Unlocking the Potential of Groundwater for the Poor

UPGro CATALYST PROJECTS

Synthesis and individual project summaries

Final edition, June 2016

Produced by the UPGro Knowledge Broker Team*
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Welcome to UPGro

"Unlocking the Potential of Groundwater for the Poor (UPGro), is a seven-year (2013-19) international research programme funded by the United Kingdom. It focuses on improving the evidence base around groundwater availability and management in sub-Saharan Africa (SSA) to enable developing countries and partners to use groundwater in a sustainable way in order to benefit the poor.

UPGro projects are interdisciplinary, linking the social and natural sciences to address this challenge. They will be delivered through collaborative partnerships between the world's best researchers. The programme's success will be measured by the extent that its research generates new knowledge which can be used to benefit the poor in a sustainable manner.

For everyone involved this is a really exciting opportunity to undertake great science and make a positive contribution to addressing SSA's water crisis. The Catalyst Projects ran for one year and have established UPGro's dynamic approach to research and impact. This report presents just some of the highlights so far and glimpses of what is to come. We hope that it inspires you to join us on this important journey."

Professor Declan Conway

Grantham Institute on Climate Change & Environment, LSE

Chair of the Programme Executive Board of UPGro

Contents

Abbreviations and acronyms

AMGRAF	Adaptive Management of Groundwater Resources for Small-Scale Irrigation in Sub-Saharan Africa
ARIGA	Assessing Risks of Investment in Groundwater Resources in Sub-Saharan Africa
BGS	British Geological Survey
BRAVE	Building understanding of climate variability into planning of groundwater supplies from low storage aquifers in Africa
DFID	Department for International Development
ESRC	Economic and Social Research Council
Gro for GooD	Groundwater risk management for Growth and Development
GroFutures	Groundwater Futures in Sub-Saharan Africa
IAH	International Association of Hydrogeologists
ICRAF	International Centre for Research in Agro-Forestry
INGROUND	Inexpensive monitoring of groundwater pollution in urban African districts
NERC	Natural Environment Research Council
PI	Principal Investigator
SSA	Sub-Saharan Africa
T-GroUP	Experimenting with practical transition groundwater management strategies for the urban poor in Sub Saharan Africa
UCL	University College London
UPGro	Unlocking the Potential of Groundwater for the Poor

This report

This report summarises the contribution to groundwater knowledge of the 15 Catalyst Projects funded through the UPGro programme between 2013 and 2016, plus the The Africa Groundwater Atlas and Literature Archive.

The projects worked in 12 individual countries (see next page - some countries had more than one project), and three had an Africa-wide focus or component.

All the Catalyst Projects are now complete, and four of the Catalyst Teams were awarded larger 'Consortium' grants to continue the work in more depth from 2015 – 2019*. The Groundwater Atlas project will also continue as a major archive of African groundwater information.

Please cite this report as *UPGro (2016) UPGro Catalyst Projects: Synthesis and individual project summaries. June 2016.* www.rural-water-supply.net/en/resources-top/details/658

*There are five Consortium projects (see page 34) as one non-Catalyst project was accepted through an open call.

Programme overview

Awarded a Consortium Grant to continue work (2015-2019)

ET Optimizing Road Development for Groundwater Recharge and Retention — wr inf gov

KE Groundwater Risks and Institutional Responses for Poverty Reduction in Rural Africa — wr gov ag inf min

KE Assessing Risks of Investment in Groundwater Resources in Sub-Saharan Africa (ARIGA) — wr gov

MW ZW Resource limitations to sustainability of groundwater well-points in basement complex regions of sub-Saharan Africa — wr

Africa-wide Groundwater recharge in Africa: identifying critical thresholds — wr inf

ET ZA GH Adaptive management of groundwater resources for small-scale irrigation in sub-Saharan Africa (AMGRAF) — wr ag gov

KE KM TZ Towards groundwater security in coastal East Africa — wr cc

TZ IN-GROUND: Inexpensive monitoring of Groundwater pollution in Urban African Districts — pol urb

UG A hidden crisis? Strengthening the evidence base on the sustainability of rural groundwater services — ws inf

NG ZM Mapping groundwater quality degradation beneath growing rural towns in sub-Saharan Africa — pol urb

KE Sustaining groundwater safety in peri-urban areas — pol urb

BF GH Building understanding of climate variability into planning of groundwater supplies from low storage aquifers in Africa (BRAVE) — wr cc

GN SN Use of remote sensing and terrain modelling to identify suitable zones for manual drilling in Africa and support low cost water supply — wr inf

ET Improving access to safe drinking water: prospection for low-fluoride sources — pol wr gov

ET TZ GH Groundwater Futures in Sub-Saharan Africa (GroFutures) — wr ag inf gov cc

RESEARCH THEMES

- ag agriculture
- gov water governance & risk
- min mining
- urb urban groundwater
- cc climate change
- inf infrastructure planning and performance
- pol groundwater quality and pollution
- wr water resources and aquifer properties

Report structure and format

The first part of the report presents the synthesis and overall findings – an overview of the different ways in which the projects have contributed to groundwater knowledge.

In the first part of the report individual projects are referred to by the name of their Principal Investigator (PI)*.

The second part of the report contains one-page summaries of The Africa Groundwater Atlas and Literature Archive and each of the 15 Catalyst Projects.

It is intended that the format and style of the report will make it accessible both to readers with substantial knowledge of groundwater, and to those for whom it is more mysterious.

*Two of the PIs share the same surname, so in these cases their first names or first initials are used for clarity.

Synthesis: methods and tools

- Two projects (Lapworth, Velasquez-Orta) explored the use of **novel water quality testing methods**, with the latter designing a new biosensor to do so.
- Four projects (David MacDonald, van der Leeuw, Gowing, Colombo) developed **modelling frameworks** for resource development and management.
- One project (Gowing) used **community-level monitoring** of water resources.

