Resilience of drinking water supplies in low income countries

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Millions of people in low income countries are exposed to poor drinking water. Rural communities in particular face a number of challenges such as the lack of capacity for essential management of the water supplies, operation and maintenance, and implementation of technical improvements. The exposure of drinking-water infrastructure to natural and human-induced hazard can have severe consequences on human health. Broken standpipes for example may result in communities having to use alternative unsafe supplies. Women and children in particular in low income countries may face extensive walks to find an alternative safe source, reducing time for other activities such as education and childcare. Although experience shows that small community water supplies are more at risk of breakdown and contamination, leading to outbreaks of waterborne disease and gradual decline in their functionality and service, piped supplies also pose risks to health where they are damaged resulting in the potential for microbial contamination and outbreaks of infectious disease, such as acute diarrhoeal illness. Every year, about 2.5 million deaths worldwide are attributed to diarrhoea alone and approximately half who die are children under the age of 5 (WHO, 2011). It is therefore imperative that infrastructure designers and operators deliver resilient infrastructure which can withstand the effects of *multiple* hazards, both natural and man-made and climate change effects. This truly multidisciplinary project aims address some of these challenges.

The novel aims of this project are:

1. To map and assess the hazards and implications of those hazards affecting drinking-water infrastructure assets and networks in low income countries;
2. Evaluate and identify efficient existing approaches and techniques for dealing with the effect of hazards on drinking-water infrastructure in low income countries;
3. Adapt and apply the resilience assessment framework for critical infrastructure assets exposed to a sequence of individual and/or multiple natural, environmental and human-induced hazard events in order to:
   3.1 Quantify the robustness of drinking-water infrastructure against a variety of single and multiple human-induced and natural hazards;
   3.2 Quantify the rapidity of recovery after damage using empirical and expert-elicited reinstatement and recovery models.
   3.3 Validate the restoration models, based on recorded data, evidence and input from testimonies, expert judgement and the literature, with participation by owners, stakeholders and engineers.

The project will use a method for lifetime resilience assessment which has been developed and used in the transport sector by Surrey University (see Argyroudis et al., 2020) but not previously applied to drinking-water infrastructure. There is an urgent need for owners and operators of small drinking-water supplies to enhance safety, leading to significant cost savings and efficient allocation of resources toward resilient infrastructure. This novel, challenging and exciting study aims to adapt, apply and extend the methodology to a selection of water supply infrastructures such as standpipes, wells and

piped supplies exposed to selected hazards and combinations of hazards in low income countries. It will provide the applicant with the opportunity to undertake fieldwork in a low income country as Uganda will be used as a case study (subject to travel restrictions being lifted will be a fieldwork location), supervised by Dr Kenan Okurut, Kyambogo University. Hazards may include floods, but also general deterioration caused by heavy use of the technology. Climate change predictions may also be used to forecast future resilience under different scenarios. Verification will be undertaken through qualitative research techniques – interviews will be conducted with stakeholders, engineers and communities using the drinking water technologies, both in Uganda and elsewhere. This project has real-world impact addressing the aims of the sustainable development goals and potentially helping to improve the drinking water infrastructure for millions of people globally.

Training opportunities:
There is the potential to undertake fieldwork in Uganda, subject to the current COVID situation improving. In the first year, you will be trained as a part of a single cohort on research methods and core skills at University of Surrey. Throughout the PhD, you will be offered the opportunity to attend MSc and undergraduate modules from the University of Surrey to extend your knowledge on skills related to structural engineering, global challenges facing drinking water supplies and their users, hydraulic modelling. Specific training in modelling skills, statistical and climate data analysis for example will also be given by Surrey University.
You will also be included in all Departmental / group research seminars and talks relevant to their field.

Student profile:
This project would be suitable for students with a degree in engineering or a closely related environmental or physical science.

References: (optional)

Pond K, King R., Herschan J, Malcolm R, McKeown RM, Schmoll Or (2020) Improving Risk Assessments by Sanitary Inspection for Small Drinking-Water Supplies? Qualitative Evidence, Resources 9 (6) 71 MDPI DOI: 10.3390/resources9060071

Fawell John, Pond Katherine, Pedley Stephen, Hyllestad Susanne, Drazdova Alena, Shinee Enkhtsetseg, Schmoll Oliver (2019). Strengthening drinking-water surveillance using risk-based approaches, WHO/Unicef.

If required, put in any relevant recent publications.

Argyroudis SA, Mitoulis SA, Hofer L, Zanini MA, Tubaldi E, Frangopol DM (2020). Resilience assessment framework for critical infrastructure in a multi-hazard environment. Science of the Total Environment, 714, 136854.

McKenna G, Argyroudis SA, Winter MG, Mitoulis SA (2020). Multiple hazard fragility analysis for granular highway embankments: moisture ingress and scour. Transportation Geotechnics, https://doi.org/10.1016/j.trgeo.2020.100431

https://research.reading.ac.uk/scenario/