HUMANITARIAN INNOVATION FUND
Early Stage Innovation Final Report

- Please try not to exceed 5 pages (Arial, 12pts) excluding attachments –

Organisation Name	WaterScope

Project Title	WaterScope: A rapid test for bacterial water contamination that can be used by anyone, anywhere.
Partner(s)	Oxfam
Problem Addressed / Theme	Water Quality/Diagnostics
Location	Cambridge, UK. Dar es Salaam, Tanzania.
Start Date	31st January 2017
End Date	31st December 2017

Total Funding	£29, 964
Total Spent	Total: £32,216 £19,708 (HIF), £12,508 (WaterScope)

Innovation Stage	Research and Development, field testing and iteration
Type of Innovation	Biotechnology, device, bacterial testing system
Project Impact Summary	Globally there are 663 million people without access to safe drinking water. Waterborne diseases from bacterial pathogens result in over 2.2 million deaths every year. The vast majority of those affected are in rural communities, which rely on infrequent visits from water testing companies. Kits currently available to test for bacteria are time consuming, require power, and cannot be used by scientifically unskilled workers. There is also no integrated way to share test results meaning that we frequently lack the information required to bring clean water where it is most needed. The innovation proposed will allow for affordable, rapid, simple testing, not dependent on resource availability or skill set. Our test will greatly reduce the amount of labour time for trained water testing companies while also increasing the dissemination of results by automatically uploading data. Data sharing will allow real-time action, allowing immediate intervention if required.

ACTIVITIES CARRIED OUT

1. Describe all the activities carried out. Please attach a workplan or log frame, if these were used.

Main Planned activities	Implementation period Months											
	1	2	3	4	5	6	7	8	9	10	11	12
WP1.1: Optimise cartridge												
WP1.2: Make case for prototype												
WP1.3: Make prototype robust												
WP1.4: Increase image contrast												
WP2.1: Field Trial												
WP2.2: Post-Trial Modifications												
WP3.1: Evaluation of results to date												
WP3.2: Advisory board meetings												
WP3.3: Company Meetings (weekly)												
WP4.1: Full-time employee												
WP4.2: Software Developer												
WP4.3: Summer Student												
WP5: contingency 10%												

Table 1: Workplan for proposed project

Throughout the project the project plan in table 1 was used as a guide.

WP1.1: The cartridge was designed and prototyped in Cambridge, before testing it in the field in Nyarugusu Refugee Camp with our partner Oxfam. This allowed us to collect user data allowing further iteration and testing in Cambridge. As a result, the functionality of the cartridge has been much improved, making sample collection much simpler.

WP1.2, WP1.3 and WP1.4: In January we refined our entire optical system permitting a much more robust system. This included expanding the field of view using more sophisticated optics, removing superfluous 3D-printed parts and creating a custom-made housing box. Further the new optical system allowed for increased image contrast making software processing easier. Post-field trial motors were integrated allowing for automatic focussing of the sample, further reducing chance of user error contributing to a more consistent system.

WP2.1: The field trial occurred in August 2017 to Dar es Salaam, and Nyarugusu Refugee Camp. Nyarugusu Refugee Camp is home to over 150,000 refugees; Oxfam supplies and manages the water in the camp from boreholes and shallow wells. During the field trial we conducted over 50 tests, including tests done by trained Oxfam water engineers.

WP2.2: After field trial we used the user feedback and our own notes made to make critical iterations to our system. First, this included redesigning the cartridge to make it simple, more consistent and quicker to prepare. Further the cartridge has been designed to allow detection of *E. coli* specifically, which we found to be important during the field trial. Second, the imaging system was made more robust as it was poorly incubated to light and temperature. The optical system has also been redesigned to increase the speed of test results, and to incorporate autofocusing to make

testing even simpler. Lastly, we have redesigned and simplified the electronics in the optical system to reduce power consumption.

WP3.1, WP3.2, and WP3.3: Weekly meetings occurred between the WaterScope team and the full-time employee Alexander Patto. During the project we had 3 advisory board meetings, at critical times; before prototype redesign in January, Before field trial in August, and at the close of the project in December.

WP4.1: Alexander Patto went full-time on the project as planned.

WP4.2, WP4.3: Due to software engineer being too expensive for the project proposed, and the optical system needing further refinement, we only hired a summer student. Alfred Wong was hired as a summer student; Alfred implemented autofocussing into our optical system.

