# **Tanzania:** Groundwater Dossier

## Key recommendations

### Government: National and Local

- Actively engage with the **AMCOW Pan-African Groundwater Program**
- Decision makers should focus on **diversifying and decentralising water supply solutions**. Conjunctive use, managed aquifer recharge, and suitable treatment measures are vital to make groundwater a strategic resource on the urban agenda.
- As groundwater resources are increasingly seen as a potential source of irrigation and domestic water in rural and urban areas, there are also **widening access inequalities among users**. In Tanzania, the water security of shallow well and spring users is being threatened by increased groundwater exploitation by large, industrial users. It is important to understand the processes of groundwater access and assess how these are being **reinforced by the prevailing policy and regulations**.
- The continued ability of the Makutapora Wellfield, which supplies the capital of Tanzania to sustain intensive pumping now, and to meet Dodoma's rapidly growing demand for safe water, is unclear and requires an **urgent expansion in monitoring infrastructure**.
- **Continuous and strategic groundwater monitoring** is needed to build an understanding of groundwater recharge processes and patterns in different aquifer systems over the long-term, contributing to more effective, forward-looking and resilient groundwater management strategies
- In coastal areas of Tanzania shallow large-diameter wells are better protected from saltwater intrusion than deep boreholes. Promoting the use of large numbers of shallow wells requires **coherent management of the resource at local and national scales and the engagement of local communities**.
- There is a need for sensitization and **awareness raising around formal institutions** for groundwater governance, as awareness and effectiveness are currently low with focus remaining on informal values and norms.

### Civil society, national NGOs and private sector

- **Participatory governance** approaches, such as Transition Management, have multiple benefits for management of WASH services in Sub-Saharan Africa. Successful engagement relies on critical **assessment of structural and cultural inequalities** and combining them with trust- and capacity-building based on local needs and priorities.
- Developing community initiatives for Transition Management **requires careful actor analysis and selection**. Consideration of power dynamics, identification of frontrunners, engagement of most vulnerable community members, and selection of actors from institutions are all key factors.
- **Behavioural and cultural change** related to water, sanitation and waste management need time, resources and capacity building activities at multiple levels (local team, communities, authorities, NGOs). Behaviour change needs to be constantly supported by organizing awareness raising and education activities, by mobilizing and empowering community members, and by ensuring the reinforcement of laws. The collaboration and dialogue between local community members,

**Commented [SF1]:** Target Audiences

**Government**

**Donor/Development Partners**
DFID Country Office
UNICEF WASH team (country/regional)
World Bank
African Development Bank

**iNGOs**
Millennium Water Alliance

**Private Sector**

institutional organisations, NGOs and private companies play a key role in the implementation of these actions.

### International Development Cooperation and Aid agencies (iNGOs, UN organisations)

- Recommendation !

**Commented [HP2]:** Inputs welcome

## Further research

In the urban water security context, further research is needed into the potential for participatory governance approaches, such as Transition Management, to be successfully applied in the cultural and political context of sub-Saharan Africa to support changes away from non-existent or unsustainable practices towards sustainable urban groundwater management which takes the interests of slum dwellers into consideration.

**Commented [HP3]:** T-GroUP inputs welcome here

Emerging research priorities from GroFutures research into groundwater recharge and resource availability for the future include further research into the widespread occurrence of episodic, focused recharge and the sustainability of small-holder irrigation from shallow groundwater replenished via ephemeral river flow. There are specific questions that need to be addressed around the scale and sustainability of local groundwater use, including consideration of use by whom and for what. Furthermore, the impact of water capture (for hydropower?) on downgradient water resources requires research and consideration in basin water management planning.

