INTEGRATING CLIMATE RESILIENCE INTO THE WASH SYSTEMS STRENGTHENING CONCEPTUAL FRAMEWORK

This paper summarizes the findings of the master's thesis by Dominik Zell[1], which explores how climate resilience can be integrated into the conceptual framework of WASH systems strengthening.

In light of increasing climate-related risks and slow progress toward global water and sanitation targets, the study investigates key factors that influence the resilience of WASH systems and identifies leverage points to enhance their ability to adapt to and recover from climate shocks. Drawing on a qualitative methodology that combines a systematic literature review with expert interviews, the research applies a systems perspective to analyze the complex interrelations between WASH service delivery and climate risks. The findings include targeted recommendations for adapting each of the building blocks of the systems strengthening framework and propose a set of parameters to monitor climate resilience in WASH programming. This work contributes to ongoing efforts to align WASH interventions with the demands of a changing climate through more systemic and forward-looking approaches.

Background, Conceptual Framework and Research Questions

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, but progress has been slow. As of today, only 17% of the Sustainable Development Goals (SDG) are on track, and none of the targets under SDG 6 - ensuring safe and sustainable water and sanitation services for all - are advancing at the pace required. This is underscored by the fact that an estimated 2.2 billion people still lack access to safe drinking water, while 3.5 billion people remain without adequate sanitation services [1]. Climate change is further increasing the pressure on WASH-systems and amplifies existing challenges: Extreme weather events can have a multitude of impacts from the contamination of water resources and disease outbreaks to service disruption of WASH infrastructure [2] [3] [4] [5] [6] [7]. Vulnerable groups like the elderly, disabled people, women, and children are particularly affected by these impacts [8] [9] [10] [11] [12].

[1] Dominik Zell holds a B.Sc. in Geography and completed his M.Sc. in Geography of Environmental Risks and Human Security at the United Nations University and the University of Bonn. Alongside his studies, he gained practical experience with the humanitarian directorate of Welthungerhilfe and through internships with the Danish Refugee Council's Emergency Unit, as well as GIZ's Sector Programme on Peace and Security and Disaster Risk Management. His work has focused on disaster risk reduction, climate change adaptation in displacement settings, and risk-informed development. His full thesis is cited as: Zell, D. (2024). *Integrating Climate Resilience into the SSI Framework for WASH-Systems Strengthening*. Master's Thesis, UNU & University of Bonn, in collaboration with Welthungerhilfe.

Addressing the growing challenges in the WASH sector requires a fundamental shift in approach. Over the past several years, there has been broad recognition within the sector of the need to move beyond fragmented, project-based interventions toward nationally and locally led efforts that strengthen entire WASH systems. This evolution has led to increasing convergence around what is now widely referred to as the WASH systems strengthening approach.

Welthungerhilfe, a member of the Agenda for Change, adopted this approach 2017 under its Sustainable Services Initiative (SSI) and is currently taking steps to systematically integrate climate resilience into its systems strengthening efforts.

Figure 1: Welthungerhilfe's Systems Strengthening Framework with its 9 Building Blocks

As part of Welthungerhilfe's efforts to integrate CR into the 9 Building Blocks of the SSI Systems Strengthening Framework (Fig. 1), a research collaboration was established with the United Nations University and the University of Bonn to explore how climate risks can be effectively embedded.

The research conducted by Dominik Zell, available here, was guided by the following three research questions.:

1. What factors affect a WASH system's climate resilience?
2. What leverage points exist to increase climate resilience?
3. How do these findings reflect on the concept of resilience?

Research Methodology

Research Design

This study followed a qualitative approach to explore factors that contribute to the climate resilience of WASH systems. The research addresses three key questions and employed semi-structured expert interviews alongside systematic and grey literature reviews for data collection. A conceptual framework, based on the SSI framework and resilience theory, informed the qualitative content analysis and systems mapping. Systems thinking was applied to visualize key factors and leverage points.