2. If you have made changes or amendments to the planned activities and objectives that have not been detailed in an *Agreement Amendment Form*, please list them here.

In addition to the listed activities above, we also conducted the following activies:

SWP6: Creation of External incubator
An external incubator was created allowing us to incubate an increased number of samples at one time. After discussing with Oxfam Water Testers, it was established that around 5-10 tests per day is the optimal amount.

We established a partnership with STIClab, a local manufacturing company in Tanzania. With STIClab we explored local manufacturing by printing 10 microscopes for education. We are continuing this project to explore local manufacturing of our educational system.

Note: a 3D-printer was not purchased in Cambridge as there was access to 3D-printers at the University for the duration of the project.

ACHIEVEMENTS

3. Has the project demonstrated the success of the innovation or idea?

By 'success' we mean that the innovation has achieved the planned positive impact/outcome, or that the idea has proven effective.

☐ Completely successful
☒ Significantly successful
☐ Partially successful
☐ Completely unsuccessful

Please explain further:

The scope of the project was to develop and test the feasibility of our water testing system. To this extent, the invention described was prototyped and tested in the field as planned. The initiative received much positive feedback and importantly the fundamentals achieved in the HIF project has led to two follow-on projects being funded, with a total budget of £90,000.

4. Please describe how the project achieved the planned objectives, and describe all of the results achieved through the activities indicated in Question 1.

The project involved large amounts of research and development, which was conducted at the host laboratory at the University of Cambridge and Makespace, a communal workshop. The techniques used were 3D-printing, and laser cutting. The development stage was iterative with prototype of different stages developed. Pertaining to research and development, the following prototypes were created and tested:

- Bacterial imaging device
    - Version 1 (self-contained in box)
    - Version 2 (with larger field of view, contained in box, with autofocusing)
- Bacterial Collection Cartridge
    - Version 1 (initial prototype capable of sample imaging)
    - Version 2 (cartridge with simplified collection and imaging protocols)
- External Incubator
    - Version 1 (3D-printed incubator)
    - Version 2 (Laser cut incubator with fan)

The bacterial imaging device (version 1), and the cartridge (version 1) were tested during the Tanzanian field trial. The feedback during this trial led to the creation of version 2 of these prototypes. The external incubator version 1 and 2 was developed in Cambridge, with Version 2 tested in Tanzania. The testing system and external incubator was received with positive feedback and encouragement. We are continuing the development to bring a product to commercialisation.

In addition we explored local manufacturing with a partner organisation, STIClab, with whom we printed 10 microscopes for education. We are continuing this project to explore local manufacturing of our educational system.

METHODOLOGY

5. Describe how the methodology used was or was not appropriate to carry out the planned activities or achieve the planned objectives.

As the project was a feasibility study, consisting of large areas of research and development, the methodology broadly used was as follows:

Prototype -> **test** -> **iterate** -> **test** -> **iterate** -> …..

This methodology follows the human centred design model (1), which allows design of technology that is tailored to the user's needs. By working with Oxfam water engineers we can allow our technology to be suited to the water testers unique requirements, ensuring we develop a useful and impactful solution to a problem.

The project, due to the underestimated amount of development needed, and limited resource available, required longer to iterate before testing. This methodology will benefit from a longer project with more personnel resource.

1) http://www.designkit.org/human-centered-design

MAJOR OBSTACLES

6. Please list the three most significant obstacles faced during the implementation of the project and describe how they affected the planned activities and results.

Obstacle	Impact of Obstacle
1. Redesign of optical system	This obstacle delayed field testing and cartridge prototyping and thus implementation of the project.
2. Ordering necessary components	We found it difficult to order some of the necessary parts, especially those pertaining to microbiology. This forced us to order through university grants, which delayed the project initially.
3. Lack of personnel resource	The project was fairly ambitious, and with only one full-time member being the full-time on the project, progress was slower than expected.

7. Please indicate what steps were taken to address these obstacles and whether the solutions were effective.

Solution	Effective?
1. The first three months was spent solely on redesign, which was much expanded on what was planned initially. This crucially allowed us to get a working prototype by May 2017, however delayed cartridge development.	Yes, but increased burden on personnel resource.
2. We were successful in obtaining a large grant to enable Alex to be hosted at the University for the duration of the project. This allows ordering of sensitive material.	Yes.
3.Regarding the lack of personnel resource we utilised the WaterScope team as much as possible. Further we took two members of the team to the field trial in August.	This was effective, but the project should have had a budget for two people full-time.