Synthesis: data and information

All projects generated data, but of particular note,

- One project (Taylor) identified 25 continuous or near-continuous long-term **groundwater level data-sets** from around Africa.
- One project (Chilton) generated **down-hole and social / management data** on abandoned boreholes-with-handpumps.
- One project (Alan MacDonald) assembled and reviewed more than 200 **groundwater recharge studies**.
- Three projects (Lapworth, Wright, Smedley) generated **groundwater quality data-sets**.
- Two projects (Hope, Obando) generated data on **water demand, use and welfare indicators**.
- One project (Colombo) generated **structured and codified datasets** of stratigraphic borehole logs, allowing an automatic analysis of hydrogeological parameters.
- The Africa Groundwater Atlas / Groundwater Literature Archive project indexed **more than 5000 documents**, many with links to full text documents or abstracts.

Synthesis: subject matter

- Most projects focused on groundwater resources or quality in the context of **domestic water use by the poor**.
- Six projects (Obando, Hope, A. MacDonald, D. MacDonald, Wright, Taylor) explicitly considered **future threats** from environmental degradation, population growth, increasing demands and climate change.
- Only one project (Gowing) explicitly focused on **shallow groundwater for productive use**.
- One project (van Steenbergen) examined the interaction of **roads and groundwater**.

Findings: groundwater resources

- Information on groundwater resources is patchy in Africa, but **some good data-sets, maps and other materials do exist** (Taylor, A. MacDonald, Lapworth, Wright, Smedley, Colombo).
- It is evident that renewable groundwater resources are limited by rainfall amounts and their distribution over time (A. MacDonald, Taylor). In relatively dry climates it is more appropriate to **report recharge on a decadal basis** than as an annual average.
- Groundwater resources in the Basement Complex may be limited and scarce locally, but this is not always the case (Burgess).
- Competent borehole **site selection and evaluation of groundwater resources** are both important in order to deliver sustainable yields (Chilton, Burgess). Systematic analysis of hydrogeological context is essential for identification of suitable drilling locations (Colombo).
- **Climate change** will alter the local water balance, but its impact on groundwater recharge is likely to be very location-specific (A. MacDonald, Taylor).

Findings: groundwater quality

- **Groundwater is often highly corrosive**, and so the careful selection of suitable borehole lining and water pumping materials is very important (Chilton).
- Peri-urban groundwater quality is compromised, and the situation is likely to worsen. Nevertheless **many consumers are dependent on such unsafe waters** (Lapworth).
- **Novel water quality techniques** hold some promise for easier and more cost-effective measurement and monitoring (Lapworth)
- **Geogenic contaminants** (such as fluoride) pose difficulties for water supply. None of the available mitigation options is without disadvantages (Smedley).

Findings: developing groundwater

- **Weaknesses in siting, design and construction** (made worse because of poor supervision of contractors) result in many boreholes coming into service which should never have been commissioned (Chilton). This results in high rates of abandonment.
- **Novel ways of thinking** such as combined roads / water planning and design (van Steenbergen) still remain to be explored.
- **Combining data sources** such as indigenous and "scientific" knowledge (Gowing); and remotely sensed and down-hole data (Colombo) offers real synergies.

Findings: risk, uncertainty and change

- Modelling the future is only as good as modelling of the past. **There are still significant uncertainties** inherent in combining land, water and climate modelling (D. MacDonald).
- **Groundwater resources are at risk** from environmental and demographic change. The services they provide are therefore also at risk (Obando, Hope, D. MacDonald).

Findings: groundwater governance

- **Water users** are enthusiastic and competent participants in groundwater management (Obando, Gowing).
- **Information and participation** hold the promise of better water management (van der Leeuw).
- Sustainable groundwater management requires the **collaboration** of domestic water users, agro-industry, mining and other large-scale users, and public authorities (Hope).
- **There is willingness for Africa-wide collaboration** among groundwater scientists and civil servants (Taylor).

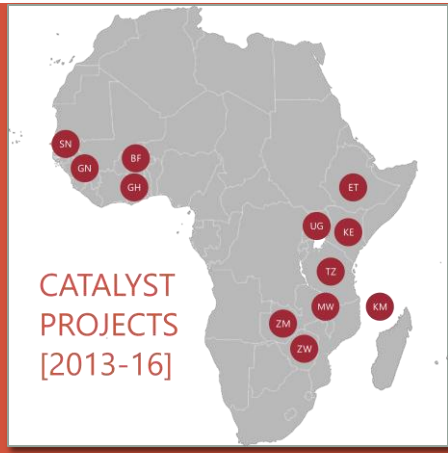
Synthesis: catalyst projects overview

At the outset of the UPGro programme, this statement was made:

The quantity and quality of groundwater in Africa, and its spatial and temporal variability, are inadequately understood. This poses problems for the design, implementation and sustained management of water supply systems which use groundwater. These challenges are exacerbated by variability and change in the factors which determine groundwater availability.

At the end of the catalyst phase, and as five consortium projects are under way, the following major achievements have been realised:

1. Data-sets on groundwater quantity and quality have been assembled.
2. A substantial body of documentary data and maps has been gathered.
3. New tools and methods have been developed and trialled.
4. There is clearer understanding of the need for multi-stakeholder collaboration in groundwater governance.
5. Professional networks have been built and strengthened.
6. Links between hydrogeology and other natural sciences, the social sciences, and the key issues pertaining to groundwater governance have been forged.



INDIVIDUAL PROJECT SUMMARIES

The Africa Groundwater Atlas and Literature Archive

www.bgs.ac.uk/africagroundwateratlas/index.cfm

The problem Much of the data and information that already exists about groundwater in Africa is not available to the people who could make use of it. This project aims to address that problem.

Key findings The Atlas and Archive will be of use to practitioners, researchers, policy makers and decision makers. The development and publication of the atlas will also involve many African groundwater scientists and be a platform to both publicise their knowledge and to deposit and secure their research and data.

Being web-based means the Atlas and the Literature Archive can be quickly updated and grow as more information becomes available. An offline version of the Atlas is also available electronically through the British Geological Survey, and the entire Atlas (or individual sections) can be downloaded as a PDF from the Africa Groundwater Atlas webpage.

The approach Development of a literature archive and an Atlas of groundwater maps.

