Assessing the sustainability of groundwater-fed water supplies to intensive pumping and climate variability: evidence from detailed monitoring of the Makutapora Wellfield

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Background

Dodoma is the rapidly growing capital city of Tanzania, with a population of ~500,000. Groundwater is the exclusive perennial source for the city's water supply and is pumped from The Makutapora Wellfield, 20km north in semi-arid, central Tanzania, where daily pumpage now exceeds 50 000 m^3 per day. Geologically, the well field draws from deeply weathered and fractured Precambrian crystalline rock overlain by alluvium.

A vital research and management question is whether groundwater abstraction of this magnitude is sustainable in a semi-arid environment where mean annual rainfall is ~550 mm per year.

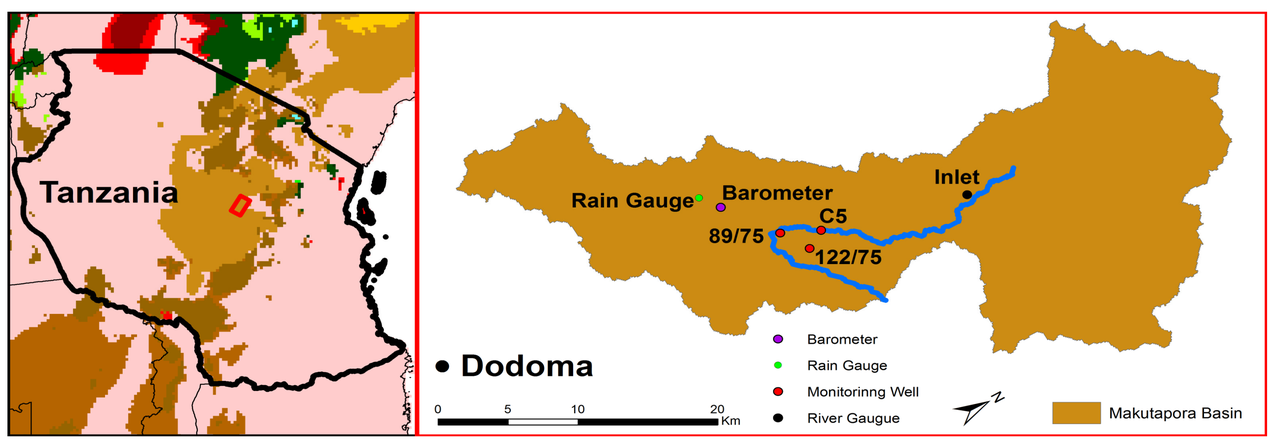

Figure1. Left–Map showing the context of the Makutapora Groundwater Basin (right) within the climate zones of East Africa. Right–Map showing the Dodoma, The Makutapora Basin, its primary ephemeral river, and deployed data loggers (Seddon *et al.*, 2016)

Recent research carried out by a team of scientists from Sokoine University of Agriculture, University College London (UK), and the Ministry of Water and Irrigation including the WamiRuvu Basin Water Board compiled a near-continuous 60-year record of groundwater-level observations, which reveal that recharge sustaining wellfield pumping occurs episodically (*i.e.* 2 or 3 years each decade) and depends on heavy seasonal rainfall associated with El Niño Southern Oscillation (ENSO); the 7 highest years of recharge account for over half of the total amount of recharge that has occurred over the last 60 years.