OPTIONAL: BENEFICIARIES/HUMANITARIAN INTERVENTIONS IMPACTED

***If** your project was intended to impact upon beneficiaries, please answer question 8.*

8. Indicate the affected population as well as the humanitarian interventions that have benefited from the project.

OPTIONAL: PARTNERSHIPS AND COLLABORATION

***If** you received HIF funding with partners or collaborators, please answer questions 9 and 10.*

9. How and why did the partnership change during the course of the project?

During the project we expanded our collaboration with Oxfam in Tanzania, critically we were successful in a joint project of £30,000 to expand on the HIF project to explore feasibility of WaterScope's device as a Cholera testing system.

We are also working with STIClab on a larger project over 2 years to explore local manufacturing of an educational microscope. This microscope can help enable education around water quality and sanitation.

10. Are there plans to continue your partnership, either while continuing this innovation or on other projects?

☒ Yes, with this innovation
☒ Yes, with another project
☐ Maybe
☐ No

Please describe further:

As described in question 9, we have been successful in a follow-on project with Oxfam, and STIClab.

DISSEMINATION

11. Please describe any steps taken to disseminate the outcomes of the project.
Please include all completed and forthcoming, as well as all planned and unplanned products (for example, research and policy reports, journal articles, video blogs, evaluations).

During the project we published a blog around our work, primarily leading up to the field trial. We will publish a final blog detailing our results.

During the Royal Academy of Engineering Enterprise fellowship, Alexander Patto will pitch the outcomes of the project to obtain further funding. Further Alex has been invited to numerous conferences, roundtables and talks in which he has disseminated some of the outcomes from the project, including:

- Invited Guest lecturer for Global Health Module, Institute of Public Health, Cambridge.
- Invited to present at the Global Challenges Initiative Roundtable
- Invited to participate in panel discussion at SymBLS 2017
- Invited to present and mentor at Global Challenges Initiative Tech4Dev Sandpit
- Invited judge for ITIC Lent Showcase
- Invited to present for Maxwell Impulse Entrepreneurship Alumni event

Importantly some of research conducted in the HIF led to the award of the University of Cambridge, Vice Chancellor's Overall Impact Award in July 2017. Over the next three months, Alexander Patto has been invited to present at the Entrepreneurial Post-docs of Cambridge in May 2018, as well as the Maxwell University of Cambridge Showcase, March 22.

We will continue to update our followers on our project though WaterScope's Twitter and on our Website, waterscope.org.

NEXT STEPS

12. Will the project, idea or innovation be replicated, carried forward or scaled up?

☒ Yes
☐ No
☐ Maybe

Please describe further:

We have been successful in receiving funding for two projects to carry on the project:

- Enterprise Fellowship for Dr Alexander Patto (£60,000)
- EPSRC Global Research Challenges Fund follow-on grant by with Oxfam (£30,000)

The above projects will continue until March 2019. We are also looking for further funding to enable hiring of additional personnel.

WaterScope aim to commercialise at the end of 2020. Continued efforts are in research and development to finalise out product design by 2019 (figure 2). A patent will be filed in 2018 for our cartridge developed during the HIF project. We will also explore manufacturing partners and expanding our cartridge functionality by incorporate different bacteria testing, including Cholera, which will be explored in the EPSRC grant with Oxfam.

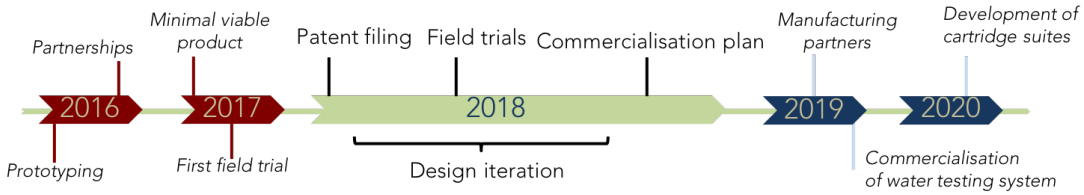

Figure 2: timeline for continued development.

13. If the project, idea or innovation could be carried forward, replicated or scaled up, please list the three most important issues or actions that will need to be considered *(where 1 = most important and 3 = least important)*

Suggestion/issue	***1***	***2***	***3***
1 Personnel resource. We suffered from a lack of people-power during the project. In the future a project of this size would benefit from having two full-time members of staff.	☒	☐	☐
2	☐	☐	☐

3	☐	☐	☐