Improving water quality and quantity in emergencies: The Inclined Plate Settler water treatment system

Alice Obrecht

CASE STUDY

humanitarian innovation fund

ALNAP

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Front and back cover: An early prototype of the Inclined Plate Settler, at the testing site in Pune, India. Credit: Dorea et al (2014).

Contents

HIF-ALNAP case studies on successful innovation

This study is one in a series of 15 case studies, undertaken by ALNAP in partnership with ELRHA's Humanitarian Innovation Fund (HIF), exploring the dynamics of successful innovation processes in humanitarian action. They examine what good practice in humanitarian innovation looks like, what approaches and tools organisations have used to innovate in the humanitarian system, what the barriers to innovation are for individual organisations, and how they can be overcome.

About the case studies

Case study subjects are selected from a pool of recipients of grants from the HIF. The HIF awards grants of between £20,000 and £150,000 to support the recognition, invention, development, implementation and diffusion stages of the innovation process. The HIF selects grantees on the basis of a variety of criteria designed to achieve a robust representation of the range of activity in humanitarian innovation.

The case study subjects are chosen to reflect innovation practice in the humanitarian system. They cover information communication technology (ICT) innovations and non-ICT innovations, and they offer a balance between innovations that have reached a diffusion stage and those that have not. They also reflect the wide geographic range of the areas where innovations are being trialled and implemented. (For more information on the methodology and criteria used to select case study subjects, see the forthcoming 'Synthesis report' for the case study series).

About HIF-ALNAP research on successful innovation in humanitarian action

These case studies are part of a broader research partnership between ALNAP and Enhancing Learning and Research for Humanitarian Assistance (ELRHA) that seeks to define and understand what successful innovation looks like in the humanitarian sector. The ultimate aim of this research is to improve humanitarian actors' understanding of how to undertake and support innovative programming in practice. This research partnership builds on ALNAP's long-running work on innovation in the humanitarian system, beginning with its 2009 study, Innovations in International Humanitarian Action, and draws on the experience of the HIF grantees, which offer a realistic picture of how innovation actually happens in humanitarian settings.

Innovation is a relatively new area of work in humanitarian action, yet it is one that has seen exponential growth in terms of research, funding and activity at both policy and programming levels. While the knowledge base around innovation in the humanitarian sector is increasing, there remain a number of key questions for humanitarian organisations that may be seeking to initiate or expand their innovation capacity. The HIF-ALNAP research has focused on three of these:

Primary research questions

What does successful humanitarian innovation look like?

What are the practices organisations can adopt to innovate successfully for humanitarian purposes?

Secondary research question

What are the barriers to innovation in the sector and how can they be mitigated?

The case studies will be used to produce a synthesis document that addresses these three questions. The outputs of this research are aimed at humanitarian organisations interested in using innovative practices to improve their performance, as well as organisations outside the humanitarian sector, such as academic institutions or private companies, seeking to engage in innovation in humanitarian action.

1. About this case study

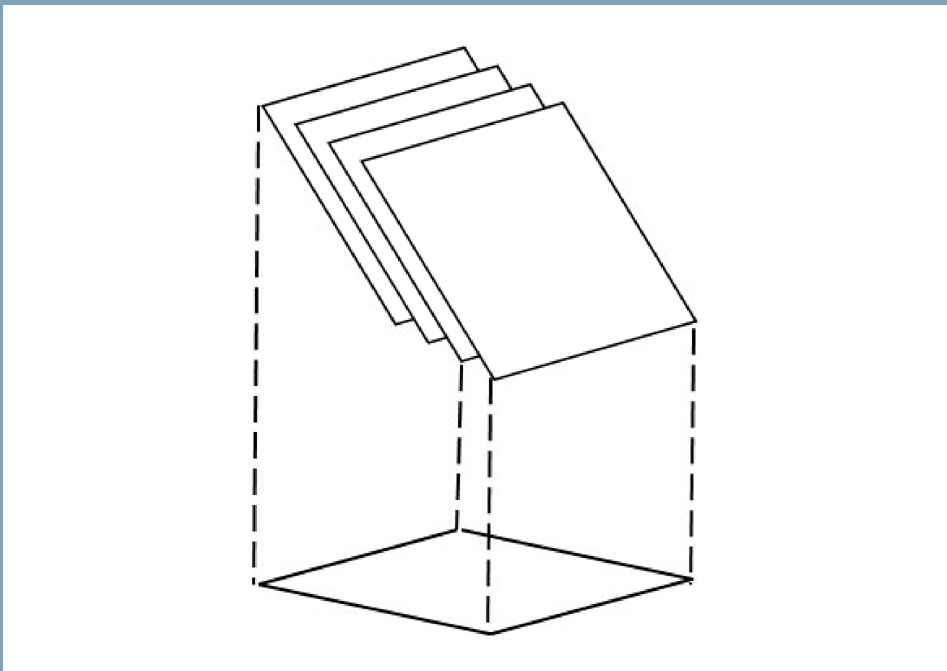
Organisation	Université Laval
Partners	Oxfam GB, Easol Ltd (formerly AquaPlus Ltd); Red-R India
Project	The Inclined Plate Settler water treatment system

Grant	Development	Diffusion
Start date	September 2012	September 2015
Grant period	18 months	6 months
Total HIF budget	£107, 341	£56,568
Location	Quebec City, Canada; Pune, India	Juba, South Sudan

This innovation process in the WASH sector featured a unique partnership between an academic organisation (Université Laval), a humanitarian NGO (Oxfam GB) and a private sector company (AquaPlus Ltd, now Easol Ltd). Together, these partners sought to develop a water treatment system that would increase the supply of water in an emergency at a significantly reduced cost, using technology that field staff can easily operate and maintain. The result of this innovation process was the Inclined Plate Settler kit, a system that uses a set of inclined plates to increase the surface area of a water tank without needing to increase its size, thereby processing large quantities of water while remaining relatively small and less costly.[1] Inclined plate technology is not new to the water treatment industry—it is used widely in domestic water treatment systems in high-income countries—however it has yet to be successfully applied in a field setting in emergency response.

While the WASH sector is in general a fertile area for innovation in humanitarian action,[2] many water treatment products are offered by private sector organisations and tend to be driven by a focus on high-tech solutions rather than an understanding of humanitarian operational realities. The project partners sought to avoid the pitfalls of this supply-driven approach by developing the Inclined Plate Settler kit in a setting that approximated field conditions and through a process that drew on Oxfam GB's field expertise. As a result, the Inclined Plate Settler kit is intended to be a fit-for-purpose water treatment system for use in humanitarian response in highly turbid groundwater conditions.

Figure 1: Drawing of the Inclined Plate Settler technology



The system was developed in Pune, India with a secondary testing site in Quebec City, Canada. At the time of writing, it is being deployed in Juba, South Sudan, in a pre-existing Oxfam-run water treatment programme. Overall, the innovation process has generated significant learning about applications of the Inclined Plate Settler technology to emergency settings and the comparative performance of different water treatment systems. While the system has yet to be fully tested in the field, early lab results show it can treat water to Sphere standard-level quality over a longer period of time than an alternative system that is widely used in current humanitarian programming.

This case study was conducted on the basis of a review of key documents and interviews with 10 informants with project partners and other stakeholders.

