12):e008169. https://doi.org/10.1136/bmjgh-2021-008169 PMID: 34969684
31. Seward N, Hanlon C, Hinrichs-Kraples S, Lund C, Murdoch J, Taylor Salisbury T, et al. A guide to systems-level, participatory, theory-informed implementation research in global health. BMJ Glob Health. 2021;6(12):e005365. https://doi.org/10.1136/bmjgh-2021-005365 PMID: 34969685
32. Diamond IR, Grant RC, Feldman BM, Pencharz PB, Ling SC, Moore AM, et al. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. J Clin Epidemiol. 2014;67(4):401–9. https://doi.org/10.1016/j.jclinepi.2013.12.002 PMID: 24581294
33. Spickermann A, Zimmermann M, von der Gracht HA. Surface- and deep-level diversity in panel selection — Exploring diversity effects on response behaviour in foresight. Technol Forecasting Soc Change. 2014;85:105–20. https://doi.org/10.1016/j.techfore.2013.04.009
34. Agenda for Change. https://washagendaforchange.org/glossary/
35. Niederberger M, Köberich S, members of the DeWiss Network. Coming to consensus: the Delphi technique. Eur J Cardiovasc Nurs. 2021;20(7):692–5. https://doi.org/10.1093/eurjcn/zvab059 PMID: 34245253
36. Schifano J, Niederberger M. How Delphi studies in the health sciences find consensus: a scoping review. Syst Rev. 2025;14(1):14. https://doi.org/10.1186/s13643-024-02738-3 PMID: 39810238
37. UN Water. GLAAS 2022: strong systems and sound investments - evidence on and key insights into accelerating progress on sanitation, drinking-water and hygiene. 2022.
38. Sørup HJD, Brudler S, Godskesen B, Dong Y, Lerer SM, Rygaard M, et al. Urban water management: can UN SDG 6 be met within the planetary boundaries? Environ Sci Policy. 2020;106:36–9. https://doi.org/10.1016/j.envsci.2020.01.015
39. Shiva R, Saha S. Towards gender equity and social inclusion (GESI) responsive WASH systems strengthening. The Hague, Netherlands: IRC; 2025.
40. Marphatia AA, Simiyu S, Flint O'Kane M, Alexander KT, Nascimento de Castro ACA, Azcona G, et al. Gender equality and quality of life must be central to the design and delivery of sanitation. BMJ Glob Health. 2025;10(1):e018238. https://doi.org/10.1136/bmjgh-2024-018238 PMID: 39848639
41. Robinson HJ, Barrington D, Evans B, Hutchings P, Narayanaswamy L. An analysis of gender inclusion in Water, Sanitation and Hygiene (WASH) projects: intention vs. reality. Dev Policy Rev. 2024;42(2). https://doi.org/10.1111/dpr.12741

42. WaterAid. Practical guidance to address gender equality while strengthening water, sanitation and hygiene systems. 2017.
43. Suter F, Lüthi C. Delivering WASH education at scale: evidence from a global MOOC series. Environ Urban. 2021;33(1):99–116. https://doi.org/10.1177/0956247820987759
44. Leal A, Saleh A, Verhoeven J. E-learning for WASH systems strengthening: lessons from a capacity-building platform. H2Open J. 2022;5(2):379–94. https://doi.org/10.2166/h2oj.2022.066
45. Pories L, Fonseca C, Delmon V. Mobilising finance for WASH: getting the foundation right. Water.org, IRC and the World Bank; 2019.
46. Fogelberg K, Lockwood H. Agenda for change: WASH systems change research. synthesis findings from case studies. Unknown; 2023.
47. WHO, UNICEF. Strengthening water, sanitation and hygiene systems – towards a core set of indicators and common framework. 2024.
48. Tortajada C. Water governance: some critical issues. Int J Water Res Dev. 2010;26(2):297–307. https://doi.org/10.1080/07900621003683298
49. Franceys R, Gerlach E. Regulating water and sanitation for the poor. London, UK: Routledge; 2008.
50. UNDP Water Governance Facility, UNICEF. WASH and Accountability: Explaining the Concept. Stockholm and New York: UNDP Water Governance Facility at SIWI and UNICEF; 2015.
51. UNDP Water Governance Facility, UNICEF. Accountability in WASH: A Reference Guide for Programming. Stockholm and New York: UNDP Water Governance Facility at SIWI and UNICEF; 2015.
52. Mdee A, Ofori A, Lopez-Gonzalez G, Stringer L, Martin-Ortega J, Ahrari S, et al. The top 100 global water questions: results of a scoping exercise. One Earth. 2022;5(5):563–73. https://doi.org/10.1016/j.oneear.2022.04.009