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Review of systems thinking in rural WASH programming and research

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Review

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Abstract

Almost half of the global population lives with inadequate or unsafe water, sanitation or hygiene (WASH) services. The consequences of this situation include negative impacts on individual and public health, the environment and economic production. The WASH sector is linked with other international development sectors and is embedded within complex social, environmental and governance structures. This complexity led us to reflect on how WASH sector practitioners and researchers are applying systems thinking tools and techniques to progress an agenda of sustainable and universal WASH services. From this perspective, we then discuss the near- and long-term future needs of the sector in coming to a comprehensive understanding and application of systems thinking to progress the ultimate aim of universal access to safely managed, accessible and abundant water, sanitation and hygiene services.

Impact statement

Systems thinking refers to a broad range of tools and philosophical approaches that relate to complex adaptive systems theory. It is acknowledged that the rural water sanitation and hygiene (rural WASH) sector faces complex adaptive systems problems. However, while systems thinking approaches to research, programming and evaluation in rural WASH have been used for over 20 years, these approaches still tend to be "one off" attempts by practitioners to apply systems thinking within the sector. This paper provides a broad review of the main tools and applications of systems thinking recently used in the rural WASH sector and points to directions for future research that would be useful for bringing systems thinking into mainstream use in rural WASH programming.

Introduction

This paper explores the development and use of systems thinking tools and techniques in the water, sanitation and hygiene (WASH) sector, predominantly rural WASH, over the last 15 years. It is well known that access to appropriate WASH services is essential foundations for human and economic development. These services are most noticeable in their absence; from a global population of ~8 billion people, currently ~2 billion people lack safe and adequate access to clean drinking water and ~ 3.6 billion people lack access to safely managed sanitation (JMP, 2021). In communities that do not have a reliable source of close and abundant water, the potential for adequate hygiene and sanitation is lowered. The potential for the development of intensive agriculture or industry-based livelihoods is also lowered, and the potential risks of poverty, malnutrition, illness and disability are raised. Hence, safe and adequate WASH is significant to healthy lives and livelihoods.

Traditionally, the WASH sector focused on local and rural water supply and sanitation. More recently, we have seen the WASH sector being active within the overlaps between WASH and other sectors. These overlaps include but are not limited to: health; child development; animal husbandry; environment; one health; climate change; disaster risk reduction; and infrastructure planning. The intersections between the sectors challenge WASH actors to develop an understanding of the connections and interdependencies that impact WASH services and where WASH services fit within other sectors. We need to look beyond our disciplines, generally engineering or engineering-related disciplines, and take a broader systems view that encompasses the interconnectedness of WASH provision in the systems, services and societies in which we work.

Since around 2005, WASH sector actors have begun to view WASH explicitly within a *complex adaptive systems* framework. Working explicitly within this broad framework is usually referred to as systems thinking. Systems thinking (or a systems approach) enables us to "*understand the interplay between various aspects of the situation under investigation and how the parts of a social-ecological system drive change in each other*"(Dyball and Newell, 2015). Systems thinking is also described as "*a framework for seeing interrelationships rather than things, for seeing patterns rather than static snapshots. It is a set of general principles spanning fields as diverse as physical and social*

sciences, engineering and management" (Senge, 2006). For WASH practitioners, the aspects of systems of interest might be the relationships between ecology, politics, multiple social structures and the mechanical and environmental aspects of water supply. Systems thinking opens the WASH sector to the use of theories and tools that have been developed in other disciplines but which are highly transferable and adaptable to the WASH context. Aspects of systems thinking are derived from diverse sectors, including ecology, cybernetics and organizational research (Ison, 2008), hence, there are a range of tools and techniques available to facilitate systems thinking. The WASH sector is actively taking systems thinking tools onboard and adapting them to suit our purposes, as can be seen in a recent review of systems thinking approaches to WASH by Valcourt et al. (2020a), who found 41 methods that they considered to be systems thinking applied across 133 studies documented in the academic and gray literature. However, the study also found that very few of these methods had been applied in more than one or two contexts, raising questions about the value of these approaches to operate at scale.