2. The Problem

The provision of clean water is one of the most important and logistically challenging services humanitarian agencies offer in a crisis. One of the leading causes of death in a humanitarian emergency is diarrhoeal disease, which is often caused by contaminated water.[3] Yet clean water, in the absence of sufficient groundwater resources, can be extremely costly to provide. It is partly for this reason that water treatment has been one of the most active areas for innovation within the WASH sector,[4] generating a relatively large market of 'innovative' filtration kits for use in emergency response.

Many of these kits are efficient in the removal of contaminants in controlled conditions, however they face at least two significant constraints when applied to emergency contexts:

- **The quantity of water many filtration systems produce.** Water in an emergency is required for two main functions: 1) direct hydration; and 2) personal and domestic hygiene purposes such as bathing, hand washing and food preparation.[5] There is some evidence that life-threatening diarrhoeal disease is predominantly caused by insufficient quantities of clean water for hygiene purposes rather than the direct consumption of contaminated water.[6] For some, this indicates that quantity is just as important as quality when it comes to water supply, or, more precisely, that *a larger quantity of sufficiently good-quality water is more important than a smaller quantity of higher-quality water.*[7]

  While many water treatment systems place a high emphasis on producing high-quality treated water, they do not produce sufficiently large quantities to fulfil the second type of need. As a result, they offer relatively costly and inefficient approaches to water treatment for large numbers of people in a response.

- **Usability.** Many 'innovative' filtration systems rely on high-tech designs produced by private sector organisations without consultation with humanitarian agencies and are therefore difficult to operate by non-technical end users and unreliable in the field.[8]

For these reasons, several humanitarian organisations are still seeking a water treatment system that, in **contexts featuring highly turbid (dirty) water**, can produce a sufficient **quality** of water, at maximal **quantity over time**, while being **usable** and **transportable**, at the lowest **cost**.

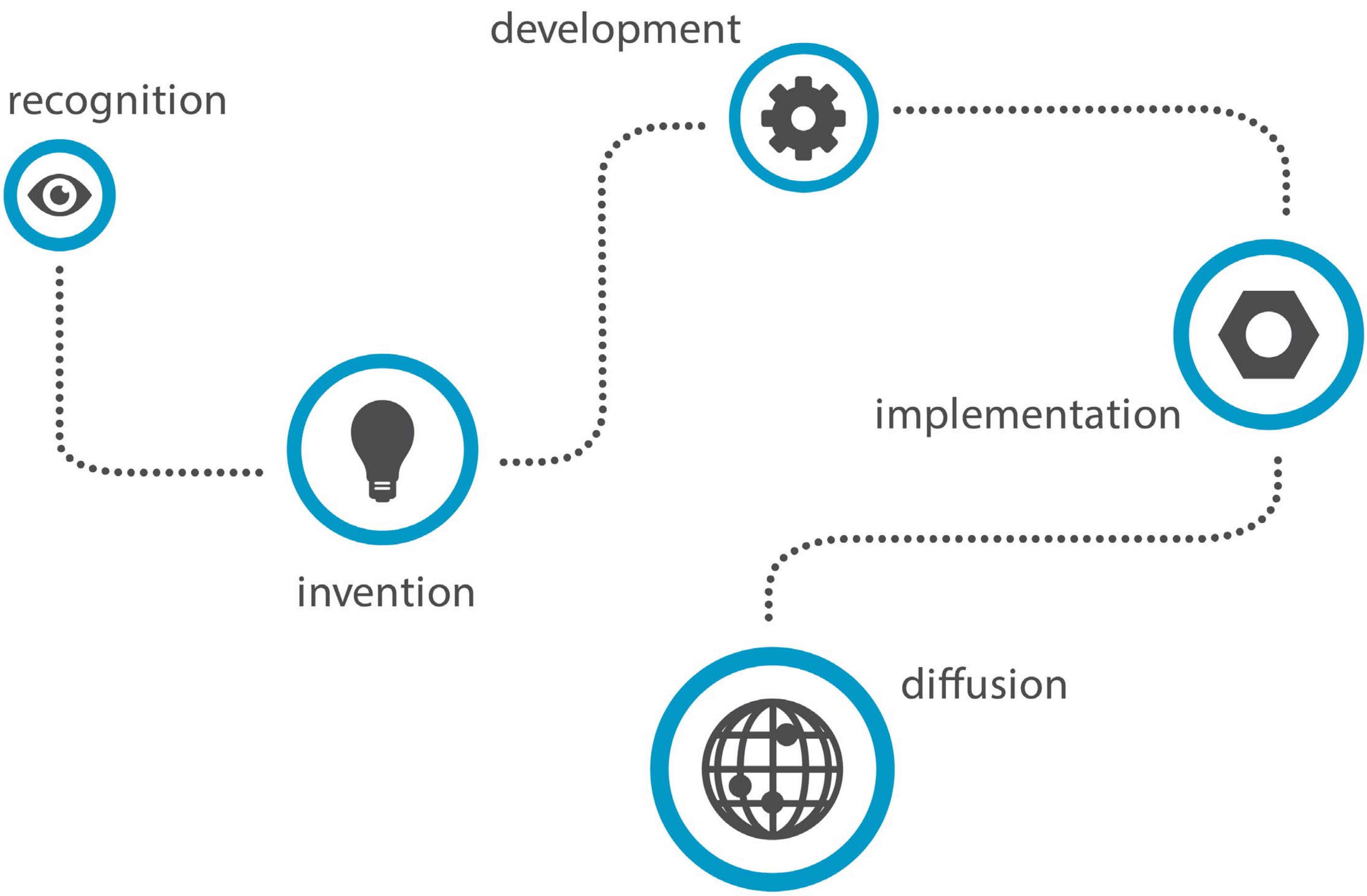
3. The innovation process

The stages through which successful innovations progress are often unpredictable and dynamic in nature, but there are often similarities. It is therefore useful to understand this innovation process when trying to capture why particular innovations succeed or fail.

There are various models to describe the innovation process, but HIF uses a model based on five stages:

- **Recognition** of a specific problem, challenge or opportunity to be seized
- **Invention** of a creative solution or novel idea that addresses a problem or seizes an opportunity
- **Development** of the innovation by creating practical, actionable plans and guidelines
- **Implementation** of the innovation to produce tangible examples of change, testing it to see how it compares with existing solutions
- **Diffusion** of successful innovations – taking them to scale and promoting their wider adoption

These five steps provide a useful archetype for the innovation process and are used in the HIF case study methodology. But they come with the caveat that innovation is complex and non-linear, and that identifying deviations from this model is just as important as (and possibly more so than) confirming the applicability of the model itself. The HIF-ALNAP case studies will seek to map in greater detail the chronology of these stages and how they overlap and interact for each HIF grantee.



3.1 Recognition

As a sector, WASH offers a more supportive environment for innovation than other areas of humanitarian programming,[9] including greater collective activity around problem recognition and the targeting of key challenges. As a widely recognised leader in the WASH sector, Oxfam GB has for decades been involved in several initiatives bringing multiple actors together to identify challenges in WASH programming and brainstorm potential solutions. For example, they held a 'battle of the water treatment units', an interagency Water and Sanitation (WatSan) meeting in 1999, where six agencies brought along different treatment systems to compare performance. Oxfam also had students carrying out research into different water treatment technologies from 2000 to 2004.

