Kenya: Groundwater Dossier

Key recommendations

Government: National and Local

- Actively engage with the **AMCOW Pan-African Groundwater Program**
- In coastal areas of Kenya 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**.
- Drought resilience in Kwale can be improved by inter-agency collaboration on data collection and sharing to improve **drought early warning**, **deepening hand-dug wells** which are at risk of going dry during drought periods, and ensuring **emergency water supplies** are available to reduce communities' reliance on expensive vended water during droughts.
- Welfare in Kwale can be improved through increasing household **energy access**, promoting higher **education** attainment, improving **rural drinking water services**, and ending **open defecation**.
- Government leadership is needed to manage the groundwater aquifers as a system for **all water uses**, including industry, communities, and environmental services.
- **Monitoring and mapping of welfare** should be conducted more frequently to evaluate impacts of different poverty reduction strategies.

Civil society and NGOs

- Recommendation !

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

- Recommendation !

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Further research

Further studies are needed to better understand the causal pathways that underlie risk factors for poor functionality of handpumps. Survival analysis and longitudinal study designs could be applied more widely to increase the rigour of water point sustainability assessments.

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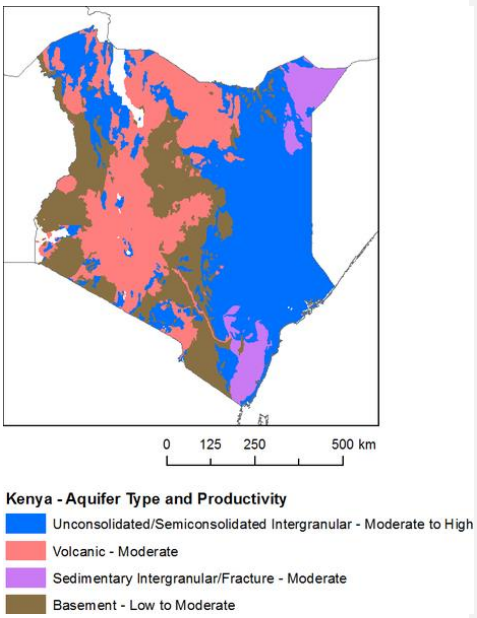
Context: highlights from the Africa Groundwater Atlas

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

Groundwater Quantity

- The total potential groundwater resource (storage) in Kenya is estimated to be 619 million m^3.
- The total groundwater abstraction rate in in 2012 was estimated at 7.21 million m^3/year, and the total safe abstraction rate (annually recharged) in Kenya is estimated to be 193 million m^3/year.
- Some aquifers are identified as being over-abstracted with associated problems of water level decline and sometimes water quality deterioration, in particular the Nairobi volcanic aquifer.



Groundwater Quality

- Some aquifers, mostly with recharge from fresh water rivers, are excellent groundwater sources e.g. the Lodwar Aquifer recharged by the River Turkwel; the Merti Aquifer recharged by the River Ewaso; the Gongoni Aquifer recharged by the Mkurumudzi River and the Baricho Aquifer recharged by the River Galena.
- Many aquifers have groundwater quality issues. For example, the Nairobi aquifer has high fluoride concentrations, which mostly exceed WHO standards, especially towards the Embakasi area.
- The Lotikipi Aquifer is very saline with conductivity exceeding 8000 µS/cm.
- The Mombasa Island Pleistocene sands and limestones and related aquifers are impacted by pollution and saline intrusion. The Mumias granites are impacted by pollution and salinisation.

Various contamination problems arise due to the hydraulic continuity between surface water and shallow groundwater systems in Kenya, e.g.:

- Poor sewerage and drainage systems are major contributors to groundwater contamination. This is an increasing problem in Nairobi and its environs.
- Open cast mining of stones pose a threat to groundwater because of contaminated water infiltrating into the ground.
- The Kiserian reservoir has suffered contamination problems due to inadequate sewage systems in nearby towns; this contaminated water may find its way into groundwater. Equally, groundwater may be becoming directly contaminated because of reliance on pit latrines and soakaway pits.
- River pollution by industrial wastes and sewage pose a great risk for groundwater protection.