The Africa Groundwater Atlas is an online introduction to the groundwater resources of 51 African countries, and a gateway to further information. For each country there are summaries of key geological environments and aquifers, with new overview maps, and supporting material on groundwater status, management and wider hydrogeological issues. The accompanying Africa Groundwater Literature Archive lets users search and freely access nearly 7000 documents on African groundwater.

Where? Africa-wide.

Contact: Brighid O'Dochartaigh, BGS, beod@bgs.ac.uk

Africa Groundwater Literature Archive

Hidden crisis: the causes of failure in rural groundwater supply

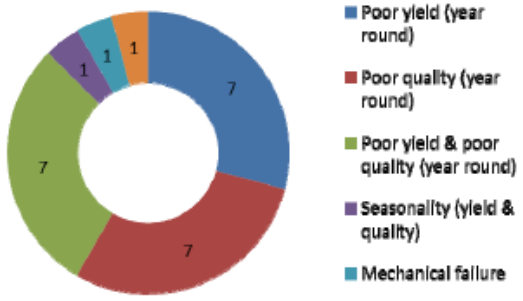
upgro.org/catalyst-projects/hidden-crisis1/

The problem Rural water boreholes with handpumps suffer frequent failure. Understanding the causes of these failures is crucial to carry out more effective service provision

The approach A conceptual framework involving symptoms, causal factors and underlying conditions. Field studies including community meetings and detailed borehole / handpump inspections.

Key findings Low yield and poor water quality are symptomatic of poor siting, construction and materials selection. Underlying causes lie in poor practices of implementing agencies, and especially the lack of competent construction supervision.

Dominant symptoms of failure



Where? Uganda

Awarded consortium follow-on grant

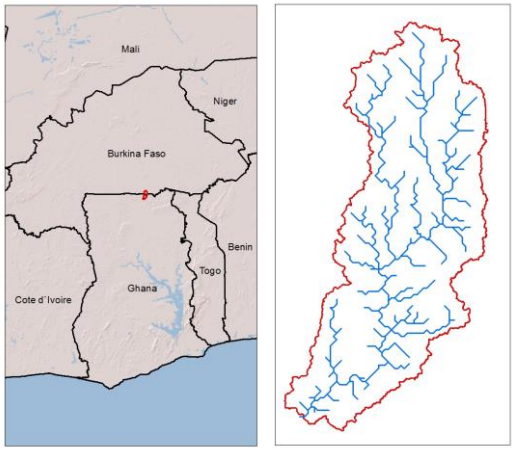
PI: John Chilton, IAH, jchilton@iah.org

Building understanding of climate variability into the planning of groundwater supplies from low storage aquifers in Africa (BRAVE)

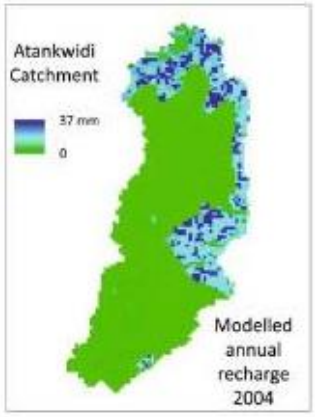
upgro.org/catalyst-projects/brave1/

The problem Increasing water demands set in a context of variable climate and changing land use, together with dependence on low-storage, low-yield aquifers.

The approach
Application of linked land surface and groundwater models to assess impact on groundwater supplies of periods of reduced recharge; investigation of sensitivity of groundwater recharge to key climate and land use controls; development of stakeholder networks to examine planning needs and support decisions on groundwater development.



the study catchment



modeled annual recharge

Key findings Although the study shows that the land surface model used needs work to add in all the key processes, early findings confirm that annual groundwater recharge can be highly variable. The impact of this variability on the continuity of supply during drought depends on how water that isn't pumped seeps out or flows from these low storage aquifers.

Where? Burkina Faso, Ghana

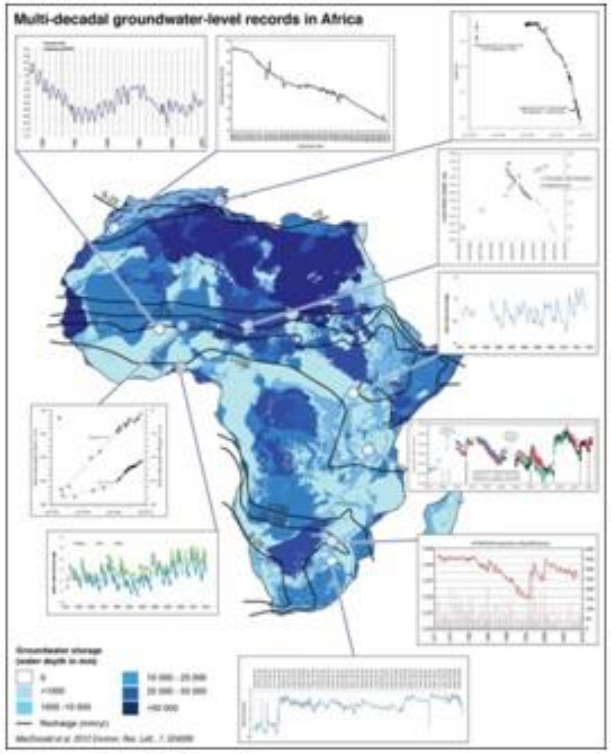
Awarded consortium follow-on grant

PI: David Macdonald, BGS, dmjm@bgs.ac.uk

GroFutures: Groundwater Futures in Sub-Saharan Africa

upgro.org/catalyst-projects/grofutures1/

The problem Despite the importance of groundwater for growth and development, substantial uncertainty concerning the renewability, accessibility and management of groundwater resources remains.



Above: location of ten long-term groundwater level data-sets.
Right: monitoring water levels in the Makutopora wellfield, Tanzania.

The approach Measuring changes in groundwater demand and supply. Development of an interdisciplinary, pan-African consortium for more in-depth research. Identifying long-term groundwater data-sets.

