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Mapping water, sanitation and hygiene achievements to prosperity, stability, and resilience outcomes

April 2023

Evidence
Gap Map
Report 18

Water, sanitation and waste management



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This report presents the findings of a systematic search, screening, and machine-learning assisted process to identify and map the research base of studies of selected WASH intermediate outcomes and selected prosperity, stability, and resilience outcomes in low- and middle-income countries. All content of this report is the sole responsibility of the authors and does not represent the opinions of 3ie, its donors, or its Board of Commissioners. Any errors and omissions are also the sole responsibility of the authors. Please direct any comments or queries to the corresponding author Sridevi Prasad, sprasad@3ieimpact.org.

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Summary

Background

In 2020, the COVID-19 pandemic brought a renewed focus to water, sanitation, and hygiene (WASH) issues across the globe. The pandemic highlighted that, though there had been significant progress made in the WASH sector, there was still additional work to be done, both in delivering services and in understanding the impacts of such services. Most WASH research has focused on the sector's impacts on human health, and multiple impact evaluations and systematic reviews have addressed this question.

However, the broader implications of WASH on higher-level development outcomes such as prosperity, stability, and resilience have received less attention. As additional resources are leveraged to meet Sustainable Development Goal 6, it is important to understand the link between achieving WASH outcomes and higher-level outcomes, as a means of more accurately understanding the far-reaching impacts of delivering WASH services.

This outcome-to-outcome systematic map aimed to go beyond the effects of WASH on health to understand the research base on the associations between achieving intermediate WASH outcomes (improving access to drinking water and sanitation facilities, and increasing practices of hygiene behaviors) and high-level development outcomes (improved prosperity, increased stability, and enhanced resilience) in low- and middle-income countries.

It serves as one of the first research maps to focus explicitly on these outcomes and the relationships between them. Specifically, we address the following research questions:

1. What are the extent and characteristics of the literature on the association between selected WASH intermediate outcomes and selected prosperity, stability, and resilience outcomes in low- and middle-income countries?
2. What are the major primary research and synthesis gaps in the literature?
3. What outcome areas could be prioritized for primary research and/or evidence synthesis?

Methods

We used systematic search and screening methods, assisted by a machine learning process, to identify studies for inclusion in this map. Relevant studies assessed the association between achieving a WASH outcome and achieving one of the high-level outcomes of interest. Full inclusion criteria are presented in [Appendix A](#). We extracted descriptive information from all included studies and critically appraised included systematic reviews. We extracted summaries of findings from systematic reviews that had a medium- or high-confidence quality rating.

Using the International Initiative for Impact Evaluation's evidence gap map software, we created an online, interactive map of all included studies, organized according to a framework of intermediate WASH outcomes and reported high-level outcomes. This provides a visual display of the volume of research, the type of research (impact evaluation, systematic review, observational study, completed or ongoing), and a confidence rating of the quality of systematic reviews. The interactive map provides additional filters so that users can further explore the available evidence, for example by

global regions, income levels, or population. The WASH Systematic Map can be viewed at this link [here](#).

Main findings

We identified 41,639 records from our search, out of which 279 studies were included. We included 211 quantitative observational studies, 49 impact evaluations, and 19 systematic reviews. The majority of studies were published between 2016 and 2021 (n = 213).

We identified studies spanning many contexts, but with a heavy concentration of research in just a few countries and a lack of focus on marginalized populations. Studies were set in diverse geographic contexts and spanned 104 low- and middle-income countries. However, Kenya (n = 40), India (n = 36), and Ethiopia (n = 33) had the greatest number of studies. WASH programming frequently targeted participants on the basis of gender (n = 80) or socioeconomic status (n = 38), but few studies targeted indigenous (n = 1) or displaced populations (n = 4), or on the basis of disability status (n = 4).

Intermediate WASH outcomes are generally well represented in the map, with research concentrations primarily among WASH access outcomes and a research gap for safe food hygiene. Most included studies examined the association between access to drinking water (n = 91) or access to sanitation and/or hygiene (n = 71) and a high-level outcome. A large number of studies also looked at multiple intermediate WASH outcomes, often combining access to drinking water with other aspects of WASH.

We found a cluster of studies that analyzed *drinking water systems that had been sustainably operated, managed, or maintained* (n = 28), but did not identify any medium- or high-quality systematic reviews on the topic, indicating an opportunity for future synthesis work. Few studies looked at the association between the *uptake of safe food hygiene practices* (n = 3) and high-level outcomes.

Most studies link WASH outcomes to high-level outcomes in the prosperity domain, but we found several research gaps among the stability and resilience outcome domains. Most included studies measured high-level outcomes related to *education* (n = 92), *livelihoods* (n = 97), or *public perceptions of institutions* (n = 99). Although we identified a research concentration on the association between WASH outcomes and these topics, there are relatively few impact evaluations investigating the causal links between them, and there is a general lack of quality research synthesis on these topics.

We did not find many studies that looked at *conflict* (n = 3) or at *climate-linked outcomes* (n = 3). No includable studies examined the association between WASH outcomes and *climate-linked migration*. This gap is due to the inclusion criteria: studies examining migration outcomes were excluded, as migration was not linked to climate change.

There is a lack of quality synthesis work in the research base on WASH outcomes. From the systematic review critical appraisal, we rated only one systematic review as high confidence and one systematic review as medium confidence. All other systematic reviews were rated as low confidence, as the authors either did not conduct a quality appraisal of included studies, did not independently screen studies, or had limitations in their search strategy.

The high-confidence systematic review on menstrual hygiene and health found mixed effects of *enabling environments for menstrual health and hygiene* on *education* and *women's empowerment*-related outcomes. Authors of the medium-confidence systematic review on *drinking water quality* and *pollution* identified two technologies that showed promise in removing arsenic from groundwater. Generally, studies included in these two systematic reviews were rated as having a high risk of bias; therefore, their results should be interpreted with caution.

Conclusions and implications

Overall, we found a moderate volume of research on the association between WASH outcomes and high-level outcomes, but a relative lack of causal research in this arena. There are multiple primary research gaps within this map, particularly in the resilience domain and the *conflict* outcome within the stability domain, as defined by the inclusion criteria. The map also identifies research clusters where additional causal analysis and synthesis work could be conducted, particularly on drinking water systems management and public perceptions of institutions.

Users should take care in interpreting study findings: observational studies investigate whether there is a relationship between outcomes, impact evaluations explore causal links between outcomes, and systematic reviews may examine either, depending on the research question. Policy makers, program implementers, and researchers can consult the map for findings and contextual implications identified in individual studies, and utilize this information when designing programs or theories of change, or when considering where additional research should be commissioned.

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List of acronyms

EGM	Evidence gap map
IE	Impact evaluation
L&MICs	Low- and middle-income countries
MHH	Menstrual health and hygiene
RFS	Bureau for Resilience and Food Security
SR	Systematic review
WASH	Water, sanitation, and hygiene

1. Introduction

The International Initiative for Impact Evaluation (3ie), the Massachusetts Institute of Technology, and the University of Notre Dame were commissioned by the US Agency for International Development's (USAID) Bureau for Resilience and Food Security (RFS) in 2021 to support enhanced intersectoral and bureau-wide use of evidence for programmatic decision-making. RFS is the Agency's home for resilience and food security programming; it coordinates the US government's global strategies in food security and water, as well as the Agency's multi-sectoral nutrition strategy.

RFS comprises three offices and four technical centers, which bring together programmatic and technical expertise in agriculture-led growth; water security, sanitation and hygiene; nutrition; and resilience. The RFS Evidence Aggregation for Programmatic Approaches (REAPER) project was designed to serve two primary aims. The first is to present a systematic evidence gap map (EGM) underlying the bureau's strategic approaches in its four technical areas and its cross-cutting areas on inclusive development and policy. The second is to explore and incorporate machine learning and automation methods to aggregate and accelerate the production of EGMs. This goal was in service to the primary aim of mapping and presenting findings on the evidence base.

This systematic map report presents the findings of a systematic search, screening, and machine-learning-assisted process to identify and map the research base of studies of selected WASH intermediate outcomes and selected prosperity, stability, and resilience outcomes in low- and middle-income countries (L&MICs).

1.1 Structure of this report

This report is organized as follows:

- Section 2 presents the subject background.
- Section 3 presents the scope.
- Section 4 presents a brief discussion of systematic map methods. More information can be found in the appendices.
- Section 4 presents findings.
- Section 5 concludes and provides a set of considerations for future policy and research.

2. Background

2.1 Development problem being addressed

Access to services and knowledge of appropriate practices for water, sanitation, and hygiene (WASH) are expected to improve prosperity, enhance resilience, and increase stability.

The COVID-19 pandemic highlighted the importance of handwashing and associated behavior change interventions to improve hygiene practices when helping countries to navigate the pandemic (Stoler et al. 2020). But it also underscored the extensive work still needed to reach Sustainable Development Goal 6 of clean water and sanitation for all (Stoler et al. 2020). As of 2020, over 2 billion people still lacked access to safely managed drinking water (UN 2022), approximately 3.6 billion did not have access to safely managed sanitation, and 2.3 billion did not have basic hygiene infrastructure, including 670 million people without handwashing facilities (UNICEF and WHO 2021).

Along with the need to extend WASH services to individuals, the WHO has also emphasized that healthcare facilities require adequate WASH services (WHO, 2019). In 2021, 78 per cent of healthcare facilities had access to basic water services, and 51 per cent had basic hand hygiene services (WHO and UNICEF 2022). In the least-developed countries, 21 per cent of healthcare facilities had access to basic sanitation services (WHO and UNICEF 2022). However, most countries still had not included WASH indicators in national health systems monitoring or generated national strategies to be able to meet these targets (WHO and UNICEF 2020).

The most immediate effects of inadequate WASH are on human health. Multiple studies have examined how improving access to clean drinking water reduces waterborne diseases such as diarrhea, cholera, and schistosomiasis (Fewtrell et al. 2005; Grimes et al. 2014; Strunz et al. 2014; Taylor et al. 2015; Wolf et al. 2018; Prüss-Ustün et al. 2019).

Large-scale randomized controlled trials have studied the impacts of combined WASH interventions on stunting and other nutrition-related outcomes (Cumming and Cairncross 2016; Luby et al. 2018; Null et al. 2018; Humphrey et al. 2019; Bekele et al. 2020). The link between improved access to sanitation and the reduction of fecal-oral diseases have been well enumerated (Brown et al. 2013; Strunz et al. 2014). Though WASH primarily affects health, it also impacts lesser-studied systemic outcomes, such as prosperity, stability, and resilience.

Inadequate WASH can impact prosperity by reducing access to education and hampering the growth of small and medium-sized enterprises. Improving prosperity includes improving people's productivity and the ability for businesses and markets to thrive, and supporting economic growth (USAID 2017, 70). Women and girls without access to WASH are often disproportionately impacted relative to men and boys, as they spend more time collecting water or are unable to attend school due to lack of sanitation facilities and an enabling environment to support menstrual hygiene (Graham et al. 2016; Tull 2019). This then affects their ability to use their time for other tasks or to join the workforce.

