Institution: Leeds Beckett University (LBU)

Unit of Assessment: Architecture, Built Environment and Planning

Title of case study: Sustainable development of water quality infrastructure and operational reliability of rural community water-points throughout the Global South

Period when the underpinning research was undertaken: 2005 - Present

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g., job title):	Period(s) employed by submitting HEI:
Dr Martin Pritchard	Reader	2001 - Present
Dr Andy Swan	Reader	2008 - Present

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Multidisciplinary research work conducted by LBU, and partner organisations, has helped improve the water supplies for around 10,800 rural people in southern Malawi. It has established the country's first postgraduate course on water management at the Polytechnic. Graduates are now working in-country on water improvement projects as well as the development of new policy to promote and implement good practise. Furthermore, our MANTIS (Monitoring & Analytics to Improve Service) pilot trials have helped Gambia's government to monitor the operational status of water pumps serving approximately 3,000 people across the country allowing the Rural Water Resources Department to quickly respond and repair broken infrastructure.

2. Underpinning research (indicative maximum 500 words)

Rural water infrastructure across the Global South is often broken, and groundwater frequently contaminated and consumed untreated. The subsequently high levels of water-related diseases annually kill over 3.5 million people. These issues require urgent attention if the United Nations Sustainable Development Goals (SDGs) are to be met by 2030.

In 2005 Dr Pritchard commenced an extensive shallow well field-monitoring programme throughout southern Malawi to document the drinking water quality of over 17,000 Malawians over 5 years [1], funded by the WARFSA (P232) and WaterNet. This demonstrated that approximately 80% of wells failed in the dry season, increasing to 95% in the wet season (*this work was submitted in REF2014*). Follow-on activities sought to address these grossly contaminated shallow wells. Primarily, this involved dialogue with water officers and village chiefs to develop short-term remediation strategies. However, the evident need for longer-term approaches led to our current two-pronged strategy:

(1) To tackle policy and educational issues regarding current practises

- Funding was obtained from DelPHE (Round 4 #603) to develop an in-country postgraduate provision at the Malawi Polytechnic to educate water officials, community leaders, NGO practitioners and other water stakeholders.
- Further grants were secured from the EU FP7 and Innovate UK funding mechanisms. These projects facilitated dialogue with water stakeholders in the EU, Brazil, India, Gambia and Sierra Leone.

(2) **To develop appropriate field-based technologies to significantly improve the water quality infrastructure and operational reliability of rural community water-points.** This work consisted of the following themes (detailed below) and was conducted in Malawi (2010–ongoing), India (ongoing), Brazil (2013–17), Sierra Leone (2016–17) and Gambia (2017).

- ***Scientific investigation of more appropriate and sustainable materials (plant extracts) for water treatment:*** The limited availability and expense of chemical coagulants led to research into the use of indigenous coagulants for the Global South. This involved the formulation of a plant extract inventory, including coagulation performance and toxicity related laboratory analysis [2]. Under optimum conditions, it was shown that 90% of impurities can be removed from shallow well water. Our investigations were subsequently expanded to explore the use of plant extracts for water treatment within the Amazon Region of Brazil [3]. This collaborative research with Universities from Brazil, Italy and Spain was supported by the EU FP7 AguaSocial Project (Ref: PIRSES-GA-2013-6126) and spin-off Erasmus+ (UK-Brazil) partnerships. Project outputs were disseminated to various stakeholders via international events (e.g., EU Green Week 2014); academic publications and social media.
- ***Development of innovative community-based water purification systems:*** The LBU team developed a novel retrofit system for treating groundwater from existing extraction points [4]. Basically, water is extracted from the well to a coagulation chamber. Once this chamber is full, the coagulant (natural plant extract) is added and mixed, the supernatant (purified water) is then decanted, with around an 80% improvement in water quality achieved.
- ***Operational reliability:*** In 2010, Dr Swan began research into the operational reliability of rural water supplies; this evolved into two projects to improve: (a). post-construction monitoring and (b). maintenance funding streams [5 & 6]. These investigations benefited from three separate Innovate UK funding awards. This funding facilitated MANTIS project field trials in Gambia and Sierra Leone – leading to collaborations with three SMEs and resulting in a marketable product. Spin-off Innovate UK/GCRF funding was awarded in 2020 to explore market opportunities in India for the MANTIS system.

