Functionality and resilience of hand-pumped boreholes in sub-Saharan Africa

DJ. MacAllister, A.M. MacDonald, S. Kebede, D. Nedaw, M, Owor, T, Mkandawire, H. Fallas

British Geological Survey, Edinburgh

In sub-Saharan Africa as many as 184 million people rely on hand-pumps. Thus, hand-pumps are, and will remain, a crucial water source in a changing climate, although as many as one in three are non-functional at any time. Drawing on the results of three studies we demonstrate that hand-pumps are resilient and safe, and we examine the physical factors that determine hand-pump functionality.

In the first study we analysed the performance of 5196 water points (hand-pumps, motorized boreholes, springs, open-sources) and the success of a proactive maintenance programme during the 2015-16 drought in Ethiopia. Water sources were visited every week for 12 weeks to gather data on access and functionality. The second study, again in Ethiopia, involved monitoring 51 groundwater points (hand-pumps, springs, hand-dug wells) over an 18-month period in 2016. Water sources were equipped with water level loggers and were tested monthly for thermo-tolerant coliforms.

All sources were put under considerable strain during the drought. Most demand was placed on motorised boreholes in lowland areas. However, increases in functionality of motorised boreholes, as a result of the maintenance programme, lagged behind those of hand-pumps. Functionality was low for both sources at the on-set of the drought (65% and 75% respectively). Motorised boreholes had longer downtimes due to a lack of appropriate and/or accessible maintenance skills. Water level monitoring showed that hand-pumped boreholes recovered most quickly from daily abstractions. All sources were contaminated with thermo-tolerant coliforms during the rains marking drought cessation but hand-pumped boreholes were least affected.

Our results show that hand-pumped boreholes are resilient and less prone to contamination than springs and hand-dug wells. However, like the other sources we studied, hand-pumps had low levels of functionality at the onset of the drought. To better understand the factors affecting functionality we systematically dismantled 150 hand-pumped boreholes in Ethiopia, Uganda and Malawi in 2017. We conducted detailed inspections of hand-pump components and borehole design. Water levels were measured and a pumping test was conducted to measure aquifer yield (transmissivity).

In each country specific contextual factors influence functionality. In Ethiopia deep water levels (>60 m) strongly influence functionality. Many hand-pumps operate beyond lift limits (45 m). Aquifer yield is an order of magnitude larger for fully functional hand-pumps than partially functional hand-pumps in Ethiopia. In Uganda many hand-pumps are installed in aquifers with transmissivities close to the minimum required to sustain a hand-pump (c.1 m^2/d). The use of galvanized steel components, along with corrosive groundwater, results in high rates of corrosion in Uganda. In all three countries hydrogeology, borehole design and pump condition interact to determine functionality outcomes.

Our results reinforce the importance of appropriate borehole siting and design, on-going operation and maintenance and use of appropriate and good quality materials. When supported by responsive and proactive maintenance hand-pumped boreholes, which are less prone to contamination than other shallow groundwater sources, are a resilient water source in a changing climate and are capable of providing water continuously during drought.