elrha

SAFE WATER OPTIMIZATION TOOL

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ACRONYMS

AQA	Accountability and Quality Assurance Initiative
DRC	Democratic Republic of Congo
IDP	Internally Displaced Person
KIIs	Key Informant Interviews
FRC	Free Residual Chlorine
HIF	Humanitarian Innovation Fund
MSF	Médecins Sans Frontières
NRC	Norwegian Refugee Council
SWOT	Safe Water Optimization Tool
UI	User Interface
UNHCR	United Nations High Commissioner for Refugees
UX	User Experience
VHT	Village health teams
WASH	Water, sanitation and hygiene
WHO	World Health Organization

EXECUTIVE SUMMARY

Introduction

Access to safe drinking water remains a major global problem, as millions of people lack access to safely managed water services. Chlorination is a common method used to provide safe drinking water in humanitarian emergencies as it eliminates harmful microorganisms, preventing waterborne diseases. Current guidelines, such as the Sphere Handbook, recommend maintaining free residual chlorine (FRC) levels of 0.2–0.5 mg/L at points of delivery for safe consumption. However, these guidelines provide a single universal treatment rule that is not based on field evidence from humanitarian settings and so not applicable to all settings.

A 2015 Humanitarian Innovation Fund (HIF) research study conducted in Jordan and Rwanda identified that the current FRC guidelines do not always ensure safe water consumption at the point of use, especially in high-temperature and low-hygiene settings. Therefore, context-specific FRC targets are needed to ensure that people in humanitarian settings have access to safely chlorinated water.

Following these findings, the Safe Water Optimization Tool (SWOT) was developed to address this challenge. The SWOT is a web-based platform that uses water quality data to generate site-specific, evidence-based chlorination targets by considering water quality data including time-stamped FRC measurements at the tap stand and households, water temperature and electrical conductivity. This ensures a minimum of 0.2 mg/L FRC not only at tap stands but also for household consumption and storage.

The vision behind the innovation is to enable access to safe drinking water for people affected by crises, through the SWOT's effective and reliable provision of accurate chlorination targets over time and in different use cases. The SWOT has been deployed in nine countries with different contexts, using varied water systems. In all nine countries, the SWOT has conducted validation studies that have evidenced its ability to produce accurate chlorination recommendations that have ensured adequate FRC levels at least 18–24 hours after collection. This has resulted in the SWOT supporting access to safe drinking water for 465,000 people.

In order to achieve this vision, the team foresees that the SWOT is used routinely and consistently as part of water quality monitoring for organisations delivering safe drinking water in humanitarian contexts. There are three underlying assumptions in this change area:

Firstly, organisations will have adequate resources (financial and non-financial) and technical capabilities to implement the SWOT. The SWOT is designed to work alongside already established water quality monitoring practices so that organisations do not have to incur any additional expenses during implementation. International guidelines also recommend humanitarian water providers conduct household water testing to ensure that water is safe at the point of use. However, from the studies conducted, the SWOT team found household-level testing is not consistently or regularly conducted. Since the SWOT requires household-level data to provide accurate targets, in reality, organisations incur some additional staffing costs to carry out this step. For example, Médecins Sans Frontières (MSF) is implementing the SWOT in Benue State, Nigeria and incurs £400 per month on additional staffing costs.

Secondly, the SWOT team assumed that the implementing organisation would have adequate technical capabilities to implement the tool after training. However, in reality this varies: some organisations do not require further training to implement the SWOT, while others also require fundamental water quality testing and water treatment training.

The third assumption was that after training and implementation, the SWOT would be integrated into an organisation's standard practice. Even though seven organisations have implemented the SWOT, integration into standard practice has been limited with only MSF in Nigeria using the SWOT on a monthly basis. For Uganda, the SWOT team worked with Oxfam on a time-bound project with objectives and associated funding from the HIF, however, this did not translate into a change in practice after the project ended.

Implementation of the SWOT has Highlighted Four Key Lessons:

- Funding for all stages of the innovation process has been essential, as the SWOT's key milestones were only possible due to grant awards like the HIF's (£336,832) that facilitated the foundational research highlighting the gap in FRC guidelines as well as the development and testing of the SWOT in different kinds of emergency water systems in Somaliland and Uganda.
- It's not enough to prove an innovation works for it to be adopted: most implementing partners have not (yet) integrated the SWOT into their standard practice. The SWOT team will need to carry out significant advocacy work to convince humanitarian water service providers of the need to change practice before they can hope to achieve wide uptake of their solution.
- Tailored support and training are crucial for organisations as they have varying capacities to effectively adopt and implement the SWOT. This will need to remain an important component of any scaling model for the innovation.
- Personal networks and word-of-mouth are strong enablers for early scaling, but not sufficient to drive adoption in the longer term. For example, the SWOT has mainly been adopted by individuals in organisations that have past relationships with the SWOT team.

In Conclusion

SWOT offers a promising solution to improve safe drinking water access in humanitarian settings. Its evidence-based approach has already shown positive results; with continued support and increased advocacy efforts it has the potential to make a significant and lasting impact on addressing water quality-related challenges in crises-affected areas.

Médecins Sans Frontières worker carries out water quality testing in South Sudan. Credit: Syed Imran Ali

INTRODUCTION

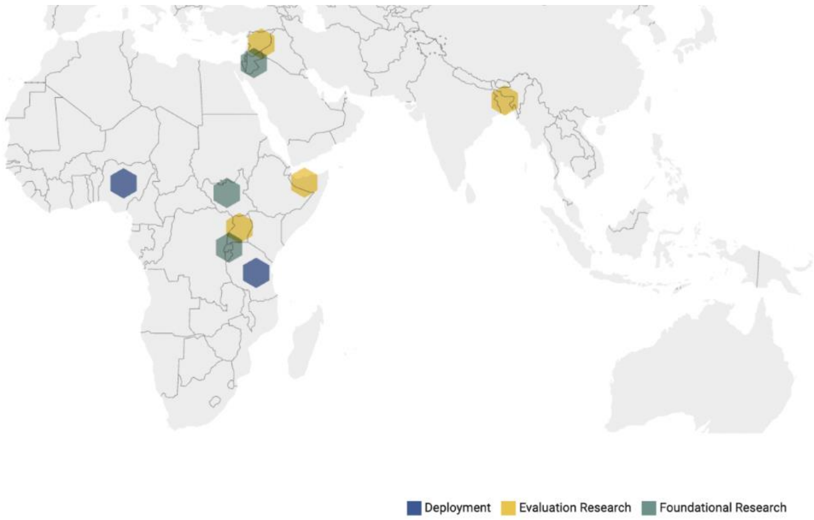
The Challenge

Access to safe drinking water is an essential human right, yet it remains a significant challenge during humanitarian crises. To address this issue, humanitarian water suppliers use chlorine to treat water so that it is safe to drink. Existing guidelines, such as those in the Sphere Handbook water supply, sanitation and hygiene promotion (WASH) technical chapter, outline a range of chlorine concentrations that indicate water is safe to drink. However, these guidelines offer a one-size-fits-all approach to chlorination that is not based on field evidence from humanitarian settings[1] and does not consider context-specific factors like high temperatures and poor hygiene conditions prevalent in crisis settings.