Key findings Multi-decadal groundwater level time series have been compiled. This has supported the Groundwater Recharge catalyst (page 30). A strong collaborative network has been established to take the consortium research forward.

Where? Ethiopia, Ghana, Tanzania, Uganda, Africa-wide

Awarded consortium follow-on grant

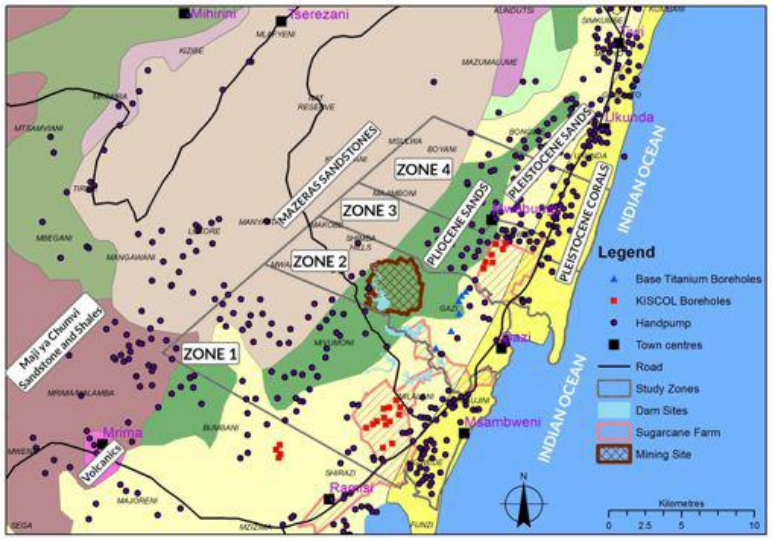
PI: Richard Taylor, UCL, richard.taylor@ucl.ac.uk

Groundwater risks and institutional response in rural Africa

upgro.org/catalyst-projects/gro-for-good1/

The problem In locations with limited groundwater resources, but where large-scale demands are increasing, the question arises as to how groundwater can be sustainably managed to the benefit of both the wider economy and the rural poor. Can water risks be managed for both growth and development?

The approach A case study in Kenya, involving hydrogeological assessments, handpump monitoring, a household survey to inform understanding of water poverty, and key informant interviews and focus group discussions to understand groundwater governance.



Key findings A great deal of data regarding ground-water level and quality, water use, health and indicators of welfare has been generated. An inter-disciplinary Groundwater Risk Management Tool has been proposed for development in the consortium phase.

Where? Kenya

Awarded consortium follow-on grant

PI: Rob Hope, Oxford University, robert.hope@ouce.ox.ac.uk

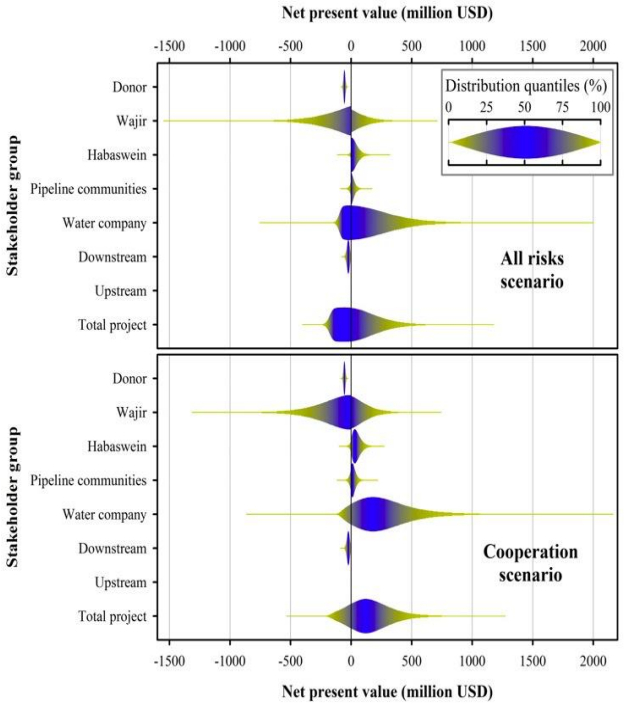
Assessing Risk of Investment in Groundwater Resources (ARIGA)

upgro.org/catalyst-projects/ariga/

The problem Groundwater investments are often pursued without adequately considering the associated risks. These investments then frequently fail to meet their development objectives. A broader, inclusive socio-hydrological approach is needed.

The approach The case study involved a proposed 110km pipeline from boreholes at Habaswein to the town of Wazir. The hydrological, social and financial risks were examined through stakeholder engagement, modelling and social surveys.

Key findings Investment risks were judged to be high as a result of risks of salinisation, socio-political risks and lack of knowledge. Stakeholders with opposing opinions appreciated the risk perspective offered and the opportunity for dialogue. They indicated that better information might assist them to reconsider their opinions.



Where? Kenya

PI: Jan der Leeuw, ICRAF
j.leeuw@cgiar.org

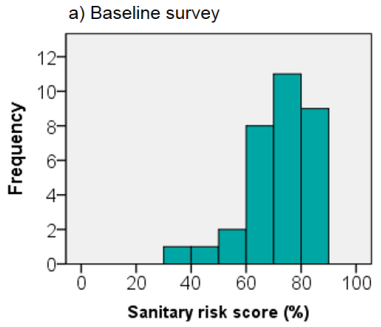
Domestic groundwater safety in Kisumu, Kenya

upgro.org/catalyst-projects/groundwater-safety-in-peri-urban-areas/

The problem As urban populations outgrow the ability of utilities to supply piped water, the growing dependence on privately developed urban groundwater raises questions of water safety for consumers.

The approach Examination of past records of groundwater quality, field studies of present water quality, and projections and expert modelling of possible futures.