Groundwater use

- Many parts of Kenya rely on groundwater, either directly from privately owned or communal boreholes, or via piped supplies from groundwater wellfields. Groundwater from communal boreholes or hand-dug wells supplies most of the rural population.
- Groundwater is used locally for mining, e.g. the Gongoni well field used by the Base Titanium mining company.
- The Daadab refugee camp depends on groundwater abstracted from the Merti aquifer.
- Most irrigation in Kenya is supplied by surface water, but groundwater supplies a small proportion of irrigation water.
- It is reported that although groundwater exploitation has considerable potential for boosting water supplies in Kenya, its use is limited by poor water quality, overexploitation, saline intrusion along the coastal areas, and inadequate knowledge of the occurrence of the resource.
- Nevertheless, many areas of Kenya are reliant on groundwater sources for domestic, commercial and industrial needs, including the coastal zone which is almost entirely dependent on groundwater. Other areas include Mombasa and Malindi (which depend on the Baricho wellfield); Kwale (dependent on the Tiwi wellfield); and Wajir (dependent on the Merti aquifer); as well as Naivasha, Nakuru, Mandera, and Lodwar.

Transboundary aquifers

Kenya shares several transboundary aquifers with neighbouring countries, defined by IWMI (2014) as:

- AFS31 Coastal sedimentary basin 1 (Kenya/Tanzania) - Quaternary and consolidated sedimentary rocks
- AFS32 Kilimanjero aquifer (Kenya/Tanzania) - Volcanic alluvium
- AFNE1 Rift aquifer (Kenya/Tanzania/Uganda) - Volcanic
- AFNE2 Merti aquifer (Kenya/Somalia) - Semi-consolidated sedimentary
- AFNE3 Mount Elgon (Kenya/Uganda) - Volcanic
- AFNE4 Dawa (Ethiopia/Kenya/Somalia) - Volcanic rocks, alluvials and Precambrian basement
- AFNE5 Juba aquifer (Ethiopia/Kenya/Somalia) - Aquifers in Precambrian and intrusive rocks
- AFNE7 Sudd basin (Ethiopia/Kenya/South Sudan/Sudan) - Precambrian and volcanic rocks with patches of alluvials/sedimentary

Key activities and findings from UPGro research in Kenya

General UPGro findings with relevance to Kenya

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.

Kenya-specific activities and findings

Climate Resilience & Groundwater Resources	▶ Investigations of the coastal aquifer in Kwale agreed with other UPGro studies that groundwater recharge happens more readily with more intense rainfall events. ▶ In coastal areas of Kenya (Kilifi County) saltwater intrusion impacts water quality from wells and boreholes. Shallow large-diameter wells show less saltwater intrusion than deeper small-diameter boreholes. ▶ Significant groundwater resources have been identified for the first time in Msambweni sub-County, with the potential to make a significant contribution to local water supplies. ▶ Current industrial groundwater use does not conflict with local community use, as industry uses deep boreholes and communities use shallow ones. ▶ Community water supply is affected by long drought periods when shallow wells dry up, such as the period 2016-2017.
Groundwater and Poverty	▶ The relationship between groundwater access and poverty is not clear-cut because welfare of households in Kwale is also strongly linked to education, energy access and ending open defecation. ▶ Schools clubs are a way to improving understanding of water issues among girls and boys and can strengthen links and trust between community, government and local industry.
Sustainable Rural Water Services	▶ Community waterpoint use reduces substantially for 1-2 days after rainfall events. ▶ Collecting sufficient revenue from water users is a key stumbling block to effective and sustainable operation and maintenance of rural water supplies. ▶ Revenue collection systems become unstable and are prone to collapse if user contributions drop below a 60% threshold in the wet season or 40% in the dry season.

- A survey of 337 water points in Kwale found the average pump was 24 years old and only 64% were currently functional.
- Risk of handpump failure was associated with salinity, static water level, geology and distance to spare parts.
- There are tensions between financial sustainability and universal access to rural water supply services.
- Pay-as-you-fetch payment models are associated with higher levels of revenue and faster repair times, compared to monthly payment models, but also with an increased likelihood of households choosing an unimproved drinking water source.
- "Smart Handpump" technology has unlocked insights into water user behaviour and allows Fundifix (a local social enterprise) to drastically increase service uptime.
- Financial sustainability of the Fundifix service is improved, but not completely covered, by means of a blended finance water services trust fund at the District level.