The Safe Water Optimization Tool (SWOT) was developed to address these challenges. The SWOT is a web-based platform that uses routine water quality monitoring data to generate site-specific chlorination targets, ensuring context-specific free residual chlorine (FRC) levels for safe water up to the point of consumption. Elrha's Humanitarian Innovation Fund (HIF) has supported the SWOT's journey through proof-of-concept, development testing and now roll-out at scale.

The SWOT has been tested in multiple refugee and internally displaced peoples (IDP) camps and has been deployed by seven humanitarian organisations in nine countries across 17 sites. The initial foundational research modelling post-distribution chlorine decay was conducted in South Sudan, Jordan, and Rwanda between 2013–2015. Proof of concept and evaluation research was undertaken in Bangladesh, Uganda, Somaliland and Syria between 2019–2022. The SWOT was also deployed for use in Tanzania, by the United Nations High Commissioner for Refugees (UNHCR), and Nigeria, by Médecins Sans Frontières (MSF), between 2020–2022.

Figure 1. Foundational, deployment and evaluation sites of the SWOT[2]



[1] Ali SI, Ali SS, Fesselet JF. Effectiveness of emergency water treatment practices in refugee camps in South Sudan. Bull World Health Organ. 2015 Aug 1;93(8):550-8. doi: 10.2471/BLT.14.147645. Epub 2015 Jun 1. PMID: 26478612; PMCID: PMC4581656.

[2] Image and information from [SWOT website](#) which was developed by [Datawrapper](#).

This case study focuses on implementation of the SWOT by Oxfam, in Kyaka II refugee camp in Uganda in 2022. It also draws on experiences and examples from the implementation of the SWOT in other countries.

As part of Elrha's commitment to accountability and learning, this case study provides evidence of impact achieved through the organisation's grant-making activities and insights into "what works" when supporting humanitarian innovation. The case study explores the reasons why change has (or has not) occurred in relation to the innovation's intended outcomes and seeks to identify relevant learnings for actors developing and scaling humanitarian innovations.

Summary of Methodology

The case-study explores six primary research questions:

1. How **relevant** is the innovation to addressing the specific humanitarian problem it focuses on?
2. How **effective** has the innovation been in reaching its intended objectives?
3. What is the **cost** associated with delivering the innovation?
4. What **impact** has the innovation achieved so far?
5. What is the potential for the innovation to achieve further impact in the future and effectively address the problem at **scale**?
6. What **key learning** has emerged from the innovation? In particular, what can this case-study tell us about enablers and inhibitors of innovation in humanitarian settings?

Development of the case study was conducted through four stages:

- **Inception phase** to finalise research questions and methodology; review relevant literature and develop the data collection tools.
- **Exploratory sessions** with the SWOT team to better understand the innovation and development costs. The SWOT team did not have a theory of change. Therefore, we facilitated a discussion with the team to reconstruct their vision, change areas and underlying assumptions from the start of working in Uganda.
- **Key informant interviews** (KIIs) with grantee team/partnership (innovators directly receiving Elrha funds), project partners but not receiving Elrha funds, SWOT users, potential adopters of the SWOT and external observers.
- **Validation meeting** with Elrha and the SWOT team to present and reflect on the findings.

We used thematic analysis, coding the primary data against the research questions, change areas and key assumptions to identify the key trends to inform the findings. The secondary data from the document review supported our triangulation processes of the data. Analysis included exploring whether SWOT's assumptions held true or not during the implementation of the innovations, using Uganda as a test case. A detailed methodology can be found in Annex 1.

HUMANITARIAN PROBLEM

The Problem

Access to safe drinking water is a fundamental human right. Yet the World Health Organization (WHO) estimates that, in 2022, 2.2 billion people did not have access to safely managed water services, with 296 million people taking water from unprotected wells and springs and 115 million people collecting untreated surface water from lakes, ponds, rivers, and streams.[3]

Existing Ways of Addressing the Problem

One way humanitarian actors ensure that water is safe to drink is through chlorination. The introduction of chlorine into available water supplies eliminates harmful microorganisms, such as bacteria, viruses and parasites, which can cause waterborne diseases like cholera, dysentery and typhoid. This disinfection process helps prevent outbreaks of these diseases and saves lives, especially in humanitarian emergencies.

A key advantage of chlorination over other disinfection methods is that free residual chlorine (FRC) may remain in the water, preventing recontamination. The Sphere Handbook[4] includes guidelines for the provision of water, sanitation and hygiene (WASH) services. The guidelines indicate that humanitarian actors should ensure that chlorinated water has 0.2–0.5mg/L FRC at points of delivery for it to be safe for consumption and use.[5]

Remaining Challenges

The Sphere Handbook maintains a single universal treatment rule of ensuring water contains 0.2–0.5mg/L FRC at point of delivery[6] of chlorinated water regardless of the context. In 2015, the Safe Water for Refugees project, funded by the HIF, conducted a research study in refugee and IDP camps in Jordan, South Sudan, and Rwanda. The aim of the study was to investigate chlorine decay post-distribution in diverse settings. The study found that the current guidelines on FRC offer insufficient protection in refugee and IDP camp settings with high temperatures and poor hygienic conditions. It recommended that FRC targets at tap stands might have to be increased from the current 0.2–0.5 mg/L range up to 0.5–1.0 mg/L range.[7]

Additionally, the Sphere Handbook recognises that water can be re-contaminated post-delivery during collection and storage of drinking water.[8] This was confirmed by the 2015 HIF study that found temperature, ambient environmental hygiene, and sunlight exposure are major drivers of post-distribution chlorine decay.[9] This means that the FRC levels might only be maintained at the tap stand,

[3] World Health Organisation fact sheet available here.

[4] Sphere Association. The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response, fourth edition, Geneva, Switzerland, 2018.

[5] The Sphere Handbook page 110

[6] The point of delivery is usually the tap-stand and not at the household where water is stored and used.

[7] Ali, S.I., Ali, S.S. & Fesselet, JF. (2015). Effectiveness of emergency water treatment practices in refugee camps in South Sudan. Bulletin of the World Health Organization, 93 (8), 550 - 558. World Health Organization. http://dx.doi.org/10.2471/BLT.14.147645

[8] The Sphere Handbook page 111

[9] Ali, Syed Imran et al. (2015)

and not at household level or point of consumption, rendering the water unsafe where people actually drink it.