Improving WASH services in schools can also improve equity and empowerment outcomes for girls, through the provision of separate latrines and menstrual products that can reduce menstruation-related school absenteeism (WHO and UNICEF 2020). Providing access to clean drinking water and sanitation facilities on school grounds ensures that students and school staff do not need to go off-premises to drink water or to use the toilet (WHO and UNICEF 2020). With access to these facilities on the school premises, students and staff are able to spend more time in the classroom, and therefore have better educational opportunities. Poor water supply has also been found to impede the growth of small and medium-sized enterprises, thereby affecting overall economic growth (Olawale and Garwe 2010; Selelo et al. 2017).

There has been some research studying the impacts of WASH on building stability. Building stability within a society requires a reduction of conflict at all levels (from interpersonal to interstate) and building trust in, and legitimacy of, institutions (USAID 2017, 70). Though there has not been substantial research assessing the impact of WASH on societal stability, WASH interventions have been found to impact political governance and stability, as the provision of such services can improve perceptions of political leaders (JPAL South Asia 2014). Water insecurity can exacerbate strained relations between

countries that share drinking water sources; therefore, improving the availability and accessibility of safe drinking water can reduce international conflict (Levy and Sidel 2011). Improving access to safe drinking water can also reduce interpersonal conflict, especially gender-based violence (Pommells et al. 2018).

WASH is an important determinant in enhancing resilience and is a key infrastructure system affected by resilience interventions. Enhancing resilience entails improving the ability of people, households, communities, systems, and countries to adapt to and recover from shocks and stressors (USAID 2022). The provision of WASH services is critical in emergency and humanitarian settings; however, its role in humanitarian settings is understudied when assessing effectiveness (Als et al. 2020). The sectoral focus remains on researching gaps relative to health outcomes, rather than higher-level resilience outcomes (Lantagne et al. 2021).

The increasing threat of climate change leaves water and sanitation services more at risk. Increasing temperatures and changes in rainfall can impact the availability of safe drinking water sources, increase the transmission of water-borne diseases, and damage infrastructure that can then impact human health (Howard et al. 2016; Romanello et al. 2021; UNICEF n.d.). Sanitation also increases greenhouse gas emissions via containment and treatment processes, though additional research is still needed to quantify this impact (Howard et al. 2016; Johnson et al. 2022). Household water insecurity has also been linked to migration-related climate change (Stoler et al. 2021).

2.2 Policy response

As part of the 2030 Agenda for Sustainable Development, Sustainable Development Goal 6 (SDG 6) focuses specifically on ensuring availability and sustainable management of water and sanitation for all. It calls for universal access to safe and affordable drinking water, sanitation, and hygiene, as well as improvement in water quality by 2030 (UN n.d.). Compared to the previous Millennium Development Goals, which focused on providing basic WASH services, SDG 6 emphasizes moving populations up the WASH service ladders – from basic WASH services to safely managed WASH services (WHO and UNICEF 2021).

A wide variety of actors from the private sector, public sector, and international aid agencies have funded and implemented interventions to increase WASH coverage. National governments have created or revised their drinking water, sanitation, and hygiene policies to be aligned with SDG 6 (WHO and UN Water 2019). However, these plans rely on the availability of sufficient financing to be successful.

In 2019, \$8.8 billion in official development assistance was disbursed to the water sector (UN Water 2021), with over 30 per cent going to countries within Sub-Saharan Africa. Within the humanitarian WASH sector, over \$650 million was spent in 2021 (Humanitarian Funding Forecast 2022). Most of this funding was provided by high-income governments such as the US and UK, or from multilateral institutions such as UNICEF. Additional emphasis has been placed on diversifying WASH-sector funding sources with programs such as USAID's WASH-FIN investing resources to close financing gaps within the sector (USAID n.d.).

However, these resources are still not enough to address the lack of progress on SDG 6. Analyses by the Water Resource Institute found that delivering sustainable water management globally would cost approximately \$1.03 trillion per year. Ensuring global access to drinking water and sanitation would cost \$113 billion and \$150 billion annually, respectively (Strong et al. 2020). To improve access to basic hand hygiene services would cost between \$12.1–15.3 billion over the next ten years (Ross et al. 2021). As of 2020, achieving universal access to WASH by 2030 would require that the current rates of progress be quadrupled (WHO and UNICEF 2021).

There must be additional focus on L&MICs, populations in fragile contexts, and the most marginalized, as they are most at risk of not having access to improved WASH (WHO and UNICEF 2021). Ensuring full coverage of basic WASH in healthcare facilities is estimated to cost between \$6.5–9.6 billion from 2021–2030 (Chaitkin et al. 2022).

2.3 Contribution to the literature

There has been substantial WASH research conducted over the past 50 years. 3ie's Development Evidence Portal has 297 WASH impact evaluations (IEs) and 53 systematic reviews (SRs). Though a global study on WASH research trends has not yet been conducted, SRs that compiled literature within individual countries – regardless of study design – found 272 studies set in Indonesia and 121 set in the Pacific Islands (MacDonald et al. 2017; Satriani et al. 2022). However, most of the studies included in these reviews and in the Development Evidence Portal primarily focused on achieving intermediate WASH outcomes or on health-related outcomes.

Previous mapping and evidence synthesis efforts have primarily focused on the health impacts of WASH interventions (Fewtrell et al. 2005; Jasper et al. 2012; Grimes et al. 2014; Stocks et al. 2014; Strunz et al. 2014; Taylor et al. 2015; Cumming and Cairncross 2016; Wolf et al. 2018; Mackinnon et al. 2019; Bekele et al. 2020; Chirgwin et al. 2021; Prasad et al. 2021). Other SRs focused on intermediate WASH outcomes, such as latrine coverage, but did not connect these to higher-level outcomes (Igaki et al. 2021). Even SRs that studied the relationship between climate change and WASH primarily focused on the impacts of climate change on waterborne diseases (Bouzid et al. 2013; Levy et al. 2016).

However, understanding the high-level impacts of achieving WASH outcomes that go beyond health is gaining importance as a means of informing the significant future investments needed to achieve SDG 6. By looking at the associations between achieving WASH outcomes and high-level outcomes, we can more accurately measure a more complete return on investment.

Focusing on these higher-level outcomes has become a growing area in the WASH sector. Chirgwin and colleagues (2021) found that more studies published after 2009 reported on socioeconomic outcomes. Though the area may be understudied, there is growing research on return on investment in WASH. This map serves to fill the research gap for higher-level outcomes by identifying the literature base assessing associations between achieving WASH outcomes and high-level, systemic outcomes. This study is the first systematic map to use an outcome-to-outcome mapping methodology.

2.4 Study objectives and questions

This project aims to identify, describe, and make available the literature that quantifies the association between selected WASH intermediate outcomes and selected high-level outcomes outside the health domain in L&MICs.

To meet this aim, the specific objectives of this systematic map are threefold:

1. Identify, describe, and summarize the literature that quantifies the association between selected WASH intermediate outcomes and selected prosperity, stability, and resilience outcomes in L&MICs;
2. Improve access to this literature for policy makers, researchers, and the development community; and
3. Identify potential primary research and synthesis gaps.

Research questions addressed by this study are presented in Table 1.

Table 1: Systematic map research questions

No.	Research question	Type
RQ1	What are the extent and characteristics of the literature on the association between selected WASH intermediate outcomes and selected prosperity, stability, and resilience outcomes in L&MICs?	Coverage
RQ2	What are the major primary research and synthesis gaps in the literature?	Gaps
RQ3	What outcome areas could be prioritized for primary research and/or evidence synthesis?	Research needs

This systematic map is a visualization of the research landscape, so it does not provide interpretation, analysis, or synthesis of the research content. It also does not focus on implementation considerations, such as how to effectively deliver WASH, whom to target, or how to scale. USAID is exploring these questions through the Global Water Strategy Action Research Initiative, available [here](#). However, this systematic map provides an important entry point for understanding where the research exists, including where WASH outcomes have been achieved among different populations, and where more research may be needed. It supports consideration of WASH along the causal chain of social change beyond the typical focus on interventions and initial outcomes – such as health outcomes.

This report serves as an accompaniment to the interactive map. In this report, we address the key research questions through analysis of the characteristics of available evidence and key trends (i.e., number of studies published over time, geography, focus on intermediate outcomes and high-level outcomes, targeted populations).

3. Scope

3.1 Conceptual framework

We used the WHO/UNICEF Joint Monitoring Programme's definitions of drinking water, sanitation, and hygiene to define WASH and as the starting point for the conceptual framework that sets out the scope of our systematic map (WHO and UNICEF n.d.[a,b,c,d]). Though the water sector encompasses more than just drinking water, we are not focusing on broader water governance or integrated water resource management. Both water

governance and integrated water management interventions operate through different theories of change than WASH interventions. By focusing solely on the drinking water aspect of the water sector, the outcomes that are achieved operate through similar theories of change as sanitation and hygiene interventions. For this reason, drinking water interventions are often combined with sanitation and/or hygiene interventions.

The drinking water outcomes we examine (presented in Section 3.2) focus on outcomes that improve “the accessibility, availability and quality of the main source used by households for drinking, cooking, personal hygiene and other domestic uses” (WHO and UNICEF n.d.[a]). Interventions to achieve this can include the construction of boreholes, connections to piped water systems, or provision of chlorine and water filters to improve water quality, among others. They can also include systems interventions that focus on water utilities and surveillance systems.

Sanitation outcomes focus on improving the “management of excreta from the facilities used by individuals, through emptying and transport of excreta for treatment and eventual discharge or reuse” (WHO and UNICEF n.d.[d]). Interventions to achieve this can include the construction of latrines or wastewater treatment plants, behavior change interventions to reduce open defecation, or technologies to support fecal sludge management, among others.

The final domain of WASH is hygiene, which also includes menstrual health. Hygiene encompasses “practices that help maintain health and prevent spread of disease including handwashing, food hygiene, and menstrual hygiene management” (WHO and UNICEF n.d.[b,c]). Interventions to achieve hygiene outcomes include provision of handwashing stations with soap or menstrual health products, or behavior change interventions to improve food handling and preparation.

We focus on three domains for high-level outcomes, as determined by USAID RFS’s Center for Water Security, Sanitation and Hygiene’s Global Water Strategy (USAID 2022). These three domains are: improving prosperity, enhancing resilience, and building stability. Prosperity outcomes are those that improve the productivity of populations, allow businesses and markets to thrive, and support economic growth (USAID 2017, 70). Outcomes in this domain include education, livelihoods, women’s empowerment, benefits to enterprise, and economic growth.

Resilience outcomes refer to the ability of people, households, communities, systems, and general society to respond to shocks and stressors (USAID 2022). Within the context of this map, resilience outcomes are restricted to climate change-related stressors (food insecurity, economic challenges, migration, and natural disasters) and pollution.

