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TRANSFORMATION TOWARDS SUSTAINABLE
AND RESILIENT WASH SERVICES

Making the case for improved planning, construction and testing of water supply infrastructure in Malawi

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Detailed surveys of poorly functioning rural water supply points (boreholes fitted with handpumps) in the Southern Region of Malawi show that poor functionality is most commonly caused by a) poor water resource (quantity and quality) and b) sub-standard borehole construction. Only 24% of surveyed water points showed problems caused by poor handpump operation, maintenance and management. The majority of problems observed are caused by sub-standard construction of water points prior to commissioning for use, and are typically permanent and irremediable. These issues are contributing to excessive service delivery costs through a) extended down times, b) disproportionate maintenance requirements and c) abandoned infrastructure; the resulting burden precipitates the failure of community based management approaches. This burden could be dramatically reduced by ensuring water points are proven to comply with Malawian Government standards, prior to commissioning for use. Water points not meeting these standards must not be commissioned for use.

Introduction

The Scottish Government Funded 'Climate Justice Fund: Water Futures Programme' has been working in the Southern Region of Malawi since 2011. This programme works closely with the Malawian Government Ministry of Agriculture, Irrigation and Water Development (MoAIWD) to tackle rural water supply issues, with focus upon meeting the terms of SDG6 before 2030. In Malawi, the direct and indirect costs of poorly functioning water supply infrastructure place an excessive burden upon efforts to achieve sustainable service delivery, escalating required expenditure far beyond available resources (Wahaba et al, 2017) and leads to the failure of water point community-based management (CBM) (Chowns, 2015). This study reports the initial findings of a programme of detailed water point functionality surveys in the Southern Region of Malawi, specifically looking at boreholes fitted with handpumps which have been reported as poorly functional or non-functional.

It is often assumed that water points become poorly functional due to poor operation, maintenance and management of the handpump, and it is supposed that functionality issues (and consequent service delivery costs) can be overcome through improved operation, maintenance and management of the handpump (see UNC, 2016 for summary and literature review of this topic). Results from these surveys do not support these assumptions. The majority of functionality issues recorded in this study are permanent and irremediable, caused by poor planning, construction and testing of the water point prior to commissioning for use. Unfortunately, these issues are not possible to overcome through improved operation, maintenance and community based management (CBM). In this region of Malawi, improving the standard of works undertaken in planning and constructing water points prior to commissioning for use would significantly reduce the service delivery burden and greatly improve water point functionality of future installations.

The Malawi Government MoAIWD have published standard operating procedures and technical manuals in which minimum requirements for the drilling, installation and testing of water points are presented. All water point installations should comply with these standards (MoAIWD, 2016a and 2016b), non-compliant water points should not be commissioned for use. These standards are in line with international best practice.

Approach

Functionality surveys of boreholes fitted with handpumps often focus upon the condition above-ground components of the handpump, as this is the only part of the water point which is visible or easily accessible from ground surface. It is important to remember that this is only the tip of an iceberg, and a significant portion of the water point is hidden from sight underground. By assessing the functionality of the handpump only, a surveyor may record an apparent 'handpump' problem, where this issue could actually be a symptom of a problem in the sub-surface. A good example would be a brand new fully functional handpump placed inside a completely dry borehole. The lack of water could be recorded as a non-functional handpump (requiring improved operation, maintenance and management), where actually the handpump is in perfect condition and the water resource or borehole are the source of the problem.

This study breaks the water point (borehole fitted with handpump) into three parts which can be assessed separately, (1) water resource (aquifer), (2) access point (borehole), (3) lifting device (handpump), as shown in table below. The handpump is the final stage of this delivery method, sufficient quantity and quality of water must travel from the water resource (1) to the access point (2) before the handpump functionality impacts delivery.