Through this work, Oxfam GB recognised a host of problems with water treatment systems: 1) the majority of them are very expensive; 2) many require a high degree of technical knowledge from the operator and use too many chemicals; 3) many focus on achieving high quality over producing high quantities in a short period of time, even though in an emergency the quantity of usable water is also a critical issue; 4) many focus on 'point of use' or household-based solutions rather than centralised 'batch' water treatment systems that can produce greater quantities of clean water.

As an initial response to these problems, in 2004-2005 Oxfam GB invented and developed a modular treatment system called the Up-flow Clarifier. The aim behind its design was to produce high quantities of clean water in settings with highly turbid water. During this time, Oxfam recruited Dr Caetano Dorea, who would eventually become the Project Lead for the Inclined Plate Settler HIF grant, and sent him to field locations including Pakistan to set up and implement the Clarifier. Dorea and Oxfam Head of WASH Andy Bastable came into contact in 2001 through the Centre for Environmental and Health Engineering (CEHE) at the University of Surrey, where Dorea was completing his PhD. CEHE has served as a testing lab for humanitarian WASH products for several decades and, through this, has created the space for humanitarian organisations to interact more regularly with academics.

The Clarifier was effective in the field but Oxfam GB faced difficulties in rolling the system out more widely, as setting it up required a high level of technical expertise. It was therefore never widely diffused by Oxfam HQ. Dorea moved back to academia after his placement with Oxfam, moving first to the University of Glasgow and then to Université Laval.

This early process pointed to two key problems that set the criteria that were eventually used to guide the design of the Inclined Plate Settler system.

Table 1: Inclined Plate Settler – key problems and implications for design criteria and process

Problem	Implications for the criteria for an improved solution[10]	Implications for process
Highly turbid (dirty) water in emergency contexts where there is significant need for sufficiently clean water (for the purposes of personal and domestic hygiene) in large quantities	Led to criteria of: **Sufficient quality:** Attaining the minimum quality level, as set by the Sphere standards, of <5 NTU (nephelometric turbidity units) **Maximal 'throughput':** Attaining a high volume of water/time ratio (as the intended use of the system is to produce high volumes of treated water very quickly)	Test site based in India, to have better access to water that would more closely approximate high turbidity levels; heavy emphasis in development phase on achieving quality standards while maintaining high quantities over a short period of time
High-tech solutions that are not practical on the ground and do not respond to operational realities	Led to criteria of: **Transportability:** Creating a highly mobile product **Usability:** Ensuring the system could be operated by non-technical field staff **Cost-efficiency**: Maintaining a competitive cost that yields a high volume of water per cost unit	Partners designed the process to centre on a strong partnership between academic, manufacturing and humanitarian organisations in order to ensure design was grounded in field realities

3.2 Invention

The invention stage proceeded over six years from 2005 to 2011, primarily through a series of discussions between Dorea and Bastable. Inclined plate systems have been used in the water treatment industry in high-income countries for over two decades, but had not been used in emergency or recovery settings. Dorea and Bastable felt the inclined plate technology was an option that could maintain the benefits of a continuous clarification system (the ability to achieve sufficient quality water in large quantities) while speeding up the processing time. Dorea had also discussed the technology with Joos van den Noortgate, of the Water, Hygiene & Sanitation Unit in MSF Belgium, at a Registered Engineers for Disasters Register (RED-R) training in 2005. MSF Belgium had tried to develop it for use in emergencies starting in 2001, but could not achieve sufficient levels of quality in the water without further filtration, and therefore put aside plans to develop it further. MSF Belgium shared with Dorea some early information from its experience with the technology. Dorea also had several conversations with ACF Spain, which was also exploring the potential of the technology, during the early development of the Inclined Plate Settler.

Simultaneously, Andy Bastable came into contact with Rahul Pathak, Managing Director of AquaPlus, a company based in Pune, India, that develops and manufactures water treatment systems. AquaPlus had been participating in trainings on their water system equipment with RED-R India, who facilitated the introduction to Oxfam GB. All three actors (Oxfam, AquaPlus, UL), as well as RED-R India, began discussions in 2010 on adapting the Inclined Plate Settler system for emergency contexts.

These conversations eventually led to a commitment of resources by all three to an invention phase. Several factors contributed to the transition from discussion of a recognised problem and an opportunity to apply the technology to the active work needed to create a novel solution.

First, while Caetano Dorea had left Oxfam for the University of Glasgow, then later moved to Université Laval in Canada, he maintained contact with Andy Bastable at Oxfam and was proactive in putting his time towards developing a proposal for the proof of concept. His continued motivation and initiative were cited as a factor in Oxfam's decision to provide an initial investment. Also, Oxfam's involvement was significant. Oxfam is a known "entrepreneur"[11] in the WASH sector: it has made significant internal resource commitments to innovation through its own Internal Innovation Fund, allowing it to take a more proactive approach to capitalising on opportunities to improve its operations.

The collaboration appears to have been a significant asset in the development of the technology and was an intentional part of the design of the innovation process. At a broad level, Oxfam provided the humanitarian experience to identify the key constraints and criteria the Inclined Plate Settler needed to meet to be useful in an emergency context; Université Laval provided the research and technical capacity to identify what needed to be adapted in the design to meet these performance criteria; and AquaPlus held the manufacturing and marketing expertise on how to execute these adaptations and minimise costs in order to keep the product affordable and thus attractive to potential buyers. While there has been significant private sector research and development (R&D) activity in WASH, private sector companies are widely perceived to be more concerned with selling their product than adequately addressing the challenges faced in the sector; very few private sector companies collaborate with humanitarian agencies in the development of water treatment systems. This has resulted in many 'innovative' water treatment kits that fail to work reliably and effectively in the field. Partnership with the private sector early on in this case was meant to avoid this shortcoming.

Also important, the key leads at Aqua-Plus and Université Laval, Rahul Pathak and Caetano Dorea, each had several years of humanitarian experience. This meant they did not have to rely solely on input from Oxfam, as they themselves had a basic understanding of the emergency response context. Each organisation also had different and intersecting interests: Oxfam was seeking a better water treatment system; Université Laval aimed to publish research findings generated from the process; AquaPlus, as a private sector organisation, works from a 'win-win' business model with its humanitarian products, in which the costs of R&D in its humanitarian products are mitigated by finding commercial uses for the same product and marketing it to other commercial sectors.

Using seed money from Oxfam's Internal Innovation Fund, Université Laval recruited two research students to travel to the AquaPlus facilities in Pune, India, to develop the initial prototype of the water filter from late 2011 to early 2012. The initial design and testing of design options were guided by three initial criteria of *Sufficient quality, Maximal Throughput and Transportability* (Table 1). Throughout the process, the researchers held daily or weekly review meetings with Rahul Pathak, and questions or problems regarding the testing were reported back to Caetano Dorea on a continuous basis.

From this initial phase, a prototype was created that could significantly reduce turbidity levels for high volumes of water. However, similar to the experience that MSF had in its work with the technology, this early prototype was not achieving the minimum quality levels as indicated by the Sphere standards (<5 NTU). Despite this, the technology showed sufficient promise to be further developed, with a focus on addressing the challenges around quality.