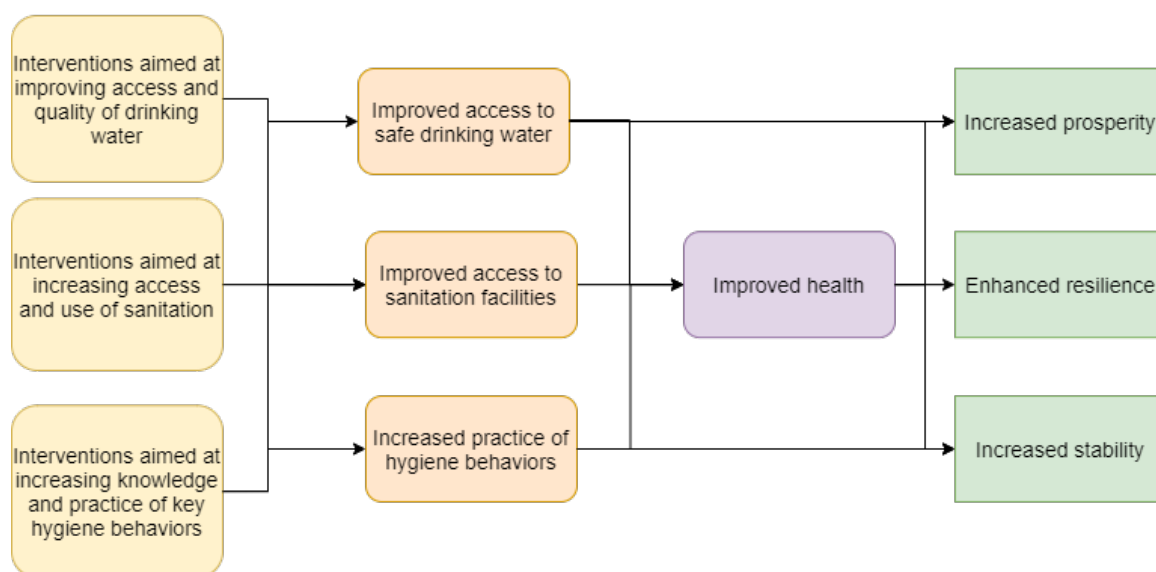
The final high-level outcome domain is stability. Stability refers to reduced conflict and legitimate and trustworthy institutions (USAID 2017, 70). Stability outcomes include public perceptions of institutions, governance processes or services, and conflict from the intrapersonal to the interstate scale.

There are many different interventions that are implemented within the WASH sector, and they can often be combined. They typically target three intermediate outcomes (Figure 1), which can be summarized in three broad domains: (1) improved access to safe drinking water; (2) improved access to sanitation facilities; and (3) increased practice of hygiene

behaviors. These intermediate outcomes can lead to improved health and ultimately increased prosperity, enhanced resilience, and increased stability.

There are also pathways that lead directly from the intermediate outcomes to increased prosperity, enhanced resilience, and increased stability that are not mediated through improved health. The foci of this map are the orange outcomes (intermediate WASH outcomes) and the green outcomes (high-level, systemic outcomes). A detailed theory of change can be found in [Appendix A](#).

Figure 1: High-level theory of change for how WASH might affect high-level outcomes



3.2 Intermediate and high-level outcomes covered by the systematic map

3.2.1 Intermediate WASH outcomes

By intermediate WASH outcomes, we are referring to measures of immediate aims within the WASH theory of change that are achieved due to the successful implementation of WASH interventions. We used the Center for Water Security, Sanitation, and Hygiene’s strategic approaches as the basis for identifying the intermediate WASH outcomes listed on the y-axis of the map. Specifically, the Center determined that the scope of this map should focus on two of their four strategic approaches: (1) achieving access to sustainably managed drinking water and improvements in service quality; and (2) achieving access to sustainably managed sanitation and increasing uptake of key hygiene behaviors.

Descriptions of each intermediate WASH outcome category are listed below. To be eligible for inclusion, studies had to demonstrate improvement in one of these outcomes.

Table 2: Intermediate WASH outcome details

Intermediate WASH outcome	Description	Exclusion criteria
Drinking water outcomes		
Improvement in drinking water systems' sustainability management, operations, and maintenance	<p>Improvements in management, system monitoring, oversight, preventative or responsive maintenance, system repairs, and operation of drinking water supply systems (reliable water supply; reduction in non-revenue water; improved billing and financial management; improved infrastructure and reduction in leaks; improved monitoring processes)</p> <p>Improvements in water service authorities'¹ capacities (training and qualifications completed or obtained; increased knowledge, skills, abilities; improved performance and adherence to regulations and standards)</p>	Exclude studies focusing on management, operations, or maintenance of river/watershed basins, industrial water sources, irrigation systems, broader integrated water resource management, and water governance not related to drinking water supply
Improvement in water utility consumer relations	Measures of new consumer sign-ups; reduction in complaints; improved revenue collection from consumers paying; improvements in incorporating community comments	Exclude utilities that do not disaggregate drinking water provision from other water provision (irrigation/agriculture, industrial water, water resource management)
Improvement in external agencies' and local surveillance systems' capacity to provide oversight and regulatory functions of drinking water systems	Improvements in external oversight agencies' and local surveillance systems' capacities (i.e. training and qualifications completed or obtained; increased knowledge, skills, abilities; improved performance and adherence to regulations and standards); improved oversight and regulation of water service providers (i.e. compliance with policies and monitoring processes; lack of violations). Oversight agencies and local surveillance systems include institutions that are separate from the water supplier.	Exclude studies focusing on oversight and regulatory functions of river/watershed basins, industrial water sources, irrigation systems, broader integrated water resource management, and water governance not related to drinking water supply
Improvement of drinking water quality in drinking water systems	Measures of the change in water quality (physical, chemical, or biological contaminants) in improved drinking water systems (piped water supply, boreholes, wells, taps, community standpipes, water tankers)	Exclude irrigation, non-potable water, non-improved water drinking sources (surface water, unprotected wells or springs)

¹ Service authorities refer to any institutions that provide water, sanitation, or hygiene services and include water and sanitation utilities (publicly or privately owned), government agencies, or ministries that manage WASH, and non-governmental entities that provide WASH infrastructure.

Intermediate WASH outcome	Description	Exclusion criteria
Increased access to enhanced drinking water services	Measures of the participants who have access to and/or use enhanced drinking water service levels (limited, basic, safely managed) as defined by the WHO/UNICEF Joint Monitoring Programme. ² Change can either occur within an enhanced drinking water service level, or from a non-enhanced drinking water service level to an enhanced drinking water service level.	Exclude irrigation, non-potable water, or non-improved water drinking sources (i.e. surface water, unprotected well or spring) if only focus of study
Increased uptake of safe drinking water management practices by individuals and communities	Measures of participants who start practicing safe drinking water management, including safe storage, point-of use testing and treatment, avoidance of recontamination	Exclude irrigation, non-potable water, or non-improved water drinking sources (surface water, unprotected wells or springs) if only focus of study
Sanitation and hygiene outcomes		
Improvement in management and oversight of communal or public sanitation and/or hygiene facilities	Improvements in management, regulation, oversight, maintenance, conditions, and operation of communal or public sanitation or hygiene facilities Improvements in sanitation and hygiene service authorities' capacities (training and qualifications completed or obtained; increased knowledge, skills, abilities; improved performance, customer service, and adherence to regulations and standards)	Exclude wastewater treatment that does not have to do with sewage or fecal waste, such as slaughterhouse or abattoir or industrial waste, wastewater, or effluent
Increased demand for sanitation and/or hygiene facilities, products ³ and/or services ⁴	Measures of demand for sanitation and/or hygiene facilities, products and/or services	Exclude oral or dental hygiene
Expansion of functioning markets for sanitation and/or hygiene products and/or services	Measures of commercial supply and/or availability of sanitation and/or hygiene products and services, may be from either private or public sources, involves a purchase price	Exclude oral or dental hygiene

² Joint Monitoring Programme definitions of drinking water service levels can be found [here](#).

³ Sanitation and hygiene products include toilets, soap, sanitizing agents, detergents, disinfectants, washing stations, toilet tissue, wipes, or personal washing supplies; MHH products include sanitary pads, tampons, menstrual cups, and reusable menstrual products.

⁴ Sanitation and hygiene services include the provision and maintenance of toilet or latrine facilities, waste management (transportation and treatment), sewer connections, provision of handwashing facilities, etc.

Intermediate WASH outcome	Description	Exclusion criteria
Increased consistent and convenient access to sanitation and/or hygiene products and/or services	Measures of both access (the potential to use these items, improvements in coverage and accessibility) and use (the number of people who use these items), as study authors may not always be clear about this distinction	Exclude oral or dental hygiene
Expansion of enabling environments for menstrual health and hygiene (MHH)	Measures to facilitate MHH are implemented or expanded (menstrual supplies provided, private washrooms, disposal options)	Exclude studies that only focus on barriers to MHH
Increased uptake of hand hygiene practices by individuals and communities	Measures of participants who start practicing handwashing with soap or hand sanitization	Exclude oral or dental hygiene
Increased uptake of safe excreta disposal practices by individuals and communities	Measures of participants who start practicing the safe disposal of feces – includes on-site fecal waste collection and treatment and all fecal waste management through non-centralized systems.	Exclude studies that focus on change in unimproved sanitation sources ⁵ (pit latrines without a slab or platform, hanging latrines or bucket latrines)
Increased uptake of safe food hygiene practices by individuals and communities	Measures of participants who start practicing safe food hygiene: washing hands before food handling and eating, using clean food preparation surfaces and utensils, avoiding cross-contamination of raw and ready-to-eat foods, cooking foods to appropriate temperatures, serving and storing food at appropriate temperatures	Exclude oral or dental hygiene

3.2.2 High-level outcomes

We refer to large-scale development aims along the WASH theory of change – beyond the focus of much WASH literature on near-term change in behaviors, uptake, diarrhea and other waterborne illnesses – as high-level outcomes. The three outcome domains considered, which reflect higher-level social change, were: improving prosperity, building stability, and enhancing resilience. Descriptions of each high-level outcome category are listed below. Studies must demonstrate that at least one of these outcomes has been measured in order to be included in the map. Studies did not need to demonstrate that the high-level outcome has been achieved; positive, negative, or null associations were included.

⁵ Joint Monitoring Programme definitions of sanitation service levels can be found [here](#).