Data Collection

Systematic Literature Review: A systematic review of academic papers was conducted using the SCOPUS database. Search terms included "climate resilien*" "Water, Sanitation, and Hygiene" and "WASH," focusing on literature published after 2014 due to the significance of the Paris Agreement and Agenda 2030. After an initial 69 papers were identified a total of 47 papers was excluded after screening the abstract and the full text.

Grey Literature Review: Reports and guidelines from experienced WASH think-tanks and WASH-actors were reviewed to expand the literature base. By searching the publications section of these actors, an additional 17 publications were identified and included in the analysis.

Semi-Structured Expert Interviews: Interviews were conducted with WASH practitioners and climate resilience experts. The interviewees were identified through WHH's network and represented both field-level and HQ-level perspectives. The interviews lasted between 45 to 60 minutes and were conducted online.

Data Analysis

Qualitative Content Analysis (QCA): Mayring's approach was used to systematically code and analyze the collected data. The analysis focused on identifying factors within the nine SSI building blocks that contribute to an enabling environment for climate-resilient WASH systems. As part of this method the literature and interviews were reviewed and relevant codes were allocated to one of the nine building blocks (Fig. 2). For instance, if a quote said that having multiple water points with different risk profiles increase the climate resilience of a community this quote was counted as one code for the service delivery infrastructure building block.

Qualitative Systems Mapping & Network Analysis (Fig. 3): A systems map was developed to visualize the interconnections between factors. Using the Kumu.io platform, elements were clustered according to the SSI's framework, and relationships between elements were mapped. Metrics such as system density and degree were calculated to identify leverage points for enhancing resilience (Fig.3)

Findings of the research

This chapter presents the results of the research. The findings include the codes identified as influencing climate resilience and assign them to the nine building blocks of the WASH Systems Strengthening Framework. In addition interconnected key elements have been identified as leverage points and are visualized in a systems map.

Factors Increasing the Climate Resilience of WASH Systems

A total of 1438 codes were identified through the Qualitative Content Analysis (QCA) of the literature and interviews. The majority of these codes were linked to the building blocks of water resources & environment and service delivery infrastructure, accounting for 56.4% of the total. The other building blocks, including institutional arrangements & coordination, finance, monitoring, and demand behavior & political will, were relatively evenly distributed. However, only few codes were found in the building blocks of learning & adaptation and regulation & accountability.