Systems thinking approaches are being applied in the WASH sector for implementation, policy influence and monitoring and evaluation. There has been a progression in thinking from the WASH sector as a provider of taps, tanks and toilets; to the WASH sector as a provider of ongoing services; to the WASH sector as an influencer of governance, policy, individual behaviors and social norms. The WASH sector has moved from engineering to service provision, and now to a sector that incorporates both of these, as well as concerning itself with the broader social and governance system that forms the environment of WASH provision. At the same time, the WASH sector has moved towards ensuring sustainable outcomes of its activities, including continued demand, active use, and operation and maintenance of WASH services and infrastructure.

This paper encompasses a breadth of academic, gray and organizational literature that reflects the diverse contributions to systems thinking and work in the WASH sector but is not intended as a systematic review. In this paper, we provide a unique review of the trajectory of systems thinking in the WASH sector and suggest ways forward for expanding the use of systems thinking techniques for research and programming within the sector. In the following sections, this paper proceeds to discuss the development of systems thinking in the WASH sector, then it highlights some of the most common system thinking tools used for theory and practice in the rural WASH sector. We then consider the issues of context and whole of systems actions, followed by a discussion of the current state of systems thinking within the WASH sector, and we conclude with recommendations for securing systems thinking as a valuable and accessible addition to the WASH toolbox.

Development of WASH sector in using systems thinking

Low resource settings are scattered with the artifacts of WASH projects from the period when WASH was predominantly considered a problem of infrastructure, engineering and technology. These artifacts, include tanks, taps, toilets and pipes, some are partially functional, many are not. WASH equipment and infrastructure is sometimes repurposed in ways that could not be envisaged by the program managers responsible for them, for example, the use of galvanized pipes for washing lines. These artifacts not only represent a massive loss of investment of donor and community members' resources, their creation persists, with non-functionality of water systems remaining at 30%–40% despite a relatively uniform and 'proven' set of technologies and approaches for delivering WASH services (Lockwood and Smits, 2011, p. 1).

Accordingly, around 2004, the WASH sector began to move away from the infrastructure approach and towards programming that included communities in both the physical labor and the planning process. It was considered that higher levels of community involvement would ensure better sustainability of outcomes. The move towards community participation was championed by people like Robert Chambers, whose book "Whose Reality Counts; Putting the First Last" published in 1997, has inspired development workers towards participatory planning and action. Community-led total sanitation (CLTS), developed by Kamal Kar, is a participatory method that leads communities to demand action and then devolves responsibility for that action back to the community. CLTS rose in popularity and usage to become, arguably, one of the dominant methods of sanitation programming for rural communities across low-resource settings well into the second decade of the 21st century. The focus on sanitation in CLTS belies the fact that many CLTS processes are/were conducted in conjunction with water supply programs. As with the infrastructure approach, participatory WASH has also left its mark on communities. The lasting results from participatory WASH tended to be social impacts that include either aspirations for increasingly better standards of WASH or disillusionment when programs fail. When participatory WASH programming succeeds, it can lead to better health, economic advancement, and more recently, progress towards gender equity and inclusion (Neely and Walters, 2016).

Early in the 2000's, the development sector, including the WASH sector, began to focus its efforts towards improving governance and institutional arrangements by integrating governance and policy advocacy into programming (Rosenqvist et al., 2016). This combination of looking at WASH from both a community perspective and a governance perspective paved the way for the WASH sector to recognize the many interconnected 'actors and factors' in WASH. This recognition then led to an understanding that WASH services can be seen as a complex adaptive system. Leveraging broader work in development and systems thinking (for example Green (2016), Ramalingam (2013) and Bar-Yam (2004)), organizations such as IRC, USAID, WaterAid and other WASH sector actors were becoming more explicit in the systems thinking conceptualization of WASH services and the application of systems thinking within implementation programs. This pivot was solidified in 2016 when these actors and others met to outline a path forward for mainstreaming systems thinking into WASH programming (Lockwood et al., 2016).