Table 3: High-level outcome details

High-level outcomes	Description	Exclusion reason
Prosperity outcomes		
Education	Measures of school enrollment, registration, presence or absence, drop-out rate, advancement or graduation or completion at the primary, secondary or tertiary level. Learning outcomes such as test scores, literacy and numeracy skills, and academic achievement	Measures of cognitive development, early childhood development, child development, biological indicators, outcomes measuring achievements outside of a school or classroom educational setting such as tutoring, after-school programs, and extra-curricular activities
Livelihoods	“The activities, the assets, and the access that jointly determine the living gained by an individual or household” (Ellis 1999). Specifically, these include income-generating and productive activities; physical and financial assets and intangible assets such as knowledge, skills, social capital; and the ability of individuals and households to access these resources and opportunities.	Exclude livelihoods that are focused on provision of water, sanitation products, or hygiene products
Women's empowerment	<p>“...a process by which women who have been denied the ability to make strategic life choices acquire such an ability” (Kabeer 1999; see also Perezniето and Taylor 2014 for dimensions of women's economic empowerment). Includes measures of women's advancements in the following areas:</p> <ul style="list-style-type: none"> • Resources: material, human, and social resources that serve to enhance the ability to exercise choice, including time and time-use studies; • Agency: the ability to define one's goals and act upon them, and operationalized decision-making; and/or • Achievement: ways of being and doing which can be realized by different individuals. 	Exclude studies that do not disaggregate outcomes by gender (e.g., studies that focus on time use but not disaggregated by gender)
Benefits to enterprise	Micro- or meso-level economic benefits: innovation, start-ups, expansion and growth, job creation, productivity, profitability, investment and funding, risk and loss mitigation for enterprises of all sizes, public and private. Pertains to businesses operating above the household level	Exclude enterprises that focus on provision of water, sanitation products, or hygiene products
Economic growth	Macro-level economic benefits: GDP growth, market development, sector growth and development, trade	Exclude inequality indices

High-level outcomes	Description	Exclusion reason
Stability outcomes		
Public perceptions of institutions	Public perceptions of service reliability, service equity, trust in water provision and quality, performance of officials, satisfaction, public approval; confidence in WASH services as measured in willingness to pay, fees paid, ratings	Exclude studies that focus on perception of water quality
Governance processes or services	Adoption of institutional (public or private sector) improvements in transparency and accountability, participation and inclusion, bureaucratic processes, infrastructure and service provision, reform, timely response, upholding access to WASH as a basic human right as well as specific water access and ownership rights. Includes reductions in corruption, defined as: the abuse of entrusted authority for private gain (USAID 2005).	Exclude improvements to WASH systems themselves
Conflict	Conflict prevention (inter-personal to inter-state scale): preventing, reducing, and addressing violence, abuse, disputes, grievances, theft, conflict, war. Peacebuilding: social cohesion, reconciliation between different groups, increased understanding and trust between different groups, collaborative contact to get different groups working together, or intergroup dialogue to build trust.	Exclude peacekeeping forces
Resilience outcomes		
Climate-linked food insecurity	Food insecurity outcome areas when explicitly linked to climate change : hunger, food availability, food access, malnutrition, stunting, wasting, suboptimal child growth outcomes, low birthweight, micronutrient deficiencies including anemia	Exclude general food insecurity studies not linked to climate change
Climate-linked economic challenges	Economic hardship outcome areas when explicitly linked to climate change : poverty, crop loss, asset loss, debt, any household economic hardship	Exclude broader economic challenges studies not linked to climate change
Climate-linked migration	Migration outcome areas when explicitly linked to climate change : emigration, immigration, internal migration, displacement, refugees and asylum seekers	Exclude migration studies not linked to climate change
Resilience to climate-linked natural disasters	Measures of individuals', communities', or countries' ability to mitigate, adapt to, and recover from shocks and stressors due to natural disasters such as floods, droughts, landslides, extreme storms, extreme temperatures, fires, sea level rises or others when these events are explicitly linked to climate change . Resilience: "The ability of people, households, communities, countries, and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth" (USAID 2012).	Exclude natural disasters studies not linked to climate change

High-level outcomes	Description	Exclusion reason
Pollution	<p>Pollutant(s) in a body of water or watershed. A pollutant is defined as a "substance which disrupts and interferes with the equilibrium of a water system and impairs the suitability of using the water for a desired purpose" (UNEP 2018, 18). Pollutants may include chemicals, salinity, organic matter and excess nutrients, physical waste and particulates, wastewater, effluent, sewage, pathogens, pharmaceuticals, and radioactivity.</p> <p>Greenhouse gas emissions: carbon dioxide, carbon footprint, methane; gas reduction and mitigation measures including gas or carbon capture, carbon offsets. Soil pollution.</p>	Exclude studies that focus on water, air, or soil quality in general without a focus on change of pollutants in the environment

4. Methods

To develop this systematic map, we adapted standards and methods for EGMs developed by 3ie (Snilstveit et al. 2016). The 3ie methodology is defined by the following evidence standards:

1. Transparent and explicit population, intermediate outcome, high-level outcomes, and study design inclusion and exclusion criteria;
2. Consultations with advisory groups from USAID RFS and with external sectoral experts;
3. Systematic search, screening, and data extraction procedures; and
4. Critical appraisal of SRs.

We developed a protocol with detailed description of our methodology *a priori*. This can be found in [Appendix A](#). In brief, we developed a systematic search strategy covering an expansive list of databases, websites, and gray literature. We utilized new machine-learning approaches to assist with identification of eligible studies (also described in more detail in the appendix).

We then systematically extracted data from included studies and used 3ie's EGM software to create an online, interactive map of all included studies displayed according to the intermediate and final outcomes framework. This provides a visual display of the volume of evidence, the type of evidence (IE, SR, observational study, completed or ongoing), and a rating of our confidence in the findings of available SRs based on an objective and transparent assessment. The platform provides additional filters so that users can further explore the available evidence, for example by global regions, income levels, or population. The WASH Systematic Map can be viewed [here](#).

The map includes studies that answer different types of research questions, and which cannot be interpreted in the same way. We included three types of quantitative studies in the map: observational studies, IEs, and SRs. Each answers a different type of research question and uses methods of varying levels of rigor. Observational studies investigate whether there is an association, or relationship, between WASH and high-level outcomes and seek to measure the magnitude of that association. The methods used cannot provide

causal evidence or confirm the direction of the association. For instance, a study may use multivariate regression analysis to measure the association between WASH access and education, but it cannot reveal whether WASH access leads to increased educational attainment or whether better educated people have better WASH access.

IEs investigate these causal questions and provide evidence of the effects of attaining WASH outcomes on high-level outcomes within their specific study contexts. SRs take this causal analysis further, by using explicit and transparent procedures to identify all available research evidence relevant for a specific question, then appraising and synthesizing the available high-quality evidence on the effectiveness of a given WASH approach or other research question.

4.1 Analysis and reporting

To answer research question 1 regarding the extent and characteristics of the research base, we present the distribution of studies by date of publication, intermediate outcome(s) studied, high-level outcomes reported, and population considered, including regions, countries, and specific population groups. For the high- and medium-confidence SRs included, we further extracted summaries of the key findings for policy implications.

To answer research question 2 regarding gaps in the research, we combined analysis of the evidence distribution with sectoral knowledge to determine meaningful primary research gaps, where no primary research exists, and synthesis gaps, where no up to date or high confidence SRs exist despite a cluster of research.

To answer research question 3 regarding which research and synthesis gaps should be prioritized, we shared the draft findings with stakeholders at USAID and in the advisory group, and solicited input regarding policy maker and practitioner priorities for future research.

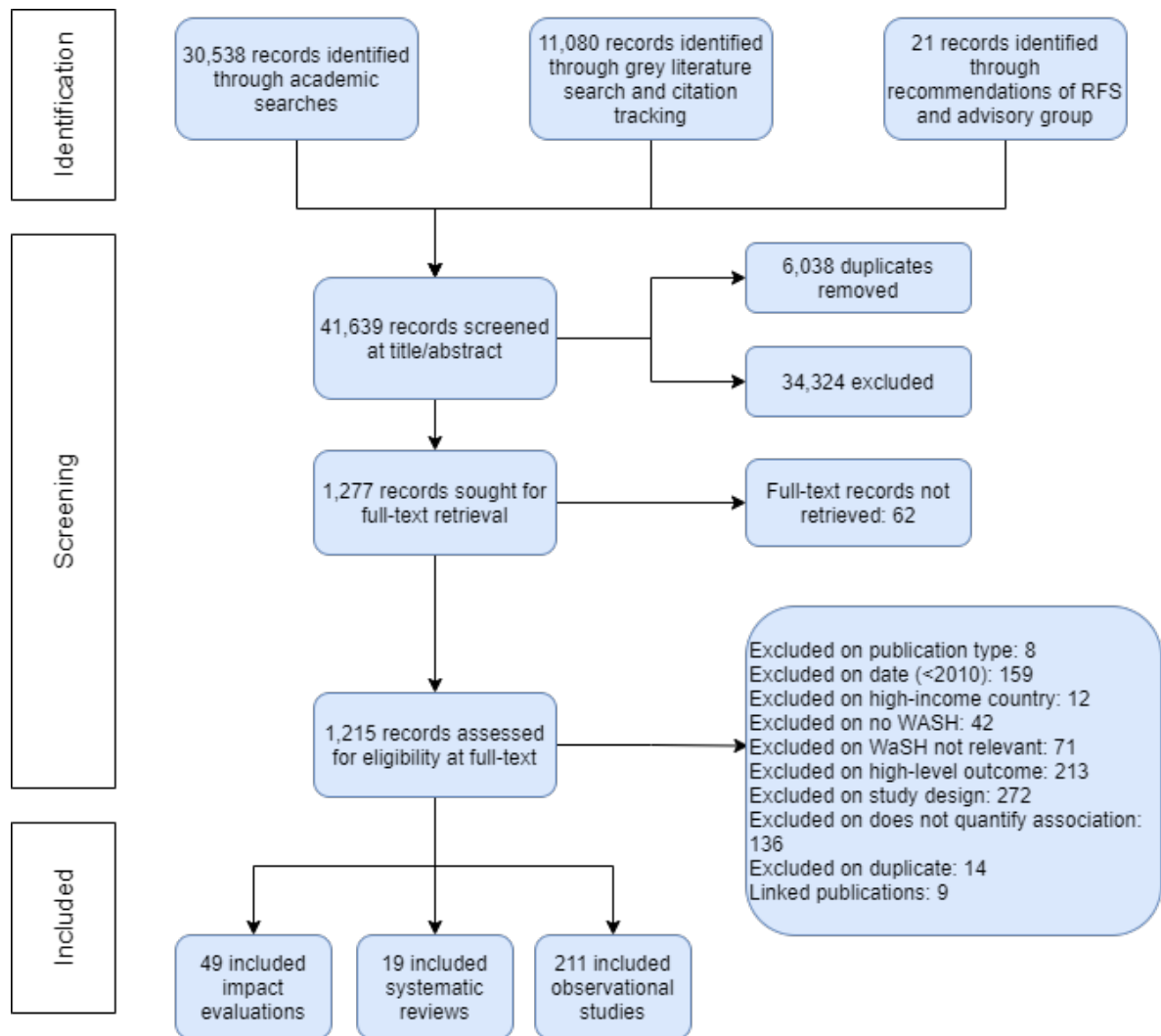
5. Findings

5.1 Volume of the literature

Through the systematic search conducted for this map, we identified 41,639 papers, of which 35,601 remained after removing duplicates (Figure 2). After title and abstract screening, 34,324 records were excluded and 1,277 records were included for full-text screening. Finally, 279 studies were included in this map, with the majority being observational studies (n = 211). We also included 49 IEs and 19 SRs.