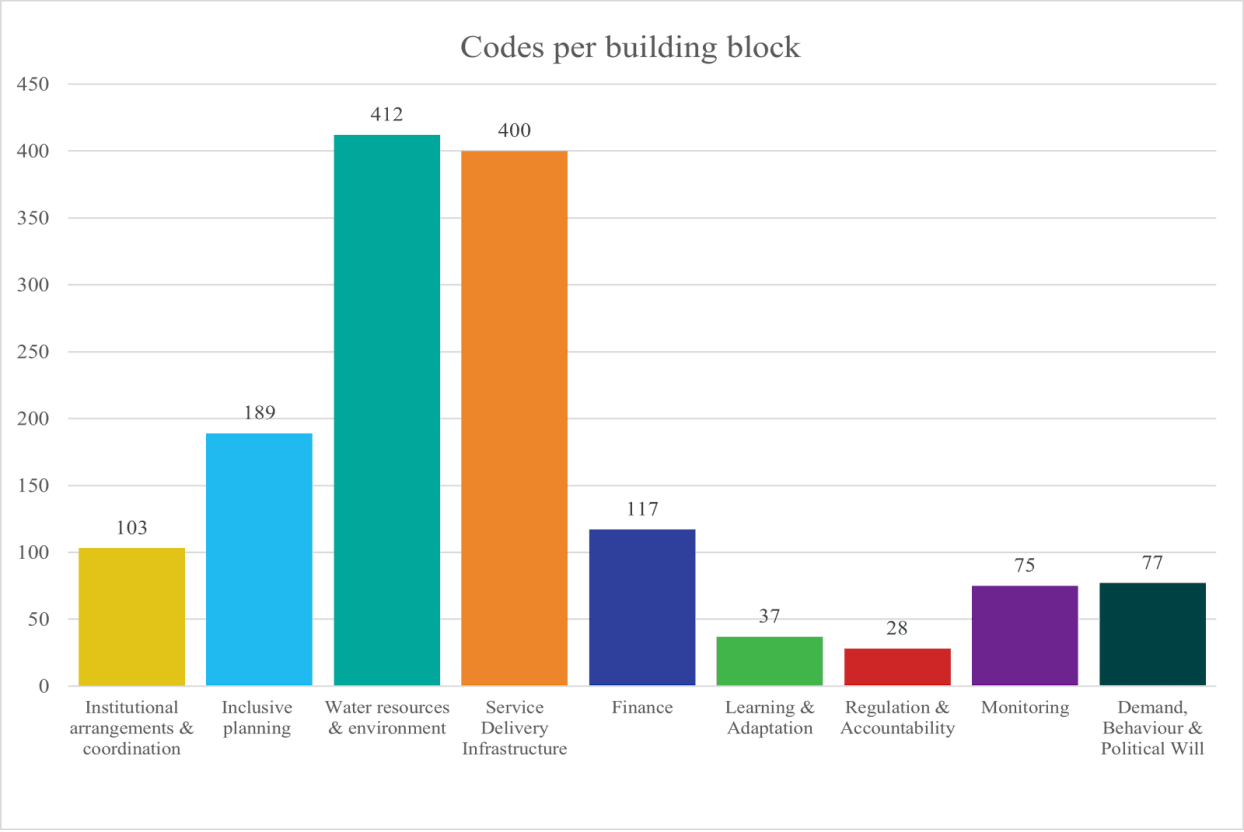

Figure 2: Codes identified per building block as result of the Qalitative Content Analysis.

1 Institutional Arrangements & Coordination

A total of 103 codes were identified under this building block, focusing on clear responsibilities, coordination with other sectors, the role of local governments, and capacity building. Scholars emphasize that unclear responsibilities and poor coordination across administrative levels weaken the climate resilience of WASH systems [13] [14] [15].

Local governments often face challenges in implementing national policies, sometimes due to limited awareness or budget constraints. Additionally, local government operations can be siloed, complicating cross-sectoral coordination within WASH. Scholars suggest designating a lead climate resilience ministry at the national level and cross-agency working groups at the local level to improve collaboration [Interview] [15] [16][17]. Furthermore, to facilitate coordination, relevant institutions should have designated climate change desk officers or focal points. Lastly, the government should establish guidelines, best practices and provide trainings for service providers and local governments [15] [18].

2 Service Delivery Infrastructure

With 400 codes, this building block has the second largest evidence base. Key themes include the need for diversified infrastructure, decentralized systems, and risk-informed design. Resilient service infrastructure should be capable of withstanding or adapting to climate impacts like floods and droughts.

Recommendations include conducting risk assessments to identify vulnerabilities, designing adaptable systems to cope with varying climate conditions, and ensuring the availability of multiple water sources and service providers to reduce reliance on a single supply [19] [20] [21] [14]. Decentralized and modular systems can further enhance resilience by isolating failures and therefore prevent the spread of contamination through the system and allows to adapt to changing demands over time [22] [11] [20] [22].

Additionally, storing spare parts locally and training community members in basic repairs can reduce service disruption times as a result of extreme events [23] [24]. If natural hazards occur on a seasonal basis or early warnings are issued, preparedness actions such as preemptive emptying of fecal sludge containers should be [25] [4] [15] [26]. Lastly, the financial and technical capacity to maintain the infrastructure should be taken into account during the appraisal process, because a lack of maintenance can increase the susceptibility of the infrastructure to the impacts of extreme events over time [20] [6] [27] [28].