3. References to the research (indicative maximum of six references)

[1] Pritchard, M., Mkandawire T. and O'Neill, J.G. (2008) 'Assessment of groundwater quality in shallow wells within the southern districts of Malawi, Physics and Chemistry of the Earth Journal, Vol. 33, Aug. pp. 812–823. ISBN 1474-7065 - Peer-reviewed, impact factor 1.362, 5-year impact factor: 1.138.

[2] Pritchard, M., Craven, T., Mkandawire, T., Edmondson, A. and O'Neill J.G. (2010) "A study of the parameters affecting the effectiveness of *Moringa oleifera* in drinking water purification", Physics and Chemistry of the Earth Journal, Vol. 35, Aug. pp. 791–797. ISBN 1474-7065 – Peer-reviewed, impact factor 0.975, 5-year impact factor: 1.292 (based on 2009 data).

[3] Cardoso-Castro, P., Swan, A. and Mendes, R., 2018. Exploring the key issues and stakeholders associated with the application of rainwater systems within the Amazon Region. *Journal of Entrepreneurship and Sustainability Issues*, *5*(4).
DOI: https://doi.org/10.9770/jesi.2018.5.4(2)

[4] Pritchard, M., Edmondson, A., Craven, T. and Mkandawire, T. 2015, Chapter 18: Development of sustainable drinking water quality solutions for rural communities in the developing world. In Gorse, C and Dastbaz, M (Eds.) International SEEDS Conference, 17–18 September 2015, Leeds Beckett University UK, Sustainable Ecological Engineering Design for

Society. Springer International Publishing, pp. 259–277. ISBN: 978-3-319-32645-0 (Print) 978-3-319-32646-7 (Online).
DOI: http://link.springer.com/chapter/10.1007%2F978-3-319-32646-7_18

[5] Swan, A., Kenny, O., Logan, I. and Ballam, D., 2019, December. A pilot study from The Gambia to improve access to water, energy and mobile phones. In *Proceedings of the Institution of Civil Engineers-Water Management* (Vol. 172, No. 6, pp. 273-283). Thomas Telford Ltd. DOI: https://doi.org/10.1680/jwama.17.00053

[6] Swan, A., Skipworth, P., Walker, L. and Thursfield, G., 2018. Field testing a remote monitoring system for hand water pumps. *Water Practice & Technology*, *13*(4), pp.821-831. DOI: https://doi.org/10.2166/wpt.2018.093

4. Details of the impact (indicative maximum 750 words).

Potable water is vital for improving the health, welfare, and productivity of populations. Clean water is also essential for sustainable development. The longer-term benefits of consuming potable water will directly contribute to the health of the population, quality of life, and drive economic growth.

Improving water quality in Malawi

After undertaking the shallow well field-monitoring programme in southern Malawi pre-2014, LBU's team worked with water officers, community leaders and village chiefs associated with heavily contaminated wells to implement short-term remediation strategies to minimise potential outbreaks of water-related diseases. For example, this involved segregation of water supplies into washing and drinking; the use of basic indicators to assess quality; and the implementation of primary treatment before drinking. Also, to repairing and maintaining the extraction points and surrounding areas to eliminate further deterioration of water quality. Approximately 88% of Water Officials contacted reported that *"there has been less reported cases of waterborne diseases, such as cholera, and child mortality rates have gradually dropped"* thereby resulting in a corresponding *"economic growth"* [A].

This work was awarded first prize at the 'Research Councils/UK Water' Research Impact Awards in 2015 for 'reducing waterborne diseases from shallow wells in the developing world' [B]. *Inter alia*, the 'Water Resources Investment Strategy', World Bank funded, captured the data to develop policy. Hence, influencing future policy [C].