Table 1. Three stage approach to water delivery

Stage	Water resource		Access point		Lifting device
Name	Accessible groundwater (aquifer)	» » » »	Borehole	» » » »	Handpump
Phase	Water held in aquifer		Water flows into borehole		Water lifted to surface by pump
Yield constraints	Potential yield is fixed by hydraulic properties of aquifer		Potential yield can be maximised through good planning, design and construction of borehole		Yield of handpump fixed by design capabilities
Maintenance and remediation outlook	Not possible to maintain or remediate		Heavy machinery and significant knowledge to maintain and remediate		Can be maintained and remediated at a local level through OMM

Table 1 demonstrates that only the lifting device (handpump) can be maintained at a local level through CBM. It is important to note the following:

- Water resource or borehole issues cannot be addressed or remediated at a local level (CBM)
- Water Resource or borehole issues are extremely difficult to remediate after construction is complete
- Water Resource or borehole problems can easily be misdiagnosed as handpump problems.

Methodology

A 21-step detailed functionality survey (taking between 1 and 3 days to complete) is run at each water point. This survey is designed to allow identification of issues of (1) water resource, (2) borehole and (3) handpump, separately. These surveys include the use of equipment which allows the performance of the water resource and borehole to be tested without involvement of the handpump (such as down-hole camera, down-hole deviation measurement tool, and submersible pumps). Results of the surveys are assessed against criteria as presented in Malawi Government Standards for the drilling and installation of boreholes fitted with handpumps (MoAIWD, 2016a and 2016b). A total of 34 criteria are assessed.

For this paper, a simplified set of 10 assessment criteria are shown to ensure results can be easily presented and digested (Table 2). Issues relating to the contamination of water supply have not been covered in this study as these are extensive and deserve a separate study of their own for full assessment.

Pumping test results (standing water level, SWL, pumping water level, PWL, calculated hydraulic conductivity, K) are assessed against borehole installation design (slotted intake depths, and total depth) and borehole condition (sedimentation, precipitates, slimes) to decide if any observed low yield (below 0.25l/s) is caused by the water resource (aquifer) potential or poor borehole design and construction. All assessments are made with reference to the maximum recommended installation depth of the Afridev handpump at 45m below ground level.

Table 2. Assessment criteria

Stage	Criteria	Acceptance requirements	How measured
Water resource (aquifer)	Hydraulic properties	Aquifer properties (0 to 45m depth) at this position will allow minimum 0.25l/s to enter borehole (Malawian standard)	Pumping test analysis Borehole design inspection Borehole condition inspection
	Salinity	Maximum 3,500uS/cm Electronic Conductivity (EC) (Malawian standard)	Handheld EC meter
	Iron	Maximum 3mg/l iron concentration (Malawian standard)	Laboratory measurement
Borehole	Borehole verticality	1:57 as stated in USEPA 570/9-75-001, for boreholes fitted with vertical moving pumps (USEPA)	Deviation survey (accelerometer magnetometer tool)
	Design (yield)	Borehole design allows minimum 0.25 l/s to enter borehole with drawdown less than 45 m below ground level (Malawian standard)	Pumping test analysis Borehole design inspection Borehole condition inspection
	Design (sediment)	Borehole design does not allow significant sediment to enter or accumulate inside borehole (Malawian standard)	Borehole design inspection Borehole condition inspection Turbidity measurements
	Installation condition	Borehole is open through its whole depth, no build-up of precipitates or slimes inside (Malawian standard)	Borehole design inspection Borehole condition inspection
Handpump	Parts specification	Parts are made to Afridev handpump specification (Malawian standard)	Handpump Inspection
	Correct installation	Parts are installed according to Afridev handpump installation guideline (Malawian standard)	Handpump Inspection
	Parts condition	Parts are in reasonable state of repair, and not impacting handpump performance (Malawian standard)	Handpump Inspection

