UP Gro — Unlocking the Potential of Groundwater for the Poor

Gro for GooD — Groundwater risk management for growth and development

## Why groundwater?

Groundwater is essential for economic growth and can contribute to human development if resources are used sustainably to benefit the poorest in society. The ***Gro for GooD*** (*Groundwater Risk Management for Growth and Development)* project is striving to help government and groundwater users find a management approach that balances human health, economic growth, and resource sustainability demands and benefits everyone.

This newsletter has been created by the Gro for GooD partners to share monitoring information and research findings associated with the project and provide an update on some of the local engagement and outreach that has been taking place recently.

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# 1. FOREWORD

**Colin Forbes, General Manager Environment & Community Affairs**


Kwale County provides an excellent example of the challenges in achieving sustainable community based water resource management. Although periodic droughts have had impacts in the past, generally, to the east of the Shimba Hills, the quantity of groundwater supplies has not been a problem. This region has benefitted from numerous developmental programmes such as the SIDA borehole project and the Tiwi aquifer project to name but a few, with the specific intent to benefit from this abundant groundwater resource.

For various reasons, many of the projects implemented from the '70s to the '90s fell into disrepair but it is encouraging to see the County Government of Kwale addressing this deficiency with an emphasis on rehabilitation of infrastructure and investment in equipment to assist with borehole drilling. Together with decades of learning and recent understanding of local conditions the outlook for water resources management is brighter than ever before.

The work done by Gro for GooD has provided considerable impetus for achieving sustainability in ongoing infrastructure upgrades. Base Titanium is proud to be a partner with other stakeholders in the County to see this programme bring innovation to water resource management and integrate educational programmes into the school curriculum. This will enable communities to take responsibility for the future of their water resources and realise the accompanying benefits for upcoming generations.

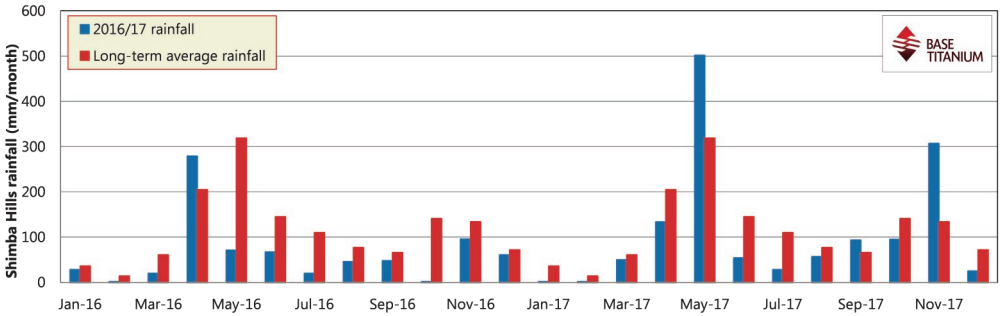
Colin Forbes
May 2018

## 2. 2016-2017; A DROUGHT AND RECOVERY CYCLE SHOWN BY RAINFALL AND GROUNDWATER LEVELS

***by Mike Lane (GfG hydrogeologist) and the Base Titanium Environment Team***

Early in 2017 the Kenya Government declared the 2016-2017 drought a National Emergency. Although northern Kenya suffered more than Kwale County did, the South Coast nevertheless experienced a challenging drought. Just how severe was it? By examining rainfall and groundwater level data we can answer this question in a straightforward way. We can also observe how 'good' rains can restore groundwater levels.

Rainfall data from 2016-2017 shows that 2016 was a poor rainfall year. At Shimba Hills Centre it was the second driest year on record (out of 47 years of data). 2016 had an annual total rainfall of 739 mm, which is low compared with the long term average of 1,380 mm per year. 2017 was much closer to that average, with a total of 1,349 mm of rainfall over the year. 2017 was characterised by two particularly intensive rainfall events, in late April-early May (413 mm of rain fell in 14 days) and in early November (228 mm fell in 5 days). The chart illustrates the differences in the amount of rainfall that fell in 2016 and 2017 versus the long-term average for Shimba Hills.

