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Handpump usage changes in response to rainfall

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Abstract

Drinking water that is free from chemical and bacteriological contamination is a cornerstone of good health [1]. In order to operationalize the theory that better water leads to better health outcomes certain types of water supply infrastructure were deemed "improved", creating a simple metric against which the Millennium Development Goal water supply target 7.C could be judged [2].

The link between good health and improved water sources is predicated on the assumption that given the existence of an improved source, people choose it as their drinking water source. Evidence presented here shows that certain rainfall patterns reduce the use of handpumps, an improved water source.

This suggests that communities are choosing to source their water from other, potentially unimproved, sources. In addition to having implications for communities' health this challenges some of the assumptions behind WASH policy and practice, and the definitions and metrics used to monitor water supply targets.

Smart Handpumps Project

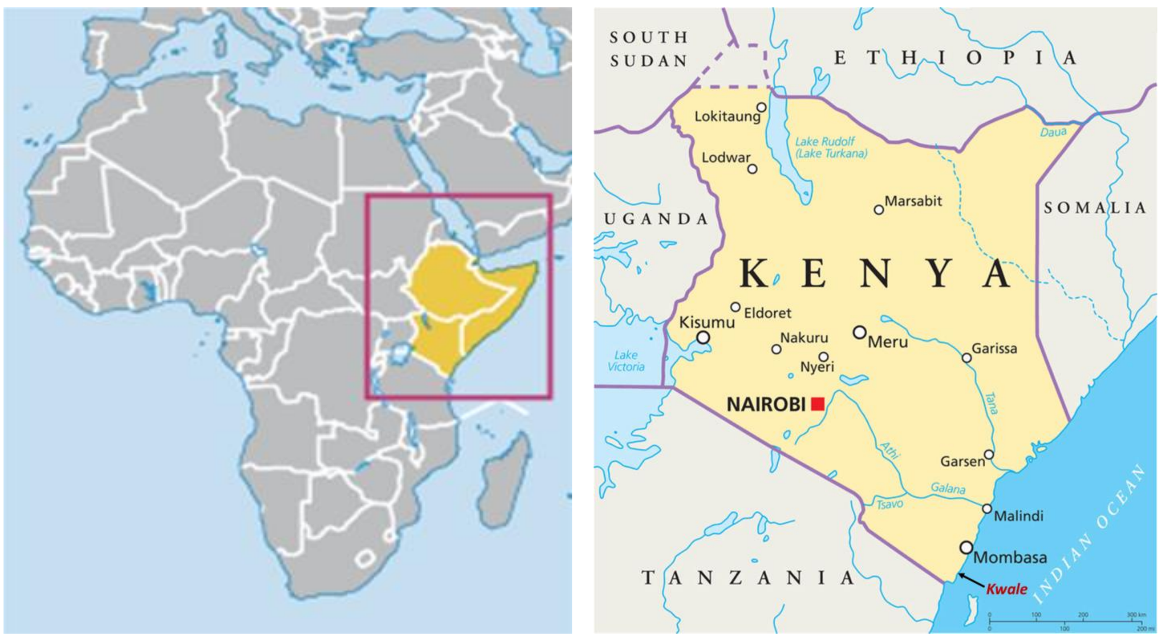
Handpumps abstracting groundwater provide a key source of drinking water for rural communities across Sub-Saharan Africa [3]. However it is estimated that at any moment, one third of these are non-functional [4], with simple repairs taking weeks or even months, leaving communities without an improved source of water until the pump is fixed.

A project based at Oxford University developed a Waterpoint Data Transmitter in order to test the hypothesis that improved information can lead to faster handpump repairs. This unit can be fitted to the handle of any handpump, in this case it was installed in the Afridev handle, and uses a low-cost solid-state accelerometer to sense changes in the angle of a pump handle in order to measure pump usage and estimate volumetric abstraction [5]. As well as being used to trigger and monitor repairs, these transmitters have provided data on water use patterns. Hourly data provide unprecedented insights into usage over both short (hourly) and long (seasonal) timescales.

This research started in 2011 with operational deployment in Kitui and Kwale Counties in 2012 and 2013 respectively, funded by the UK government through DFID and ESRC. This poster presents data and findings from the work in Kwale, based on handpump data from 2014 and additional extensive and focused household surveys conducted in 2015 and 2015.

Study Area

The study site in Kwale County, Kenya covers an area of approximately 1,500 km^2 around 50 km south of Mombasa. It receives around 1,300 mm/year rainfall with two distinct wet seasons and almost half the annual rainfall occurring in April and May.



Geology is variable, with karstic corals formations at the coast, transitioning into sands as elevation increases to the NW. Population density is high along the coastal strip near the main Kenya-Tanzania highway, becoming lower inland.