At the same time, academic research groups were also exploring the use of systems thinking approaches for WASH, with Valcourt et al. (2020a) noting a 'rapid expansion' in the publication of systems thinking tools, frameworks and approaches in the WASH literature. Many of these new and novel systems approaches were trialed under the USAID-funded Sustainable WASH Systems Learning Partnership (SWS) by a consortium of WASH actors working on various dimensions of WASH programming across multiple, divergent contexts (USAID, 2018). This project represented the first practical implementation of USAID's Local Systems Approach for integrating systems thinking concepts into the agency's development programming (Walker, 2014).

Alongside the growing interest of systems thinking for WASH in academia and among bilaterial donors, there have also been a number of practical case-based texts in systems thinking and general development developed by Burns and Worsley (2015)

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and specifically in WASH by Neely (2019). More recently, practitioners such as Kimbugwe et al. (2022) have published specific cases of uses of systems thinking techniques to engage, involve and assess WASH programming across a range of contexts.

An overview of some of the major thematic tools and approaches is explored in the following section.

Systems thinking tools and techniques used in the WASH sector

From the plethora of systems thinking tools and techniques available, individuals and organizations are pragmatically choosing those that fit with their ethos of practice, are usable, and have the potential to provide insights and innovations beyond our current knowledge. Valcourt et al. (2020a) indicate in their review that the three most commonly used systems thinking methods in the WASH sector are frameworks, composite scoring and qualitative data analysis. Valcourt et al. (2020b) also noted that the prominence of frameworks as the most commonly used systems approach seemed to be in conflict with a previously conducted survey, which reported that 80% of WASH sector professionals indicated that they did not use a formal planning tool in the implementation of water and sanitation projects because "the context-specific nature of project planning decreases the applicability of a planning framework" (Barnes et al., 2014, p. 79). However, the use of various tools is not consistent among WASH sector actors. For example, within the academic literature there appeared to be an inclination towards the use of more analytically complex approaches such as Bayesian analysis (Fisher et al., 2015), social network analysis (McNicholl et al., 2017) and system dynamics (Liddle and Fenner, 2017) that are not as commonly referenced in the gray literature (Valcourt et al., 2020a).

The second most referenced method in Valcourt et al.'s review consisted of a broad range of methods referred to as 'composite scoring', an accessible tool for defining and scoring the strength, influence or capacity of various dimensions of the WASH system. This approach has gained a lot of traction in the sector as it presents an accessible and easy-to-understand framework for quickly evaluating the 'overall health' of a WASH system and identifying potential weak points for intervention and strengthening. Composite Scoring has been used in a series of checklists focused on evaluating service sustainability, including the Water for People's Sustainability Service Checklist (Burns, 2020), the DWA Sustainability Monitoring Framework, the WASH Sustainability Index Tool (SIT) Comparative Analysis (Annis and Moreland, 2015), the World Bank's Sustainability Assessment Model (World Bank Group, 2017), and the IRC's Building Blocks (Huston and Smits, 2017), among many others. Overall, composite scoring approaches represent an approachable and functional resource for WASH actors to identify, evaluate and monitor the various elements of the WASH system that support service sustainability.

Yet, the use of systems thinking in development and WASH is not remotely a new concept; one of the first identifiably systems thinking approaches to WASH can be found in the participatory action research (PAR) work of Chambers (1994) and is linked to implementations that include community action planning and methodology for participatory assessments. PAR is a widely accepted and practiced form of qualitative research that aligns well with systems thinking principles in that, as a methodology, it engages diverse stakeholders in making sense of complex situations (Bossyns et al., 2016). In the WASH sector, a recent practical application of PAR is demonstrated within a systems thinking framework by Huston et al. (2021) during a transition phase in water services in Uganda, where their mixed methods analysis engaged diverse stakeholders to successfully explore service performance under various management models.

Systems thinking frameworks provide users with ways to explain complexity and to invite the participation of stakeholders in elucidating both the problem and the potential solutions. This is well demonstrated by Starkl et al. (2013) in applying a "planning-oriented sustainability assessment framework" in a WASH context in Mexico that provided support for modeling and consensus around environmental issues in water service provision. Another significant use of systems thinking as a framework is demonstrated by Kimbugwe et al. (2022), who combine empowerment and participatory approaches within a systems framework to strengthen the learning and capability of individuals and organizations within the WASH sector.