2002-04



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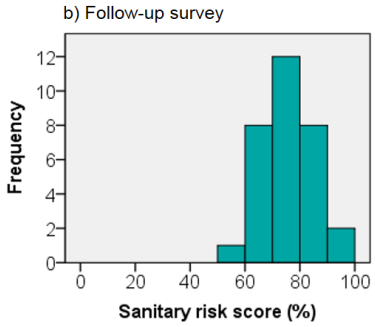
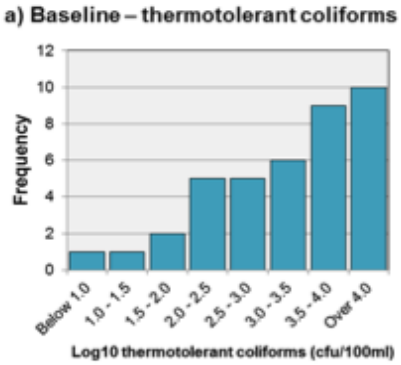
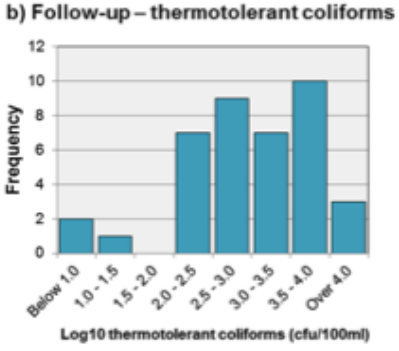






Key findings Urban groundwater use has remained high over the study period (1999-2014). Risks to water safety have increased, according to sanitary surveys. Groundwater quality data tells a less clear story. Future (to 2030) risks may be highest in small towns and peri-urban settlements.

Where? Kenya.

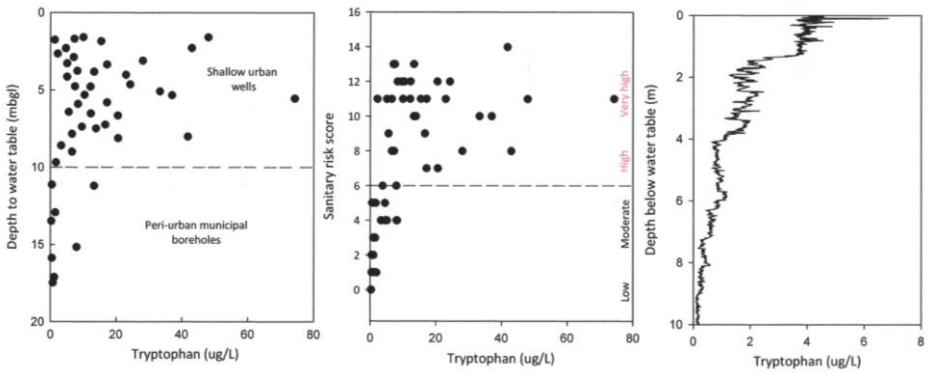
PI: Jim Wright,
University of Southampton
j.a.wright@soton.ac.uk

New ways to understand contamination and risk in shallow urban groundwater

upgro.org/catalyst-projects/mapping-groundwater-quality/

The problem Shallow hand dug wells and boreholes in urban areas are potentially at high risk of contamination. Mapping of groundwater contamination and understanding the key risk factors remains a priority.

The approach *In-situ* optical fluorescence for tryptophan (a protein waste water marker) and molecular pathogen screening (qPCR), alongside conventional measurements and assessments for groundwater quality surveys during the wet and dry seasons at 50 sites.



Key findings High groundwater vulnerability in shallow wells irrespective of land use; overall degradation of water quality during the wet season; nitrate contamination in some deeper sites; pumping induced connectivity between shallow and deep GW based on age tracers and organic contaminants; impact of mine waste in some nearby shallow wells detected. The Tryptophan Sensor is a powerful new groundwater quality monitoring tool.

Where? Zambia

PI: Dan Lapworth, BGS, djla@bgs.ac.uk

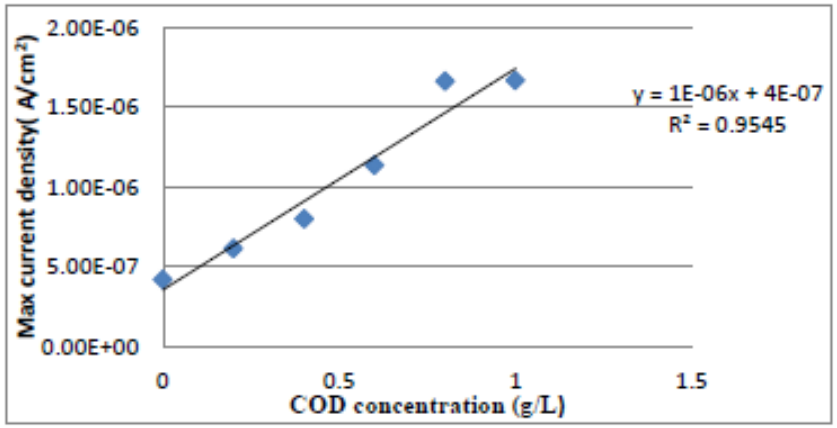
INGROUND: Evaluating an inexpensive biosensor to detect pollution in groundwater

upgro.org/catalyst-projects/inground/

The problem The majority of the urban population in Africa uses on-site sanitation systems which pose a threat to groundwater quality and safety. The monitoring of water quality in such environments needs to be made easier and cheaper.

The approach Design a prototype biosensor for testing and development in Tanzania.

Experimental set-up in the laboratory.



Correlation between COD (anthropogenic pollution) and current density (biosensor response)

Key findings A biosensor has been designed and tested in the laboratory, with encouraging initial results. The device has been field-tested, and further analysis and development are on-going.