Seasonal Response to Rainfall

Handpump usage drops significantly when the rains start in April, with wet season usage being around 40% lower than that of the dry season.

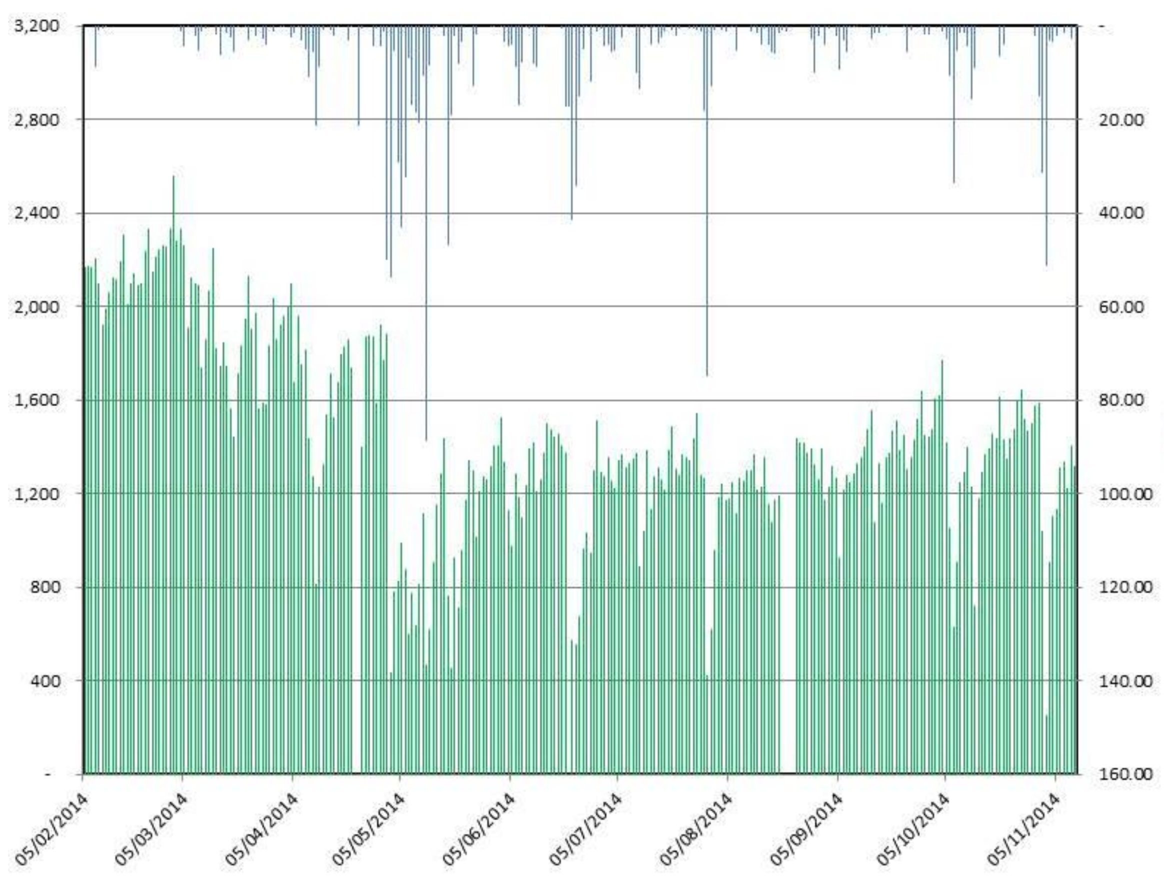


Figure 1. This figure shows how community pump usage (litres per day, in green, left hand y-axis) varies over the year in response to rainfall (mm blue, right hand y-axis) in 2014. [The zero periods in May and August represent network outages.]

As well as the obvious seasonal effect, this chart also suggests a more immediate response in the level of pumping to spikes in rainfall. This precipitated more detailed analysis of the data.

Immediate Response to Rainfall

The data show an immediate response to heavy rainfall. The day following heavy rainfall sees an significant drop in pump usage: usage drops slightly on the day of the rainfall but the largest drop is seen the following day, with average usage recovering to pre-rainfall levels after a few days but with variation is usage across pumps increasing. The effect is non-linear with no response seen on days with only light or moderate rainfall; it is only observed in days following rainfall above the 90th percentile.