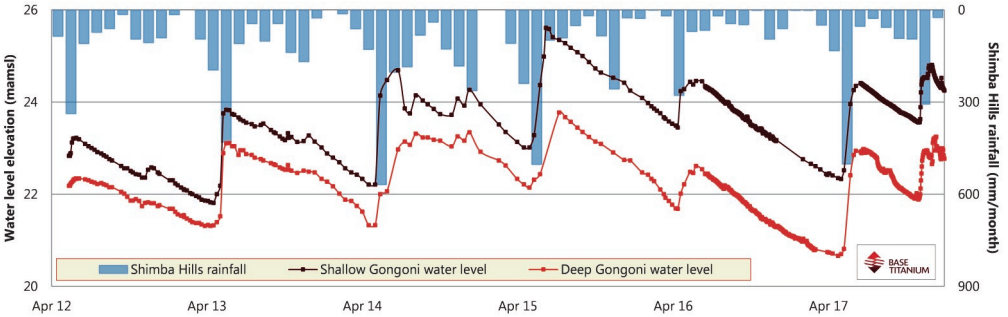



***Actual and average monthly rainfall at Shimba Hills (1 January 2016 to 31 December 2017)***

How does rain influence aquifers, the porous rocks that store groundwater? Base Titanium monitors water levels in the aquifers beneath the Gongoni Forest and the surrounding area; there are two aquifers, a shallow aquifer used by local communities for water supply from shallow wells, and a deep aquifer that supplies water to Base's mine from four boreholes. These aquifers have been monitored since early 2012.

***Members of Base Titanium Environment team measuring borehole depth***
***© Base Titanium***

The results from monitoring these boreholes are shown below. Water levels are shown as metres above sea level. When the elevation of the water level is low, it means that there is less water stored in the aquifer; conversely, when the elevation is high, there is more water stored. Monthly Shimba Hills rainfall is shown as blue bars falling from the top axis. Water levels in both aquifers clearly show how high rainfall months lead to swift increases in groundwater level, or what we call 'groundwater recharge'.




***Groundwater levels beneath Gongoni Forest (May 2012 to December 2017)***

The chart shows that the depth to shallow water in early 2013 was greater than it was at the start of the long rains in 2017, which suggests that groundwater drought in 2012-2013 was worse than in 2016-2017. The chart also shows that in years when the short rains are good, a second recharge event occurs. This happened in November 2017, leaving water levels at the end of the year in both the shallow and the deep aquifer much higher than they were at the end of 2016. Detailed examination of these data shows that it is not only the amount of rainfall that is important; the intensity of rainfall and the previous soil moisture conditions are also really important factors when it comes to groundwater recharge, at least in these aquifers.

## 3. FundiFix Ltd partners with dōTERRA® to support agriculture-based livelihood programmes

***by Jacob Katuva***


***Jacob Katuva, Director of FundiFix Ltd, is conducting research in Kwale County towards his PhD at the University of Oxford as part of the Gro for GooD project with support from Base Titanium, UK Research Councils and DfID.***

Kwale County has a largely rural population (80%) with over 7 out of 10 people living below the poverty line of less than USD 1.25 a day. dōTERRA in collaboration with FairOils are responding to the need for improving the lives of farmers in Kwale County through agriculture-based livelihoods programmes. dōTERRA has a range of out-grower farming programmes that promote cultivation of ginger, tea tree and other high value crops in Kwale County. As a start, 240 farmers have been selected and supplied with seeds and other agricultural inputs to start farming during the long rains of March-June 2017.

FundiFix Ltd partnered with dōTERRA to establish a baseline understanding of the welfare of the 240 farmers, as well as to gather information on demographics, socio-economic status of households, and households' health status, water sources, water point management, water payments, water resources management, governance and political engagement. FundiFix used a questionnaire and methodology that built on previous surveys conducted by the Groundwater Risk Management for Growth and Development (Gro for GooD) research project, for which over 3,500 households were surveyed within Matuga, Msambweni and Lunga Lunga sub-Counties.