3.3 Development

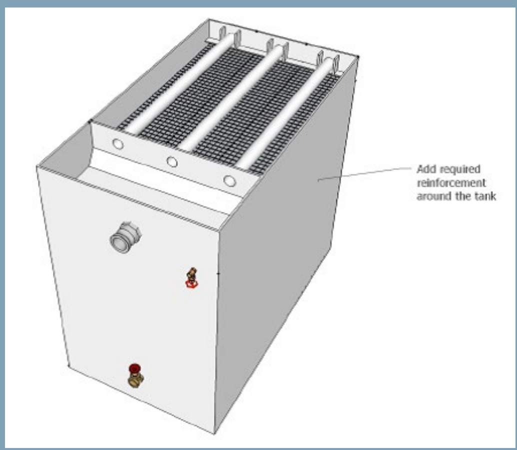
In 2012, Université Laval, Oxfam GB, AquaPlus and RED-R India applied for a HIF development grant in order to work up the prototype into a functioning treatment system that could achieve the key criteria listed above as well as the additional criteria deemed essential for uptake – namely, *Usability and Cost-efficiency* (see Table 1). The original aim was to significantly modify the design from the 'proof of concept' prototype, by creating an 'Origami'-style, collapsible unit (see Figure 2), so the filter could be easily transported.

> **"[Having the testing site in Pune was] incredibly valuable because we had such a good knowledge base over there. Everybody was very practical, everyone was very hands on, so you could knock up prototypes quite easily. I think that just keeps the cost down very well. If you were doing the same thing, say in the UK, then when you're getting made to measure parts made to test whether it works or not, you're going to be paying a lot of cash for that kind of stuff."**
>
> **John Williams, Research Assistant**

The partners once again chose to use the AquaPlus facilities in Pune as the main testing and development site, although a second lab was set up at Université Laval midway through the development phase (as explained below).

Pune was chosen as the development site for two main reasons: 1) embedding the development of the Inclined Plate Settler within the manufacturing company that would, ideally, end up producing and selling it was done to ensure co-ownership over the product from the beginning; 2) several components of the system needed to be experimented with and the cost of these materials was much higher in Canada or the UK than they were in India. This allowed the project team to take more risks in the development project and make mistakes that would have been more costly elsewhere.

Figure 2: Comparison of the inspiration for the original Origami concept design[12] for the Inclined Plate Settler (left) and the final design (right)



However, changes were made to the innovation process based on unexpected delays. The research assistant from Université Laval faced challenges securing a visa for travel to India, and a strike by traders early on in the development process led to disruptions in the supply of materials and services, delaying construction. Further challenges in securing materials for the speedy design of new parts and problems with the accuracy of the instrumentation in Pune led Université Laval to decide to build a smaller model in-house 2013. This model was a third the size of the prototype in Pune and was used for quick fine tuning and experimentation with different components.

One of the key limiting factors in innovation in the WASH sector is the lack of standard testing protocols for water treatment systems.[13] This makes it difficult to compare different water treatment systems and assess performance. While the Sphere standards provide a set of protocols for the outputs a system should achieve, there are no protocols for specifying the conditions in which a particular water treatment system can reliably be expected to produce those outputs (e.g. 'In conditions where turbidity levels are at X, this system will achieve Y level of quality at a throughput rate of Z'). The implementing team therefore had to develop its own protocol for the development of the Inclined Plate Settler.

Despite the delays, the eventual development process was highly iterative, with two tracks feeding into the continual design and redesign of different components of the water filter (see Section 4.6):

- Research assistants based in India ran experiments with the new prototype on a daily or weekly basis to test the different effects of design changes on performance. Straightforward problems were dealt with and modified on the ground in India
- Problems that were not fully understood – for example when it was unclear why the experiments were producing certain results – were referred back to Université Laval, where:
    - Further desk-based research was carried out on the broader literature to investigate a potential explanation and solution;
    - Where necessary, lab testing took place using a much smaller model of the inclined plate filter.

Research assistants based in Université Laval and in India worked simultaneously, feeding information back and forth throughout the development process. While the lab in India was useful for assessing the overall performance levels of the prototype, the smaller model in Quebec City was used to work on isolated aspects of the design that did not require a full 'test run' in order to tweak and change. The Quebec City lab produced probable design improvements, which were then tested for effectiveness in the Pune lab.

Early on, the project aimed to convene a workshop of potential users to solicit their feedback on design. This did not take place, given the amount of staff time eventually needed to execute the trials in Pune. Instead, the criterion of Usability – ensuring the treatment system was easy to operate and maintain by field technicians – was met primarily through the involvement of Andy Bastable at Oxfam, who provided guidance based on his years of experience with successful and unsuccessful new products in the WASH sector. Bastable and Dorea also presented on the innovation throughout the development process to several audiences at practitioner and academic conferences to get feedback, including Inter-Agency Standing Committee (IASC) Global WASH cluster meetings.

During the development process, a key tension arose between the original Origami design, which was collapsible and lightweight, and the goal of developing a system that could treat large quantities of water up to the Sphere minimum standard of <5 NTU. *Quality and Throughput* were the priority criteria for the first phase of development. As a result, the implementing team decided to put aside the collapsible design and instead use a rigid, tank-like structure. Given the cost of materials, the second prototype was made of mild steel, which is low cost but extremely heavy (the prototype weighed 800 kg). This had an unexpected benefit: during the monsoon season in Pune, part of a tree collapsed on the prototype; had it been the lighter-weight structure of the Origami design, the system would likely have faced significant damage. This highlighted to the innovation team the importance of physical robustness as a supplementary criterion in the design.

After the *Quality and Quantity/Time* goals had been achieved, the later development phase focused on meeting the Mobility criterion, with the implementing team seeking lightweight material for the construction of the tank.

3.4 Implementation

During the development phase, Typhoon Haiyan struck the Philippines. At this point, the prototype was delivering strong results in meeting quality standards with high volumes of water. Early on in the aftermath of the typhoon, Université Laval and Oxfam discussed the possibility of deploying the prototype to the Philippines. However, because it was built using such heavy materials and because the investigation into a lighter-weight adaptation had not yet begun, it was decided it would take too long, and would be too costly, to send to the Philippines.

> **"You think, "How does innovation happen?" It happens backwards and forwards, with lots of circular conversations between a supplier or manufacturer and an agency or between agencies and involves quite a long process of reiterations building on the initial idea."**
>
> **Andy Bastable, Oxfam**

Instead, the first field pilot is currently being carried out in Juba, South Sudan, with a HIF WASH grant.[14] While it was originally hoped a field trial would occur during the development phase, Université Laval and its partners now believe greater uptake will be achieved by implementing a more fine-tuned prototype and linking this implementation to an explicit diffusion strategy (see Section 3.5). A lighter-weight model of the treatment system was built in 2014/15. At the time of publication of this case study, the system was en route to Juba. In preparation for the trial, the project partners weighed two options: send the kit with the guidance package on its own to Juba without further support, in order to see whether it can be set up, operated and maintained by field staff with no prior training; 2) send a researcher to the Juba site to oversee setup and to monitor the use of the kit.