Results

Table 3 presents the results for each of 25 water points against the 10 assessment criteria. An X marks a failure to meet the minimum requirements as described in Table 2. A combined total of 72% of the water points had water resource (aquifer) issues causing poor functionality. These are 12 cases of poor hydraulic properties and 6 cases of extreme salinity. These issues are symptomatic of the hydrogeological environment of the Southern region of Malawi, which is noted for areas of both low shallow groundwater potential (0-45m depth) and saline groundwater. 72% of water points were also found to have borehole construction and installation issues. Most commonly boreholes were found to be outside the limit for verticality (boreholes must be drilled vertical for pumps to work correctly) in 13 cases. There were four cases of borehole installation design leading to excessive sediment ingress, and three cases of poor borehole design leading to poor yield directly. Most surprisingly, only 6 of the 25 water points (24%) had handpump parts which were worn to a point impacting performance (loss of functionality), which is used here as an indication of poor operation, maintenance and CBM. Only one of the water points had sub-standard parts specification (sub-standard class rising main pipe) and only one case in which the handpump had been installed incorrectly.

Discussion

Need to meet required standards

Table 4 presents a summary of the possible causes for the failures to meet the minimum requirements in each criteria. Many of the water resource and borehole issues recorded could have been prevented through:

- Better oversight of the water point construction and testing phases by a suitably experienced engineer (hydrogeologist), to ensure compliance with Malawian Standards prior to commissioning for use

- Ensuring water points not in compliance with these standards are not commissioned for use (as they will lead to excessive service delivery burden).

Table 3. Assessment results at each water point

Stage	Criteria	Count	Percentage	Chigawa	Chikowa	Chitambuli	Galawanda	Kunthembwe	Lunzu	Macheka	Michiru	Ntenjera	Tabiya	Chandire	Jauma	Makuya	Mankhokwe	Muonda	Piyasoni	Rodaviko	Tsiku	Mwanje	St.Michael's	Kampani	Ndakwera 2	Movati	Chauwa	Chauwa 2
Aquifer	Hydraulic properties	12	48%	X		X	X	X	X		X	X				X			X		X	X	X					
	Salinity	6	24%												X			X		X				X	X	X		
	Iron	0	0%																									
Borehole	Verticality	13	52%	X	X	X	X	X			X	X		X	X		X		X		X	X						
	Design (yield)	3	12%		X												X	X										
	Design (sediment)	4	16%										X											X			X	X
	Installation condition	0	0%																									
Handpump	Parts spec	1	4%																						X			
	Installation	1	4%											X														
	Parts condition	6	24%			X				X		X				X			X				X					

In the era of the Sustainable Development Goals, organisations responsible for implementing water point construction programmes (and those funding these initiatives) have a duty to ensure their water points are fit for purpose and will provide long term sustainable water supply solutions. A good starting point for this would be to ensure all installations meet the Government standards, which follow internationally accepted best practice, which would be made possible through ensuring a suitably experienced groundwater engineer is engaged in the work programme. At present it is clear that these standards are not being met, and sub-standard water points are being commissioned for use, placing an excessive burden upon efforts to achieve sustainable service delivery, through a) extended down times, b) disproportionate maintenance requirements and c) abandoned infrastructure. It is proposed that these excessive service delivery burdens would be greatly diminished if all water points met the required standards.

Need for better planning

It is essential to complete a detailed preliminary study leading into a detailed works specification and scope prior to any groundworks taking place. This ensures potential risks to water supply effectiveness and sustainability are identified, understood and managed in good time. These risks should be accounted for in time and financial plans, to ensure the proposed works are realistic and achievable. Detailed works scope and specification is also required in advance of tendering for a contractor (drilling contractor) and preparation of contracts, which will typically include drill position siting by an independent and suitably experienced groundwater engineer. It is at these early stages that programmes are set up for success or failure. It is extremely beneficial to have a suitably experienced engineer involved from the very early stages to guide this work. Observations from Malawi indicate that good planning is rarely completed, and work programmes commonly encounter issues that were not prepared for, leading to programme failure (i.e. sub-standard water points, time and financial resources being used up trying to tackle unforeseen issues).