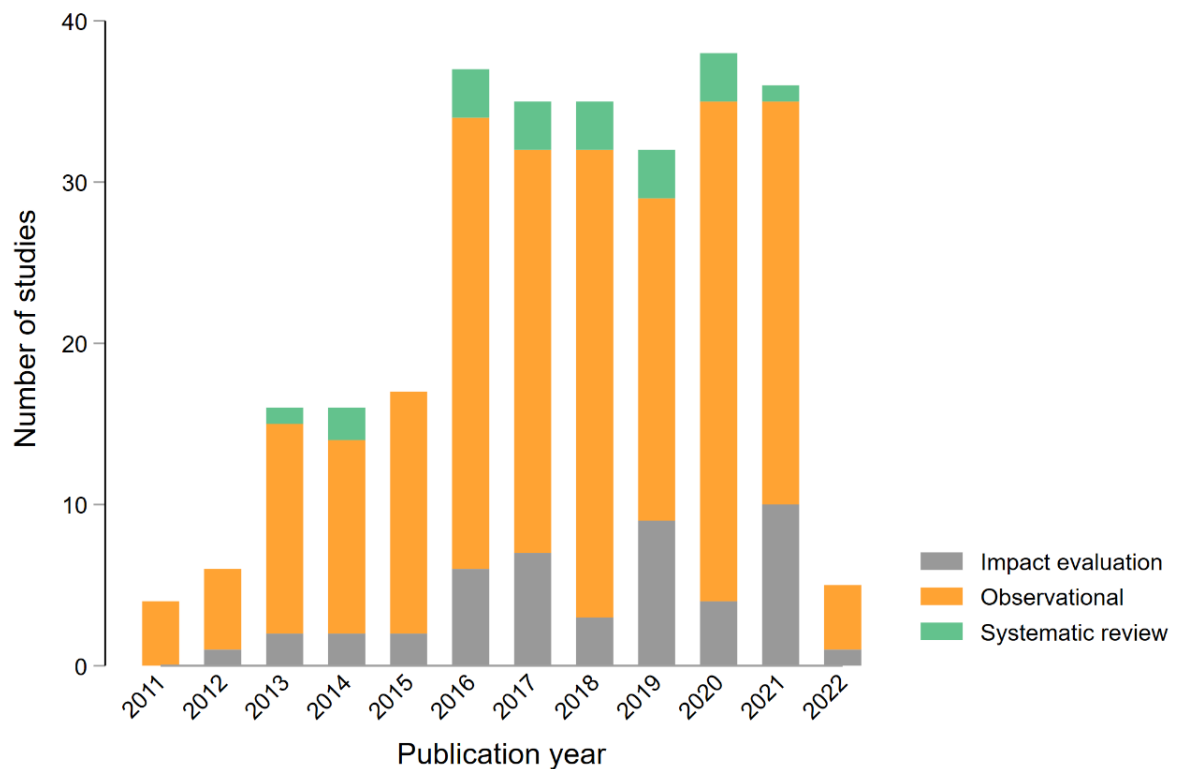
Common reasons for exclusion were not measuring a relevant high-level outcome or not meeting our study design inclusion criteria. Many studies were excluded because they examined the association with a health-related outcome or they used qualitative or descriptive methods. Additionally, studies were excluded if they considered high-level and intermediate outcomes but did not quantify the relationship between them.

Figure 2: PRISMA diagram of included studies



Most of the studies included were published between 2016 and 2021 ($n = 213$, Figure 3). Between 2015 and 2016, there was a substantial increase in the number of studies included in this map ($n = 17$ in 2015; $n = 37$ in 2016). The largest increase was in observational studies ($n = 15$ in 2015; $n = 28$ in 2016). Only five studies were included from 2022, though this is related to the timing of the search (December 2021–May 2022), rather than an indication of a trend.

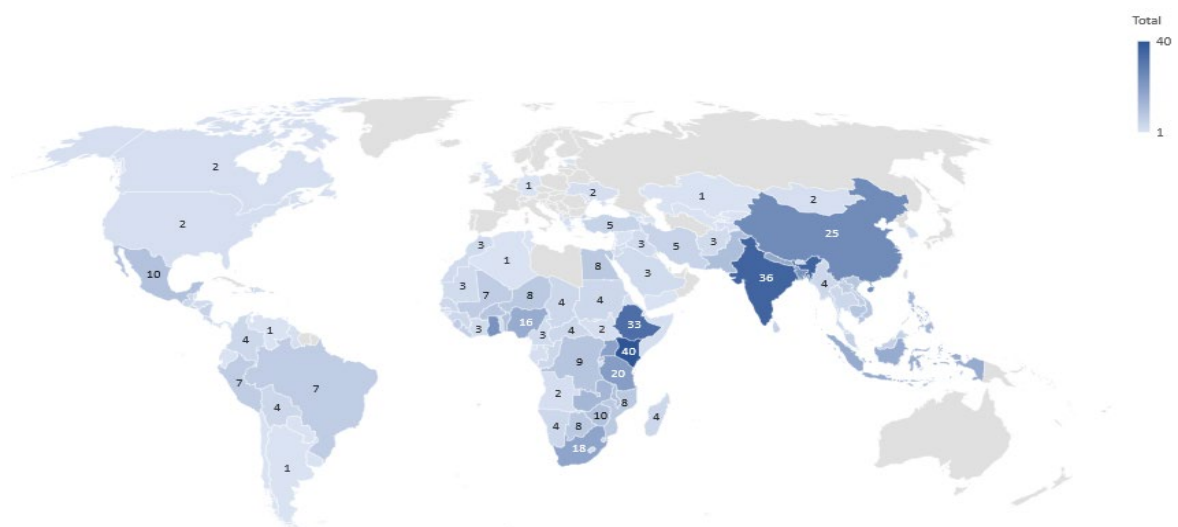
Figure 3: Studies by publication year and study type (n = 279)



5.2 Characteristics of the literature base

The included studies represented data from 125 countries (Figure 4). There were eight studies with data from over 15 countries included in the analysis. Kenya had the largest number of studies (n = 40), followed by India (n = 36) and Ethiopia (n = 33). All L&MIC regions are represented in this map. High-income countries (n = 21) were included only if they were part of multi-country analyses that separately analyzed high-income countries and L&MICs.

Figure 4: Geographic distribution of included studies (n = 719)



Note: This map tallies studies across each country it examines; each study can include multiple countries, therefore the total number of countries is greater than the total number of included studies.

Most studies (n = 129, 42.3%) did not target a specific population when analyzing the associations between intermediate and high-level outcomes (Table 4). However, for the studies that did target population demographics, 26.2 per cent (n = 80) targeted gender and 12.5 per cent (n = 38) targeted socioeconomic status when constructing their sample population.

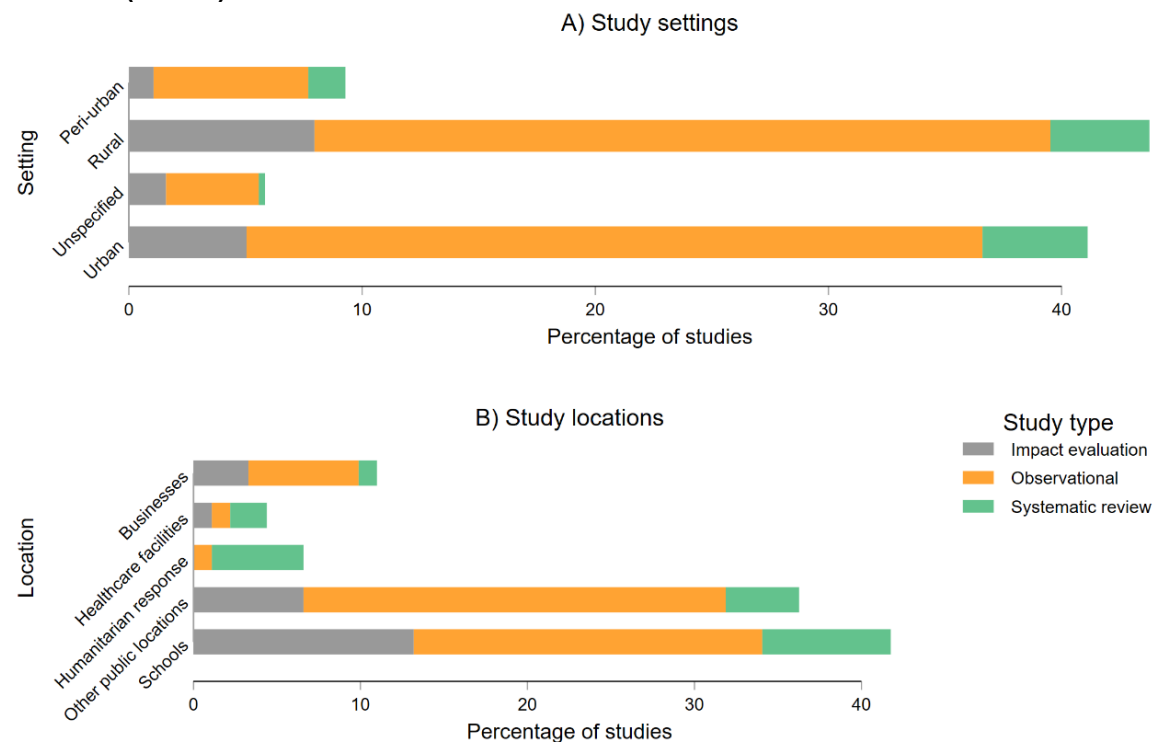
Table 4: Populations targeted in included studies

Population targeted	N (%)
Caste	9 (3.0)
Conflict-affected	7 (2.3)
Disability	4 (1.3)
Displaced populations	4 (1.3)
Ethnicity	14 (4.6)
Gender	80 (26.2)
Indigenous people	1 (0.3)
Religion	3 (1)
Sex	12 (3.9)
Socioeconomic status	38 (12.5)
Not applicable	129 (42.3)
Other	3 (1)

Note: The studies (n = 279) were coded by the populations they targeted when sampling (e.g., specific ethnic groups, women and girls), and some may have targeted multiple characteristics of a population (e.g., women of lower socioeconomic status); therefore the total is higher than the number of studies.