While the first option may have offered a more 'realistic' set of testing conditions, it was felt having a researcher on the ground to monitor performance would ensure higher-quality learning from the trial that could be used to make final improvements to the design. As Dorea framed the decision, 'We want to generate evidence and document this properly to see what went wrong. Just an engineer telling us "It won't work" won't help us. We want to know how well it works and what are the limits; and if it doesn't work, we want to know more about why than simply "it's too complicated, etc." We want to rely less on anecdotal accounts and opinions.'

Photo: The Inclined Plate Settler water treatment system: final design deployed in field trial. Credit: Caetano Dorea.

3.5 Diffusion

In this innovation process, Université Laval and Oxfam have attempted to learn from previous experience with the Oxfam Clarifier kit. Oxfam did not pursue diffusion of the Clarifier because field staff were finding the system too complicated to set up.[15] It was felt the lack of involvement of potential end users in its development had contributed to this setback, as end user needs were not fully met by the design.[16]

While Université Laval, AquaPlus and Oxfam aimed to avoid these challenges by including a clear criterion of Usability, similar to the design process for the Clarifier, potential end users have not participated in the development of the Inclined Plate Settler. Instead, as described above, the partners have relied primarily on Oxfam's expertise to understand the end users' needs. In the view of the project team, the best approach to achieving diffusion is to demonstrate the performance of the system in the field: 'Potential users need to "see it to believe it".'[17] In particular, it is felt seeing a large agency such as Oxfam deploy the unit in the field will help generate broader support across other agencies.[18]

Therefore, while the development process for the filtration system has not featured wide involvement of potential end users, the diffusion strategy is 'bottom-up', in the sense that it is reliant on field staff recognising the value of the Inclined Plate Settler system and exercising influence upwards to HQ levels by requesting the system for their programmes. In developing this strategy, the partners have drawn on the work of Everett Rogers, the prominent innovation theorist, and his guide to generating acceptance of a new innovation, in particular the points of 'Compatibility (i.e. ensuring that the selected technology is compatible with the objectives and field conditions they will be deployed in) and Relative advantage (e.g. increasing the cost-effectiveness of the proposed system in relation to others).'[19]

After the pilot in Juba, further adaptations, as required, will be made to the Inclined Plate Settler system and/or the guidance manual. It is then planned that AquaPlus, which has recently changed corporate identity into Easol Ltd, will take over production of the system. There is no patent for the system, as it relies on pre-existing technology (its innovation factor lies in adapting this technology to an emergency setting), and current arrangements between the partners are such that AquaPlus/Easol will retain any profits that may come from sales. However, the market for the system is expected to be very small, and therefore AquaPlus/Easol is hoping to apply its standard business model of making the system available to commercial sectors, such as the car wash industry, in order to increase profits. While AquaPlus/Easol does not currently have plans to market the Inclined Plate Settler (as it would increase the cost of the product), they will include it in their catalogue of products, which they present at RED-R trainings and other fora.

> **'I would define success as me having zero involvement in this [at some point in the near future]. Will it take off on its own right? In five years' time, 10 years' time, is it still a thing? That's where it is key to see whether it will succeed or not.'**
>
> **Caetano Dorea, Université Laval**

4. Was this a successful innovation process?

Inherent in all innovation processes is some degree of failure. This presents a challenge to understanding what contributes to a good innovation process: even successful processes will experience difficult pilots or setbacks in design or diffusion. The HIF-ALNAP research on innovation processes therefore distinguishes between a good innovation – an output of an innovation process that leads to measurable gains in effectiveness, quality and efficiency – and a good innovation process. This research defines a successful innovation process through three criteria:

Table: Criteria of success for innovation processes

Increased learning and evidence	There is new knowledge generated or an enhanced evidence base around the problem the innovation is intended to address, or around the performance of the innovation itself.
Improved solution	The innovation offers a measurable, comparative improvement in effectiveness, quality, or efficiency over current approaches to the problem addressed by the innovation.
Adoption	The innovation is taken to scale and used by others to improve humanitarian performance.

Through the research process for the case studies, ALNAP and HIF are also seeking to understand how HIF grantees define success in their work, in order to identify unexpected or unacknowledged benefits from engaging in innovation.

The research team used evidence collected for this case study to assess the success of the Inclined Plate Settler innovation process against the above three criteria. Overall, this process was highly successful in achieving increased evidence and learning, and highly successful at achieving an improved solution in lab conditions. As field implementation and diffusion are still underway at the time of writing this case study, it is too early to assess whether the Inclined Plate Settler kit will outperform alternative water systems in the field, or to determine the extent of its wider adoption.

Specifically, findings for the three success criteria were as follows:

Increased learning and evidence

The development process for the Inclined Plate Settler generated a great deal of learning around inclined plate technology and how to adapt it for an emergency response. Caetano Dorea presented findings at multiple international and regional conferences attended by practitioners and academics, including the Water, Engineering and Development Center conferences in Nakuru (2013), Hanoi (2014) and Loughborough (2015), as well as the International Water Association (IWA) Development Conference in Nairobi (2013), where the Inclined Plate Settler was awarded the IWA's Project Innovation Award–Development. There have also been multiple publications written on the basis of the research from developing the Inclined Plate Settler.[20]

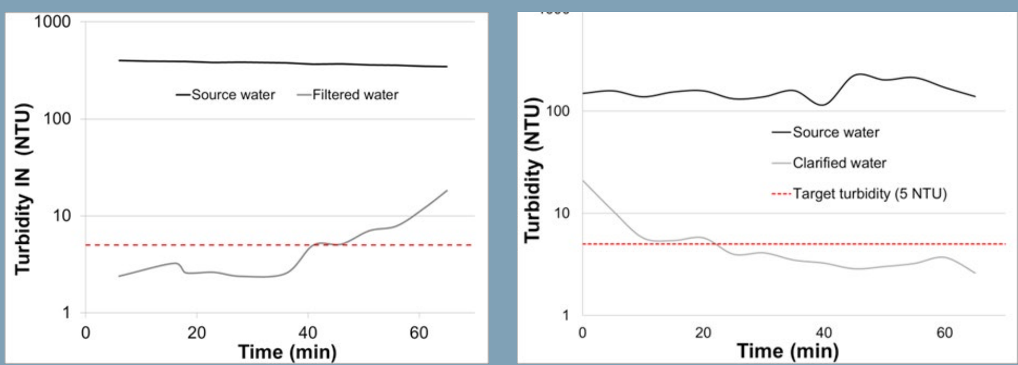
Improved solution

The project lead, Caetano Dorea, has previously written on comparing the cost-effectiveness of water treatment systems[21] and therefore paid specific attention to measuring the performance of the Inclined Plate Settler against alternative systems. While a comparative analysis is easier to apply to this type of innovation – a tangible product developed for the WASH sector – the proactive approach Dorea took to comparing the innovation and common alternatives is rare and deserves to be highlighted as a best practice.