## Findings from dōTERRA® farmer survey

Result from the socio-economic survey of the 240 farmers revealed the following:

1. Less than 3% of all the farmers had college education. The highest level of education attained by majority of the farmers was primary education.

2. Over two thirds of all the farmers were categorized in the bottom welfare quintiles with the majority living in Pongwe, Boyani and Kiwegu.

3. The most pressing issues among the farmers were health, water, agriculture and education. The main concerns relating to health were medication and clinic fees being too high while the main concerns relating to water were distance to water sources being too long and poor water quality.

4. The main water sources for the majority of the farmers were unprotected wells, however, handpumps were very common in the Majoreni location.

5. About 1 in 5 farmers practiced rainwater harvesting in the wet season with more than a quarter of all the farmers relying on surface water sources in the wet season. Surface water sources were common in Pongwe and Boyani where over one third of the farmers depend on them.

Following this initial survey work, FundiFix continues to partner with dōTERRA to implement water related interventions and monitor socio-economic changes of the farmers over time using both face to face and mobile phone panel surveys. These data will be useful to assess impact of different interventions and inform policies related to poverty reduction and provision of safe drinking water for all.

# 4. Research report: How long should a handpump last?

***by Tim Foster***

***Dr Tim Foster conducted his PhD research on the sustainability of rural water services in Kwale during the development and early stages of the Gro for GooD project. Tim worked with 100 communities in Kwale, researching the operations and maintenance of handpumps and how funds were collected to undertake repairs. This article summarizes a series of scientific papers documenting his findings and providing useful insights into the factors affecting handpump breakdown.***

Having just published the fourth instalment in a series of papers examining rural water supply sustainability on the south coast of Kenya, it is timely to reflect upon some of the common threads that emerge from these related but separate studies. Throughout our investigations we have examined all sorts of factors which may affect rural water sustainability, including repair time, household financial contributions, revenue collection longevity, water source preferences, and - most recently - operational lifespan.

The research focused on Kwale County, which provided a unique setting for understanding the drivers and dynamics of rural water supply sustainability. The county played host to the first large scale deployment of the Afridev handpump, a now common technology in many African and Asian countries. The handpump installation programme, which ran for 12 years between 1983 and 1995, has since been held up as a 'gold standard' of rural water programming. As a result, a number of relatively rare data sources were available, including a consolidated set of installation records, water committee financial records dating back to the 1980s, and a good record of which handpumps continued to work and which did not.

The institutional starting point for operation and maintenance appears to have been relatively consistent throughout Kwale County's long-running handpump installation programme, allowing this research to assess how environmental and geographic factors affect operational outcomes. Despite the relatively small area in which more than 500 handpumps in Kwale are situated, our results have consistently shown that groundwater characteristics and settlement patterns play an important role in shaping the long term prospects of community water supplies. For example, the likelihood of premature failure was higher for handpumps that supplied water with elevated electrical conductivity (a measure of salinity), pumped water from greater depths, and were underlain by unconsolidated sands.

The association with salinity probably reflects a user satisfaction issue: people may not want to pay for ongoing maintenance of a handpump when the water tastes salty. Indeed, we found that palatability (taste) was a significant determinant of whether or not a household would pay their monthly fees as well as their decisions about which water source to use. By contrast, the relationships with depth and geology signify differences in the maintenance requirements and the associated financial burden of keeping the handpump in working condition.

Location of the water point also matters. The closer a community was to spare part suppliers, the lower the risk of failure. This could be directly linked to the costs of obtaining spares (e.g. travel) - or there may be other socio-economic reasons. The proximity of a water point to user households was also found to be a key driver of household contribution rates and water source choices.

These findings show us that there are a variety of environmental and geographic challenges to keeping water supply systems working, and communities are each dealt a different hand. Some factors - such as salinity - may undermine the willingness of users to pay to maintain the system; other factors - such as groundwater depth or distance to spare parts - may make it more difficult or expensive to do so. It is thus little wonder that rural water supply outcomes are mixed, even if the quality of implementation is high.