A commonly used practical application of a WASH systems framework comes in the form of a Theory of Change (ToC), which is a mapping technique that has been applied in program evaluation since 1995. ToCs can range from linear maps more akin to logic frames, to maps that show the interconnections and feedback loops expected of complex adaptive systems (Wilkinson et al., 2021). The WASH sector now routinely applies ToC maps in planning and evaluation processes, but these still tend to be represented in quite linear input – output - outcome maps with little consideration of nuance or complexity, such as the feedback mechanisms of outcomes on outputs. Advances in ToC mapping that combine ToCs with Participatory Systems Mapping have been tested by Wilkinson et al. (2021) and could provide a useful means for the WASH sector to generate consensus on problems and solutions that require change across different levels of systems that strongly affect WASH services.

Another way that systems thinking approaches have been actioned within the WASH sector is through group model building (GMB). Initially described by Vennix (1996), GMB is a systems thinking approach that draws on the diversity of lived experience and expertise of a group of participants to represent a group's collective 'mental model' of a given complex issue. GMB includes a range of techniques, including rich pictures, three-dimensional models and simulations, messy mapping, and influence diagramming or collaborative conceptual modeling (Newell and Proust, 2012). One of the key benefits of GMB is its ability to assist in communicating and interrogating the implicit mental models of diverse actors in ways that do not marginalize individual actors' voice's based on their education, gender, discipline or social status. Within the WASH sector, GMB has been used to develop consensus on both the problem and solutions to WASH issues and has been applied with village water management groups and with expert groups (Valcourt et al., 2020a; Walters et al., 2017).

Systems thinking frameworks, ToC's and GMB activities are all inherently qualitative systems approaches to understanding a complex problem. Within this methodological genre, there are a multitude of evaluation approaches that have been applied to systems thinking in WASH, including Outcome Harvesting / Mapping, Most Significant Change, Qualitative Comparative Analysis (QCA). Outcome Harvesting and Mapping are two techniques that are used to examine the influence of various factors on a desired outcome (i.e. sustainable services) in a retrospective fashion to gain a better understanding of how combinations of different elements led to a certain outcome (Wilson-Grau, 2019). In effect, Outcome Harvesting and Mapping act as a monitoring counterpoint to the more planning-oriented ToC techniques. Similar to this approach,

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QCA draws on secondary qualitative data and researchers' case knowledge to examine the combinations of factors and conditions that lead to certain outcomes of interest. For example, a recent application of QCA to understand collaborative approaches to strengthening WASH systems found that while there are multiple pathways to successful collaboration, nearly all pathways necessitated the involvement and uptake of these efforts by government actors (Pugel et al., 2022).The application of a wide array of similar qualitative approaches for systems thinking in WASH was documented by the SWS project to highlight the value of systems approaches for monitoring systems change in the factors and actors that support WASH services (Hollander et al., 2020).

A related but more quantitative form of systems analysis increasingly employed for WASH systems thinking is social network analysis (SNA), an analytical method that is used to map, visualize and explore the key linkages between individuals and/or actors in a network that can represent the flows of information or resources between them (McNicholl, 2019). SNA allows users to objectively define social concepts within an assumption that the relationships between nodes (i.e. people, organizations, etc) are influential in determining the outcomes of actions (Wasserman and Faust, 1994). SNA has been used in the WASH sector to explore and understand the influence of different actors within a broad service context as well as the local power structures in villages around WASH services (Neely, 2015). These applications of SNA have illuminated key insights such as the potential for NGOs to "break" the lines of communication between citizens and governments and how 'elite takeover' is prevalent within the siting of village water supplies. Demonstrating the increased prevalence of SNAs in WASH, McNicholl (2019) describes four different types and uses of social network analysis applied within WASH contexts, including snowball networks, whole network analysis, ego networks and network change over time used to inform network characterization, centrality measures, strategies and leverage points and to monitor progress, respectively. Additionally, the SWS Learning Partnership applied SNA in design, monitoring and strengthening of WASH interventions and networks, including enabling communities to understand and influence government structures around water and environment issues (Harper, 2020).