For these reasons, the universal FRC target range does not ensure that water is safe to drink. Water can be safe for consumption at the tap stand, but due to variable FRC decay, may be susceptible to recontamination before it is consumed. The research available confirms that there is an urgent need to identify context-specific FRC targets that are grounded in the realities of people's access to and storage of water in real-world conditions.

THE INNOVATION: SWOT

Background

With the water quality data set collected from the 2015 HIF-funded research study in South Sudan, Jordan and Rwanda, the research team (which would later become the SWOT team) successfully developed a process-based modelling[10] method used to create evidence-based water chlorination targets for each site. This was later tested by Médecins Sans Frontières (MSF) in Mtendeli refugee camp (Tanzania) through a validation study,[11] which proved that the guidance provided by the process-based modelling outperforms the status quo of universal chlorination guidelines. This led to the development of the SWOT by the Dahdaleh Institute for Global Health Research at York University, in collaboration with MSF, in 2018–2019.

Addressing the Problem

The SWOT is a web-based platform onto which humanitarians can upload water quality data to generate site-specific, evidence-based chlorination targets. The SWOT utilises advanced process-based and machine learning modelling with routine FRC monitoring data to forecast FRC decay and furnish precise, site-specific chlorination targets. These targets assist teams in treating water sources with the appropriate chlorine dosage, ensuring the maintenance of adequate and context-specific FRC levels for safe water consumption. The SWOT's computation of the chlorination targets models FRC decay rate and field worker inputs of typical storage times. The modelling is based on water quality data collected from taps and households and so encompasses the effect of numerous factors known to impact chlorine decay, such as temperature, distances between households and water collection points (tap stands), and handling practices. This ensures that the chlorinated water contains a minimum of 0.2mg/L of FRC not only at the tap stand but also for the entire duration of household storage and use.

Change Areas and Assumptions

The vision of the SWOT is to reduce water-borne diseases for populations in crisis by ensuring that water is protected against recontamination throughout the post-distribution period of collection, transport, storage and use. This vision is underpinned by two main change areas with underlying

[10]Syed Imran Ali, S.I., Ali, S.S., Fesselet, JF (2021). Evidence-based chlorination targets for household water safety in humanitarian settings: Recommendations from a multi-site study in refugee camps in South Sudan, Jordan, and Rwanda, Water Research, 189, 116642, ISSN 0043-1354, https://doi.org/10.1016/j.watres.2020.116642. (https://www.sciencedirect.com/science/article/pii/S0043135420311775)

[11]This study was funded by MSF.

assumptions indicated in Table 1, along with a summary of the main findings for each change area. The assumptions were validated through the data collection.[12]

Table 1. SWOT's change areas and assumptions

Change area	Assumption	Does it hold true?
People affected by crisis have access to safe drinking water.	The SWOT effectively and reliably produces accurate chlorination targets over time and in different use cases.	**Yes.** Evaluation studies have been conducted, most recently in Uganda and Somaliland, that showed that the SWOT's chlorination targets maintained 0.2 mg/L of FRC at household level for the typical duration of household storage and use.
There will be sustainable use and scale of the SWOT within an organisation.	There will be user uptake and organisations will integrate the SWOT into standard practice after training and use.	**Partially.** MSF has used the SWOT in nine projects. However, so far, user uptake by organisations after training is limited to single projects, rather than integrated use across the organisation's projects.
	Organisations will have adequate resources to implement the SWOT.	**Yes.** Organisations that have used it so far have recruited additional water quality monitoring staff and increased chlorine use; however costs are minimal compared to overall project budgets.
	Organisations have adequate capabilities to implement the SWOT.	**Partially.** Some organisations require more support than others to implement the SWOT and implement its water treatment targets.

12 Triangulation of document review and key informant interviews.

Cost of the Swot Compared to Existing Solutions

Development costs: The total cost of developing[13] the SWOT was £722,473 with £337,273 (46.7%) as HIF's contribution. A breakdown of costs is provided in Table 2 below.

Table 2. SWOT development funding breakdown

Funder	Period	Amount (£)
MSF Holland	2013	9,400
United Nations High Commissioner for Refugees	2014–2015	41,400
HIF	2015	19,725
Achmea Foundation	2018–2019	186,600
Grand Challenges Canada	2019–2021	147,800
HIF	2020–2022	317,548
Total		722,473

Children collecting water in Azraq refugee camp, Jordan. Credit: Syed Imran Ali

[13] Dissemination grant not included in this.

Elrha Contribution to SWOT

Elrha has supported the development and dissemination of the SWOT through three separate grants, totalling £356,905.

Safe Water for Refugees

Budget: £19,725

Duration: February 2015 to September 2015 (8 months)

Grantees: MSF Netherlands

The grant launched observational and intervention studies in multiple refugee/IDP camps globally in order to develop and evaluate evidence-based guidelines for centralised batch chlorination in humanitarian operations. This became the foundation for the development of the SWOT.

Building the evidence to support scaling of a machine learning-enabled safe water optimisation tool for humanitarian response.

Budget: £317,548

Duration: November 2020 to June 2022 (19 months)

Grantee: Dahdaleh Institute for Global Health Research

Using the evidence-based guidance developed by the Safe Water for Refugees project, the innovation team designed the SWOT, a web-based platform that generates site-specific, evidence-based chlorination guidelines. This grant allowed the team to gather evidence on the effectiveness and feasibility of the SWOT in other humanitarian use cases.

Research and innovation uptake strategy: SWOT.

Budget: £19,632

Duration: July 2023 to December 2023 (6 months)

Grantee: Dahdaleh Institute for Global Health Research

This grant supported the SWOT team to deliver a targeted uptake strategy for the innovation, including publishing the evidence as peer-reviewed literature, presenting at a range of key events, and developing and delivering marketing and training materials and modules for a range of audiences.

Operational costs: The SWOT team spends a total of £1,750 per month in operating costs. The total monthly operating costs include £180 per month on maintaining the web-based platform and £1,570 on staffing. This monthly total assumes there is no new feature development, minimal marketing, and limited user training and support.

