38th WEDC International Conference, Loughborough University, UK, 2015

WATER, SANITATION AND HYGIENE SERVICES BEYOND 2015:
IMPROVING ACCESS AND SUSTAINABILITY

A hidden crisis: strengthening the evidence base on the current failures of rural groundwater supplies

H. C. Bonsor, N. Oates, P. J. Chilton, R. C. Carter, V. Casey, A. M. MacDonald, B. Etti, J. Nekesa, Musinguzi F, Okubal P, Alupo G, R. Calow, P. Wilson, M. Tumuntungire & M. Bennie (UK)

BRIEFING PAPER 2181

New ambitious international goals for universal access to safe drinking water depend critically on the ability of development partners to accelerate and sustain access to groundwater. However, available evidence (albeit fragmented and methodologically unclear) indicates >30% of new groundwater-based supplies are non-functional within a few years of construction. Critically, in the absence of a significant systematic evidence base or analysis on supply failures, there is little opportunity to learn from past mistakes, to ensure more sustainable services can be developed in the future. This work presents a new and robust methodology for investigating the causes of non-functionality, developed by an interdisciplinary team as part of an UPGro catalyst grant. The approach was successfully piloted within a test study in NE Uganda, and forms a basis for future research to develop a statistically significant systematic evidence base to unravel the underlying causes of failure.

A hidden crisis

New international goals aimed at achieving universal access to safe drinking water depend critically on the ability of development partners to accelerate and sustain access to groundwater (UN Water 2013). However, available evidence for SSA, albeit fragmented and methodologically unclear, suggests that 30% or more of groundwater-based water supplies are non-functional at the time of monitoring and a greater number can experience seasonal problems (for example 50% in Sierra Leone) (RWSN 2009). Achieving improved sustainability of supplies and universal access to safe water will, therefore, require a step-change in understanding of the inter-related causes of water point failure and unreliability, and actions that can be taken to mitigate risks. Growing evidence indicates that this is not a simple problem solved by capacity building alone, additional finance, strengthening post-construction support to water facilities, or a new design of pump. The roots of failure are likely to lie in a complex set of multifaceted issues, in which there are immediate causal factors of failure (e.g. poor siting, basic maintenance) and more systemic, deep-rooted underlying conditions that shape an environment in which failure is more or less likely – Fig. 1.

The evidence challenge

Despite the scale of the problem, there is little evidence on why groundwater-based supplies continue to fail in sub-Saharan Africa. Critically, in the absence of a common diagnostic framework; varying definitions of failure are used; and, few of the studies consider all facets of service failure, many focusing on management of supplies, whilst others are focused on the quality of borehole construction, or the availability of groundwater resources. There is also a lack of research on how the different facets of failure interact (e.g. technical and institutional factors) to cause failure of a water point.

The Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region (RiPPLE) programme has undertaken some of the most systematic studies of groundwater supply failure to date (Abede and Hawassa 2008; Deneke and Hawassa 2008). The findings clearly reveal that supply sustainability cannot be reduced to a single cause and, a comprehensive diagnostic assessment approach framework is essential to begin to understand causes of failure across different socio-economic and physical environments (Dessaelgo et al. 2013). Unravelling the different inter-related contributory causes requires an understanding of (1) groundwater resources, (2) water point siting, design and construction, (3) financing, management, external support and community arrangements, and (4) demand pressures.

UPGro research programme

This report provides a summary of the work funded by a one-year catalyst grant funded under the UPGro research programme ('Unlocking the Potential for Groundwater for the Poor') for sub-Saharan Africa funded by NERC, ESRC and DfID running from 2012-2019. The overall aim of the catalyst project was to develop and test a methodology and toolbox approach which can be used to investigate the causes of groundwater service failure in sub-Saharan Africa and develop a statistically significant evidence base. The methodology was tested by the catalyst project in a pilot study in eastern Uganda.

Development of a toolbox to examine causes of supply failure

The toolbox is designed primarily as a field-based tool and provides a set of robust and repeatable data collation methods to provide a detailed post construction audit of the water point and the local governance arrangements. Social science, engineering and hydrogeological data are collated. The different data collation methods are employed in a rapid phased approach with: an initial phase of reconnaissance work to identity the total number and different immediate symptoms of water point failure in an area; then, focused research at a selection of the sites involving community surveys to ascertain community capacity and management arrangements; and, finally, technical investigations examining the possible engineering and hydrogeological aspects of failure.