System dynamics (SD) is a more quantitative-focused field of systems thinking that examines the dynamic flow of information, resources and other elements through factors within a system to understand how they affect the outcome. SD relies on building and running models based on causal loop diagrams (CLDs) that are used to elucidate causal relationships, feedback loops and time delays within a system (Liddle and Fenner, 2019). CLDs can be employed to create rich narratives of systems, especially when combined with participatory GMB approaches (Hovmand, 2014). The utility of SD for WASH has been demonstrated in a number of past cases including Libey et al. (2022), who used this method to simulate and determine optimal expenditure ratios of new installation versus operation and maintenance on boreholes in East Africa. SD was also used by Chintalapati et al. (2022) who modeled the interaction of technical, financial, and environmental factors underpinning the scaling of professionalized maintenance services for rural water services in Kenya. These examples demonstrate the growing application of SD to model complex dimensions of WASH services. Aided by an increased global focus on the collection and use of quantitative WASH data, modeling techniques, such as SD, are likely to be used more frequently in the future, especially as we come to understand the power of data available for simulations and evidence-informed policy making.

As WASH data becomes increasingly available, other techniques that reflect large datasets within a complexity framework include agent-based modeling as applied by Mallory et al. (2019)) in predicting the outcomes of programs recycling fecal sludge in Malawi. Machine learning and Artificial Intelligence are applied to questions of health and epidemiology related to WASH by Tadesse et al. (2023) and Pandey et al. (2022), but it is not clear that these functions encompass complexity, as we define it, or are better considered as complicated due to the large datasets involved. Coupled human and nature systems (CHANS) modeling, used within integrated water management (Feng et al., 2018), has potential application within the rural WASH sector. We believe that quantitative techniques employing large datasets within a complexity framework are likely to be employed usefully within the WASH sector over time.

In this section, we have shown an array of innovative systems thinking tools, noting that they exist on a spectrum ranging from highly qualitative to highly quantitative in nature. However, regardless of the specific method employed, all systems approaches greatly benefit from significant engagement with relevant communities of policy makers, practitioners and WASH users so that the resulting systems models and analyses represent the diversity of stakeholders' mental models as best as possible. The significance of systems thinking processes in creating a narrative of WASH that is developed in collaboration with a wide group of stakeholders is a notable aspect of post-positivist development and one that may have the potential to drive localization agendas as demonstrated in non-WASH examples by Tan et al. (2019).

While this is not an exhaustive list of systems thinking tools, it does provide a generalized overview of the breadth of systems approaches for WASH. As experienced practitioners, we tend to choose the tools that we use from a pragmatic 'what do we think is most suitable in this situation' perspective. Yet, we realize that this may not be particularly helpful for practitioners who are new to systems thinking and modeling, so we suggest that a useful research program would be the mapping of problem types in WASH to the appropriate systems thinking tools and frameworks. While this has been written about elsewhere more generally for development (see Amadei, 2015), to our knowledge, there are no specific examples of this in the WASH sector, although McNicholl's (2019) exploration of SNA applications in WASH programming provides some decision support for SNA implementation in different situations. Thus, there remains plenty of opportunity for systems thinkers and WASH researchers and practitioners to explore and share different tools and techniques, as well as their applications within different WASH contexts and the outcomes from these applications.

Contexts of WASH and systems thinking

One of the reasons why WASH is still problematic after more than 70 years of development input to the sector is that every context is different. As a complexity and systems thinking concept, path dependence and the tendency of systems to co-evolve with interrelated systems tell us that no matter how similar two contexts appear to be, we cannot assume that the same WASH intervention is appropriate to both contexts. Differences in organizational and local history, aspirations, education levels, culture and experience all impact what people want, what they can and will contribute, and whether their approach is communitarian, individualistic, family-oriented or a combination of these. Path dependence and co-evolution therefore remind us to be wary of "silver bullets" or

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the idea that we can scale programs without significant attention to context differences (Neely, 2019).