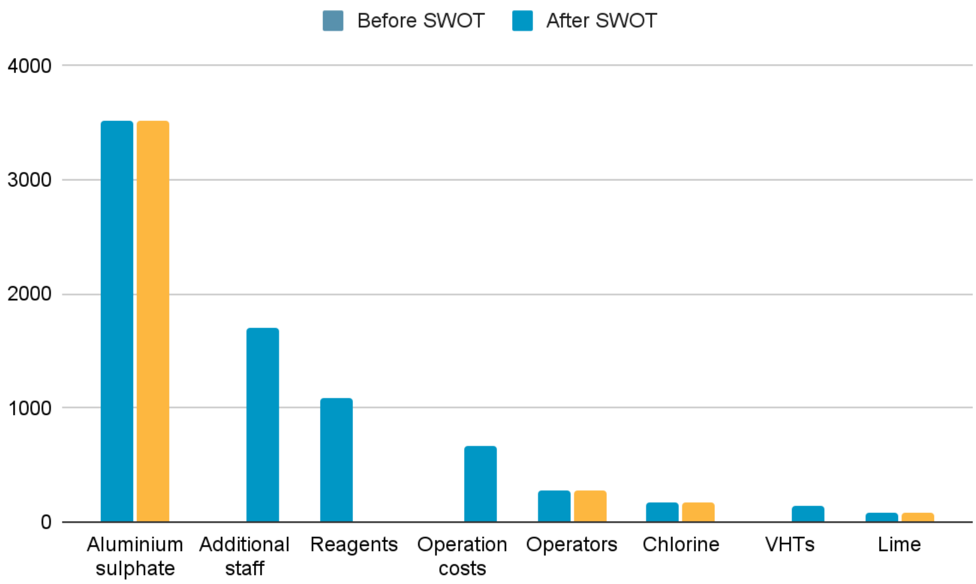
SWOT user costs: The SWOT is free-to-use and designed to be incorporated into an organisation's daily water quality monitoring practices. Therefore, an organisation can use the equipment and staff already in place with no significant additional costs.

The SWOT was implemented in Uganda by Oxfam who acted as the United Nations High Commissioner for Refugees (UNHCR) water, sanitation and hygiene (WASH) partner in Kyaka II refugee camp 2020–

2022. The SWOT team and Oxfam deployed the tool in Kyaka II from April to August 2022 using HIF funding.

Before implementing the SWOT, Oxfam spent £5,134 per month on treating its water systems in Kyaka II. After implementation of the SWOT, the costs increased to £6,584.00 (28%). The increased costs catered for five additional staff, village health teams (VHTs) and chlorine as indicated in Figure 1 below.

Figure 1. Daily chlorination costs (£) incurred by Oxfam Uganda before and after use of the SWOT



The most significant and new costs were associated with staffing (five additional staff and VHTs). However, the number of additional staff was large because the SWOT team were conducting more extensive data collection for the study[14] than a typical SWOT implementation would require in regular water quality monitoring. For example, MSF is implementing the SWOT in Nigeria (Benue State) and recruited two additional staff to assist with water quality monitoring at household level. MSF in Nigeria spends £400 per month (£200 each) on remuneration for this staff.

The other increased cost was chlorine. Before the SWOT, Oxfam treated its water using 2.3 litres of chlorine for 108,000 litres of water. This cost Oxfam Uganda £171.51 per month. During implementation of the SWOT, Oxfam increased its dosage to 3.3 litres of chlorine for the same amount of water. This cost Oxfam £202, an 18% increase in the cost of chlorine per month.

In sum, organisations implementing the SWOT incur some additional costs. However, these costs are not linked to implementing the SWOT itself but the need to do routine testing at household level and not only at the point of water collection. Therefore, the increase in cost is significantly reduced or eliminated altogether if this is already being done as required by guidelines such as the Sphere Handbook.[15] Additionally, there may be a small increase in the budget for chlorine if the SWOT

[14] There were additional components of the study including taste and odour focus groups, disinfection by-products and microbiological water quality testing, as well as extensive household and implementer surveys that would not be needed for a routine SWOT implementation.

[15] Water supply standard 2.2 on water quality requires measurement of water quality parameters (FRC and coliform forming units) at the point of delivery and point of consumption or use.

recommendation is for more chlorine than the universal chlorination guidelines; however, the bulk of the chlorine will already have been budgeted for.

Assumption	Testing the assumption
Organisations will have adequate resources to implement the SWOT.	Minimal extra resources and capacity maybe needed to cover the additional time needed to monitor household-level water quality and additional chlorine.

Benefit of the Costs

Development of the SWOT. The main benefit of the funding is that it allowed engineering experts to develop a numerical novel process-based and machine learning modelling approach that provides context-specific chlorination targets from otherwise under-used routine water quality monitoring data. This funding has also been used to facilitate validation and evaluation studies that have generated evidence on the effectiveness of the SWOT across multiple and varying sites and water supply system types. Furthermore, the funding has enabled the SWOT team to begin the development of a new tool that will be incorporated into the SWOT toolkit to rapidly determine chlorine taste and odour rejection thresholds for recommending FRC targets.

Free for humanitarian WASH operators. The SWOT platform is open access and so humanitarian WASH operators do not have to pay to access it. The second version (V2) of the tool was developed with an improved user interface based on feedback from users.[16] The site has been designed to work in low-bandwidth settings with common digital data collection tools used in the humanitarian sector (eg, KoboToolbox) and is accessible using computers, tablets and smartphones.

Anticipated Scaling Costs

The team anticipates an increase in costs associated with upgrading the SWOT since the team is continuously working to refine and advance its modelling capabilities, user experience/interface (UX/UI), and functionalities. For example, SWOT V2 has various new advances including a redesigned UX/UI, enhanced modelling performance, integrated guidance resources, and modelling performance diagnostics.[17]

Scaling costs would also require an increase in team members' dedicated time. The team members will provide training and support to SWOT users and engage in advocacy activities. These advocacy activities would be aimed at highlighting the extent of the problem and how the SWOT effectively addresses it, to encourage buy-in and user uptake.

An exact figure is not currently available, but the SWOT team is working with expert technology consultancy ThoughtWorks to map and test business models, including revenue generation, for sustainable scaling.

[16] User testing was conducted with MSF Nigeria as well as other implementing sites.

[17] A white paper describing SWOT's advances is available here.

Cost Efficiency at Scale

The significant initial development and testing costs of the SWOT are now completed. This means using the SWOT at scale does not significantly increase the SWOT team's budget for capital costs. However, as the SWOT scales, the SWOT team will ultimately need to dedicate more staff time to effectively support both new and existing users, while continuing to improve the SWOT modelling capabilities, UX/UI, and functionalities for different users (eg, donors, coordination platforms), and advocating for its use. For humanitarian organisations, the minimal additional costs described above would remain the same per implementation site regardless of scale.

IS THE SWOT EFFECTIVE?

Objective of the Swot

As discussed above, the main objective of the SWOT is to ensure that water is safe to drink, not only at the tap stand but also at the last point of consumption, by providing site-specific, evidence-based chlorination targets that ensure adequate FRC levels up to the point-of-consumption.