Handpumps in Malawi

The number of hand-pump specific issues (8 cases total) recorded in this study is half the number of both water resource and aquifer issues (both 16 cases each). All surveyed handpumps were Afridev type. The Malawi Government enforces the use of the Afridev as the standard handpump, and this requirement is generally adhered to. It seems that the country has benefitted immensely from this standardisation through:

- Establishment of good parts supply chain, parts available for (generally) standardised prices even in rural areas
- Parts quality is generally acceptable (within specification), with sub-standard suppliers being pushed out of the market
- Contractors know how to install properly, ensuring extended life
- Local persons responsible for operation and maintenance (i.e. borehole mechanics, water point committees) are knowledgeable of common breakdowns and how to fix these.

Table 4: Potential causes of failure

Stage	Criteria	% failure	Potential cause
Water resource (aquifer)	Hydraulic properties	48%	Poor siting, poor pumping test and pumping test analysis prior to commissioning
	Salinity	24%	Poor siting, poor installation design, Inadequate measurements prior to commissioning
	Iron	0%	Poor siting, poor installation design, Inadequate measurements prior to commissioning
Borehole	Borehole verticality	52%	Rushed drilling and installation, Use of sub-standard drilling equipment, use of inappropriate drilling method, poor drilling supervision
	Design (yield)	12%	Poor drilling supervision, poor borehole design, Inadequate development after installation, poor pumping test analysis
	Design (sediment)	16%	Poor drilling supervision, poor borehole design, Inadequate development after installation
	Installation condition	0%	Rushed drilling and installation, use of sub-standard materials, poor borehole design, inadequate development after installation
Handpump	Parts specification	4%	Sub-standard parts supply
	Correct installation	4%	Rushed installation, installed by inexperienced persons
	Parts condition	24%	Insufficient OMM of handpump

Limitations to sustainable groundwater management in Malawi

The lack of long term groundwater level and quality monitoring data is a clear limitation of this study, and functionality assessments in general. This study only has measurements taken during the survey. Without longer term data, sustainability assessments cannot be confidently completed. The Climate Justice Fund: Water Futures programme is compiling longer-term groundwater level and quality data throughout this region, with a view to commencing larger groundwater resource studies, however for now the data remains limited.

The water points surveyed in this study are within districts which are renowned for poor shallow (<45m) groundwater potential and salinity, as demonstrated in the results (Table 3). The results of this study should not be used to make inferences in other regions (which may have very different groundwater environments). The purpose of this study is to demonstrate the importance of good water resource assessment and borehole construction, using these points as examples poor practice.

Next steps

The results presented in this report are part of a larger ongoing data collection programme (see: https://www.cjfwaterfuturesprogramme.com/), it is anticipated that up to 200 water points will be surveyed by the end of 2018. The findings of these surveys will be compiled into a larger study and reported in the first quarter of 2019 This preliminary review allows identification of areas which require further investigation, such as contamination impacts to water point functionality as borehole verticality impacts to handpump condition.

Conclusions

- Handpumps are normally not the cause of poor functionality as compared to water resource (aquifer) and borehole issues in this study. It is thought that Malawi has a reduced the number of handpump breakdowns through enforcing the use of only the Afridev handpump as a standard;
- The observed water resource (aquifer) and borehole issues are typically permanent (after water point construction), and cannot be remediated (certainly not at a local level through CBM);
- The standard of works prior to commissioning by NGOs and Donors for use needs to be greatly improved, to meet the standards set by the Malawian Government (international best practice);
- There is a need for more technical oversight of planning and construction phases by suitably experienced engineers to make sure planned are achievable and risk assessed;
- Implementing organisations have a duty to ensure that their installations are fit for purpose prior to commissioning for use, and should be held accountable if not.

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