Urban Water Security

- In informal settlements of Kisumu, faecal contamination is affecting urban groundwater safety. Future pressures from urban population expansion and climate change are likely to have important consequences for shallow groundwater use in informal urban settlements.
- Hydrological, social and financial risks of groundwater investments should be considered prior to development of infrastructure. In Wazir, Kenya, a risk assessment for a proposed pipeline revealed high risks of salinisation, socio-political risks and lack of knowledge as barriers to investment.

Kenyan Early Career researchers

Dr Jacob Katuva[1]

My name is Jacob Katuva and I'm a researcher with Oxford University. I largely work in the water and poverty area. My research has been in Kenya – Kwale County specifically – where I've been looking at the links between water and welfare. Kwale County has a population of close to 900,000 people. The majority of the people there – over 70% – live below the poverty line and the main source of water for the community drinking water supplies is groundwater through handpumps.
We found that there are four priority goals that the County needs to focus on for sustainable development in the county: the first goal is to maintain primary education while maintaining access to primary education; second is to improve access to reliable, affordable and safe drinking water sources within the county; third is to improve access to household energy sources by expanding the national grid or also investing in small scale solar systems; and the final priority goal is to end open defecation as this was the largest cause of reduced welfare in Kwale County.

Suleiman Mwakurya[2]

Suleiman Mwakurya worked as a research assistant on the Gro for GooD project in Kenya, based out of the Rural Focus field office in Kwale. He later took on a new role working for the Kwale County Government.
I worked on the Gro for GooD project for about two and a half years. I was based in the field office in Bomani, Kwale County and was closely involved with the water quality research – sampling and recording data at 49 sampling sites every fortnight. I also assisted on the geophysical surveys, household surveys and surface water monitoring. Actually, the skills I acquired at UPGro have made a big improvement in my career, particularly the experience of working on geophysical surveys and groundwater monitoring. Working with the Gro for GooD project has also inspired me on the welfare side – the household surveys made me aware of issues for people around here who face difficulty with water supplies

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[1] Edited from https://upgro.org/2019/07/16/the-top-4-welfare-priorities-for-kwale-county-kenya/
[2] Edited from https://upgro.org/2019/03/15/upgro-early-career-researchers-qa-with-suleiman-mwakurya/

Case Studies

Fundifix

https://reachwater.org.uk/wp-content/uploads/2016/11/Fundifix-booklet-WEB.pdf

Part of the Gro for GooD UPGro project has been trailing the deployment of performance-based payment models for rural water services, using the FundiFix model. The FundiFix model focuses on the maintenance of existing water infrastructure for communities, schools, clinics and other rural facilities. Led by local entrepreneurs and powered by Africa's mobile network, the FundiFix model offers a performance-based approach working with government, communities and investors to keep water flowing.

The business rationale is 'scale reduces risk'. If all rural waterpoints are networked in one system economies of scale can improve service delivery and lower costs. Essentially, it's insurance logic applied to rural water infrastructure.

The FundiFix model has four connected dimensions:

- Professional Services – user payments and investor finance are contingent on service delivery. The FundiFix model guarantees a rapid service with offices staffed by local entrepreneurs and qualified technicians, with contracts contingent on high quality service delivery.
- Sustainable Finance – stable and adequate flows of finance from government, users and investors are required to maintain water infrastructure across a diverse portfolio of waterpoints serving everyone, every day.
- Smart Monitoring – regular data flows from mobile technologies with data analytics support a rapid repair service and inform sector monitoring, regulation and resource management.
- Institutional Coordination – government leadership in separation of policy, regulation and delivery is critical to ensure sector partners have clear roles and responsibilities.

What's new is mobile technologies now allow operational and financial data to flow quickly and cost-effectively. Better information permits improved institutional design. Rather than each community tackling often similar but infrequent repairs, local companies guarantee a high-quality team to fix repairs fast. Regular servicing also reduces the risk of breakdown in the first place.

Communities subscribe to a service contract which protects their rights but makes them responsible for regular payments. Local entrepreneurs have established companies in Kenya working in partnership with government, investors, communities and UNICEF.

School Water Clubs

Ancient rivers discovered beneath Kwale

Water for Wajir

https://www.frontiersin.org/articles/10.3389/fenvs.2015.00016/full

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Groundwater investments are often pursued without adequately considering the associated risks. These investments then frequently fail to meet their development objectives. The ARIGA project applied risk assessment tools from the field of business to groundwater investments.