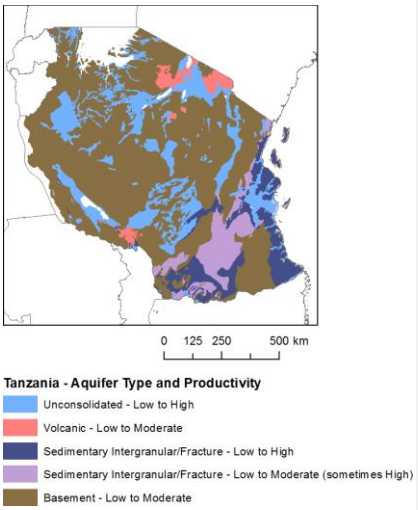
**Commented [HP4]:** GroFutures inputs welcome here

Modelling of the impacts of climate change on groundwater resources has demonstrated the importance of long-term groundwater monitoring records for model validation. Greatly increasing the spatial coverage of long-term groundwater monitoring across Africa is needed to support model validation and improve projections of climate impacts on water security. Investment in observation-driven research into ground and surface water resources is therefore needed, to support modelling and development of pathways for future water resource use, to inform national adaptation planning for the Water Sector.

## Context: highlights from the Africa Groundwater Atlas

http://earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Tanzania

### Groundwater quantity




In Tanzania there is inadequate data and information available for the major aquifers. Data that exists are often scattered, fragmented and incomplete. Some of the key groundwater issues in Tanzania are:

- Overexploitation - parts of the Makutupora Basin are showing declining water levels, decrease in borehole yields particularly in the Sanawari area, overexploitation has led to saline intrusion in coastal regions particularly around Dar es Salaam. There is no country-wide monitoring network to fully understand issues of overexploitation and no groundwater resources management to deal with them.
- Pollution - many aquifers are showing deteriorating groundwater quality, no established safe distance between groundwater abstractions and potentially contaminating human activities, polluting activities are increasingly encroaching on important recharge areas, inadequate public awareness of potential sources of pollution and their impact on the groundwater environment.
- Management of abandoned wells - poor borehole construction can lead to borehole collapse leaving deep aquifers vulnerable to pollution, inadequate institutional regulation of groundwater resources, inadequate government control of the private drilling sector.

### Groundwater quality

Generally, the natural groundwater quality in Tanzania is considered potentially good and acceptable for use, with notable exceptions:

- High chloride concentration (salinity) is a problem in the coastal regions of Lindi and Mtwara, and in central regions such as Singida and Shinyanga where there is a high evaporation rate and poor drainage.
- In Lindi and Mtwara regions, high levels of carbon dioxide have been reported in groundwater which causes issues with corrosion.
- High fluoride concentrations are a common problem in the areas surrounding the Rift valley system (e.g. Kilimanjaro, Arusha, Singida and parts of Shinyanga regions).
- High iron content in groundwater has been observed in Mtwara and Kagera regions.
- Nitrate levels of more than 100 mg/l were reported in the Makutupora basin, Dodoma and Singida town.

### Groundwater use

Groundwater is a vital source for both rural and urban water supply schemes in Tanzania. Towns such as Dar es Salaam, Singida, Babati, Arusha, Moshi and Dodoma depend largely on groundwater for public water supply. Many rural water schemes are also built on groundwater sources. Most sources consist of boreholes with electric or hand pumps.

The current volume of groundwater used across Tanzania (1,265,000 $m^3$/day) is estimated to be 12% of the total available volume. The main uses of groundwater are urban water supply (10% of total volume), rural water supply (50%), agriculture (10%), industry and mining (2%). Other uses including livestock and dry land fishing (28% of total volume).

# Key activities and findings from UPGro research in Tanzania

## General UPGro findings with relevance to Tanzania

**Climate Resilience & Groundwater Resources**

- Climate change may enhance groundwater recharge in arid and semi-arid areas, presenting opportunities for long-term management as part of national climate adaptation strategies.
- Across the West African Sahel, rainy seasons are projected to be later than historically, with fewer but more intense rainfall events.
- This may favour more focused groundwater recharge along watercourses.
- Observed groundwater levels have generally risen across the Sahel, despite declining rainfall, this "Sahelian Paradox" is thought to be due to changes in the land use and vegetation cover. UPGro research aligns with this view.
- Local hydrogeological understanding is required to define the sustainable yield of water points, particularly in weathered basement aquifers.
- Numerical groundwater models can be used to assess the sustainability of different groundwater scenarios to inform groundwater management and planning.
- Bacteriological contamination of groundwater is likely to be a significant barrier to achieving safely managed water services under SDG6, but this can be tackled by improved construction practices.