Where? Tanzania

PI: Sharon Velasquez-Orta, Newcastle University sharon.velasquez-orta@newcastle.ac.uk

Groundwater fluoride mitigation in the Ethiopian Rift Valley

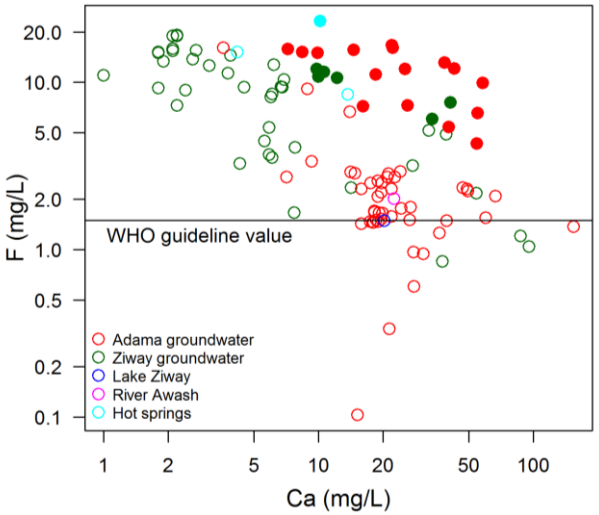
upgro.org/catalyst-projects/prospection-for-low-fluoride-sources-of-groundwater/

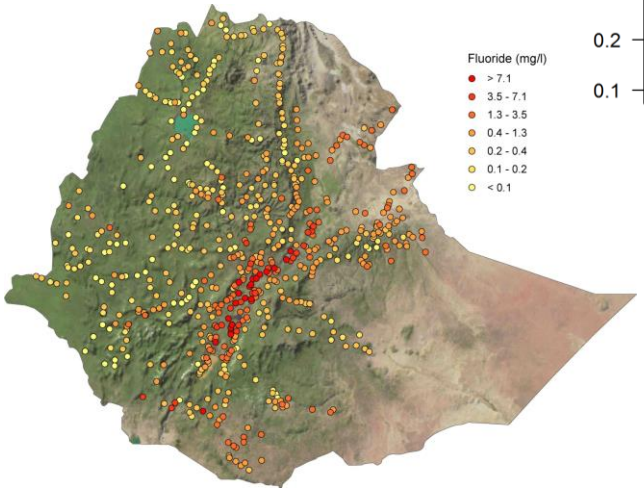
The problem High levels of fluoride in groundwater cause dental and skeletal fluorosis in those who consume it. It is necessary to find ways to mitigate this problem for the estimated 8 million people who are exposed to it in Ethiopia alone.

The approach Hydrogeological studies of fluoride occurrence. User surveys and financial analyses of alternative mitigation strategies.

Key findings Fluoride in groundwater is influenced by surface water/groundwater interactions, geothermal inputs and aquifer geology. Mitigation options include safe sourcing (locating primary low-fluoride sources); alternatives are defluoridation and multi-village piped water schemes - the former dependent on NGO capacity and subsidy and community involvement, the latter on investment, infrastructure and professional management. Of the options, defluoridation is the least sustainable.

Right: relationship between Ca and F in groundwater from the Ethiopian study areas (infilled symbols: fluorite-saturated).





Where? Ethiopia.

PI: Pauline Smedley, BGSpls@bgs.ac.uk

Roads for water

upgro.org/catalyst-projects/roads-for-water/ roadsforwater.org

The problem Road construction interferes with local runoff and recharge, to the detriment of farming and livelihoods. At the same time roads suffer serious water-related damage. The project has attempted to address both issues.

The approach Social science research to "put a human face" to the problems communities face when roads are constructed. Engineering designs to minimise these problems and optimise use and infiltration of runoff.

Key findings Low-cost solutions have been proven, and their rapid uptake by Regional and local Government and communities holds much promise for scale-up elsewhere.

Above roadside water storage pond.

Left roadside recharge ponds.

Where? Ethiopia

This work has received follow-on support from the Dutch science funding body (NOW) and the Global Resilience Partnership.

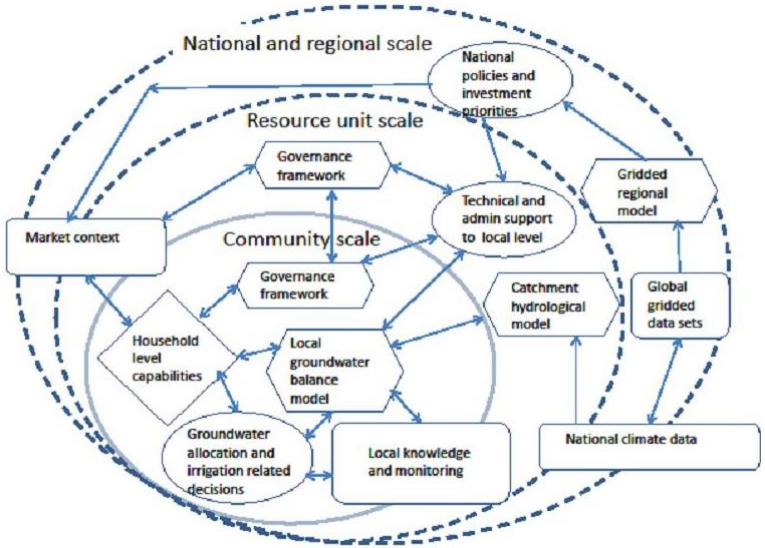
PI: Frank van Steenbergen, MetaMeta Research
fvansteenbergen@metameta.nl

Adaptive management of groundwater in Africa (AMGRAF)

upgro.org/catalyst-projects/amgraf/ research.ncl.ac.uk/amgraf/

The problem Productive use of groundwater in Africa offers many opportunities. Much information on groundwater exists in the form of global remote sensing products, while local indigenous knowledge also has much to offer. These two information sources need to be combined with hydrological modelling and appropriate social and governance systems to achieve sustainable development and to assure equitable access to the resource by the poor.

The approach A multi-scale, multi-disciplinary approach was taken, including water resource monitoring by community members, modelling and social science studies.



Key findings Potential exists for shallow groundwater irrigation. Simple water balance models and community monitoring can be used with appropriate governance systems for local adaptive resource management.