Toolbox methods

Reconnaissance surveys – identification of failed supplies

The reconnaissance phase identifies the total number, and different symptoms of failed water points in a region. A representative sub-sample is then selected for focused field research. It is essential as part of this to ascertain which communities are willing for more detailed investigations of the water point to be undertaken in the reconnaissance work, some of which involve the removal of the hand-pump and pump rods, and downhole measurements and tests. Key secondary data (e.g. borehole logs) are also collated. Local practitioners and NGOs play a key role in the reconnaissance survey work based on their knowledge of the communities and location of failed water points.

Community surveys – collation of data on local governance arrangements

The community survey is designed to collect basic information on community water use, as well as more detailed information on the non-functional water point, its history and management, and the local socio-institutional factors that may have contributed to non-functionality (e.g. water point management, finance and repairs). A survey template is used to enable accurate repetition of the survey within different communities. The main sections of the survey include:

- Community attributes
- Available local water sources
- Planning and construction of the failed water point
- Breakdowns and repairs of the point
- The Water User Committee (WUC) roles and rules
- Capacity of WUC management and enforcement, and finances

The survey methodology draws partly on the Water Economy for Livelihoods Systems (WELS) analysis approach developed and tested under the RiPPLE programme in Ethiopia (Coulter et al. 2010, Calow et al. 2013) and adapted by others (e.g. Dessalego et al. 2013).

Technical investigations – collation of engineering and hydrogeological data

A suite of engineering and hydrogeological methods are used to develop a detailed post construction audit of failed water points, and identify what, if any, hydrogeological and engineering factors are contributing to supply functionality (e.g. pump installation and condition, borehole construction, the groundwater resource).

None of the individual techniques used within the toolbox are new, but the use of all the techniques together, together with the detailed and careful deconstruction, measurement and photography of the failed pumps and boreholes, has not been done on a wide scale, or systematically, before by previous work in water supply functionality, and is a major novel aspect of the toolbox. The techniques in the toolbox include:

- **Deconstruction of a water point** to examine the conditions and performance of the pump, and rising main, as well as inspection of the construction and condition of the borehole using downhole CCTV.
- **Local physical hydrogeological investigations** – pumping tests, and bailer tests, to assess permeability and borehole performance
- **Groundwater chemistry and residence time sampling** using robust field sampling techniques for inorganic chemistry, stable isotopes and dissolved anthropogenic gases (CFC, SF_6, and tritium) to investigate local water quality and also groundwater residence times to help gain insight to recharge rates and sources.

Data analysis

A Root Cause Analysis (RCA) approach is used to interrogate the data collated and to begin to develop a systematic diagnostic framework. Two main RCA approaches are used: the 5 whys, and Causal Link Diagrams. These approaches enable the number and complexity of inter-linked factors to be identified, and to begin to frame water point failure as a system. This is important when one symptom of failure can arise from very different causal factors, in different environments.

Applying the toolbox – A pilot study in Uganda

The toolbox was applied to investigate borehole-handpump failures in the Amuria and Katakwi districts of northeast Uganda, to assess the applicability, replicability and overall success of the toolbox to develop a detailed post construction audit dataset of failed water points, which can be used to examine the immediate, and underlying root causes of the water point failure.

Study area

Existing failure rates of groundwater based supplies in the Amuria and Katakwi districts are typically around 30%. The geology of both districts is predominantly ancient Precambrian crystalline Basement Complex, covered by weathered regolith or overburden. These rocks occupy 36% of the land surface in Africa in some of the areas of highest rural population (MacDonald et al. 2012), and they provide a complex and sometimes discontinuous aquifer with low groundwater potential relative to some of the major sedimentary aquifers in Africa. Generally the aquifers can support borehole yields of 0.5-1.0 litres/second if the boreholes target the most productive parts of the aquifer and are properly constructed.

Application of the toolbox methodology

Reconnaissance surveys identified 37 long-term failed water points in the Amuria and Katakwi Districts. Detailed community surveys were carried out at 25 of these water points (Photograph 1), and technical investigations at a sub-sample of 10 – time and cost being the main limiting factor. Both the community surveys and technical investigations were completed over a period of 10 days, with two field teams working in parallel in each phase. The 10 water points examined by both the community surveys and technical investigations were carefully selected to ensure a range of failure symptoms and community arrangements were examined.