**Groundwater and Poverty**

- Communities are routinely under high water stress due to social pressures (e.g. funerals, cultural events) and environmental pressures (e.g. dry periods). These pressures cascade with routine sharing of water points.
- Women are more at risk of water scarcity due to gender roles and gender task allocation.

**Sustainable Rural Water Services**

- New methods for defining and measuring water point functionality are required to adequately monitor progress towards SDG6 for safely managed water services.
- Affordable maintenance and repair are one of the main predictors of borehole functionality. This highlights the need for effective management models to address poor functionality.

**Urban Water Security**

- In urban areas experiencing rapid population growth, increased demand for water is likely to have a much more significant impact on groundwater than climate change.
- Groundwater can only gain a role as a strategic urban resource where an integrated approach to urban water management and governance acknowledges the importance of all available resources. Conjunctive use, managed aquifer recharge, and suitable treatment

measures are vital to make groundwater a strategic resource on the urban agenda.
- Participatory, community-led approaches, such as Transition Management, can provide new and collaborative ways of using and managing urban groundwater.

**Agriculture and livelihoods**
- Access to groundwater is associated with improved agricultural production, reduced agricultural risk, and improved livelihoods.
- Knowledge sharing approaches, such as Rainwatch and Farmer Radio, can be used to increase resilience by communicating farming practices that align with sustainable intensification, climate and groundwater forecasts with farmers.

## Tanzania-specific activities and findings

**Climate Resilience & Groundwater Resources**
- In arid and some semi-arid environments, groundwater stores are replenished episodically in response to extreme rainfall events. Such events may become more common under climate change and are often related to predictable climate phenomena such as El Nino.
- During wet periods, in favourable hydrogeological environments, focussed recharge can be enhanced to make full use of groundwater storage through managed aquifer recharge (MAR).
- The Makutapora Wellfield is the primary water supply to Tanzania's rapidly growing capital, Dodoma. The sustainability of intensive groundwater pumping for the capital depends on episodic, extreme, heavy seasonal rainfalls. Focused groundwater recharge from episodic flood events has been observed. This information is informing Managed Aquifer Recharge (MAR) options in the Basin (see case study).
- 6 groundwater development pathways were described and impacts on the water table quantified (see case study). Consultation with groundwater users prioritised a pathway of medium-scale abstraction and multiple uses, managed centrally by a municipal or community-based authority.
- In coastal areas of Tanzania (Kilwa district) saltwater intrusion impacts water quality from wells and boreholes. Shallow large-diameter wells show less saltwater intrusion than deeper small-diameter boreholes.

**Sustainable Rural Water Services**
- In Mbarali District, Mbeya Region, a survey of 90 groundwater users showed that Village Councils and Community Water Supply Organizations were more effective in governing groundwater than other structures. Informal norms and values were more

| | |
|---|---|
| | effective and more well-known than formal institutions, such as the Water Resource Management Acts. |
| **Urban Water Security** | ▶ There is currently asymmetric access to good quality groundwater resources in Tanzania. The water security of shallow well and spring users is being threatened by increased groundwater exploitation by large users.<br>▶ Transition Management, a participatory governance approach, has played a crucial role in empowering and mobilizing communities in Arusha, creating a sense of responsibility for local problems and ownership of the actions and solutions developed, and building trust between communities and institutions to sustain actions and solutions over time. |
| **Agriculture and livelihoods** | ▶ In the Great Ruaha Basin, Tanzania, questionnaires from 405 households showed that groundwater-fed irrigation was practised by just 6% of people in the Basin.<br>▶ Questionnaire results also showed that access to groundwater was associated with improved agricultural production, poverty reduction, reduced agricultural risk, and increased income of farm households who have adopted groundwater irrigation as compared to their counterfactual households. |