Using systems thinking tools, techniques and frameworks within the WASH sector implies that we are explicitly seeking to ensure that we understand the social, political and natural environment and the connections between and within these in our work. Valcourt et al. (2020a) delineate the different contexts of WASH research and programing as being sited within Rural, Urban, Regional, National, Local, or City environments, all within the context of a global region, country, community, school or district. With this variation in context, it is unsurprising that variations in approaches, desired outcomes and beneficiaries all bring with them added complexity in understanding what works, when and why? In response to the confounding dimensions of context, several actors, including the Aga Khan Foundation in India, have used a 'whole of system' approach to WASH by including strengthening governance and service provision along with monitoring of sanitation coverage and hand hygiene behaviors (Umar and Varma, 2019). In contemplating 'whole of system' or 'systems strengthening' in WASH, we are alluding to an explicit understanding of both nested and interconnected systems that affect WASH outcomes. The acknowledgement of social aspects of power and advocacy, along with an emerging localization agenda within WASH-focused NGOs, confirms the need to take a systems approach, along with the requirement to develop systems-thinking technologies and approaches that are "user friendly" for WASH practitioners, including guidance on appropriate tools and approaches for differing contexts.

Systems thinking for intersections of WASH &….{everything else}

WASH programming, advocacy and research do not occur in a silo, they occur in the full context of the nested political, natural and social environments of the communities where they are enacted. This means that in WASH activities, we need to be aware of the ways that WASH intersects with other aspects of people's lives. Intersections include the tension between different uses of water, for example, a kitchen garden versus handwashing, the tension between different users of water, the requirements of health services and schools to have access to water and sanitation facilities, or planning for disaster risk reduction. One of the key aspects of systems thinking is its usefulness in the facilitation of critical conversations across existing professional, social and academic boundaries. For example, the visual languages of group model building provide a platform for questioning assumptions and for ensuring that everyone's input is heard and respected. Modeling that looks to a problem and then brings in multiple stakeholder perspectives allows groups to collaborate to develop models that can show the leverage points for solving problems while minimizing unexpected outcomes or resistance (Newell and Proust, 2012). The following section provides a series of short examples of cross-sectoral areas where WASH features and where system thinking techniques could be useful in creating collaboration for positive outcomes across sectors.

The public health sector has consistently seen WASH as a population health intervention. As an intervention, WASH by itself is considered to be effective in improving health, and it also contributes to health improvements in conjunction with other types of programming. For example, there is evidence that treatment for malnourishment is more effective when household water is also treated and that chlorination of household water during treatment results in fewer incidences of diarrhea than filtration (Doocy et al., 2017). The overlap and the need for health and WASH practitioners to work together to identify and overcome the barriers to good health that are caused by, or exacerbated by, a poor WASH environment are critical to progress. Other recent work has identified the issues of animal husbandry and health in WASH poor settings and resulted in calls for the WASH sector to incorporate a One Health approach of animal, human and environmental health as being related and interdependent (Prendergast et al., 2019).

WASH and education go beyond the provision of water and sanitation facilities in schools and may include the need to include WASH within health and science curriculum areas and in community education. Provision of water by 'self-supply' is significant in low resource settings; therefore, education that covers water supply methods and safety is critical to the health and wellbeing of people whose WASH needs will not be met alone by government, private enterprise or international development actors (Sutton and Butterworth, 2021). Sutton and Butterworth (2021) also call our attention to Clause 25 of the UN Human Right to Water, which includes the obligation of the state to "*take steps to ensure that there is appropriate **education** concerning the hygienic use of water, protection of water sources and methods to minimize water wastage*" Beyond self-supply, community management is an important aspect of rural water supply in low-resource settings and has the same requirements for community members to be educated in practical aspects of maintaining a safe and secure water supply.

Beyond public health and education, WASH intersects with a myriad of other sectors: policy and governance (Harvey, 2019), health care (Weber et al., 2018), one health (Pinto Jimenez et al., 2023), and disaster risk reduction (Wanda et al., 2017). The WASH sector is also concerned with 'cross-cutting themes' in development: climate change/environmental sustainability (Carrard and Willets, 2017) gender equality (Macura et al., 2023), disability and inclusion (Huggett et al., 2022). Systems thinking tools and techniques provide practical and actionable ways for us to explore these intersections so that we can find synergies and cooperative actions and avoid situations where sectors unintentionally work against each other because of a lack of attention to the wider system. Systems thinking can provide useful insights both to guide interventions towards sustained useful outputs and to understand the potential for unintended consequences (positive or negative) that may occur in adjacent or interlinked systems.