Results

Main symptoms of water point failure

The main symptoms of water point failure in the Amuria and Katakwi districts were found to be:

- Poor water quality and mechanical breakdown of the pump from corrosion (4 sites)
- Insufficient yield and poor water quality (2 sites)
- Insufficient yield, with adequate water quality (3 sites)
- Mechanical breakdown of the above ground headwork of the pump (1 site)

Half of the failed water points had displayed early one-off catastrophic failure within a year of completion, the other half having gone through a limited number of cycles (maximum two) of repeated failure and repair before failing within a few years, one failing seasonally over a longer time frame.

Main causal factors

Overall, poor siting and construction of supplies are identified as the most significant contributory factors to the water point failures in the pilot study area. This is a significant finding from the pilot study, as supply failure in this region has traditionally been attributed to inadequacies in community management (both social and financial management facets) and evidence to suggest otherwise was largely anecdotal.

Corrosion of GI handpump components is clearly shown to be a significant causal factor to many of water point failures in the study, with corrosion having led to, or contributed, to mechanical and/or water quality failure symptoms in almost all of the water points examined.Photograph 2 shows an example of corrosion having lead to complete perforation of a 0.5 m long section of hand-pump rising main pipe.

Poor siting and borehole design to the available aquifer resource are also shown to be significant. In half the cases where low yield was reported to have been the main, or contributory, symptom of the water point failure, the borehole design had cased out inflows from the shallow regolith aquifer, reducing borehole performance.

Poor construction quality (e.g. repairs re-threading shortened pipes (where damaged sections removed) or completely removing damaged pipes) was also found to have reduced borehole performance further in most cases. These factors are found to override deficiencies in WUC capacity to manage and repair the water points (e.g. inability to collect fees, lack of training, and difficulty in accessing external help beyond a handpump mechanic) in the pilot study area.

Underlying conditions of failure

Poor siting and construction of supplies are identified to be the most significant contributory factors to the supply failures in the pilot study area, but what are the ‘root causes’ which ultimately drive these deficiencies in water point implementation?

Practices of water point construction – lack of technical investigation and supervision

Many of the water points were sited and constructed with limited technical investigation and supervision. This is identified to stem from a shortage of trained staff, as well as entrenched procurement practices within implementing agencies, and a lack of knowledge to the importance of supervision.

Community management models

All of the community WUCs had limited or no access (i.e. immediate communication pathway) to external help beyond a Hand-pump mechanic (HPM), indicating either an overreliance on the community management model to sustain water point functionality by implementing and government agenices, or an assumption their capacity is greater than it is.

Poor evidence base to inform better practice and policy

In the absence of a robust evidence base the MWE have been unable to assess the main causes of water point failure in the Amuria and Katawki districts to inform better practice. The results of the pilot study begin to provide this robust evidence base, and the MWE are now working to enforce tighter regulation of hand-pump material quality with the Uganda Bureau of Standards. This should move to find more appropriate hand-pump materials in the region, in which GI materialhave been advised against for reasons of corrosion in Eastern Uganda since the 1990s.

Lessons learnt

The work has gone a significant way to developing a methodology and framework with which the causes of water point failure can be examined, and the tools required to gather the necessary data. Analysing the data collected in the pilot study has enabled a much more thorough investigation of why water points fail in the study area, and the toolbox approach is replicable and transferrable to other functionality studies and post-construction audits, to begin to develop a wider systematic evidence base on failure.

Future development of the toolbox needs to include: greater investigation of the wider governance and management arrangements surrounding water point functionality; examination of long-term trends in the natural groundwater resource; and include stronger inter-disciplinary analysis methods.

Future research

A larger UPGro consortium grant proposal, which was developed by the research team during the catalyst grant was awarded in November 2013, for a 4-year research programme in Ethiopia, Malawi and Uganda, from 2015 to 2019. This will represent a more substantial and larger-scale investigation of supply failure in sub-Saharan Africa and which will build on the lessons learnt from this pilot study to develop a robust, multi-country evidence base on supply failure.

