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

Japhet Kashaigili1, Richard Taylor2, Alloice Kaponda3, Praxeda Kalugendo3, Mark Cuthbert2, David Seddon2, Lucas Mihale1, Catherine Kongola1, Hezron Philipo1 & Martin Todd4

1: Sokoine University of Agriculture (Tanzania); 2 University College London (UK); 3 Ministry of Water and Irrigation (Tanzania); 4 University of Sussex (UK)

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 m³ 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.

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.

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 of groundwater levels to the research team and WamiRuvu Basin Water Board.

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.

For further information:
Prof. Japhet J. Kashaigili, Email: ikashaigili@gmail.com, SUA, Tanzania
Prof. Richard Taylor, Email: richard.taylor@ucl.ac.uk, UCL, London, UK
website: www.grofutures.org

Acknowledgements: EPSRC Global Challenges Research Fund (Ref. 172313) and NERC-ESRC-DFID UPGro programme (Ref. NE/M008932/1); we gratefully acknowledge rainfall data provided by the Tanzanian Meteorological Agency.