Ideally, the cost-effectiveness of water treatment systems could be compared by measuring their relative contributions to the reduction of diarrhoeal disease.[22] However, because of the resources needed to carry out such epidemiological research, this data is not currently collected to assess the performance of water treatment systems; therefore, doing so for the Inclined Plate Settler would not support a comparative analysis. As highlighted by the Centre for Research in Innovation Management (CENTRIM) study on innovation in the WASH sector, this lack of data, and absence of independent testing of water treatment systems, is a significant barrier to identifying innovations that offer a real improvement to the sector.[23] As found in this case study, the lack of even a standardised protocol for testing water treatment kits is a further hindrance to developing higher performing systems.

To demonstrate the comparative advantages of the Inclined Plate Settler, Université Laval ran tests comparing the quality of treated water over time (quantity being held constant), of the Inclined Plate Settler and a sand pressure filtration system commonly used in the field. The results (see figures below) show that, while the sand pressure filtration system initially produces higher-quality water more quickly, over a short period of time (45 minutes) its efficacy is reduced; in contrast, after 30 minutes the Inclined Plate Settler was able to treat water to an acceptable level, and to continue doing so for up to several days without requiring servicing.

Figure 3: Sand pressure filtration system; Figure 4: Inclined Plate Settler



For the pilot in South Sudan, Université Laval plans to run a similar test using a batch water treatment system, in order to generate further evidence of the comparative strengths of the Inclined Plate Settler.

Comparative cost-efficiency of water treatment systems can be determined through a calculation of cost (£) per yield (m3/h). In order to ensure accuracy, this figure will need to be worked out in field conditions; also Easol Ltd (formerly AquaPlus) is waiting to price the unit until all final modifications have been made post-trial. However, according to the partners on the project, based on the system's performance in the Pune lab, it is expected to offer a highly competitive rate compared with the most cost-efficient treatment system currently available (which runs at approximately £1,000 per m3 per hour).

Overall, the Inclined Plate Settler succeeds in delivering a measurable improvement over other water treatment systems, on the criteria of *Sufficient quality, Maximal quantity/Time and Cost*. Notably, the Inclined Plate Settler has not been compared with alternative systems on the criteria of *Transportability* or *Usability*. Depending on the relative importance of these two criteria and how the kit compares with current alternatives, it remains to be seen whether it offers a better solution overall to water treatment in emergency conditions with high turbidity water supply. Hence, the planned pilot in South Sudan will be critical to demonstrating the comparative advantage it offers.

Adoption

As mentioned above, it is too early to determine whether the Inclined Plate Settler will be adopted widely by humanitarian organisations. To avoid the problems faced by the Oxfam Clarifier, Université Laval ensured strong input and involvement from Oxfam, as well as from Rahul Pathak of AquaPlus, who has experience in training international NGO staff on the use of water treatment technologies. However, outside of informal discussions with ACF Spain and MSF Belgium, other NGOs were not engaged with in the development process and Oxfam's engagement remained at HQ level.

Overall, Université Laval and Oxfam believe demonstrating the system's performance 'on the ground' in a response context will be the best strategy for generating interest among other organisations. It will be of interest to see whether this approach – testing in the field to demonstrate the results of the system to potential end users – will be more successful at diffusing the innovation than an approach that engages potential end users at earlier stages of the design process.

In terms of a broader diffusion plan, the project team has planned to 'extensively document its field performance through more formal channels (conference presentations and peer-reviewed publications), as well as short videos that can be uploaded to a YouTube channel'.[24] The key partners – Dorea, Bastable and Pathak – remain highly engaged in the same RED-R trainings that facilitated their early partnership; they plan to use these courses as a key platform for disseminating the innovation to potential users. Pathak in particular cites the RED-R trainings as a key channel through which AquaPlus has diffused its products in the past. Presentations on the outcomes of the field trial are also planned for a variety of international fora.

5. What are we learning about innovation?

Drawing on research from the humanitarian sector and beyond, including previous case study material, HIF has identified a range of factors generally held to be fundamental to successful innovation processes. An important part of the case study research lies in testing, through the experience of the HIF grantees, the extent to which these propositions hold true in humanitarian settings.

- **Managing relationships and setting common objectives**

  Innovation always involves multiple actors – partners, implementers and end users – all of whom can change over the different stages of an innovation process. Assigning specific time and resources to managing these relationships and ensuring common objectives across the different stakeholders of an innovation will contribute to a successful innovation process.

- **Dividing tasks and responsibilities**

  Given the complexity of many innovation processes, a clear division of tasks and responsibilities between individuals and organisational units is important for developing a successful innovation.

- **Resourcing an innovation**

  Working in innovation requires flexibility to deal with the unknown, and this is particularly so with an innovation in the humanitarian sector. Budgets and resource plans therefore need to be suitably flexible to accommodate several possible outcomes (e.g. the need for further trials) as well as likely deviations from the original plan.

- **Flexibility of process**

  At its heart, managing an innovation process is about creating space for flexibility. Processes featuring flexible timelines, feedback loops for adaptation during the piloting phase and individuals resourced to execute changes in response to emerging results will be more likely to succeed.

- **Assessing and monitoring risk**

  Innovation processes in humanitarian action need to have an appropriate relationship to risk. We expect processes will be more likely to produce improved solutions and achieve uptake when they include an assessment of the different risks that might have an impact on the effectiveness of the innovation, as well as a strategy or plan to monitor and adjust development in light of changes in these risks on an ongoing basis.

- **Drawing on existing practice**

  Knowledge of existing practice and experiences is expected to contribute to more effective innovations through a better understanding of past attempted solutions, an accurate initial understanding of the problem or opportunity addressed by the innovation and an awareness of potential users and their needs.

Findings for these six propositions are presented in the following pages.

Managing relationships and setting common objectives

How this factor worked in this case study

Caetano Dorea's role was considered critical in coordinating the research assistants in India and at Université Laval, as well as with the main partners, Oxfam GB and AquaPlus Ltd. Dorea organised regular catch-up calls with both partners, while also managing the exchange of information between the research assistants. These meetings concluded with action points that Dorea followed up on with all involved, acting as the 'manager' of the innovation process.

A key function of this role was to bring together the manufacturing, operational and technical expertise to understand constraints on the design, and then reflect this back to Oxfam GB in order to gauge from a user perspective where compromises and trade-offs could be made.

Challenges

There were significant and unexpected delays in the development of the Inclined Plate Settler – owing to visa difficulties, workers strikes in India, transfers of funds and other issues – all of which required a great deal of patience from all three partners.

How this factor related to the performance of the innovation process

All partners felt the partnership was well managed, there was strong trust among them and their innovation process had capitalised on the different sectoral profiles of the partners (academic, operational, private sector). They viewed these factors as having delivered a clear benefit to the process by enabling them to address challenges across a range of areas, from technical design to cost-efficiency to usability.

However, the partners in this case study often focused on different criteria when describing the main objective of the design process. This may indicate that, when managing partnerships across a diverse set of actors, only a broad overarching objective needs to be shared; partners will inevitably then focus on the aspect of the shared objective that is most relevant to them.

While it is possible to draw a link between the strong relationship management and the enhanced **learning and evidence** produced by the project, based on the assessment of success criteria (see page 18) it is too soon to determine whether this correlates to an **improved solution** or wider **adoption**.