Woman fetching water in a dry riverbed, Kajado, Kenya, © WHH 2019

3 Regulation & Accountability

This building block had the fewest codes (28), focusing on the need to update technical regulations and norms to reflect climate realities. Regulations governing construction, siting, and FSM should account for changing climate conditions [25] [15]. For example, raising sanitation infrastructure in flood-prone areas can prevent contamination, and updating water abstraction laws can improve equity during times of water scarcity [20]. In rural areas in particular oversight over regulations is often fragmentized, and authorities lack the capacity to enforce regulations. Therefore, capacities for the enforcement of regulations must be strengthened [23]. Lastly, compliance can be ensure through audits and licensing systems for service providers [20].

4 Inclusive Planning

189 codes highlight the importance of inclusive planning, particularly the involvement of local communities in designing WASH systems. According to the findings, communities bring valuable local knowledge and insights that can enhance resilience [29] [30] [4]. Inclusive planning also addresses inequalities, ensuring the needs of vulnerable populations are prioritized [3] [15] [22] [4] [26]. Cross-sectoral planning is essential as climate impacts affect multiple sectors [4] [26]. For example, integrating WASH with disaster

response or agricultural sectors can strengthen overall resilience [3] [15]. Risk assessments, a recurring theme, should inform planning, enabling the identification of at-risk areas and guiding intervention priorities [20]. One option to mainstream risk assessments in the WASH sector is by integrating them into existing processes such as water safety plans [6] [11]. With regards to policies two main aspects were identified. On the one hand, climate considerations should be integrated into WASH policy. On the other hand, WASH must be integrated into NDCs and NAPs in order to attract climate financing [15].

5 Finance

117 codes were identified in this building block, which underscore the challenge of financing climate-resilient WASH systems. The initial costs of climate-proofing infrastructure are higher, yet the WASH sector has only received a small share of available climate financing [4] [15] [3]. Lack of inclusion in NDCs and NAPs further limits access to funds. In order to demonstrate the potential to save money on reconstruction of infrastructure over the long term, proactive risk assessments and cost-benefit analyses can be conducted [20]. International financing options should be explored, but local governments should also allocate budgets for adaptation. To this end, scholars and informants alike proposed that governments should establish legislation that makes it mandatory to allocate a certain percentage of the budget to climate adaptation [6] [15]. Flexible disaster response funds and targeted financing for vulnerable households are essential to ensure rapid recovery and equitable access [15] [8].

6 Monitoring

This building block had 75 codes, focusing on monitoring WASH infrastructure performance, climate resilience, and early warning systems. Regular monitoring helps inform decision-making and policy, enabling swift repairs after disasters [24] [22] [31]. However, Kohlitz et al. note challenges in tracking climate resilience, as there is no universal benchmark for measuring adaptation. Monitoring strategies should therefore focus on processes rather than outcomes [27]. Early warning systems that generate real-time data can help protect WASH infrastructure and public health during extreme weather events by enabling early action [8] [15] [22] [4]. Integrating data from other sectors, such as public health, can further enhance early warning capabilities and increase their actionability [32] [15] [33].

7 Learning & Adaptation

22 codes emphasize the importance of learning and adaptation, particularly in the context of climate uncertainties. Reflecting on past disasters allows stakeholders to identify weaknesses and improve future resilience [5][20][22][15]. Collaborative learning processes, involving communities and practitioners, can accelerate the scaling of climate-resilient solutions and can ensure that equity considerations are addressed [27] [6] [13]. Sharing lessons learned through cross-sectoral working groups and synthesizing project outcomes can further strengthen WASH planning and policy [4] [6]. Regular evaluations and reflections will ensure continuous adaptation to evolving climate risks.