# Case Studies

## Six pathways identified for sustainable groundwater futures in Africa

https://steps-centre.org/blog/six-pathways-identified-for-sustainable-groundwater-futures-in-africa/

The ultimate aim of the GroFutures project is to generate new evidence and relevant policy insights to open up new pathways towards more sustainable and 'pro-poor' groundwater futures in the wider regions around three 'basin observatories': the Great Ruaha in Tanzania, the Upper Awash in Ethiopia, and the Iullummeden in Niger and Nigeria. A key aim to achieving this has been to identify a range of existing, emerging and potential 'groundwater development pathways' in each basin.

Six groundwater development pathways were conceptualised by the GroFutures Social Science Team. These pathways describe 'stylised' ways of using groundwater, and represent broader trends found across the three basin observatories. To analyse the longer-term sustainability of groundwater in each basin, the GroFutures Physical Science Team 'stress tested' or quantified the impacts of the groundwater development pathways, together with the impacts of climate and land-use change, on groundwater recharge and storage in each basin. A key assumption is that these pathways may co-exist over time and meet the needs of different users. However, there may be cases where there are serious trade-offs between them, leading to positive and negative impacts for different water users and for the environment.

Summaries of the six pathways and their hydrological impacts for the Great Ruaha Basin, Tanzania are outlined below:

| Pathway | Groundwater usage | Occurring in Tanzania? | Impact on water table |
|---|---|---|---|
| 1 | Small-scale, self-supply for multiple uses | Yes | Minimal: groundwater levels fall less than 2 metres over the entire study area. |
| 2 | Small-scale private supply for smallholder intensified agriculture | This pathway is not evident in Tanzania yet, although it is promoted in policy. | Moderate: groundwater levels decline as much as 4 metres over approximately 40 % of the study area. |
| 3 | Medium-scale municipal supply for multiple uses | Yes | Moderate: groundwater levels decline less than 3 metres over the entire study area. |
| 4 | Medium-scale private supply for commercial agriculture | No | Moderate to substantial: groundwater levels fall up to 4 metres in approximately 40 % of the study area. |
| 5 | Medium-scale private supply for livestock husbandry | This pathway is not yet evident in Tanzania but is suggested in some policy approaches. | Moderate to substantial: groundwater levels fall as much as 4 metres in approximately 40 % of the study area. |
| 6 | Large-scale private supply for commercial agriculture | No | Substantial to very substantial: groundwater levels fall 4 to 6 metres in approximately half of the study area. |

This approach has been effective for communication with local stakeholders, enabling them to make evidence-based decisions on development options.

## The Makutapora Record – the longest published record of groundwater levels in the tropics

http://grofutures.org/wp-content/uploads/2015/10/The-Makutapora-Record-low-res.pdf

For more than half a century, the Ministry of Water, the Dodoma Urban Water Supply and Sewerage Authority (DUWASA) and the Tanzania Meteorological Agency have been monitoring groundwater abstraction, groundwater levels, and rainfall in central Tanzania at the Makutapora Wellfield. These observations comprise the longest published record of groundwater levels in the tropics and provide unique insight into the relationships among groundwater abstraction, storage and replenishment by recharge.

First, The Makutapora Record reveals that intensive pumping of groundwater (>30,000 cubic metres per day) to provide a climate-resilient water supply to the national capital of Dodoma, is sustained by recharge that results from exceptionally heavy seasonal rainfall occurring infrequently, on average, during just 1 rainy season in 5. Second, The Makutapora Record reveals that the wellfield store substantial volumes of groundwater, estimated to be 3.8±0.4 million cubic metres for every 1 metre decline in the water table. Using this observed relationship, current abstraction of 1.1 million cubic metres per month over one year, is predicted to lower groundwater levels in the wellfield by 3.5±0.4 metres in the absence of recharge.