Dividing tasks and responsibilities

How this factor worked in this case study

Distinct testing tasks were allocated to the research sites in Pune and Quebec City. Overarching responsibilities across the partners were also clearly divided. However, in the testing site in Pune, where the manufacturer and academic staff worked together, there were conflicting accounts as to whether these roles were clearly divided or whether the collaboration was more fluid. From interviews with project staff, it appeared the researchers had the clear lead in problem identification, with the manufacturer as support, but there was also the sense that anyone could suggest ideas and contribute to the problem analysis.

The innovation process relied on the engaged participation of several PhD and MSc students, both from Université Laval and from the University of Glasgow, where Caetano Dorea had previously held a position. The engagement of these researchers was organised as a series of discreet research projects; research assistants worked to the broad parameters of the innovation, yet had more specific and focused research questions to work on, arising from the trial and error process.

Challenges

The research did not identify any challenges related to the division of tasks and responsibilities in this innovation process.

How this factor related to the performance of the innovation process

Evidence for this success factor was interestingly mixed, with some project staff feeling tasks and responsibilities were divided clearly, and that this contributed to a strong innovation process, whereas others felt tasks and responsibilities were more fluid, and that the fluidity of the roles, rather than their fixed assignment, contributed to a strong innovation process. Analysis of the contribution of clear task division to the success of this innovation process is therefore inconclusive.

Resourcing an innovation

How this factor worked in this case study

Oxfam provided critical early resourcing in the development of the first prototype. In interviews, partners cited donors' willingness to fund innovations and remain fairly flexible to changes or delays in the project as critical to the success of the innovation process.

The partnership with AquaPlus is at the core of the partners' strategic approach to resourcing the long-term sustainability of this innovation. Working with AquaPlus from the very beginning was intended to serve multiple purposes, most important being that, as a private manufacturer of water treatment systems, AquaPlus would be able to produce the Inclined Plate Settler and sell it to interested humanitarian organisations. The humanitarian work that AquaPlus engages in is not its primary form of business, and in earlier stages of the innovation process there was hope that AquaPlus could find broader markets for the Inclined Plate Settler.

Challenges

At the time of writing, the primary resources for this innovation consist of the HIF Diffusion Grant, which is funding the field pilot of the Inclined Plate Settler. While AquaPlus is committed to having the Inclined Plate Settler on its catalogue and promoting it in relevant meetings, it has not devoted marketing resources to the product, out of a concern for raising the cost-per unit.

A further challenge lies in the small size of the market for this type of innovation. If successful, partners expect only four to five of the units will sell per year. As technology changes over the coming years, the Inclined Plate Settler will also inevitably become out-dated. It will therefore be useful for AquaPlus to find broader markets for the Inclined Plate Settler in the short and medium term.

How this factor related to the performance of the innovation process

A diverse range of sources has been utilised for funding this innovation: it initially used flexible international NGO seed funding for the proof of concept; based on that proof of concept it drew on HIF funding to develop the concept into a deployable kit and to pilot this in the field; after piloting and a final revision to the model, it will transition into a marketable product, purchased by interested agencies. The model thus far has worked well, particularly in terms of effectively resourcing the development of a deployable innovation into the field. However, in terms of how this strategy will impact on wider adoption, it is too early to determine whether it will be successful in the critical third stage, as it transitions from a grant-funded project into a private sector product.

Flexibility of process

How this factor worked in this case study

The design process was highly responsive and flexible with respect to findings from the experimentation process. When experimentation revealed a collapsible design could not be achieved without sacrificing performance, the team demonstrated flexibility with respect to the original design plan by changing from a collapsible model to one that was rigid, yet could be worked on to become lightweight and transportable.

Flexibility was also demonstrated with respect to the timeline of the project, although this appeared to be demanded of the process rather than necessarily 'built into' it. The continuous delays in the development phase created several periods of what was described by one project staff as 'waiting time'.

Challenges

A portion of the delays to the project occurred around the feedback loops at the site in Pune: it was not possible for the implementing team to respond to findings quickly enough and make necessary adaptations or new fittings to the prototype.

That said, as a result of those challenges, a second model was constructed at Université Laval in spring 2013 that enabled a much faster iterative process. This demonstrated an overall flexibility to the innovation approach, creating new spaces for learning and feedback processes when the original plan faced problems.

How this factor related to the performance of the innovation process

The flexibility of both the design process and the partners' expectations with respect to the project appears to have been a strong contribution to developing an improved solution and to the project reaching the field implementation stage.

Assessing and monitoring risk

How this factor worked in this case study

No formal risk assessment was undertaken, other than the assessment required by the HIF grant application. Risks were not monitored or assessed over time. In the application, the main risk identified was that of 'making assumptions that are not representative of field conditions', which the partners sought to mitigate through the strong involvement of Oxfam GB and the testing site in Pune.

For the trial in Juba, the primary risks considered were risks to the research and learning process around the trial. It was felt a slightly lower-risk environment would be ideal, in order to ensure political unrest and restrictions on the movement of international staff did not impede the ability of the team to monitor the performance of the Inclined Plate Settler. When it comes to the risk of trying an innovation on an actual displaced population, partners see the risk of providing contaminated water as minimal because of the extensive tests done in India. All the partners are confident that it will work but that the field trial may bring up modifications for efficiency purposes that have not been thought of yet.

A further risk identified in the HIF grant application was 'the risk of not constricting or hindering the innovation process itself'. This may indicate the lack of priority placed on regular risk monitoring in the project.

Challenges

As mentioned elsewhere, unforeseen risks caused significant delays in the timeline of the project. These delays, however, do not seem to have posed any clear risk to the eventual adoption of the innovation – the sector has not 'moved on', so to speak, from the core problem the Inclined Plate Settler is intended to address, nor has a competing alternative solution been rolled out.

How this factor related to the performance of the innovation process

The importance of risk assessment and monitoring to the success of this innovation depends on how much weight one gives to the delays in the timeline. Completing an innovation project on time is not a success criterion for innovation in this research, although for donors and other actors this may be a critical factor for assessing the cost-efficiency of an innovation process. The lack of regular risk monitoring did not appear to have an impact on the development of an improved solution, or on learning and evidence, and therefore the relevance of this success factor does not seem to be supported by this case study.

Given that the pilot is underway at the writing of this case study, it is too early to tell the impact of risk assessment practices on the success of the pilot.

Drawing on existing practice

How this factor worked in this case study

Andy Bastable provided a list of key requirements for emergency water treatment systems based on his extensive field experience; Bastable's experience with carrying out a gap analysis of the WASH sector for the HIF in 2011 also provided a strong understanding of the current issues concerning bulk versus point-of-use water treatment systems and the type of added value an Inclined Plate Settler system could provide.

Beyond this, Université Laval devoted considerable research capacity to identifying current practice around the Inclined Plate Settler in non-emergency settings, as well as current approaches to water treatment systems in emergencies. Research staff on the project undertook a review of peer-reviewed research on the technology and previous adaptations to it. They also reached out to companies that developed and manufactured water treatment systems for emergencies and to individuals who had developed systems for major international NGOs, such as Christian Snoad, who developed a sand pressure filtration unit used by Oxfam.

Challenges

The implementing team found it challenging at times to obtain detailed information from manufacturing companies about the water treatment kits they were producing, in particular the prices of such units, as companies viewed the Inclined Plate Settler as a potential competitor.