Of the studies included in this map, 43.8% (n = 165) took place in rural areas (Figure 5a). Urban settings comprised 41.1% (n = 155) of included studies, with only 9.28% (n = 35) in peri-urban settings. Among the studies that took place in a public location, 36.3% (n = 33) were in communal waterpoints, communal sanitation facilities, and public utilities (noted as “other public locations” in Figure 5b). Schools comprised 41.8% (n = 38) of the studies in public locations, and 11% (n = 10) of studies with a public location took place in businesses.

Figure 5: a) Setting of included studies (n = 279); b) Location in subset of included studies (n = 91).



Note: In Figure 5a, multiple settings could be selected for each study; therefore, the total number of study settings (n = 377) is greater than the number of included studies. In Figure 5b, not all studies were set in specific locations; therefore, only 91 studies had a coded location. “Other public locations” consist of communal waterpoints, communal sanitation facilities, and public utilities.

5.2.1 Impact evaluation methods

The IEs employed a limited range of research designs; nearly two thirds (n = 29) are experimental studies. The remainder used difference-in-difference (n = 7), fixed effects (n = 6), or statistical matching (n = 7) approaches. Only a few studies (n = 5) used mixed methods. We did not extract methodological data on the observational studies due to high heterogeneity of analysis methods.

5.2.2 Intermediate WASH outcomes

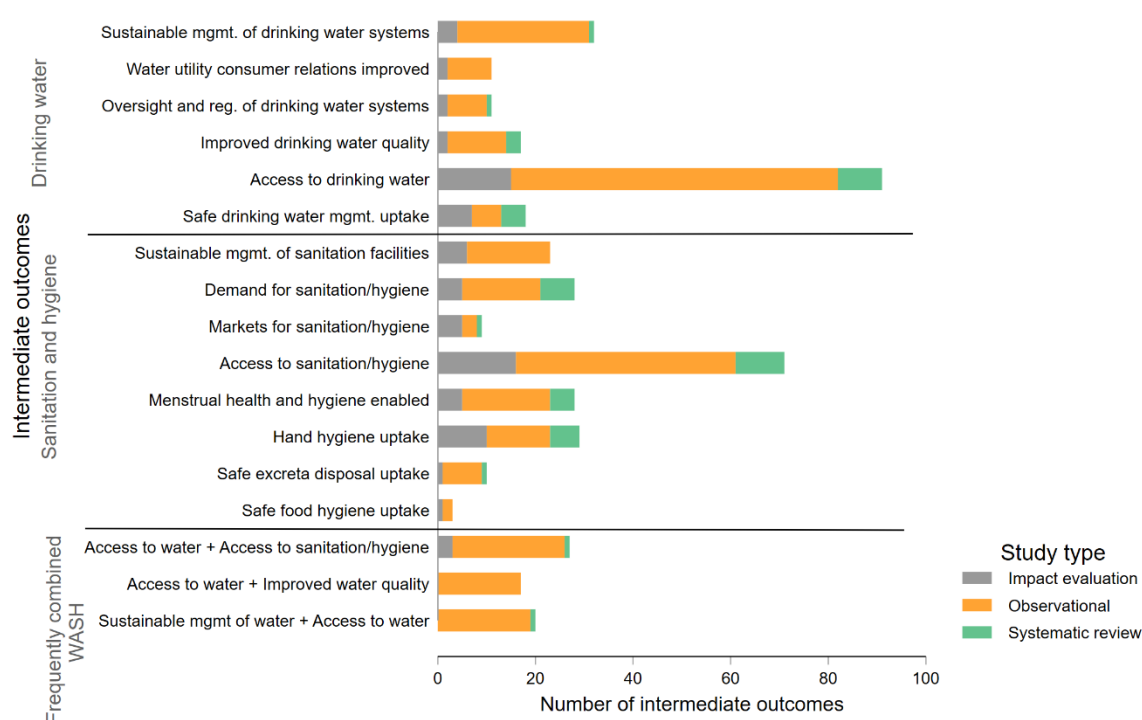
Figure 6 shows the distribution of outcome focus by study type. The most common focus of studies (across all three study types) included in this map was analysis of the associations between *increasing access to enhanced drinking water services* and selected high-level outcomes (n = 91, 20.5%, Figure 6). We also found a larger number of studies examining the associations between *increasing access to sanitation and/or hygiene facilities or products* (n = 71, 16.0%) and the high-level outcome domains of interest. IEs predominantly assessed the impact of *increasing access to enhanced drinking water services* (n = 15, 17.9%), *increasing access to sanitation and/or hygiene facilities or products* (n = 16, 19.1%), or *increasing hand hygiene uptake* (n = 10, 11.9%).

The most common foci of SRs were outcomes related to *increasing access to sanitation and/or hygiene facilities or products* (n = 10, 19.6%), followed by *increasing access to enhanced drinking water services* (n = 9, 17.7%).

We found a cluster of studies (n = 28, 6.3%) across all three study types that examined the associations between *expanding enabling environments for MHH* and the high-level outcomes of interest. We did not find many studies that analyzed the association between *safe food hygiene* outcomes and high-level outcomes of interest (n = 3, 0.7%).

There were also studies across all three study types that looked at the association of combined intermediate outcomes (n = 64, 14.4%), in which: (1) multiple outcomes were combined into a single indicator; (2) multiple outcomes were combined in the same analysis; or (3) multiple analyses were performed looking at each intermediate outcome. We included the top three combinations as separate bars in the figure below.

Figure 6: Intermediate outcomes in included studies (n = 279)



Note: Intermediate outcome titles have been shortened from full labels in Table 2, but they are listed in the same order as Table 2. Frequently combined WASH studies refer to studies that: (1) combined multiple intermediate outcome indicators into a single indicator; (2) combined multiple intermediate outcomes into the same analysis; or (3) performed multiple analyses looking at different intermediate outcomes. The top three combinations were separated out and are provided at the bottom of the graph. Any other studies that had multiple intermediate outcomes were separated into the individual outcome rows.

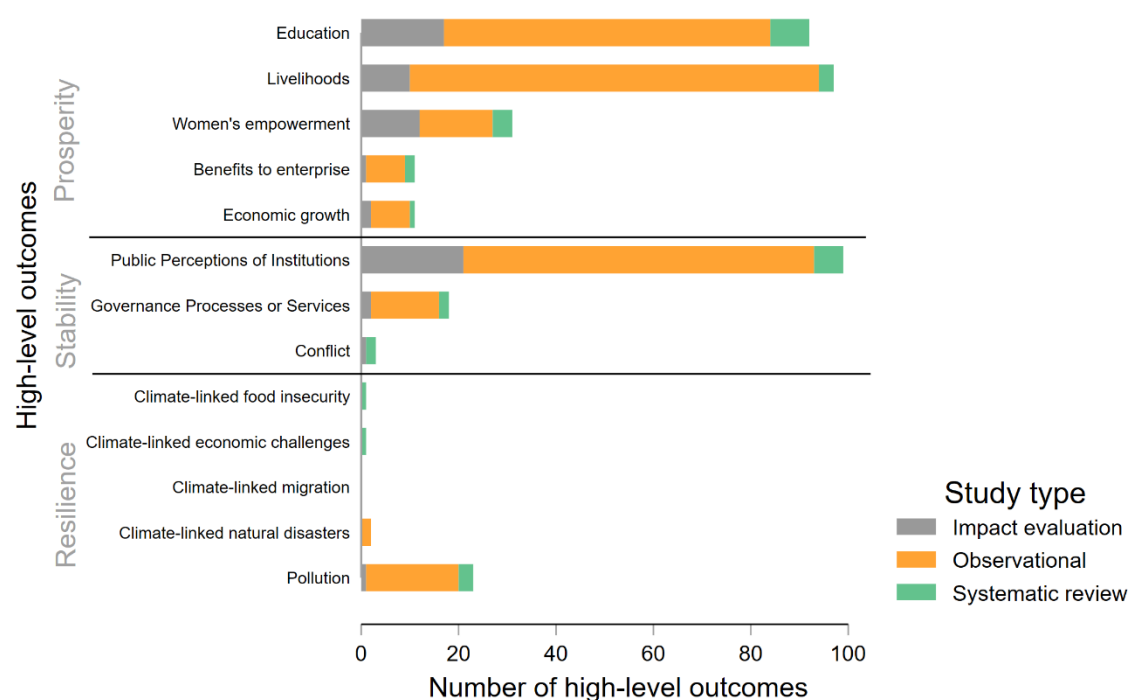
5.2.3 High-level outcomes

Figure 7 shows the distribution of studies by high-level outcomes. This highlights that the literature is focused on the prosperity domain, followed by stability, with very few studies addressing the resilience domain when including the criteria of being directly linked to climate change. There is also an uneven focus between outcomes, with nearly 75 per cent of studies focused on three primary high-level outcomes: *education* (n = 92, 23.7%), *livelihoods* (n = 97, 24.9%), or *public perceptions of institutions* (n = 99, 25.5%) (Figure 7). In the former two outcomes, education status and income or assets (components of livelihoods) were frequently included as covariates in quantitative observational studies that analyzed determinants of achieving intermediate WASH outcomes.

Many willingness-to-pay studies were included under the *public perceptions of institutions* outcome. IEs predominantly assessed the effect of intermediate WASH outcomes on *public perceptions of institutions* (n = 21, 31.3%), *education* (n = 17, 25.4%), or *women's empowerment* (n = 12, 17.9%). SRs predominantly assessed association of intermediate WASH outcomes on *education* (n = 8, 24.2%) or *public perceptions of institutions* (n = 6, 18.2%).

Most of the studies in the resilience domain focused on pollution (n = 23, 5.9%), with very few studies measuring climate-linked outcomes (n = 4, 1.0%) or *conflict* (n = 3, 0.8%). No studies measured the association of achieving WASH outcomes and *climate-linked migration*.

Figure 7: High-level outcomes in included studies (n = 279)



Note: Studies could look at the association of multiple high-level outcomes; therefore, the total number of high-level outcomes is greater than the number of included studies.

Among the studies that measured *pollution* as a high-level outcome, 53.4 per cent (n = 16) analyzed water pollution (Table 5). These included studies that measured pollutants in bodies of water that received wastewater treatment plant or drinking water treatment plant effluent. It also included studies that measured pollutants in groundwater downstream from pit latrines. Air pollution, primarily greenhouse gas emissions from wastewater treatment plant operations, comprised 33.3 per cent (n = 10) of the studies that measured pollution.