The uncertain and irregular patterns of recharge observed in The Makutapora Record complicate sustainable management of the wellfield. Sustained periods of groundwater depletion in the absence of substantial recharge are evident from The Makutapora Record during the 1970s. The Makutapora Record reveals, however, a strong link between heavy seasonal rainfalls associated with the El Niño Southern Oscillation (ENSO) and major recharge events. Because ENSO events tend to take place every 3 to 7 years, this link suggests that recharge may be expected

Further details can be found in:

Taylor, R.G., Todd, M., Kongola, L., Nahozya, E., Maurice, L., Sanga, H. and MacDonald, A., 2013. Evidence of the dependence of groundwater resources on extreme rainfall in East Africa. Nature Climate Change, Vol. 3, 374-378. doi:10.1038/nclimate1731.

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## Enhanced monitoring in the Great Ruaha Observatory

http://grofutures.org/article/enhanced-monitoring-in-the-great-ruaha-observatory/

The GroFutures Team, working with the Tanzanian Ministry of Water and Irrigation, expanded monitoring infrastructure in the Upper Great Ruaha Observatory (UGRO) to include interactions between groundwater and surface water. An outstanding question regarding the sustainability of groundwater withdrawals for irrigation and drinking-water supplies is whether groundwater in the agriculturally intensive lowlands is replenished by river flow, sustains river flow, or both depending upon the season. To try to answer these

questions, team members, Japhet Kashaigili, Richard Taylor and PhD student, Hezron Philipo, installed staff gauges combined with automated dataloggers measuring water pressure (height) and temperature hourly in the lowland areas of the Rivers Mbarali and Chimala where the GroFutures team of social and physical scientists is concentrating its research.

The installed gauges employ a new design pioneered by the team at the GroFutures Site Observatory at Makutapora in Tanzania and were constructed locally. Observations from hourly monitoring of groundwater levels (8 locations), soil moisture (2 locations), surface water levels (2 locations), and rainfall (2 locations) in collaboration with the Ministry of Water and Irrigation will enable the team to gain new insight into the pathways, timing and magnitude of groundwater replenishment as well as the interactions between surface water and groundwater in this region within the vital Southern Agricultural Corridor of Tanzania, known as SAGCOT.

## Participants of the Arena in Arusha, Tanzania, identified a multitude of interconnected problems related to urbanisation

http://t-group.science/2018/05/participants-of-the-arena-in-arusha-tanzania-identified-a-multitude-of-interconnected-problems/

*Participants during the first arena meeting identifying the main problems in Arusha*

Arusha is one of the faster-growing cities in Tanzania. The urbanization process is causing multiple interconnected problems. During the first arena meeting organized as part of the T-Group Arusha Transition Management process participants identified the existing community problems in Arusha. These included the fact that the water supplied by Arusha Urban Water Supply and Sanitation Authority (AUWSSA) is not sufficient to meet their needs. The majority of the population therefore has to obtain water from alternative sources, such as springs and shallow wells which are often contaminated, or water selling points, which are not affordable for low income inhabitants.

Water, environmental and education related problems were ranked by the arena meeting participants as the main challenges in Arusha. But why do these problems persist in the community? According to the Arena meeting, the poor economy, unemployment and low

access to services are strongly related. Poor people cannot afford to access services such as education, water, sanitation and health services. Clean water is too expensive for the poor that suffer water scarcity or use contaminated water sources.

Low awareness of environmental protection aspects causes the continuous persistence of environmental related problems. People are not aware of the importance of protecting natural resources and they maintain practices and behaviours contributing to environmental degradation such as contaminating water and soil through unsuitable sanitation practices, through improper waste disposal or deforestation. All these practices contribute to increasing other risks, such as flooding and health related problems.

## Diving into the reality of water access issues in informal settlements in Arusha, Tanzania

*Arena participants visiting one of the informal settlements in Arusha.*

On May 30, 2018, the participants of the Transition Management process, multiple actors from different organisations and sectors such as the government, NGOs and the University, visited different informal settlements in Arusha with the aim to learn about local challenges and opportunities (e.g. innovative projects and initiatives).