Service delivery models can be designed to address these very issues. For example, in Kwale County, FundiFix offer a maintenance scheme with a regular tariff structured so that communities with pumps that are likely to break due to difficult hydrogeology pay the same amount for a maintenance service as those communities enjoying less difficult conditions. A similar scheme has been running for more than two decades in Turkana, a region in Northern Kenya that presents extremely challenging conditions for rural water supply operation and maintenance. While these initiatives are themselves the subject of ongoing research, early evidence suggests they can address the issues relating to more difficult operating conditions. However, overcoming differences in willingness to pay due to variations in water quality is problematic.

Ultimately, the data from Kwale shows that under favourable conditions, handpumps can last more than 25 years. The trick then is how to achieve similarly long-lasting supplies for communities with more troublesome operating environments. Addressing this challenge is essential if the global target of safe water for all is to be met.

## 5. Back to school: The future of water starts here

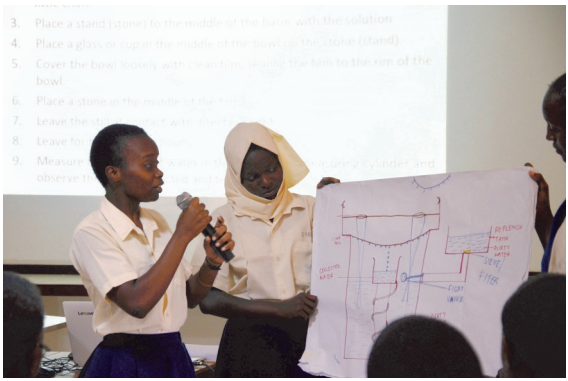
***Event held on 17th March to celebrate a successful educational collaboration between researchers, schools, local government and private sector partners***

The Gro for GooD project and Base Titanium have been delivering a programme of engagement to teach young people in Kwale County about water science and management. Water clubs at three secondary schools have been participating in field trips, practical activities, experiments and conducting their own group research projects. This outreach work has developed students' research and communication skills and provided a showcase of career options in the water sector.

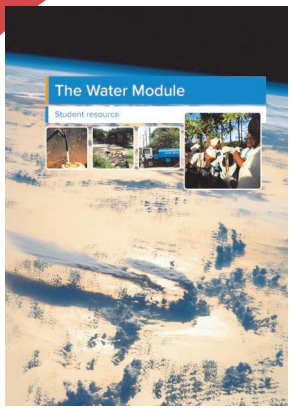
In the run up to World Water Day 2018, the project was delighted to welcome Madam Bridget Wambua, Director of Education for Kwale County, Kenya, to provide opening remarks at a special event to celebrate the success of the school water clubs supported by the project over the last year. At Leopard Beach Hotel Conference Centre, students listened with great interest to the keynote speech by Prof. Dan Olago from the University of Nairobi and then took to the stage themselves for a series of presentations about club activities including water quality testing of school waterpoints, installation and data collection from rain-gauges on school grounds led by Rural Focus Ltd, and field trips to the Base Titanium mine to see how the mine manages and recycles water in its operations.


Other students presented their own mini-research projects into topics such as strategies for keeping water safe to drink and water conservation in agriculture, and one group gave an excellent explanation of artesian wells based on an email exchange with Gro for GooD hydrogeologist Mike Lane. Students also brought practical demonstrations and posters prepared at school to show in the teabreak, including a solar still demonstration from a group who had just heard they've been invited to show their improved solar still design at the next round of Kenya's National Science Fair for schools.

Madam Wambua and Prof. Olago then presented the schools, water clubs and club patrons with certificates of appreciation for their hard work and dedication to water-related environmental education, and two laptops were given to each club. The laptops were provided by the UK charity IT Schools Africa and were preloaded with water-related environmental education resources collated by the Gro for GooD team.