8 Water Resources & Environment

This building block had the largest evidence base with 412 codes, focusing on water resource management (WRM), hydrological assessments, and continuous monitoring. Understanding local water resources is critical for WASH planning, and regular assessments help identify climate-resilient sources. Based on the assessments and the collected data, databases can be established and used as a decision-making tool. According to various sources, such databases enable modeling and analysis of climate change impacts on water resources [20]. Furthermore, these assessments can be used to identify climate resilient water resources that will benefit the communities over the long term [12] [20] [5]. Groundwater, often more resilient than surface water and abstraction of ground and surface water should be monitored continuously [26] [20]. WASH should be integrated into WRM to ensure equitable water allocation, especially during water scarcity [26]. Moreover, scholars advocate for integrated water resource management (IWRM) approaches that involve all stakeholders, including upstream and downstream users, to manage competition and ensure sustainability [22] [5].

9 Demand, Behavior & Political Will

This building block contained 77 codes, emphasizing the need for climate resilience projects to be grounded in an understanding of existing behaviors and community responses. To this end, formative research can identify behaviors that should be encouraged or modified [30] [4].

Risk perception is a key challenge; awareness of climate change impacts is often low, both within communities and among government officials [34]. To increase risk perception one option could be to discuss previous extreme events the communities experienced and how these extreme events are affected by climate change [4]. Institutional interventions, such as legal restrictions and financial incentives, can also influence demand for WASH services [13] [15]. Lastly, political will can be increased by demonstrating the cost of inaction, particularly through concrete examples of disaster impacts and future climate scenarios.

Qualitative Systems Map: leverage points for enhancing climate resilience

Based on the identified codes the systems map visualizes interconnections within the WASH system and identifies key elements that could serve as leverage points for enhancing climate resilience.