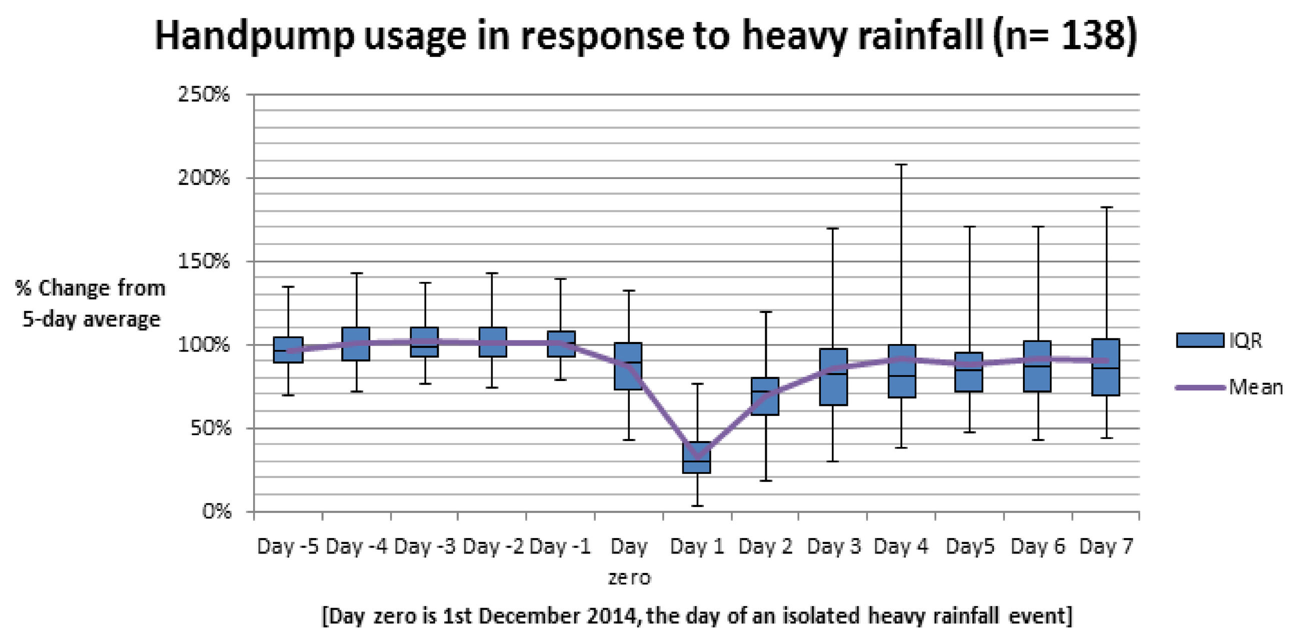


Figure 2. This diagram shows the handpump usage immediately before and after an isolated day of heavy rainfall on December 1st 2014 (n= 137).

Geographical Variation

The seasonal and immediate responses to rainfall are seen across the study site. They are both more pronounced inland, where elevation is higher and both population and handpump density are lower. Further investigation was conducted in this inland area in May 2016 (timed to be during the peak of the wet season) to understand the behaviour changes causing this effect.

In this area, the large seasonal reduction in handpump use was accounted for by reduced handpump abstraction for livestock watering and the high prevalence of rainwater harvesting household infrastructure (41%). Those households lacking extensive rainwater household infrastructure, generally those with makuti (dry palm leaf) rather than metal roofs, were observed to conduct ad-hoc rainwater harvesting from either their roofs or nearby trees. This ad-hoc rainwater harvesting is believed to explain the immediate and short-term reduction in usage in response to heavy rainfall: this type of rainwater harvesting is only effective under heavy rainfall and is limited by the number of small containers a household owns.

However, rainwater was not favoured for drinking in either case. Rainwater from makuti roofs was brown, contaminated and smoky in taste, rendering it unpalatable. Rainwater from metal roofs, on the other hand, was viewed as "having no taste" or even causing disease. This led many households to collect a limited volume of well water purely for drinking and cooking purposes.

Discussion

This research suggests that water users switch away from using pumped groundwater, an improved water source generally viewed as having a high likelihood of being free from microbial contamination, in response to heavy rainfall as alternatives become available. The evidence so far as to which alternative sources are used, and *for what purpose*, is mixed.

If the switch is in favour of contaminated sources for *drinking water* there may be significant health impacts. Modelling of the effects of consumption of contaminated water suggest that even short-term ingestion of water containing pathogenic organisms can have disproportionate and persisting effects [6].

In the area where this study took place there was no clear evidence of significant changes in water-related diseases being linked this changes in water use. However, the decision to continue using pumped groundwater for drinking, even when other cheaper and more convenient sources are available, may be related to taste rather than health considerations.

In other areas where taste and health factors do not align, the outcome may be different. Therefore further investigation into weather-induced changes in water use behaviour may shed light on disease patterns and the possible (in)effectiveness of certain rural water supply interventions.

References

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