The SWOT has been deployed in nine countries. Before the HIF grant, the SWOT had only been tested on piped water networks that used groundwater sources. The HIF grant in Uganda tested, for the first time, the effectiveness of the SWOT on treated surface (river) water, delivered both through a piped network and by water trucking. The results would help improve the robustness of the SWOT across a range of water delivery types, making it a more accurate and useful tool for field teams tasked with maintaining water safety in challenging environments across multiple water system types.

Achievement of the Objective

Two independent studies have demonstrated the effectiveness of the SWOT in determining the optimal level of chlorine for specific settings. The first study was carried out to determine the outcome of SWOT's chlorination targets in Kyaka II.[18] The findings show that the SWOT-generated chlorination targets improved household water safety outcomes compared to the status quo (ie, following Sphere Standards guidelines). The SWOT targets were applied in two water systems: water trucking and surface water in a piped system. The SWOT chlorination target had the greatest improvement in household water safety in the water trucking system. The proportion of households with at least 0.2 mg/L FRC at 18–24 hours went from 1% before implementation to 45% after implementation. In the piped water system, the SWOT chlorination target helped improve the proportion of households' water safety from 19% to 33%.

[18] Heylen, C., String, G., Naliyongo, D., Ogira, V., Ali, S.I. Brown, J., Fesselet, JF, Orbinski, J., and Lantagne, D. (2022). 'Can the Safe Water Optimization Tool help ensure water safety with surface water supplies in emergencies? Lessons from a field trial in Uganda.' UNC Chapel Hill Water and Health conference poster.

The second study was conducted in Somaliland at Las Anod Hospital operated by MSF. Water was delivered to the hospital by truck; it was chlorinated on site and then stored in an overhead tank. The water was then distributed to taps around the hospital compound. The study revealed that the SWOT helped improve water safety rates for taps around the hospital compound from 61% to 99%.[19]

In Uganda, the SWOT increased the dosage of chlorination from 2.3 litres to 3.3 litres for 108 cubic metres of water. This increased the FRC targets at the tap stands from 0.2–0.5 mg/L to 0.9mg/L for water trucking and 0.7–0.8mg/L for piped water systems.[20] One of the factors that led the SWOT to increase the FRC target is that most people store water for up to 12 hours before use. The increase in FRC levels ensured that a minimum of 0.2 mg/L FRC levels – required for water to be deemed safe – was maintained even after storage of water for 12 hours when FRC levels are susceptible to decay.

Assumption	Testing the assumption
The SWOT effectively and reliably produces accurate chlorination targets over time and in different use cases.	Tested in Bangladesh (2019), Somaliland (2022) and Uganda (2022) producing reliable and more effective chlorination targets.

Enabler of Success

Types of water systems. There was a greater improvement in water safety for households that received water through water trucking (45%) compared to the piped water system (33%). This is because water trucking is easier to manage since chlorinated water is stored in a tank and then distributed directly. The water trucking system at Kyaka II served a limited area and dealt with fixed volumes; it was therefore relatively easy for water system operators to control chlorination within and achieve the recommended FRC target. This was in contrast to the piped water system at Kyaka II which was more complicated to manage both at the treatment level (complicated by the operators limited knowledge of water quality testing and water treatment to manage chlorine dosing) and at the distribution system level. The piped water network is extensive, meaning that it is inherently challenging to maintain a single FRC target across a spatially extensive network, as chlorine decays during pipe transport as well. The combination of these factors results in less effective implementation of the SWOT recommended FRC target in the piped water system.

Support from the SWOT team proved a key enabler of success. The Oxfam team received both financial and non-financial support from the SWOT team.

Firstly, the team provided non-financial support by training water operators on how to use the SWOT and the right water quality monitoring practices that are amenable to the SWOT. In Uganda, the SWOT team also provided in-depth training for water quality monitors on the fundamentals of water treatment, eg, jar testing and appropriate chlorine dosing. This highlighted the SWOT teams' ability to adapt the training as organisations require different levels of support to ensure accurate data

[19] Heylen , C., String, G., Abib, I., Bulhan, A., Maalim , A.R., Ali, S.I., Brown, J., De Santi, M., Khan, U., Orbinski , J., Fesselet, JF, D. Lantagne. 'Ensuring drinking water safety in an MSF medical facility using the Safe Water Optimization Tool'.

[20] Ibid.

collection practices amenable to the SWOT as well as implementation of the water treatment targets generated by the SWOT.

Secondly, through HIF funding, the SWOT team set up a water testing laboratory equipped with extensive equipment to conduct the study. Although not necessary, the Oxfam team made use of procured digital tools such as the chlorometers to conduct their water quality testing. For example, before implementation of the SWOT, the team used pool testers to determine the amount of chlorine in the water. Even though the pool tester is the most commonly used tool by humanitarian water testers, it is a manual tool that is susceptible to human error. The chlorometers are more precise and accurate.

For all organisations, after the initial training, SWOT users are able to contact the SWOT team for additional support. All current and past SWOT users we spoke to in Uganda, Nigeria, Tanzania and the Democratic Republic of Congo (DRC) emphasised the importance of this support.

> ***"The fact that we've been able to get direct access to the team in Toronto ... just being able to access the team and always have a really quick response from them. If there are any questions or if there are any challenges that we're faced with, we always feel like we're able to get good support from the team in Canada."***
>
> **– DRC SWOT user**

Assumption	Testing the assumption
Organisations have capabilities to implement the SWOT	This varies as some organisations (or water quality monitoring staff) require more training than others to be able to collect the necessary quality of data for the SWOT or implement its guidance in the water treatment system.

Unintended Consequences

Rejection of SWOT-treated water due to taste and smell. In Uganda, the increased chlorination levels led to people being able to taste and smell the chlorine in the water they were using. This led to complaints from some users and complete rejection by others who sought out alternative drinking-water sources. These taste and odour issues, however, were attributed to the water being released to the community immediately after it was treated. In line with international guidelines, the SWOT team advised the water operators to allow the chlorine to react for at least 30 minutes to an hour before releasing it.[21] Additionally, the Oxfam team conducted sensitisation campaigns through local leaders to create awareness about the change and its importance to water safety.

Taste and odour issues were not unique to Uganda; they were also reported in Somaliland at the MSF medical facility after the FRC target was increased. MSF addressed this problem by reducing the target from 0.8mg/L to 0.6mg/L.

[21] This is in accordance with the World Health Organisation Guidelines for Drinking Water Quality, 4th Edition.

Challenges

Competing priorities. In order for the SWOT to provide an accurate chlorination target, it requires up-to-date water quality monitoring data from both the tap stand and household level. However, during the peak of a crisis, humanitarian actors have various tasks to juggle and household monitoring was not prioritised.

Consultation fatigue. Water quality monitoring includes household surveys to understand practices that might affect FRC decay. While these can be done quarterly or when seasons change, refugee and IDP camps have various interventions that require consultations. If multiple consultations are being conducted when water quality monitoring data is being collected, this can lead to fatigue of people in the camps.