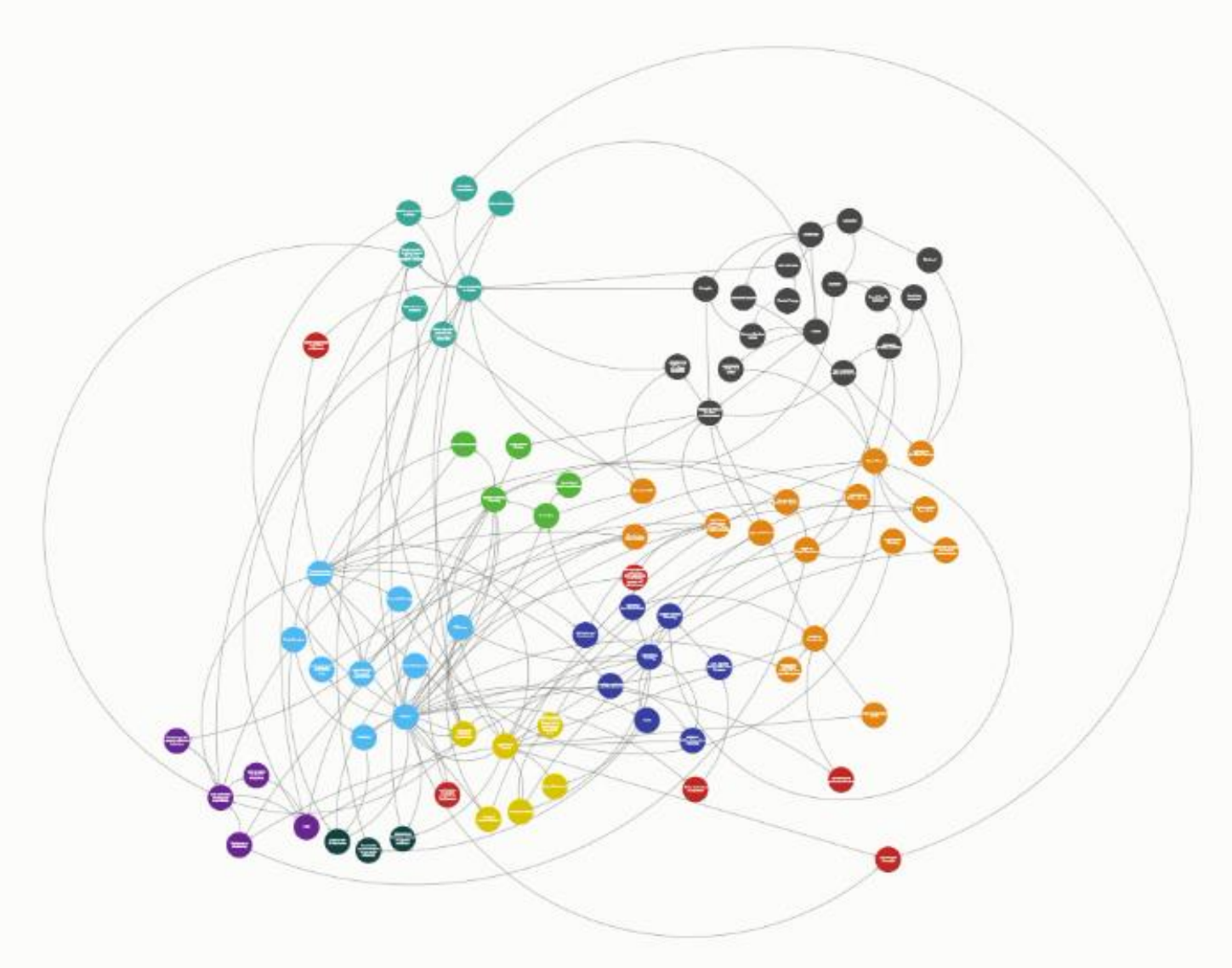

Figure 3: Systems Map. Click here to access file to enlarge.

Discussion of findings

Factors Increasing the Resilience of WASH Systems

A total of 60 factors contributing to the resilience of WASH systems were identified through the research. While some of these - such as regular maintenance - are already reflected in the existing conceptual framework, others are only partially addressed or entirely absent, despite being critical for enhancing climate resilience. Notable gaps include the mobilization of international climate finance, the integration of WASH into National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs), and the development of climate-specific monitoring indicators. Additionally, the establishment of early warning systems (EWS) and dedicated disaster response funds represent key resilience measures that are currently missing but essential for ensuring preparedness and enabling timely emergency response.

Based on these findings, 26 key considerations are proposed to strengthen the conceptual framework and improve its relevance for assessing climate resilience in WASH systems:

Building Block	Key considerations for integrating climate resilience into WASH Systems Strengthening
Institutional Arrangements & Coordination	A lead ministry/agency coordinates the work on the national/local level.
	Institutions and agencies have the capacity to address climate change (e.g. by having climate change officers).
	Inter-ministerial/cross-agency climate change working groups meet regularly.
	The national and local governments provide guidance, support, and training on aspects relevant to climate change (e.g. support to service providers for the development of operational plans for different extreme event scenarios).
Service Delivery Infrastructure	Risk assessments inform service delivery infrastructure design, siting, and appraisal.
	Operational plans have been developed to ensure the provision of services during and after extreme events (e.g. preventive emptying).
	Risk is spread, and access to services is diversified (e.g., multiple water points or service providers).
	Guidelines and standards for design and construction consider climate impacts.
Regulation & Accountability	Regulations and norms are risk-informed and consider climate change (e.g. water abstraction, siting, FSM, land use planning, zoning laws & building permits).
	Mechanisms are in place to monitor progress on NDCs/NAPs.
	Budget allocations are transparent and tracked.
Inclusive Planning	Communities participate in the planning, design, and management of WASH programs and interventions, and the needs of marginalized groups are prioritized.
	Risk assessments inform planning and policies and integrate local knowledge and climate projections.
	WASH integrated into NAPs/NDCs.
	Climate change considerations are integrated into WASH planning and policy, and the needs, experiences, and issues on the local level inform national-level policies.
Finance	The government has the capacity to mobilize international climate financing.
	Investments are risk-informed.
	Budget is allocated for climate adaptation and disaster response.
Monitoring	Context-specific climate resilience indicators have been developed and are monitored.
	The development and implementation of climate resilience strategies and processes is monitored.
	EWS are operational, integrate data from other sectors, and the public and service providers receive timely warnings.
Learning & Adaptation	Post-disaster reviews and evaluations are conducted.
	Communities, practitioners, and other relevant stakeholders are involved in reflection and learning processes.
Water Resources & Environment	Water resource databases exist and inform decision-making.
	Plans exist that detail water allocation during and after extreme events, are based on equity concerns, and prioritize water for domestic consumption.
Demand, Behaviour & Political Will	Communities, officials, and agencies are aware of climate change impacts and the cost of inaction.
	Households are incentivized to use water efficiently and to take actions that increase climate resilience