The visit started in Darajambili where Mr. Osward Mpombo from Arusha Urban Water and Sanitation Authority (AUWSA) explained how the sewage system is operating. One of the four sewage ponds had stopped working and was contaminating the river. Despite this, local residents are continuing to use it for washing and this could negatively affect residents' health.

The participants then visited the Tanzania Federation for the Urban Poor (TFUP) office in Arusha. The coordinator of TFUP in Arusha, Mama Mahija Rajab, is one of the active participants of the Transition Management process. TFUP is the national organisation of Slum Dwellers International (SDI), a global network aiming at reducing poverty in slum communities and empowering slum dwellers around the world. In Arusha, TFUP carries out multiple activities, such as conducting the inventory of the communities, setting up sanitation and water projects, constructing social houses and developing projects on health and

education (e.g. for preventing HIV). Mama Mahija shared some of the main challenges faced by the organisation such as the economic challenges and the lack of collaboration with organisations supporting them as entrepreneurs.

At lunch time the participants reached Lemalaat river. Wastewater coming from multiple industries is directed into this river. Residents are continuing to use the river water for irrigation, washing and bathing. Mr. Osward Mpombo explained that the quality of water has never been analysed so its level of contamination is unknown but that the pollution by industrial wastewater is very harmful to local ecosystems and dangerous for the health of the community.

*Wastewater coming from multiple industries flows into Lemalaat river.*

The visit also included trips to Unga Limited area, where the water taps owned by AUWSA are usually not working, so residents depend on the water supplied by a borehole owned by the Mosque. At 'Olevolosi' water project, participants engaged in a discussion around the interactions between AUWSA, community water committees and international development organisations such as World Bank. In Ngaramtoni, they visited the 'eWater' project that is allowing local residents to supply water using a smartcard connected to mobile money services.

The following day the participants gathered again and discussed what they learnt from the visit to the different areas of the city. Some of the participants shared their worry about the water contamination in the different parts of the city, while other participants said that the water should be first analysed to be sure of the contamination.

Diving into the reality of informal settlements represented a powerful learning opportunity for the Transition Management process participants. They could see with their eyes and understand at a deeper level what the existing challenges and opportunities faced by local residents were. This experience shows the importance of researchers and civil servants using innovative ways to facilitate learning processes among stakeholders from different

sectors, as well as to support the connection and trust-building between institutional actors and community members.

## More information

| Type | Organisation | Contacts |
|---|---|---|
| Ministries and authorities | Groundwater Unit, Ministry of Water | Alloice Kaponda (GroFutures) |
| UPGro projects in Tanzania | Groundwater Futures in Sub-Saharan Africa (GroFutures) | Prof. Richard Taylor (UCL) http://grofutures.org/ |
| | Experimenting with practical transition groundwater management strategies for the urban poor in Sub-Saharan Africa (T-GroUP) | Dr Jan Willem Foppen (UNESCO-IHE) http://t-group.science/ |
| UPGro researchers in-country | Nelson Mandela Institute for Science and Technology (NMIS; Tanzania) | Dr Hans Komakech, Dr Revocatus Machunda (T-GroUP) |
| | Sokoine University of Agriculture (SUA), Tanzania | Dr Japhet Kashaigili, Devotha Mosha, Prof. Andrew Tarimo (GroFutures) |
| Online tools and databases | Africa Groundwater Atlas | earthwise.bgs.ac.uk/index.php/Hydrogeology_of_Ethiopia |
| | Groundwater Assessment Platform | www.gapmaps.org/gap.protected/ |
| | Water Point Data Exchange | www.waterpointdata.org/ |
| | IGRAC Global Groundwater Information Systems | www.un-igrac.org/global-groundwater-information-system-ggis |
| | UNHCR WASH Data Portal | wash.unhcr.org/wash-gis-portal/ |

## UPGro published work relating to Tanzania

https://upgro.org/publications-papers


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