Table 5: Pollution type in included studies

Pollution type	N (%)
Air	10 (33.3)
Soil	4 (13.3)
Water	16 (53.4)

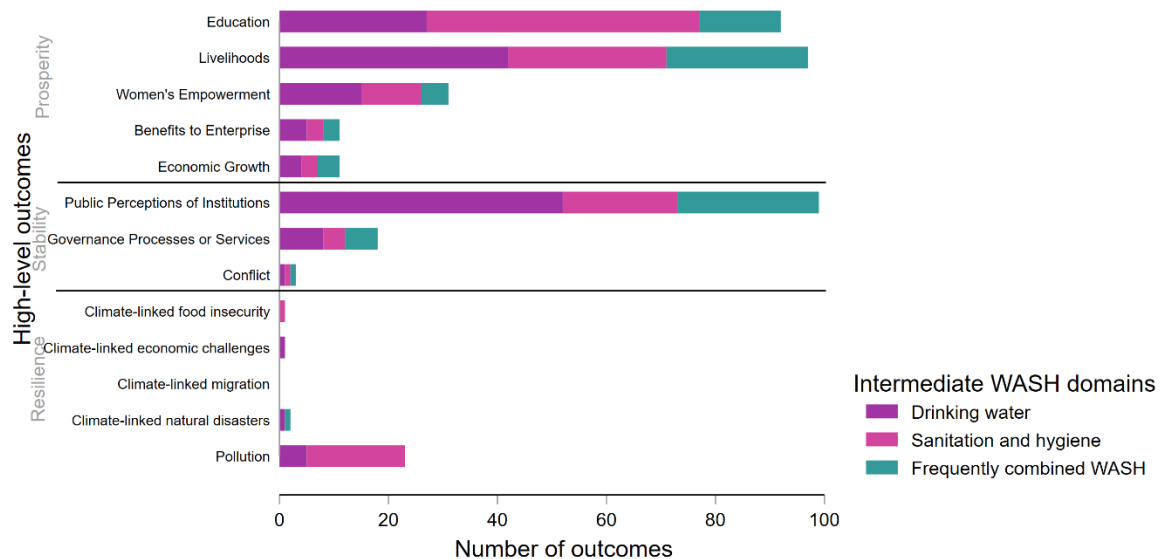
Note: Studies could have examined multiple pollution types; therefore, the total number of pollution types is greater than the number of studies that analyzed a pollution outcome.

5.2.4 High-level outcomes by intermediate WASH outcome domains

Overall, most studies that examined a sanitation or hygiene intermediate outcome also analyzed the intermediate outcome's association with *education* (n = 50, 35.5%), *livelihoods* (n = 29, 20.6%), *public perceptions of institutions* (n = 21, 14.9%), or *pollution* (n = 18, 12.8%) (Figure 8). Drinking water intermediate outcomes were mostly associated with *public perceptions of institutions* (n = 52, 32.3%), *livelihoods* (n = 42, 26.1%), or *education* (n = 15, 16.8%).

For the three frequently combined intermediate WASH outcomes, these studies analyzed the association with *education* (n = 15, 17.2%), *livelihoods* (n = 26, 29.9%), or *public perceptions of institutions* (n = 26, 29.9%). Of the three included *conflict* studies, there was one study (drinking water: 0.6%, sanitation and hygiene: 0.7%, frequently combined WASH: 1.2%) from each intermediate WASH domain. For the climate-linked outcomes, two studies (1.2%) were from the drinking water domain, one study (0.7%) from the sanitation and hygiene domain, and one study (1.2%) from the frequently combined WASH domain.

Figure 8: High-level outcomes by intermediate WASH outcome domains (n = 279)



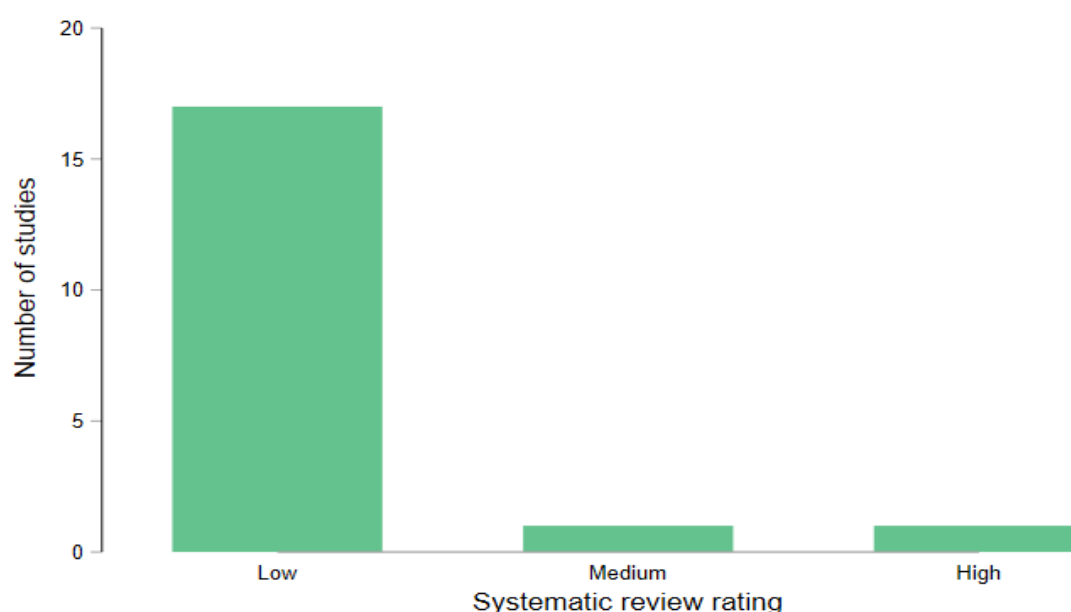
Note: Studies could examine the association of multiple high-level outcomes; therefore, the total number of high-level outcomes is greater than the number of included studies.

5.2.5 Results of SR critical appraisal

For each completed SR, we undertook a critical appraisal to assess the rigor of the review's methodology. A summary of our critical appraisal tool is provided in [Appendix D](#). We rated reviews either as low, medium, or high confidence, indicating our confidence in the review findings based on the methods used to arrive at those findings.

Of the 19 completed SRs included in the map, we assessed 17 (89%) to be of low confidence (Figure 9). The most common reasons for which we assessed a review's methods as resulting in low confidence in the findings were: (1) the authors did not conduct quality appraisal of the included studies; (2) the authors did not independently screen the included studies; or (3) there were limitations in the search strategy. We rated one SR as medium confidence and one as high confidence and provide brief summaries of the findings of each.

Figure 9: Number of included SRs assessed at each confidence level (n = 19)



Findings from medium- and high-confidence SRs

The medium-confidence SR linking *improvement of drinking water quality in drinking water systems to pollution outcomes* found that zero-valent iron and adsorption processes show the most promise in removing arsenic from groundwater (Jones-Hughes et al. 2013). This SR of the effects of field-based technologies in removing arsenic from groundwater included 51 studies from Bangladesh, Cambodia, China, India, Nepal, and Vietnam, but cautions that 50 of the 51 included studies were appraised to be of weak quality and note that the “success of each technology was highly dependent on context, especially their acceptability to users, a sense of ownership and expectations of women’s roles in society” (Ibid, 1).

The high-confidence SR found that *expanding enabling environments for MHH with additional improvements in sanitation and hygiene show mixed results on education and women’s empowerment outcomes* (Hennegan et al. 2016). Hennegan and colleagues examined the effects of interventions providing menstrual education (termed “software interventions”) and those providing menstrual products or WASH facilities (“hardware interventions”) on women’s and girls’ education, psychosocial well-being, and employment. From seven studies from Ghana, Iran (three studies), Kenya, Nepal, and Zimbabwe, the authors find:

1. Software interventions alone improved school attendance but showed no effect on psychosocial outcomes (each finding based on a single study);
2. Hardware interventions alone showed insignificant improvement on education outcomes (based on three studies); and
3. A combined software and hardware intervention showed improvement on psychosocial outcomes (based on one study).

No studies examining employment outcomes met inclusion criteria. Overall, the sparse evidence, combined with high risk of bias of most included studies, prevent the authors from drawing conclusions regarding the effectiveness of MHH interventions.

5.3 Research gap analysis

This map reveals a number of gaps in the WASH outcome research in addition to the foregoing research concentrations and characteristics identified. There are several absolute gaps wherein no research was found to meet the inclusion criteria, as well as areas where some research exists, but is thin.

5.3.1 Where there is a lack of primary research: “absolute and relative research gaps”

Overall, intermediate WASH outcomes are well-represented in the map, with one notable gap. We found only three studies that associate *safe food hygiene uptake* with the high-level outcomes of interest. This may be an under-researched area, or it may be that theoretical links between food hygiene and high-level outcomes, such as *improved governance*, are weaker than other outcome combinations in the map. Other intermediate WASH outcomes with relatively sparse representation in the map that may warrant future research consideration include *expansion of functioning market(s) for sanitation and/or hygiene products and/or services* (n = 7) and *increased uptake of safe excreta disposal practices by individuals and communities* (n = 9).

We observe several research gaps among the high-level outcomes, predominantly among climate-linked outcomes in the resilience domain. There are no studies examining the association between WASH and *climate-linked migration*, representing a major gap. We found only two studies focused on WASH and *resilience to climate-linked natural disasters*, while a single low-confidence SR is the only study listed under both *climate-linked food insecurity* and *climate-linked economic challenges*.

One reason for the low coverage of these topics may be an artefact of the screening criteria: due to the large literature base on topics such as food security and poverty, we required authors to explicitly reference a context of climate change to qualify for inclusion under the climate-linked resilience outcomes. A segment of the WASH literature focuses on building the sustainability and resilience of WASH systems themselves; however, unless studies linked the resilience of WASH systems to a high-level outcome, we were not able to include those studies. Additionally, in the stability domain, we only identified three studies that associated *conflict* outcomes with WASH achievements. Future research should be guided to fill these gaps.

The map includes studies across all geographic regions, but the geographic distribution of the research base is uneven. Eastern Europe (n = 3) and the Caribbean (n = 11) account for a smaller proportion of included studies than other regions. Most studies were set in East Africa (n = 174) or South Asia (n = 99). Studies were generally well-balanced between urban and rural settings.

There are also research gaps in the specific locations and populations considered. We only identified four studies examining WASH in healthcare facilities, which indicates a lack of WASH studies in such facilities that measure high-level outcomes. Of the 58 per cent of studies in the map that provided population targeting information, few targeted indigenous populations (n = 1), displaced populations (n = 4), or people based on their religion (n = 3) or disability status (n = 4).

5.3.2 Where there are clusters of evidence but no high-confidence SR: “synthesis gaps”

The map reveals a major gap in high-quality synthesis on WASH outcomes and their relationship to high-level outcomes. We rated 17 of the 19 included SRs as low confidence. Researchers can address this synthesis quality deficit and increase confidence in their findings by using more comprehensive search strategies, employing multiple independent screeners, and assessing the quality of the studies they review.

There is a lack of synthesis evidence on drinking water systems management, as well as WASH linkages to public perceptions of institutions. We found 28 primary studies that studied improvement in drinking water systems’ sustainability, management, operations, and maintenance. However, only one SR looked at this intermediate WASH outcome. There is a concentration of 19 IEs and 62 observational studies that measured public perceptions of institutions. We identified six low-confidence SRs examining this outcome, only one of which examined willingness to pay, which was a frequently studied component of this outcome among the primary studies. These areas present opportunities for future high-quality synthesis work.