State of system thinking for WASH

As we have shown, there is both a great need for and a profound growth of systems thinking in WASH in light of the complexities of factors and actors that influence service delivery, infrastructure and the enabling environment. In response to the substantial interest in applying systems thinking to the WASH context, Walters et al. (2022) sought to gauge the perspective of sector leaders on both the attributes of a WASH system and approaches for engaging and strengthening systems. The study found that leading experts agreed on most of the dimensions of both WASH systems and systems approaches but conspicuously disagreed about the utility of mapping approaches, the role that such approaches play in fostering collective action, and whether these approaches are scalable. The topic of scalability speaks to a potentially greater issue of balancing the context-specific nature of systems thinking approaches with the need to generate evidence on best practices for implementing such approaches.

While there are many examples of innovative systems thinking approaches being implemented across a wide variety of contexts

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(see methods cited above), as of yet there is a lack of cross-case evidence of the utility and impact of such approaches. Additionally, there appears to be a propensity for systems thinking tools to use methods that require a high level of analytical capacity to conduct. This makes many approaches functionally inaccessible to many practitioners. While systems thinking itself is oriented to embrace complexity, if the tools themselves are too technical, this will necessarily limit the ability of these tools to scale across the sector to the point where they can translate insights to impact. Thus, without a robust assessment of the tangible benefits of systems thinking for WASH, uptake, innovation and investment of such approaches may stall, and the term 'systems thinking' may find its way to the buzzword graveyard of WASH sector discourse.

Progressing systems thinking use in the WASH sector

Significant engagement in the application of systems thinking within the WASH sector presents a unique opportunity to WASH researchers and practitioners to leverage the power of an innovative, participatory and complexity-aware toolset to address the inherently interconnected issues underpinning the sustainability of WASH services and infrastructure. However, as with any novel approach, the potential for impact lies in the uptake and adoption of these approaches in a way that is commensurate with the scale of this global issue. This will necessitate WASH sector approaches that **share** information, **scout** for new techniques, and **scaleup** and spread useful system understandings.

Sharing – As a fundamental starting point, the sector needs to understand what works and what does not for integrating systems thinking in WASH, including how these approaches can be adapted and aligned for programming within the sector. This will require both the generation and sharing of robust evidence regarding the utility of various approaches as well as the considerations for how and where they should be employed. As a new-ish set of tools and techniques, we feel that it is important to share failures as well as successes and note that the WASH Fails group (Sindall et al., 2023) points to using systems thinking approaches, among others, to understand and avoid some common types of WASH failures.

Scouting – As we mentioned earlier, systems thinking comes from a wide range of fields, and the WASH sector still has a lot of exploring to do. A core step in generating evidence for systems thinking approaches will necessarily require us to look at the application of systems thinking in as many contexts as possible to develop a richer understanding of how various tools and techniques might be useful or adaptable to (hugely) varied WASH contexts. To do this, WASH sector actors all along the project cycle will need to examine how they can integrate systems thinking into dimensions of program design, implementation and monitoring across as many different contexts and locations as possible.

Scaling– Scale and spread are critical to the dissemination of any good ideas. However, the highly context-aware orientation of systems thinking approaches compels us to consider the need to work along a spectrum of local-to-macro scales in order to achieve sustainable results. Examples abound of systems thinking approaches being applied from a village to a national level. The question that must be addressed, however, is which scales are most appropriate for the system you are trying to influence?

Conclusion

The WASH sector is incorporating systems thinking into WASH research and programming. This process is driven by individuals and organizations who see the usefulness of systems thinking as a framework and who are willing to explore the various tools and techniques for systems thinking applications within the sector. This paper has shown that the systems thinking tools that are currently available tend to be limited to use by expatriate development workers and researchers; they have not spread to common use within locally driven WASH programming in low- and middle-income countries. Given the limitations on the use of systems thinking and the variability of contexts in which WASH programming and research occur, 'sharing, scouting and scaling-up' of systems thinking in WASH is an effort that is worth continuing through the next decade.

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