***Top: Madam Wambua and Prof. Dan Olago present certificates; Left: Solar still design presentation; Right: Students preparing a demonstration of sedimentation with moringa seed and alum at school (Photos: Gro for GooD project)***




***New educational resource developed by the Gro for GooD team to increase understanding of groundwater and water quality***

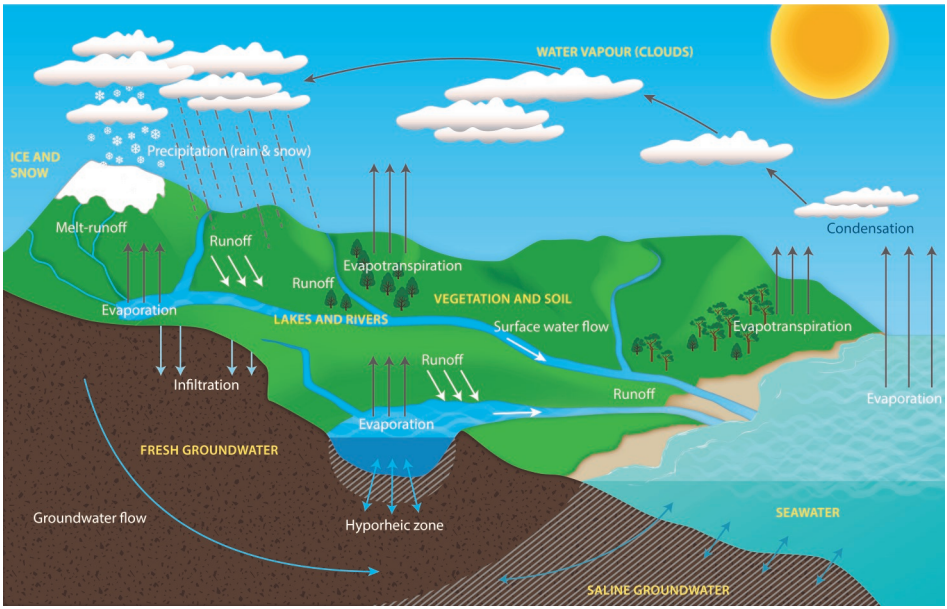
Students involved in the project have also received print copies of a newly published Water Module Student Resource which was developed by the Gro for GooD research team with input from students and teachers at the schools. Mr Joseph Kimtai, teacher and club patron at Kingwede Girls Secondary School, said, *"I find this module of activities about water so helpful to the students – it complements what we are teaching in class. It also encourages critical thinking and solving problems related to the environment which is in line with one of the competencies of the incoming competency-based curriculum for Kenyan schools. We want to widen the scope of the next module so that we include more content but still draw from what has been prescribed by the Ministry of Education."*

The resource has been published under a Creative Commons licence so that other educational programmes in Kenya can make use of the content.

Water Module editor, Nancy Gladstone, said: "*It has been a privilege to work with secondary school students in Kwale County and help to meet their really encouraging thirst for knowledge about water. Education has a vital role in achieving the Sustainable Development Goal for water and we are sure that many of these students will put their learning to good use at school and as they go on to jobs and further education.*

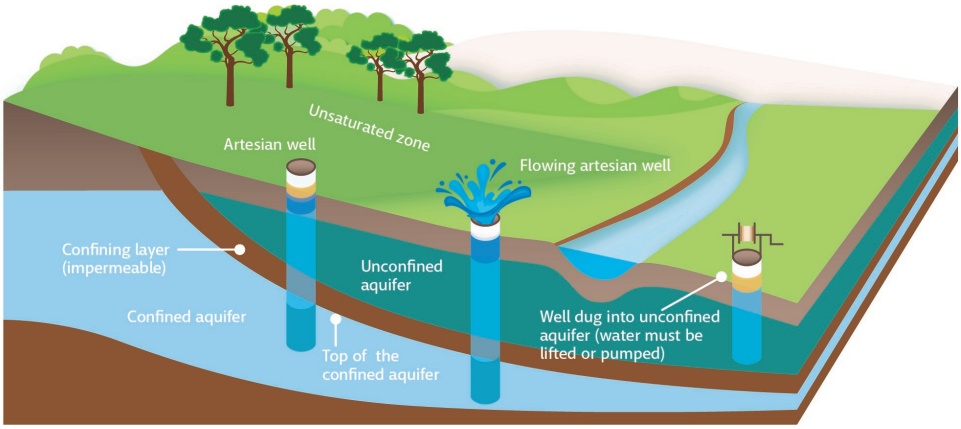
*"The Water Module event also provided us with an opportunity to thank the teachers, headteachers and local partner organisations such as Base Titanium and Rural Focus Ltd who have all been critical to the success of the clubs this past year, and to contribute to discussions about building the water module into ongoing education programmes in Kwale County, both formal and informal, so as to reach more students and further enhance learning."*