5.3.3 Methodological gaps

There is a lack of IEs assessing the causal effects of WASH achievements on high-level outcomes. While there is a growing body of literature seeking to quantify associations between WASH achievements and high-level outcomes, only 49 adopt an IE design (17.6%). Although we identified a concentration of research on the associations between WASH and education, livelihoods, and public perceptions of institutions, the volume of research under each high-level outcome is composed of over 70 per cent observational studies. Thus, evidence on the causal effects of WASH achievements on prosperity, stability and resilience outcomes is relatively limited.

IEs employed a limited range of research designs. We did not identify any studies using interrupted time series, instrumental variables, or regression discontinuity designs that met inclusion criteria. Researchers may wish to consider using these quasi-experimental IE methods in the future. For example, geographic regression discontinuity designs may offer innovative approaches for evaluating effects of large-scale WASH infrastructure or of watershed catchment areas. Interrupted time series designs may be well suited to evaluate long-term effects of WASH programming, provided that time-series data are available.

Few of the IEs used mixed methods. Incorporating more qualitative data into quantitative WASH research can provide valuable insights into contextual factors, implementation processes, and participants’ experiences and perceptions that may facilitate improvements in uptake and sustainability.

Ethical approval does not appear to be universally adopted. Of 49 IEs, 22 do not include any reference to seeking ethical approval for their research. This is somewhat concerning, especially as there were eight evaluations that used experimental methods that did not reference seeking ethics approval. While this could be an issue driven by lack of reporting of such approval, researchers should follow best practices by both seeking ethical approval from an institutional review board or other relevant research oversight body prior to working with human subjects and reporting the details of such approval.

Cost-effectiveness analysis of WASH programming represents a major evidence gap. Of the 279 studies in the map, 73 provided cost evidence including approximately 38% of IEs, 41% of SRs, and 19% of observational studies. Of this cost evidence, the most-reported metric is cost alone, which 59 studies report. Only six studies conduct cost-effectiveness analysis, while eight report return-on-investment or cost-benefit analysis results. Some studies in the map did not implement interventions or used secondary data in their analysis, and cost data may not be relevant in these cases.

6. Conclusions and implications

This WASH systematic map is 3ie's first study employing an outcome-to-outcome mapping approach. It demonstrates the applicability of rigorous, systematic research mapping further along the theory of change of development programming, to identify both causal and associational links between intermediate outcomes and high-level development objectives. Overall, we find a moderate and emerging body of research on the associations between WASH outcomes and accelerating prosperity, building stability, and, to a much lesser extent, enhancing resilience. However, while we identified 279 studies, a small share of the research base examines the link between WASH and high-level outcomes within a causal framework.

The map reveals several research concentrations. Most of the included studies focused on *increased access to enhanced drinking water services* (n = 91) or *increased access to sanitation and/or hygiene facilities, products, or services* (n = 71). Since these were explicit goals of the Millennium Development Goals and the Sustainable Development Goals, this is an unsurprising finding. We also identified 70 studies that specifically examined these two intermediate WASH access outcomes in combination.

Among the high-level outcomes, most studies looked at *education* (n = 92), *livelihoods* (n = 97), or *public perceptions of institutions* (n = 99), followed by *women's empowerment* (n = 31) and *pollution* (n = 23). Pollution studies examined water pollution more frequently than air or soil pollution. We also found a concentration of research at the intersection of *expansion of enabling environments for MHH achievements* and *education* (n = 21), which was primarily focused on school absence.

More rigorous work should be conducted to determine the extent to which these high-level outcomes can be attributed to WASH achievements. The majority of the research presented in the map is observational: it seeks to determine whether there is a relationship between WASH achievements and high-level outcomes, but the methods used mean that these studies cannot tell us much about the nature of that relationship.

Since many observational studies include education and income as control variables in a regression, they may have measured the relationship between WASH and these education or livelihood outcomes indirectly, rather than as their primary research question. Thus, a concentration of observational research without a corresponding concentration of causal evidence (as in the livelihoods outcome with 84 observational studies and only 10 IEs and one high-confidence SR) indicates an opportunity to directly investigate how varying aspects of WASH may or may not improve high-level outcomes.

If the WASH programming community wishes to clarify the ways in which investment in WASH improves prosperity, stability, and resilience in the long term, they should seek to build the evidence base of causal studies (IEs and SRs) examining these research questions.

We primarily found research gaps in the high-level outcomes. We found very few studies that looked at *conflict* (n = 3) or *resilience to climate-linked natural disasters* (n = 2). We only found one study on *climate-linked food insecurity* and *climate-linked economic challenges*. No studies examined *climate-linked migration*. Among intermediate WASH outcomes, there were very few studies linking *increased uptake of safe food hygiene practices* (n = 3) to high-level outcomes.

The research gaps and clusters identified in this systematic map reveal areas that could be prioritized for future programming, primary research, and evidence synthesis. The gaps indicate intermediate WASH outcomes and high-level outcomes where additional research could be used to further build out the WASH sector theory of change. The research concentrations indicate areas where IEs or SRs could be conducted to further inform future WASH work.

6.1 Implications for decision-makers

- **The WASH programming community should exercise caution when interpreting the contents of the map, bearing in mind that the majority of research presented is observational rather than causal.** This systematic map is a visualization of the research landscape; it does not provide interpretation, analysis, or synthesis of what the research says. An observational study at the intersection of a WASH outcome and a high-level outcome only indicates that the authors investigated a relationship between the outcomes; it does not indicate whether a relationship was found, and the methods used are unable to infer the direction of the relationship or whether the WASH outcome caused the high-level outcome. While IEs and SRs can provide causal evidence, their location in the map does not indicate whether WASH achievements have positive, negative, mixed or no effects on high-level outcomes. The map also does not reveal which types of interventions effectively achieve WASH outcomes. Studies should be consulted individually for details on findings and implementation considerations.
- **This map is a useful tool for decision-makers and development practitioners to consult when considering the types of WASH outcomes and other high-level objectives to pursue.** They can review IEs, SRs, and observational studies within the research concentrations identified to explore how WASH outcomes have been measured and achieved in the past and consider contextual factors that may be of interest. By applying filters to the [online map](#), they can easily find research relevant to their areas of interest.
- **The map can inform policy makers and program implementers when designing theories of change or testing links between WASH and other elements of a program's results framework.** To date, much of the WASH research base has examined WASH outcomes as a foundational end in themselves or as a means of achieving health improvements. The research presented in this map should encourage decision-makers and development practitioners to explore the role of WASH in high-level development outcomes. This map helps WASH practitioners easily identify a large body of research investigating WASH

associations with prosperity and stability outcomes as well as *pollution* outcomes within the resilience outcome domain. It is an excellent starting point to extend WASH program learning to bigger-picture research questions, more rigorous methods, and more definitive conclusions on the effects of WASH achievements.

- **Decision-makers and development practitioners should partner with researchers to develop the evidence base on the causal links between WASH achievements and high-level outcomes.** Doing so could bolster the prioritization of investment in WASH as not only a vital goal in its own right, but also for its effects on other development objectives. For instance, there is a concentration of observational research linking WASH achievements to *education* and *livelihood* outcomes, but relatively few causal studies. Testing the link between WASH and these outcomes for a causal relationship could build evidence for WASH programming as a form of human capital investment.

6.2 Implications for researchers and commissioners

- This map is a unique resource for researchers interested in exploring outcome-to-outcome links in the WASH sector, or as a starting place for developing a research plan to test the entire causal pathway from interventions to intermediate WASH outcomes to high-level development outcomes.
- **Researchers should conduct more IE research exploring the causal links between intermediate WASH outcomes and high-level outcomes.** We found relatively few IEs compared to the large body of observational research in this map. Concentrations of observational studies present intriguing research questions for IE:
 - We found 34 observational studies on the relationship between *increased access to enhanced drinking water services* and *livelihoods*, but only four IEs examining these outcomes. Does greater access to drinking water cause livelihood gains?
 - Eleven observational studies examine links between *increased access to sanitation and/or hygiene* and *pollution*, but we identified no IEs dealing with these outcomes. To what extent are changes in pollution attributable to increased sanitation and hygiene access?
- **Researchers can fill research gaps by examining the links between intermediate WASH outcomes and conflict and food insecurity, economic challenges, migration, and resilience to natural disasters linked to climate change.** *Safe food hygiene uptake* is a WASH outcome that may be understudied, possibly due to weak theoretical links to high-level outcomes; however, *safe food hygiene*'s relationship to education-related outcomes such as school absence may be a more productive area of inquiry.
- **WASH researchers should adhere to ethical best-practices in fieldwork and may wish to expand their methodological toolkit by incorporating more qualitative data and using a broader range of quasi-experimental evaluation designs.** Such efforts include:
 - Obtaining ethical approval prior to work with human subjects;
 - Using mixed methods approaches, which are useful in understanding how and why WASH functions in practice; and
 - Interrupted time series, instrumental variables and regression discontinuity IE designs were not identified in this map but may present feasible IE options when experimental designs are not possible.

- **WASH research would benefit from the production of higher quality SRs in outcome areas where concentrations of research were identified**, such as the effects of *improvements in drinking water systems management* on high-level outcomes, or the effect of WASH achievements on *public perceptions of institutions*, particularly willingness to pay. Researchers can improve systematic-review quality by using more comprehensive search strategies, employing multiple independent screeners, and assessing the quality of included studies. **Higher quality SRs would allow for the modest evidence bases in these areas to be synthesized and to become more useful for evidence-informed decision-making.**
- Providing **cost evidence** would allow decision-makers to know not only if WASH outcomes are achieved but if they are cost effective.

Online appendices

Online appendix A: Additional methods detail

<https://3ieimpact.org/sites/default/files/2023-02/EGM18-REAPER-WASH-Report-Online-appendix-A.pdf>

Online appendix B: Databases and grey literature websites searched; Example search string used within acadeM18-mic databases

<https://3ieimpact.org/sites/default/files/2023-02/EGM18-REAPER-WASH-Report-Online-appendix-B.pdf>

Online appendix C: Data extraction codebook

<https://3ieimpact.org/sites/default/files/2023-02/EGM18-REAPER-WASH-Report-Online-appendix-C.pdf>

Online appendix D: Systematic review critical appraisal tool

<https://3ieimpact.org/sites/default/files/2023-02/EGM18-REAPER-WASH-Report-Online-appendix-D.pdf>

Online appendix E: Systematic map advisory group

<https://3ieimpact.org/sites/default/files/2023-02/EGM18-REAPER-WASH-Report-Online-appendix-E.pdf>

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Though there has been significant progress in understanding the impacts of water, sanitation and hygiene interventions (WASH) on human health, less is understood about the broader implications it may have on higher-level development outcomes, such as prosperity, stability, and resilience. To address this research gap, USAID's Bureau for Resilience and Food Security commissioned a systematic map to understand the far-reaching impacts of delivering WASH services.

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