In the proposed Habaswein-Wajir Water Supply Project in Northern Kenya, water is to be extracted from a major aquifer near Habaswein and piped to the city of Wajir. A team of eight experts developed an Applied Information Economics model including all costs, benefits, and risks considered important for project success and expressed their uncertainty for about 100 variables in the model with probability distributions. Critical uncertainties were identified using Monte Carlo simulation to project decision outcomes, and Partial Least Squares (PLS) regression.

The project was found to be risky for most stakeholders, mainly due to the risk of political interference caused by water supply concerns in Habaswein and due to unclear profitability of the water supply business. Uncertainties about how to value decreasing infant mortality and reduction in water-borne disease incidence were also critical. The greatest hydrological risk was saltwater intrusion into the aquifer.

Careful well design, inclusive project planning and benefit sharing could raise the chance of project success. The analysis improved understanding of the decision by all stakeholders, some of which changed their opinions on the pipeline, requested more measurements, or proposed alternative water supply options. Decision analysis can help clarify decision uncertainties and outcome expectations and thereby improve decision-making processes, especially in data-scarce areas.

Evolution of informal groundwater use in Kisumu

https://sti-cs.org/2015/07/16/fancy-a-swig-water-quality-in-shallow-wells-in-kisumu-western-kenya/

A poorly maintained shallow well in Kisumu (photo credit: Steve Pedley).

The Sustaining groundwater safety in peri-urban areas project was focused on Kisumu, the third largest city in Kenya, on the shores of Lake Victoria. Informal settlements without urban planning surround the city, which often lack basic services like a piped water supply, or the

piped water supplies are intermittent and unreliable. Inhabitants commonly rely on other sources of water to meet their needs, such as shallow hand dug wells.

Testing of water quality in two informal settlements (Manyatta A and Migosi) showed that the risk of water contamination had increased over time due to an increasing number of hazards such as nearby pit latrines and waste dumps. 44 of the 46 wells tested were found to be unsuitable for drinking. However, 87% of people using well water were not using it for drinking, but for other tasks such as washing clothes and personal hygiene. When choosing the type of water for drinking, water quality and safety were top on their list of priorities, and residents were more likely to use other sources like piped or rain water.

Groundwater from shallow wells contributes a vital quantity of water to residents of these informal settlements. Generally, there is an awareness that water from different sources differs in quality, and is used accordingly. However, this awareness was not universal, and future pressures from urban population expansion and climate change are likely to have important consequences for shallow groundwater use in these settlements in the future.

More information

Type	Organisation	Contacts
Ministries and authorities	Ministry of Water and Sanitation	www.water.go.ke
	Water Resources Authority (WRA)	www.wra.go.ke/
	Water Services Regulation Board (WASREB)	wasreb.go.ke/
UPGro projects in-country	Gro for GooD: Groundwater Risk Management for Growth and Development	Dr Robert Hope (Oxford University) https://upgro.org/consortium/gro-for-good/
	Sustaining groundwater safety in peri-urban areas	Dr James Wright (University of Southampton) https://upgro.org/catalyst-projects/groundwater-safety-in-peri-urban-areas/
	ARIGA: Assessing Risk of Investment in Groundwater Resources	Jan der Leeuw, (World Agroforestry Centre) https://upgro.org/catalyst-projects/ariga/
	Towards groundwater security in Coastal East Africa	Professor Joy Obando (Kenyatta University) https://upgro.org/catalyst-projects/coastal-groundwater/
UPGro researchers in-country	University of Nairobi	Prof Daniel Olago, Julius Odida (Gro for GooD)
	Jomo Kenyatta University of Agriculture and Technology	Prof Bancy Mati, Prof John Gathenya (Gro for GooD)
	Rural Focus Ltd.	Michael Thomas, Mike Lane (Gro for GooD)
	Jaramogi Oginga University of Science and Technology	Lorna G. Okotto (groundwater safety project)
	Victoria Institute for Research on Environment and Development International	Joseph Okotto-Okotto (groundwater safety project)
	Kenyatta University	Mary Makokha (coastal groundwater project)
	World Agroforestry Centre (ICRAF)	Eike Luedeling, Maimbo Malesu, Alex Oduor (ARIGA)
Online tools and databases	Africa Groundwater Atlas	earthwise.bgs.ac.uk/index.php/
	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 Kenya

https://upgro.org/publications-papers

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Credits

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