More broadly, there are no standardised testing protocols for water treatment systems in the humanitarian sector. This continues to be a significant barrier to understanding which systems offer improvements in performance, and in what conditions.

How this factor related to the performance of the innovation process

Drawing on existing technical and manufacturing practice and the technical literature has contributed to the development of a prototype that offers an improvement over three of the five criteria outlined for the innovation (Quality, Quantity/Time, Cost).

The approach taken to drawing on the existing experiences of field workers cannot at this stage be assessed, as the first field-ready prototype has yet to be implemented, and there is no comparative assessment at this point of the Inclined Plate Settler's performance on the criteria of Usability and Transportability. Therefore, it remains to be seen whether Oxfam GB's input has been sufficient to provide the necessary understanding of end-users' priorities, or whether a fuller consultation of field staff or operating agencies would have been helpful.

Additional potential contributing factors to successful innovation found in this case study

Passion and commitment to the problem and the solution

While some research assistants have engaged in only one iteration of the process, others have participated continually in several short 'projects' for the development of the Inclined Plate Settler. Their passion and enthusiasm for the problem and the potential that the Inclined Plate Settler has to offer have been a key factor in their ongoing engagement, contributing to the successful development of a prototype in the face of several unexpected delays.

Partners with humanitarian experience

In other innovation processes featuring partnerships with actors from multiple sectors, it can be a significant challenge to 'translate' between the humanitarian work culture and other sectors. In this innovation process, the key leads from the private sector and academic partners had personal experience working in a humanitarian context and could therefore 'translate' between humanitarian realities and their organisational cultures more easily. This allowed the process to benefit from the specific areas of expertise offered by the academic and private sector partners without the downside of added process costs in bringing partners up to speed on the nature of humanitarian work.

6. Emerging lessons for best practice in innovation

- Partnerships need to be engaged strategically, with an awareness of the individual strengths and limitations each partner has to offer.
- The best partnerships for innovation begin before the innovation is even thought of, which makes it key for organisations to take greater opportunities to build networks and initiate relationships with other actors, in particular academic and private sector organisations. This interaction sows the seeds for the conversations that contribute to problem recognition and the generation of ideas for innovation.
- A lack of standardised testing protocols remains a barrier to innovation in the humanitarian sector.
- The humanitarian sector remains a funding-driven market, which can inhibit the uptake of innovative products from the private sector, even when they are developed in close partnership with a humanitarian agency.
- Processes can be flexible with respect to different aspects of project: while much of the focus in the innovation literature is on flexibility around the design of a product, for humanitarian organisations this may be easier to achieve than flexibility with respect to a timeline, given the typical time limitations placed on projects by funders.

Endnotes

1. For more information on the technology and background to the problem addressed by this innovation, see the blog created for the project, in particular the entries, 'Water Treatment in a Nutshell' and 'Testing and Turbidity'

2. Ramalingam, B. et al. (2015) Strengthening the Humanitarian Innovation Ecosystem. Brighton: CENTRIM, University of Brighton; Rush, H. and Marshall, N. (2015) Case Study: Innovation in Wash, Sanitation and Hygiene. Brighton: CENTRIM, University of Brighton.

3. Waring, S.C. and Brown, B.J. (2005) 'The Threat of Communicable Diseases Following Natural Disasters: A Public Health Response'. Disaster Management & Response 3(2): 41-47.

4. Rush and Marshall (2015). The authors of this report state that 'more than 80% of money that has been spent in the WASH sector has been on Water, both in terms of purifying it (if necessary) and providing it in sufficient quantities' (p.11). This is partly because of prevailing taboos around sanitation products, which have led to a greater emphasis on water over sanitation in WASH innovations.

5. http://www.spherehandbook.org/en/water-supply-standard-1-access-and-water-quantity/

6. Smith, M. and Reed, R. (1991) 'Water and Sanitation for Disasters'. Tropical Doctor 21(suppl. 1): 30-37, as cited in the Large Grant application.

7. Dorea, C. (2015) 'HIF Diffusion Grant Application'.

8. Bastable, A. and Russell, L. (2013) 'Gap Analysis in Emergency Wash, Sanitation and Hygiene Promotion'. London: HIF.

9. Ramalingam et al. (2015).

10. These criteria were not used by the HIF grantees to describe their innovation; they were framed by the author to provide a way of understanding the competing priorities partners were attempting to balance throughout the innovation process.

11. Ramalingam et al. (2015), p.19.

12. Copyright for the Origami concept design owned by Professor Zhong You, Oxford University

13. University of Glasgow and Oxfam GB (2011) 'High Science in Low-tech Emergency Settings: A Foreseeable Horizon or Height of Folly?' London: ELRHA.

14. In addition to its core grant funding, the HIF also has a thematic programme to facilitate innovation in emergency WASH. The funding priorities within WASH are based on a gap analysis conducted in 2013 and follow-up problem analysis research in 2015. This funding allows for more flexible support and encourages collaboration between diverse actors. For more information, see http://www.elrha.org/hif/funding/water-sanitation-hygiene-wash/

15. HIF Large Grant proposal; Interview with Caetano Dorea, Andy Bastable.

16. HIF Large Grant Proposal; HIF Diffusion Grant Proposal.

17. HIF Diffusion Grant Proposal, p. 6.

18. Interview with Andy Bastable, Caetano Dorea, Pablo Alcalde Castro.

19. HIF Diffusion Grant Proposal; also see Rogers, E. (2003) Diffusion of Innovations. 5th edition. New York: Free Press.

20. Dorea, C. and Bourgault, C. (2012) 'Towards a Cost-effective Humanitarian Emergency Water Treatment System'. AWWA Water Quality and Technology Conference, Toronto, 4-8 November; Dorea, C. and Bourgault, C. (2013) 'Inclined Plate Settling for Emergency Water Treatment', 36th WEDC International Conference, Nakuru, 1-5 July, Bourgault, C. et al. (2013) 'A Novel Water Treatment System for Emergency Relief', 3rd IWA Development Congress, Nairobi, 14-17 October; Bédard, G., Bouchard, C. and Dorea, C. (2013) 'Development of an Emergency Drinking Water Treatment System', 28th Eastern Canadian Symposium on Water Quality Research, Kingston, 20-23 September; Dorea, C. et al. (2014) 'Inclined Plate Settling for Emergency Water Treatment: Towards Optimisation', 37th WEDC International Conference, Hanoi, 15-19 September, Bédard, G., Bouchard, C. and Dorea, C. (2015) 'Inclined Plate Settling for Emergency Water Treatment: Final Design', 38th WEDC International Conference, Loughborough, 27-31 July.

21. Dorea, C. and Luff, R. (2011) 'Cost-effectiveness of Emergency Water Treatment Kits', in 2nd IWA Development Congress, Kuala Lumpur, 21-24 November; University of Glasgow and Oxfam GB (2011) 'High Science in Low-tech Emergency Settings: A Foreseeable Horizon or Height of Folly?' London: ELRHA.

22. Ibid.

23. The fact that no overarching organisations exist as yet to undertake independent testing of new or improved products coming onto the market is certainly a barrier to wide scale diffusion of such devices' Rush and Marshall (2015), p.12

24. HIF Diffusion Grant Application, p. 6.

Other case studies from HIF and ALNAP on innovation

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