Where? Ethiopia

PI: John Gowing, Newcastle University
john.gowing@newcastle.ac.uk

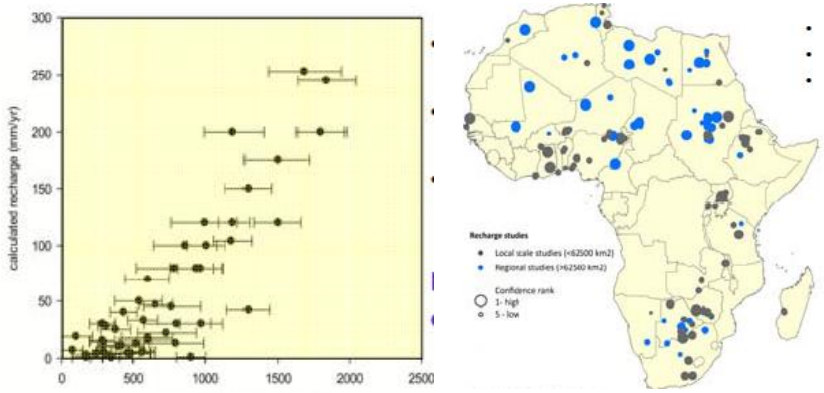
Groundwater recharge: identifying critical thresholds

upgro.org/catalyst-projects/groundwater-recharge/

The problem Groundwater recharge is one of the most difficult parameters to measure in the assessment of water resources yet is critical for reliable projections of sustainable resource development.

The approach A continent-wide review of more than 200 recharge studies. Where possible the data were extracted to identify relationships between rainfall and recharge, and in particular examine evidence for thresholds controlling recharge.

Key findings The importance of multiple methods; reporting recharge as decadal, rather than annual averages; that while broad relationships exist between average rainfall and recharge, such relationships becomes non-linear when long-term average annual rainfall is less than 1000 mm. Here rainfall intensity becomes particularly important. As future rainfall is expected to intensify with climate change, deeper understanding of the role of episodic high intensity rainfall events in governing recharge will become increasingly important.



Where? Africa-wide

PI: Alan MacDonald, BGS, amm@bgs.ac.uk

Towards groundwater security in Coastal East Africa

upgro.org/catalyst-projects/coastal-groundwater/

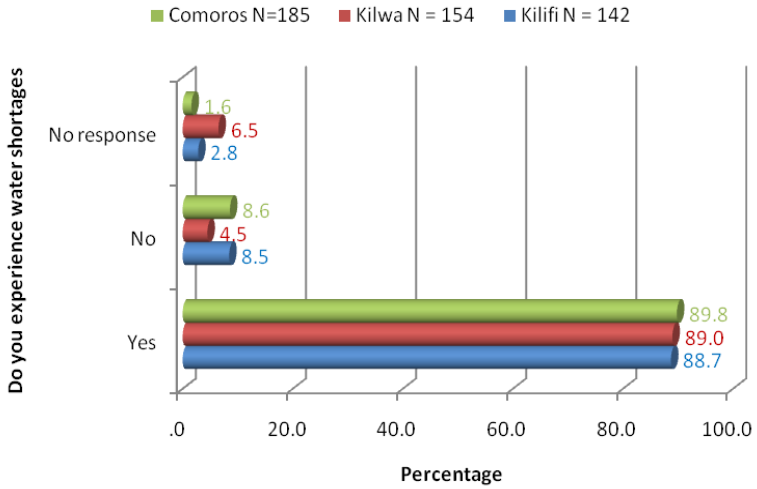
The problem Groundwater resources in coastal East Africa are at risk from growing populations and from climate change. Groundwater resources need to be understood and monitored, and sustainable management approaches designed.

The approach Hydrogeological desk studies and field studies at three case study locations. Monitoring of groundwater level and quality, and rainfall. Assessments of demand for and use of groundwater.

Year	Forest cover (km^2)
1990	1042.90
2000	940.44
2013	825.44

Left: deforestation in Kilifi study area, Kenya. Land use changes such as this affect the water balance.

Right: water shortages as experienced by households in the study countries.



Key findings Limited renewable fresh groundwater resources are under pressure from growing demands and from degradation as a result of human activity. Communities, and women especially, are willing to engage in better water management, if given the information and tools to do so.

Where? Kenya, Tanzania, Comoros

PI: Joy Obando, Kenyatta University, obandojoy@yahoo.com

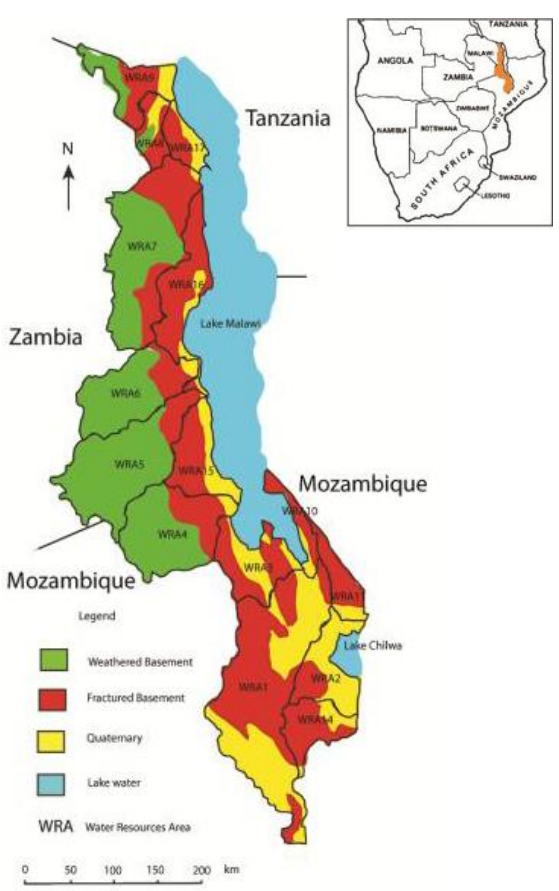
Resource limitations of groundwater well-points in Basement Complex regions