The setup and teaching of the Malawi Polytechnic's postgraduate provision

Dr Pritchard also led an international team of four academics and two industrialists to develop and promote Malawi Polytechnic's first postgraduate provision directed towards water management. As part of the setup of this programme, a dedicated postgraduate computer room was initiated. This room was the first of a kind at the Malawi Polytechnic, and helped them address the 4E framework for e-learning. This allowed novel teaching approaches to be introduced. For example, the MSc modules were structured to the format of project/problem-based learning, where students assessed water quality case study data and used this information to solve real-life problems related to Malawi. Overall, a first-class environment was created to train future water professionals within sub-Saharan Africa. Graduates from this course are now working in the water sector – promoting good practise as well as ensuring current guidelines are enforced; all of which results in less outbreaks of waterborne diseases, hence a reduction in water related deaths. For example, a graduate from the programme, who currently manages 26 people, has worked on the *"Accreditation of some methods at Central Water laboratory Lilongwe Water and Sanitation Project Water Resources Monitoring Project".* Other notable projects from different graduates include the "*Rehabilitation of Chikwina Mpamba Gravity Water Supply System*", which consisted of "*intake works, 13 kms transmission mains and 30 kms distributions mains with over 100 tap points"* as well as work on the *"review of national water policy"*. The resulting impacts from these projects, which graduates

have worked on, have been reported to have *"helped in improving people's livelihoods and this has had an effect on the economy"* [D].

Improving operational reliability of rural water pumps

A recent expansion of the team's research portfolio relates to Dr Swan's work to improve the operational reliability of rural water infrastructure [5 & 6]. Various monitoring systems have been developed for water infrastructure across the Global South. However, many such technologies use complex data collection systems, which are energy-hungry and expensive. The MANTIS system is a power efficient and low-cost system which was developed at LBU. It detects whether the water pump is in regular use and reports patterns of usage via a web-interface. The prototype technology was 'market-readied' via collaborations between the University and two SMEs: Environmental Monitoring Solutions Ltd (EMS) and VisualWind Ltd (VW). This venture attracted three separate Innovate UK funding awards (IUK Project Refs: 751888; 132583 and 67621), which facilitated demonstration projects in Gambia and Sierra Leone (2016-17) to monitor water infrastructure serving approximately 3,000 people [E]. In Gambia, the MANTIS system successfully detected water pump failures and informed the country's Rural Water Resources Department, who were able to more quickly implement repairs [E]. Spin-off meetings were held with a range of key stakeholders, including members of the Gambian government (e.g., Gambia's Minister of Water Resources) and a number of international NGOs/charities [F]. Our current Innovate UK project is exploring market opportunities for the MANTIS system in India.

In March 2020, the MANTIS system was highlighted by the Institution of Civil Engineers (ICE) as a best practice exemplar [G] for addressing the complex and pressing challenges of SDG 6. In November 2020, the ICE published a book to commemorate the 75th year of the United Nations and the corresponding progress towards engineering sustainability. This publication features an article on LBU's MANTIS project, alongside contributions from UN agencies and other prominent organisations such as WaterAid and Oxford University [H].

5. Sources to corroborate the impact (indicative maximum of 10 references)

A. Water Officials & NGOs Impact Survey Report 2021, Malawi.
B. The Research Councils UK Water Research Impact Awards – Process Technologies in 2015 for 'reducing waterborne diseases from shallow wells in the developing world' <http://www.waterindustryforum.com/whatsnew/winners-announced-for-wif-impact-awards-2015/>
C. Data from this study has been fed into the: 'Water Resources Investment Strategy, Component 1 – Water Resources Assessment' Government of the Republic of Malawi Ministry of Irrigation and Water Development Second National Water Development Project (NWDP II).
D. MSc Impact Survey Report 2021, Malawi.
E. Impact testimonial: Innovate UK MANTIS SME Partner – Industrial collaborator with the Leeds Becket University on the MANTIS Project and field trials in Gambia & Sierra Leone.
F. Letter of Support from Gambia's Department of Water Resources - confirming MANTIS Project team visit and field trials in Gambia.
G. MANTIS – Perspective from Institution of Civil Engineers (Professional Body) Urgent Action Water - ICE eBook publication, Regal Press Limited, <page 18-19> Available from: https://www.ice.org.uk/news-and-insight/latest-ice-news/new-ebook-looks-at-creating-sustainable-future
H. UN75: Sustainable Engineering in Action, ISBN-10:1911339435; ISBN-13:978-1911339434 <Pages 80-81> Publisher: Artifice Press (November 16, 2020); E-book version available from <https://www.un-75.org/ebook>