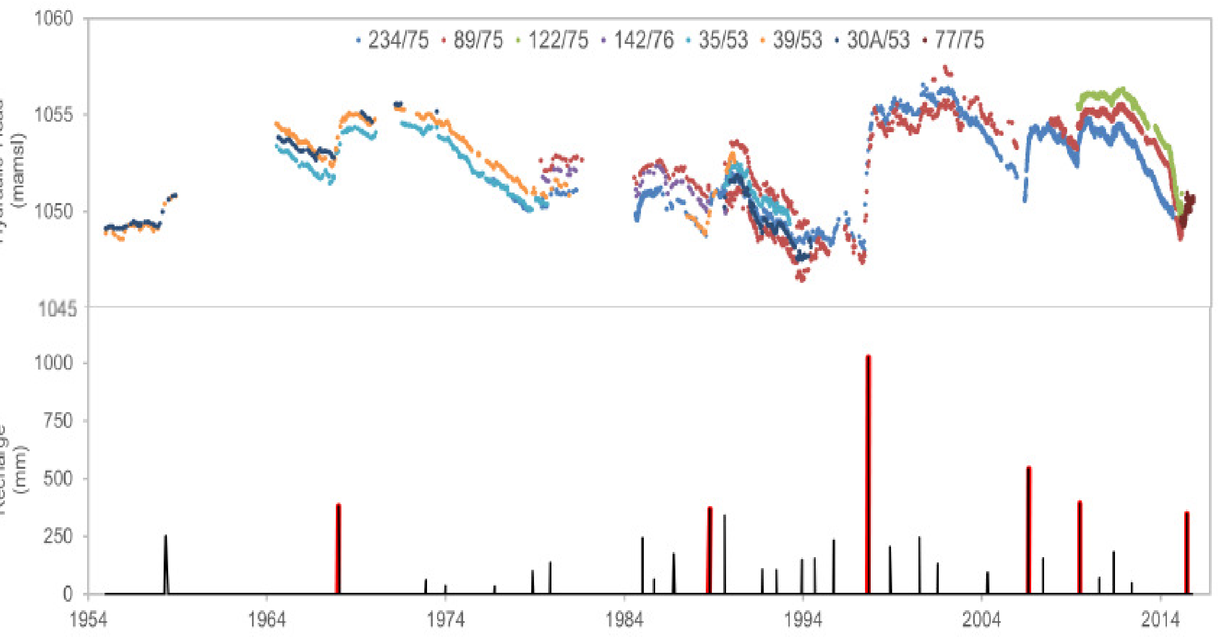

Figure 2. Top: 60-year groundwater record from the Makutapora Wellfield; bottom: quantified recharge events derived from the data above. Top 10% of recharge years highlighted in red; note: that recharge estimated for the 2015-16 . Updated analysis from Taylor *et al.* (2013).

The uncertain and episodic nature of replenishment to the wellfield complicates management of the wellfield and the estimation of a "sustainable yield".

The Intervention

Current research seeks to:

- resolve the **primary pathways by which recharge occurs**; and
- **identify potential adaptive strategies** (*e.g.* **Managed Aquifer Recharge**) by which the amount and frequency recharge can be enhanced to promote the sustainability of wellfield pumping.

This research involves both the *deployment of high-frequency (hourly) monitoring of groundwater levels prior to the 2015-16 El Niño* event using ***in situ*** **data loggers** and **telemetry** providing *real-time monitoring* or groundwater levels to the research team and WamiRuvu Basin Water Board.

Figure 3. High-frequency (hourly) monitoring of groundwater using *in situ* data loggers and telemetry.

Emerging Results

Latest analyses show:

(1) anticipated heavy rainfall during the 2015/16 El Niño temporally reversed declining trends in groundwater levels induced by intensive pumping; and

(2) the magnitude of observed groundwater recharge is directly proportional the duration of ephemeral river flow entering the wellfield.

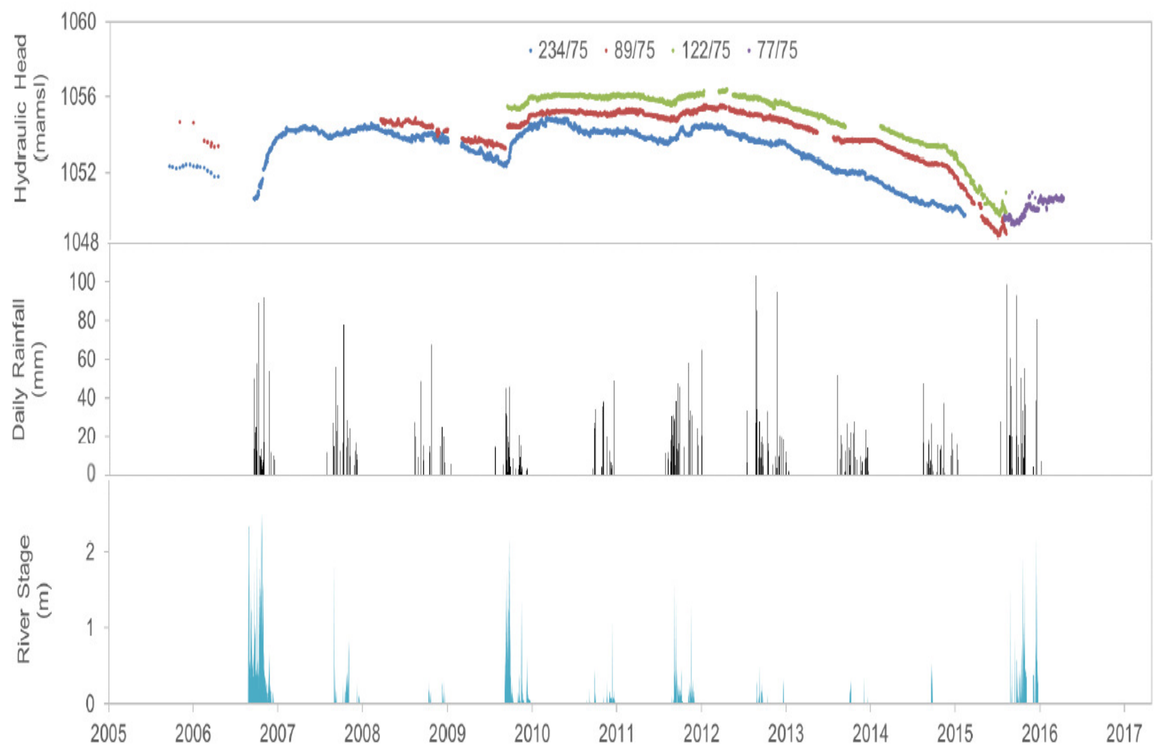

Figure 4. Top: record of groundwater levels in the Makutapora Wellfield 2006-2016; middle: daily rainfall at the Makutapora rain gauge; bottom: river stage at the Meya Meya river gauge.

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