Systems Thinking and Leverage Points

The systems map (Fig. 3) reveals that WASH systems are open and complex, characterized by multiple feedback loops. Positive feedback loops, like conducting post-disaster reviews to improve future risk assessments and design, are essential for building resilience. The system also exhibits equifinality, meaning different pathways can lead to similar resilience outcomes. For example, improving infrastructure quality, speeding up repairs, and decentralizing services can all reduce the impact of extreme events.

The low system density, with few connections between elements, suggests that interventions must be broad and target multiple areas to foster change. Leverage points with high interconnectedness, such as policies, institutional capacity, and financing, are critical areas to focus on. Policies, for example, have wide-reaching effects across all building blocks and can facilitate systemic change. Institutional capacity ensures that climate resilience can be integrated into planning processes, while financing is key for implementing resilience measures and adapting infrastructure to withstand extreme weather events.

Key Takeaways

The findings suggest that effective interventions must address multiple aspects of the WASH system due to its low density and high interconnectedness. By targeting key leverage points like policies, institutional capacity, and financing, climate resilience can be significantly strengthened.

Importantly, many standard WASH activities already contribute to resilience, such as best practices for infrastructure design and regular maintenance. However, interventions outside the WASH sector, such as improving livelihoods, are also crucial. When households have stronger incomes, they are more likely to invest in climate-resilient sanitation and water infrastructure, making them less vulnerable to disasters.

Limitations

This study has several limitations, including its broad scope and the limited number of interviews (ten experts). Most interviewees were strategic-level practitioners, and perspectives from service providers or community organizations were not included. The study also focused only on factors that increase resilience, without addressing factors that might hinder or slow down climate adaptation efforts. Additionally, the systems thinking approach presents challenges in terms of organizing findings, as systems operate simultaneously and interact in multiple directions, making linear written presentation difficult.

Conclusions

Climate change is putting increasing pressure on WASH systems, amplifying existing risks. This study sought to explore how to enhance the climate resilience of these systems by addressing three key questions. First, it identified 60 factors that help create an enabling environment for resilience in WASH systems. These factors were compared with the SSI framework to uncover gaps, resulting in the proposal of 26 additional aspects that need to be considered to complement the framework.

Next, leverage points that can drive systemic change to improve climate resilience were identified. Using a systems thinking approach, qualitative mapping, and network analysis, various leverage points were highlighted and discussed in detail.

Finally, the study connected the identified factors and leverage points to the core characteristics of resilience: the ability to recover, anticipate, absorb, and adapt to disturbances. It was emphasized that increasing climate resilience in the WASH sector requires going beyond mere recovery or reinforcing existing systems. Instead, the focus must shift toward creating adaptive systems capable of reorganizing in response to the ongoing and uncertain impacts of climate change.

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Dominik Zell, Stephan Simon, WHH

Contact

Stephan.Simon@welthungerhilfe.de
WASH Advisor – Global WASH Team, Welthungerhilfe
https://www.welthungerhilfe.org/wash

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