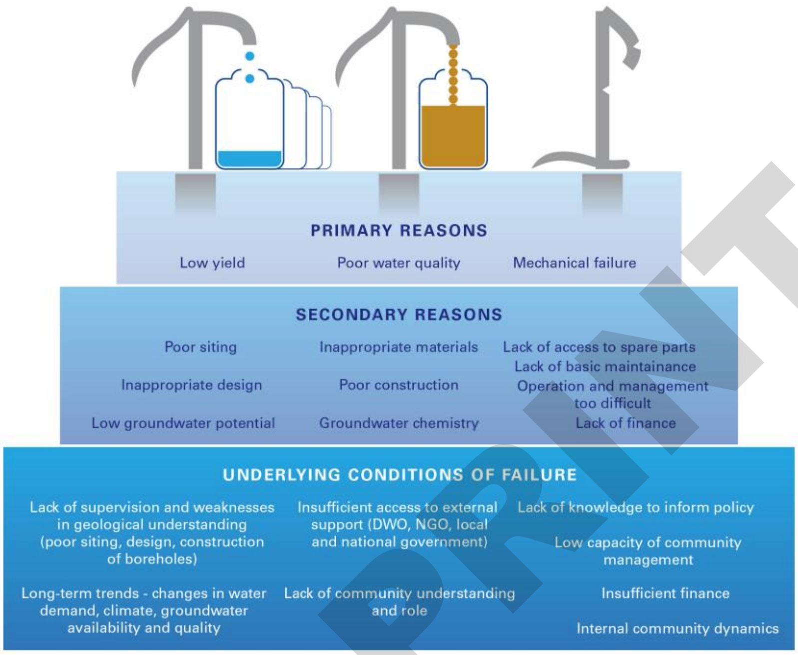

Figure 1. A range of causal factors, and deeper, underlying conditions lead to water point and supply failure

Source: Bonsor et al. 2014

Photograph 1. Well point community discussions in Amuria District

Photograph 2. Perforation of a rising main from corrosion

Acknowledgements

The hard work of a large number of individuals has made this study possible and the work so informative – in particular, the staff of the fieldwork teams and the project partners in WaterAid Uganda, and local partners TEDDO and WEDA. Particular thanks go to Eng. Aaron Kabirizi (Commissioner Rural Water Development) and Callist Tindimugaya, both within the Ministry of Water and Environment, Uganda, for their strong support and input to the project work, and guidance to the outputs. Dr Sean Furey and Dr Kerstin Danert (RWSN-SKAT) are thanked for their valuable input, and support to the project, through both RWSN and the UPGro Knowledge Broker grant. The fieldwork was conducted by an international field team of UK staff from BGS and ODI, together with staff of the Water Uganda country programme and their local partners in the Amuria and Katakwi districts – WEDA and TEDDO.

References

Abede H, Hawassa ID (2008) *The sustainability of Water Supply Schemes*. RiPPLE Working Paper 5, 104 pp.

Bonsor et al. (2014) *A Hidden Crisis: Strengthening the evidence base on the sustainability of rural groundwater supplies – results from a pilot study Uganda*, BGS Open Research Report, OR/14/074, pp 94.

Calow RC, Ludi E and Tucker J (eds) (2013) *Achieving water security: lessons from research in the water supply, sanitation and hygiene sector in Ethiopia*. Practical Action Publishing.

Coulter L, Kebede S, Zeleke B (2010) *Water and Livelihoods in a highland to lowland transect in eastern Ethiopia*, Water Economy Baseline Report, RiPPLE, Working Paper 16, 73 pp

Deneke I, Hawassa HA. (2008) *The Sustainability of Water Supply Schemes: as case study in Mirab Abaya woredo*. RiPPLE Working Paper 4, 89 pp.

Dessaelgo M, et al. (2013). *Voices from the source: struggles with water security in Ethiopia*, ODI report, January 2013. 48 pp

MacDonald AM, Bonsor HC, Ó Dochartaigh BÉ and Taylor RG. (2012) Quantitative maps of groundwater resources in Africa. *Environmental Research Letters*, **7;** 024009.

RWSN (2009) *Handpump Data, Selected Countries in Sub-Saharan Africa*, available at: http://www.rwsn.ch

UN Water (2013) *A Post-2025 Global Goal on Water: synthesis of finding and recommendations from UN-Water*, pp 41.

Contact details

Helen Bonsor
British Geological Survey
Tel: 0131 650 0261
Email: helnso@bgs.ac.uk
www.bgs.ac.uk

Naomi Oates
Overseas Development Institute
Tel: 020 7922 0402
Email: n.oates@odi.org.uk
www.odi.org.uk