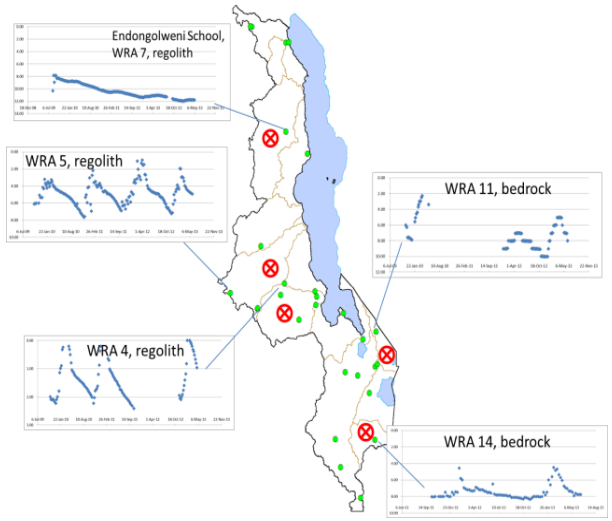
upgro.org/catalyst-projects/basement-complex/

The problem Despite the many advantages of groundwater, including its resilience to climate variability and change, a recent analysis in Malawi has cast doubt on its universal sufficiency, in the Basement Complex regions of southern Africa, where the aquifer has limited storage and demand is high.

The approach To test the analysis by comparing its implications for well-point failure against the Malawi water point database, and to develop a similar analysis for southern Zimbabwe.

Key findings The hypothesis of resource limitation in Malawi was not supported by the test. In Zimbabwe abstractions may exceed availability in places, but the analysis depends on scarce transmissivity data. Groundwater level monitoring is in its infancy in both Malawi and Zimbabwe.





Where? Malawi, Zimbabwe

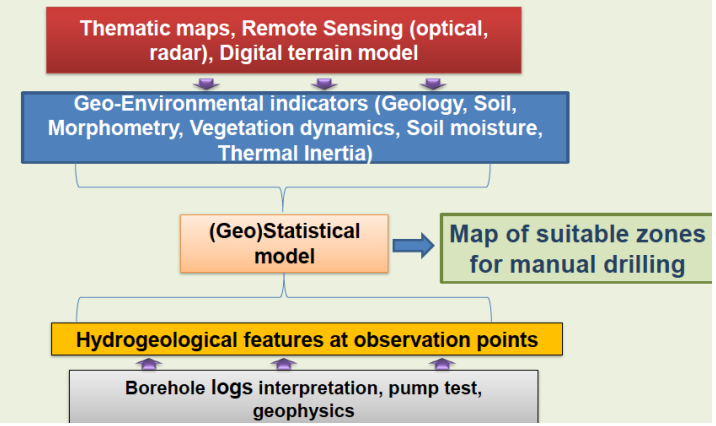
PI: Willy Burgess, UCL
william.burgess@ucl.ac.uk

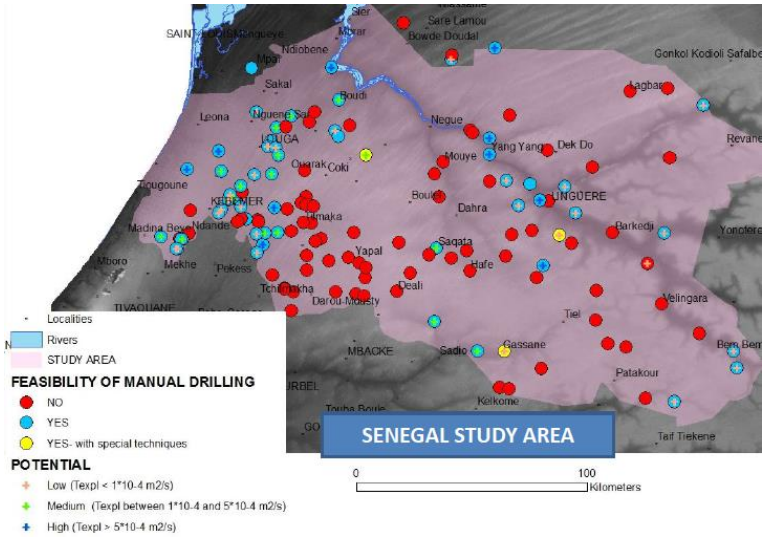
Use of remote sensing and terrain modelling to map manual drilling potential

upgro.org/catalyst-projects/remote_sensing_for_manual_drilling/

The problem Extending groundwater supply to more people is expensive using conventional technologies. Manual well drilling offers cost-saving opportunities, but the techniques involved can only be used in specific ground conditions.

The approach Development of a systematic methodology for combining remotely sensed data with direct data from drilling records, to map the potential for manual drilling.





Key findings Software has been developed to integrate drilling data and remotely-sensed data to map manual drilling potential in Senegal. Further validation of the approach is still needed.

Where? Guinea, Senegal

PI: Roberto Colombo, University of Milano-Bicocca,
Contact: Fabio Fussi, fabio.fussi@usa.net

What's next for UPGro?

In 2016, five Consortium research projects commenced. These will run until 2019 and carry out detailed research on their chosen subjects. Four of the projects evolved from the UPGro Catalyst projects, but one (T-GroUP) was added when the open call for proposals was assessed.

- **BRAVE: Building understanding of climate variability into planning of groundwater supplies from low storage aquifers in Africa – Second Phase**
  PI: Dr Rosalind Cornforth, University of Reading upgro.org/consortium/brave2/
- **Gro for GooD: Groundwater Risk Management for Growth and Development**
  PI: Dr Rob Hope, University of Oxford upgro.org/consortium/gro-for-good/
- **GroFutures: Groundwater Futures in Sub-Saharan Africa**
  PI: Professor Richard Taylor, University College London upgro.org/consortium/grofutures2/
- **Hidden Crisis: unravelling current failures for future success in rural groundwater supply**, PI: Professor Alan MacDonald, British Geological Survey upgro.org/consortium/hidden-crisis2/
- **T-GroUP: Experimenting with practical transition groundwater management strategies for the urban poor in Sub Saharan Africa**
  PI: Dr Jan Willem Foppen, UNESCO IHE Institute for Water Education upgro.org/consortium/t-group/

Find out more about UPGro at upgro.org and on YouTube at www.youtube.com/channel/UCTv5uGIhSsEiZ2ktSTn3jhA

Compiled and written by Richard Carter,
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Layout by Richard Carter and Skat Foundation

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