Determinants of hand-pumped borehole functionality: preliminary evidence from Ethiopia, Malawi and Uganda

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Determinants of hand-pumped borehole functionality: Preliminary evidence from Ethiopia, Malawi and Uganda

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Introduction

Around 25% of handpumped-boreholes (HPB) in sub-Saharan Africa (SSA) are non-functional at any time (Foster, *et al.,* 2019). The UPGro Hidden Crisis project conducted interdisciplinary assessment of factors that control HPB functionality in SSA. The project developed a tiered approach to define and measure functionality (Bonsor, *et al.,* 2018). The approach was used to select 150 HPBs on which to conduct forensic assessments in Ethiopia, Malawi and Uganda to unravel the factors governing HPB failure and success. Here we present preliminary analysis of the survey 2 dataset (UPGro, 2022), finding that hydrogeology, rising main condition, borehole (BH) design and hand-pump (HP) cylinder placement all play a role in functionality outcomes.

Methods

The forensic HPBs assessments began with systematic observations of HP condition and a sanitary survey. A sequential set of investigations were then undertaken: HPs were dismantled and components inspected; water level and BH depth was measured; a pumping test was conducted (at one litre per second for 2.5 hours and recovery measured for 20 hours) to estimate aquifer yield; and, groundwater quality was measured (pH, conductivity, dissolved oxygen, redox and temperature) to determine corrosion risk. Finally, CCTV was used to examine BH construction. Social surveys identified seven factors key to HPB management; demand, motivation, leadership, skills, finances, spares and support. The factors were determined by; focus groups; participatory mapping; and transect walks. The HPB and social science data were analysed using an indicator approach. Indicators were qualitatively assigned a value between zero and one using a conceptual understanding of the HPB system. Five indicators were used; hydrogeology (HG), BH design (BH), pump condition (PMP), water quality (WQ) and management approaches (MGT). The average indicator value for all sites was calculated to produce a single value for each functionality category (functional, unreliable, low yield, unreliable and low yield and non-functional/abandoned) in each country.

Results and discussion

Average indicator scores for each country within each functionality category and against the physical and social indicators (discussed below) are shown for each country in the coloured matrix in Figure 1.

Hydrogeology (HG). Hydrogeology (aquifer yield and water-level) appears to strongly influence functionality outcomes (Figure 1). The relationship clearest in Ethiopia where hydrogeology indicator values are highest in the fully functional category and decline through the remaining categories. Malawi displays a similar relationship but the indicator value range is lower. Hydrogeology indicator values are lowest overall in the non-functional category in Ethiopia, where water levels are often very deep (> 30 m) and transmissivities highly variable. The relationship is not as clear in Uganda where transmissivities are very low at all sites.

Borehole design (BH). In general, fully functional HPBs in each of the three countries are associated with higher indicator values for BH design (Figure 1), suggesting these BHs are more appropriately designed (with respect to screen lengths, depth and cylinder placement). In Ethiopia BH design is generally poor across all functionality categories, with lowest values in the unreliable, low yield, non-functional and abandoned categories. Uganda has a similar distribution of indicator values for BH design, while in Malawi BH design appears better but indicator values decline through the functionality categories.

HP condition (PMP). The condition of the HP (i.e. corrosion and damage of rising main, rods, and above and below ground components) appears to have a relationship with functionality outcomes in both Ethiopia (IM2 and Afridev) and Malawi (Afridev) but less so in Uganda (IM2) (Figure 1). HPs are in better condition in the fully functional category and poorest condition in the non-functional and abandoned categories or the unreliable and low yielding categories. The rising main condition is the primary contributor to the final pump indicator value. Thus, regular maintenance or replacement of rising mains is important. In Uganda pumps are in better condition in the low yield category which may reflect the specific hydrogeological context, i.e. more regular maintenance of pumps is conducted in areas where aquifer yields are very low.

Water quality (WQ w.r.t corrosivity). In Ethiopia and Malawi the lowest water quality indicator scores relate to HPBs in the unreliable and low yield categories (Figure 1). This may indicate an increased risk of corrosion and reduced yield due to poor water quality. In Uganda water quality indicator scores are low across all functionality categories. Corrosion is a significant issue in Uganda (Casey, *et al.,* 2016) where there has been widespread use of galvanised steel components that are highly vulnerable to corrosive groundwater.

Management (MGT). The preliminary analysis found no clear relationship between management and functionality (Figure 1). Likewise, Whaley, *et al.,* (2020) showed no statistically significant association, instead drawing attention the complexity of the relationship between management and HPB technology.

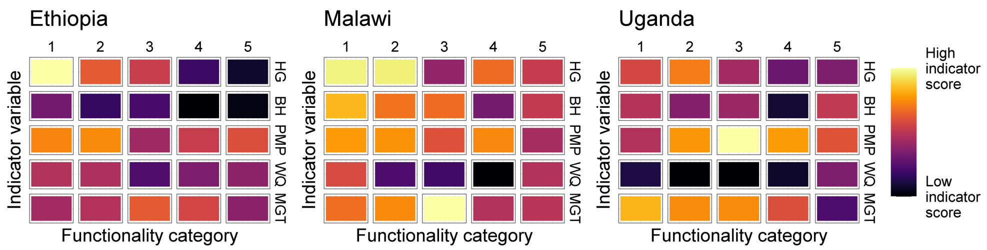

Figure 1. Indicator analysis results. Functionality categories: 1- Functional; 2 – Unreliable; 3 – Low yield; 4 – Unreliable and low yield; 5 – Non-functional/abandoned

Conclusions

Using data from Hidden Crisis survey 2 forensic assessments of HPBs and a preliminary qualitative indicator analysis we find that determinants of functionality are multifaceted and differ across country contexts. Hydrogeology, rising main condition, BH design and pump cylinder placement all play a role in functionality outcomes. The definitions and methodology developed by the Hidden Crisis project allow functionality to be better understood and have the potential to help improve HPB performance across sub-Saharan Africa.

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