Need for additional staff to collect household data. While the SWOT is designed to work within existing water quality monitoring paradigms and utilise existing human resources, SWOT users have reported needing to recruit additional staff due to existing heavy workloads prior to using the SWOT. Following Sphere guidelines,[22] SWOT requires water sample testing at the tap stand and point of consumption or use (the household) at various intervals in the day. This SWOT team found that household level water testing is not routinely done, and therefore SWOT users need additional staff to collect this data. For example, Oxfam Uganda hired five additional staff (to conduct the research study as well) and MSF Nigeria (Benue State) hired two additional staff. This has cost implications for SWOT users. Oxfam Uganda hired each additional staff at £11 per day while MSF Nigeria (Benue State) recruited them on full-time basis at £400 per month (£200 each).

Low data quality. The SWOT relies on water monitoring operators using accurate standard water testing methods at both the tap stand and household level in order to provide accurate chlorination levels. The data being collected in Uganda was not initially very robust and so the SWOT team responded to this challenge by training the water operators in more standard practice. This ensured that the team collected high-quality data and enabled the SWOT to produce accurate chlorination targets.

Ethical Standards and Vulnerable Groups

The SWOT incorporates the realities of people's access to and storage of water by considering behaviours and practices such as the distance between the water collection point and people's homes, time taken between water collection, storage and consumption. Nevertheless, the SWOT relies on the structures and policies of the organisation implementing it to reach the most vulnerable and adhere to ethical standards.

[22] Water supply standard 2.2 on water quality requires measurement of water quality parameters (FRC and coliform forming units) at the point of delivery and point of consumption or use.

IMPACT

Positive Changes for People Affected by Crisis

The SWOT has been implemented in nine countries. Overall, water chlorinated according to SWOT targets has been supplied to 527,224 people. The table below breaks down the number of people per country and site.

Table 3. Estimated number of people reached by SWOT disaggregated per country and site

Country	Area	Site	Number of people	Male	Female
South Sudan	Maban County	Jamam	15,670	7,910	7,760
		Gendrassa	15,810	7,980	7,830
		Batil	37,199	18,777	18,422
Jordan	Azraq Governate	Azraq	14,797	7,131	7,666
Rwanda	Nyamagabe District	Kigeme	18,569	9,483	9,086
Tanzania	Kigoma Region	Mtendeli	20,000	10,115	9,885
		Nyarugusu	132,000	66,762	65,238
		Nduta	66,280	33,522	32,758
Bangladesh	Cox's Bazaar	Kutapolong-Bulakhali	83,000	41,856	41,144
Nigeria	Zamfara	Anka	2,500	1,731	1,769
	Benue	Ichwa	1,387	686	701
		Mbawa	9,000	4,452	4,548
		Ortese	9,600	4,748	4,852
Uganda	Kyegegwa District	Kyaka II	37,444	18,909	18,535
Somaliland	Sool Region	Las Anood Hospital	100	75	25
Syria	Northeast Syria	Al Hol Camp	63,868	39,088	24,780
Total			**527,224**	**273,225**	**254,999**

Positive Changes for Implementing Partners During Use

For water operators

Capacity building. Interviews with the water operators in Kyka II revealed that the training provided by the SWOT team increased their capacity, not only in using the SWOT but also in water treatment, monitoring, and distribution. For instance, they learned how to conduct jar tests[23] and received advice on not releasing water immediately after treatment to allow the chlorine to react.

On Organisational practice

Testing of water at both the tap stand and household. All the SWOT users we spoke to reported that, before the SWOT, testing for FRC levels was mainly conducted at the tap stand. However, guidelines such as the Sphere Handbook[24] dictate that testing should also be carried out at the household level, a practice that was rarely followed. Implementation of the SWOT ensured that testing was also performed at the household level, as this data is essential to establish an accurate target.

> ***"SWOT had us doing more household water quality monitoring, which we weren't doing before. I think that is one of the benefits. It reminded us that we need to do additional work to make sure that the water is safe."***
>
> - **Water Operator Uganda**

Safe water chain management. Regular collection of water samples allowed SWOT users to track the same batch of water from the point of collection to the point of consumption. This capability enables water operators to identify potentially contaminated water sources or sources that may require adjustments to chlorination targets to achieve the appropriate FRC levels.

> ***"We did not follow the same pattern of water. But with the SWOT we would be able to follow the same batch of water from the taps into the household and test it. We would also do further analysis."***
>
> - **Past SWOT implementer in Tanzania**

Evidence-based decision making. Testing water samples at the household level provided SWOT implementers with crucial insights, not only regarding the safety of FRC levels in household water but also concerning household practices that could lead to water re-contamination. Poor household hygiene practices, such as using dirty storage containers, signalled to water operators the root causes of re-contamination. This helped operators to identify appropriate intervention measures, such as hygiene promotion campaigns. For example, in Kyaka II the Oxfam team was able to conduct hygiene promotion activities at the household level to strengthen their interventions.

[23] A jar test is a laboratory procedure used to determine the optimal dosage of chemicals needed to treat water. It is named "jar test" because the procedure typically involves conducting experiments in glass jars or beakers.

[24] Water supply standard 2.2 on water quality requires measurement of water quality parameters (FRC and coliform forming units) at the point of delivery and point of consumption or use.

Barriers to Sustained Organisational Practice

The above changes, although realised during SWOT implementation, were not sustained as organisations reverted to standard practice for two main reasons:

Focus on service provision rather than a public health orientation. The SWOT was implemented in Kyaka II from April–August 2022 after which its use was not continued. Interactions with the team revealed that they saw the implementation of the SWOT as a time-bound research project, which did not translate into a change in practice or sustained adoption of the SWOT.

> ***"It came as a project that had timelines and its own budget".***
>
> - **Water Operator Uganda**

In Kyaka II, prior to using the SWOT, water operators were not regularly testing the water at household level. This suggests a focus or prioritisation on water delivery rather than a public health orientation, which would prioritise water safety at the point of consumption or use.

Change in management. In some cases where the SWOT has been adopted, new management has taken over and has stopped using the SWOT.

Sudanese refugees collecting chlorinated water supply at the Batil refugee camp, South Sudan. Credit: Syed Imran Ali

WHAT NEXT?

Adoption of the SWOT

The SWOT has been deployed by seven humanitarian organisations: MSF, UNHCR (through its implementing partners, the Norwegian Refugee Council in Tanzania and Oxfam in Uganda), Solidarités International, BRAC, and Aquaya. The deployment has spanned across 17 sites located in nine countries (South Sudan, Jordan, Rwanda, Nigeria, Tanzania, Bangladesh, Uganda, Somaliland, and Syria).

Enablers of Adoption

Early engagement and buy-in. MSF has been involved in the development of the SWOT from the beginning and so understands its value. MSF was part of the team that secured funding for the 2015 HIF-funded research, which served as the foundational evidence for the necessity of a tool like the SWOT. Furthermore, they were involved in developing the SWOT prototype. This has seen MSF deploy the SWOT in some of its sites to conduct proof of concept and validation studies (nine out of the 17 sites where the SWOT has been used are with MSF). For example, MSF Nigeria is still implementing the SWOT at the Ortese IDP camp in Benue state. The MSF field team at Ortese uploads water quality monitoring data to the SWOT every month to generate and implement an updated water chlorination target at their site.

Leveraging past relationships and networks. Several members of the SWOT team not only previously worked for MSF Netherlands but also held various positions within the WASH sector. Their networks are aware of their involvement in developing the SWOT and have used word-of-mouth to advocate for its effectiveness to individuals in decision-making roles within the WASH sector. The use of word-of-mouth has led to invitations for the SWOT team members to present the tool to various organisations in the WASH sector which has resulted in the adoption of the SWOT in some cases. For example, the UNHCR WASH lead in Tanzania was looking for a more robust way of conducting water quality monitoring activities and heard about the SWOT from a colleague who had previously worked with a SWOT team member. The UNHCR WASH lead arranged a meeting with the SWOT team member who explained the SWOT and then adopted it through the Norwegian Refugee Council (NRC), their implementing partner in Tanzania.

Barriers to Adoption

Heavy reliance on past relationships and networks. Although having a strong trusted network is an enabler to adoption, it is also important to recognise how this can act as a barrier. Apart from UNHCR, all other cases of adoption of the SWOT have originated from MSF: Solidarités, BRAC and Aquaya all had projects handed over from MSF. To achieve significant uptake, adoption will need to go beyond key established relationships.

The problem of universal water chlorination guidelines being inadequate is not prioritised or well understood in the humanitarian community. It is well recognised that humanitarian organisations face a multitude of competing priorities in providing services to people affected by crisis. Although the SWOT team has worked hard to present and disseminate their research, it seems that further work is needed to ensure that organisational decision-makers and the global WASH community are aware and understand the need to improve water quality through better context-specific water quality monitoring. This is inferred by the fact that organisations do not continue using the SWOT on a routine basis after the specific project where SWOT use is planned (and funded) is finished. Users interviewed saw use of the SWOT as part of a specific project, not necessarily as a tool to integrate into their routine work on water quality assessments.[25] This barrier may also be exacerbated by the current debate on chlorine use,[26] which may also mean that some organisations are not interested in using the SWOT as they do not use chlorination for water treatment.

Assumption	Testing the assumption
There will be user uptake and organisations will integrate the SWOT into standard practice after training and use.	Main user is MSF. The use of SWOT by other organisations remains limited to specific projects.

Plans for Scale

Advocacy. The SWOT team recognise that, although they have worked hard to provide evidence of the problem on safe water distribution of universal chlorination guidelines, there is still work to be done on raising the issue up the agenda in the WASH sector, so that organisations prioritise use. In response, the team has developed an advocacy strategy that will be implemented over the next two years to create awareness about the shortcomings of the current guidelines and present the evidence collected on the effectiveness of the SWOT in addressing this problem.

Adoption of the SWOT by the Accountability and Quality Assurance (AQA) initiative. AQA, part of the Global WASH Roadmap, is setting up a monitoring framework and quality monitoring system within national WASH coordination platforms. The SWOT team is exploring how AQA can adopt the SWOT into the framework. If the SWOT is adopted into the framework, it will require WASH operators to use the tool as it will assist AQA in collecting data on the effectiveness of WASH practices. This will incentivise WASH operators to adopt and incorporate the SWOT.

Potential Long-Term Implications of the SWOT

In the long-term the SWOT team aims to:

- Reach four million people in crisis over the next ten years with safer drinking water, thus reducing the risk of water-borne diseases through water consumption and use.
- Adapt and advocate for best practices for water monitoring procedures and practices, so that all water quality assessments include regular monitoring and testing of water at household level, thus increasing the accuracy of water quality at the point of consumption.
- Embed regular water quality monitoring at the tap stand and household level, and context or site-specific chlorination recommendations in core global and organisational guidelines.

[25] Unfortunately, we did not have a chance to speak to key decision-makers to explore the organisational internal barriers to adoption further.
[26] One interviewer mentioned that within their organisation there are debates about the use of chlorine as a method of treating water.

WHAT HAVE WE LEARNED?

Implementation and scaling of the SWOT highlighted four key learnings:

It is not enough to prove that an innovation works for it to be adopted. Various validation and evaluation studies have been conducted that prove that the SWOT is effective in providing context-specific chlorination targets that account for FRC decay. These validation and evaluation studies have been conducted in collaboration with several humanitarian water service providers who have not continued the use of the SWOT after the studies have ended, aside from MSF in Nigeria. In addition, costs associated with implementing the SWOT are not significantly higher than the status quo, so cost is not a barrier.

Research has shown that decisions in the humanitarian sector are often based on personal preference or maintaining the status quo.[27] Therefore, changing organisational practice from a service provision to a public health orientation is hard even when an innovation has proven itself. Further work is needed to showcase the value of changing practices to achieve buy-in. This is why the SWOT team has developed a targeted advocacy strategy not only to create awareness about the tool but also to showcase its relevance and value compared to the status quo. The team is also adapting the usability of the SWOT to expand its features so that they meet other requirements field teams might have such as a situational analysis on overall water safety that can be plugged into various reports. This would ease the overall work of humanitarian water service providers to incentivise them to use the SWOT.

Adequate funding at all stages is a significant contributor to an innovation's success. The key milestones of the SWOT, such as the foundational research, development, validation studies and deployment of the SWOT have been possible through various funding rounds including a significant contribution from the HIF. However, the SWOT is still on its journey to scale, and while there is compelling evidence that the SWOT is effective, it will need further funding to continue to improve the tool functionality such as incorporating chlorine taste acceptability thresholds and build the advocacy capacity required to ensure wide uptake in the sector.

The rate of adoption of an innovation is dependent on institutional capacities. Teams in humanitarian organisations that have deployed the SWOT have varying capacities. Some understand the tool very easily and are able to implement the SWOT independently. Other teams not only struggle with understanding and implementing the tool, but might also need assistance with fundamental water quality testing, treatment and monitoring skills; therefore, more in-depth training beyond how to use the SWOT might be needed. The SWOT team has learnt that tailored support needs to be factored in, taking into account the current practices of an organisation and what knowledge and skills the current water operators have.

Personal networks and word-of-mouth are strong enablers for early scaling, but not sufficient to drive adoption in the longer term. The main adopter of the SWOT has been MSF Netherlands – mainly because key SWOT team members previously worked there. Former colleagues who know and trust the SWOT team lead have ensured the use of the SWOT in their programmes. These colleagues are also encouraging other organisations to adopt the SWOT, such as in the case of the tool's adoption by

[27] Heyse, L. (2013). Tragic Choices in Humanitarian Aid: A Framework of Organisational Determinants of NGO Decision-making. Voluntas: International Journal of Voluntary and Nonprofit Organizations 24, 68–92. DOI: 10.1007/s11266-012-9292-y

UNHCR in Tanzania. Additionally, a former colleague who sits on the AQA initiative is aware of the SWOT and believes it will address the gaps in the monitoring framework being developed.

In conclusion, the SWOT offers a promising solution to improve access to safe drinking water in humanitarian settings. It has been proven to increase safe drinking water at the point of consumption or use over following the single universal treatment rule, without organisations incurring significant additional costs. SWOT use has also drawn attention to the realities of current water quality assessment practices and how household level water testing is not happening consistently. Therefore, the SWOT not only supports better access to safe drinking water, but also encourages water quality assessment practices aligned to the Sphere guidelines. With continued support and increased advocacy efforts, it has the potential to make a significant and lasting impact on addressing water quality-related challenges in crises-affected areas.

Household water quality testing at the Kyaka II Refugee Settlement in Uganda. Credit: Gabrielle String

ANNEXES

Annex 1: Methodology

Case study development entailed the following four steps:

1. **Inception**

We held an inception meeting with Elrha to finalise the research questions, agree on the methodology and develop the data collection tools.

We also conducted a document review of both academic and grey literature. We used a structured template to synthesise the information against each research question to enable further analysis and triangulation of different data sources. The document review was used to analyse the existing evidence available which was later triangulated with the primary data collected.

2. **Exploratory sessions**

We conducted an introductory session with the SWOT team to understand the innovation better, its current status and identify any further research undertaken. We also facilitated an assumptions meeting with the team to understand the changes they envisioned SWOT making and the assumptions on how this change would happen. This enabled the team to understand whether their assumptions held true or not during implementation. The last session explored the costs associated with development and implementation of the tool.

3. **Key informant interviews (KIIs)**

We conducted remote KIIs to generate detailed qualitative information on the research questions. Interviews were guided by a semi-structured template with open-ended questions that lasted 45–60 minutes. SWOT identified the interviewees and asked them to identify the priority informants to contact whom we interviewed. If they were unavailable or unresponsive, we substituted them with another informant(s) on the list after consultation with the SWOT team.

We conducted 13 interviews as indicated in the table below.

Table 4: Case study participants breakdown

Category	Organisation	No. of representatives
Grantee team/partnership (innovators directly receiving Elrha funds)	Tufts University	1
	Leigh University	1
	Oxfam Uganda	1
Project partners (but not receiving Elrha funds)	MSF Netherlands	1
	UNHCR	1
	MSF in DRC	1
SWOT users	Oxfam Uganda	3
	MSF in Nigeria	2
Potential adopters of SWOT	WeWorld	1
	Accountability and Quality Assurance Initiative	1
External observers	Global WASH cluster	1
	United Nations Children's Fund	1
	Kobo Tool Box	1

4. **Validation meeting**

We presented emerging findings from the data collection to the SWOT and Elrha teams for reflection, validation and feedback.

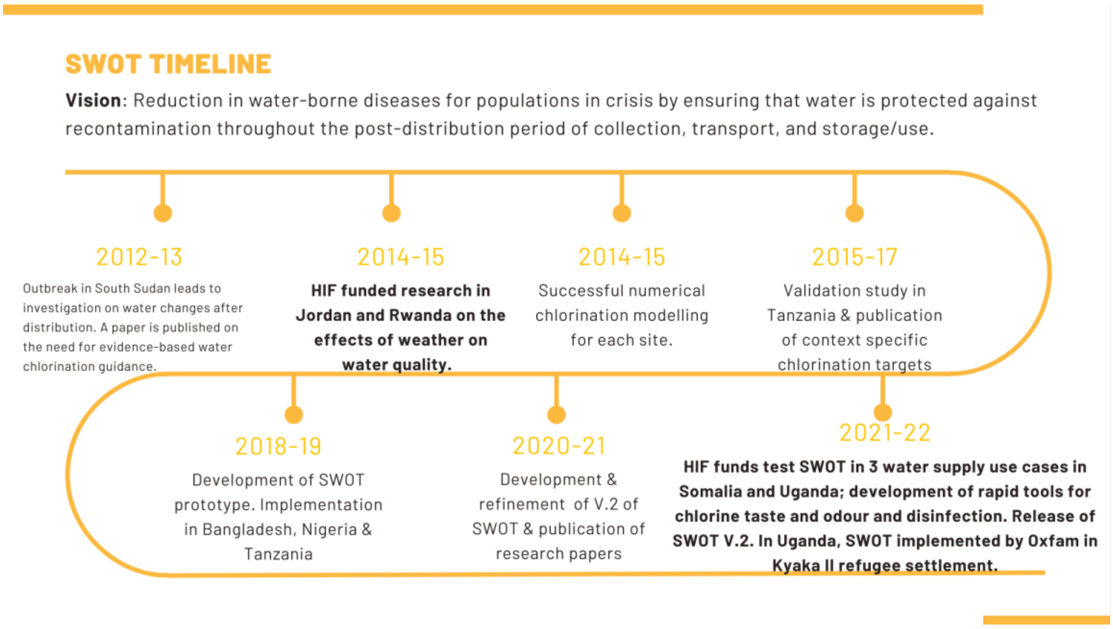
Limitations

There were three main limitations as follows:

- Since the SWOT team didn't have a fully formed theory of change and change pathways, we guided its reconstruction retrospectively which can be open to misinterpretation of what was known at the beginning or not. This might have had an impact on how change was perceived to have happened versus how change did happen. Therefore, we focused on how change did happen and whether the innovation teams' assumptions held true.
- We interviewed a small number of key stakeholders and so it was difficult to draw definitive conclusions.
- The research questions had numerous probing questions which meant we focused on breadth rather than depth whilst responding to them.

Annex 2: SWOT Timeline

Figure 2: SWOT Timeline



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ABOUT ELRHA

Elrha is a global organisation that finds solutions to complex humanitarian problems through research and innovation. The innovations funded through our Humanitarian Innovation Fund (HIF) identify, nurture and share more effective and scalable solutions to some of humanity's most difficult challenges. The HIF is funded by the UK Foreign Commonwealth and Development Office (FCDO), the Netherlands Ministry of Foreign Affairs (MFA), and the Norwegian Ministry of Foreign Affairs.

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