*Students at Shimba Hills Secondary School reading the Water Module Student Resource*




*The Water Cycle as shown in the Water Module Student Resource*

**What is an aquifer?** When groundwater in the saturated zone can flow through interconnected spaces we call this zone an aquifer. Aquifers are groundwater resources that people can take water out of. Although the aquifers in the diagram above look like big caves of water, remember they are full of sediment and rock and the water is stored in the spaces between these materials. (Diagram based on USGS 2016).

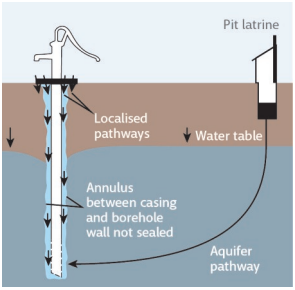



## Protecting groundwater from pollution

Protecting groundwater requires consideration of both aquifer and localised pathways. To be effective, water protection requires communities to work together. The first thing to do is identify all the possible sources of pollution in the area and then try to keep the pollutants away from the water. These are some important steps that communities can take:

- Keep the area around the water source as clean as possible (remove garbage, faeces and other types of pollutants so that they cannot be washed into the well/borehole)
- Build latrines away from and downhill of water sources
- Use latrines and avoid open defecation especially near water sources
- Build fences to prevent large animals from going near water sources
- Build animal pens away from water sources
- Build good drainage channels around taps and pumps so that water does not form pools in which pathogens can collect and then infiltrate into the groundwater
- Use concrete to cover the area around handpumps and wells so that surface water cannot flow directly into the well through the surrounding ground
- Use clean buckets to collect water

It is important to remember that this is an ongoing task. To protect water, communities need to always be aware of any potential pollutants and be careful to keep them away from the water. The most common and harmful pollutant is often human and animal faeces.




**Two pathways to groundwater pollution.**

Note: The 'casing' is the pipe that is installed into the borehole which has holes at the bottom to let the water in; the 'annulus' is a ring-shaped hole that forms between the sides of the drilled hole and the pipe/casing. The annulus is supposed to be blocked up with special material to stop water from travelling down it, but sometimes this is not done properly (Lawrence et al. 2001).

# 6. REGIONAL AND INTERNATIONAL PUBLICITY AND COLLABORATION

- Since 2015, the Gro for GooD project has convened three public stakeholder workshops in Kwale County with over 50 attendees at each event representing local institutions and communities. A final stakeholder workshop will be held on 22nd November 2018.
- In September 2017, Kenyan PhD student Jacob Katuva presented research from the Gro for GooD project at the International Association of Hydrologists' 44th Annual Congress on Groundwater Heritage and Sustainability in Dubrovnik, Croatia.
- Gro for GooD co-Investigator, Professor John M. Gathenya of Jomo Kenyatta University of Agriculture and Technology (JKUAT) was awarded a Senior Fellowship at the School of Civil and Environmental Engineering of the Technical University of Dresden, Germany, making two visits to Dresden in 2017 to participate in conferences and contribute to postgraduate education at the institute.

## Gro for GooD Research Publications


Koehler, J. (2018) Koehler, J., Rayner, S., Katuva, J., Thomson, P. and Hope, R. (2018). **A cultural theory of drinking water risks, values and institutional change.** Global Environmental Change, 50, pp.268-277.

Koehler, J. (2018). **Exploring policy perceptions and responsibility of devolved decision-making for water service delivery in Kenya's 47 county governments**, Geoforum, 92, pp.68-80

Foster, T., J. Willets, M. Lane, P. Thomson, J. Katuva, R. Hope (2018) **Risk factors associated with rural water supply failure: A 30-year retrospective study of handpumps on the south coast of Kenya**, Science of the Total Environment 626 (2018) 156-154

Colchester, F. E. , Marais H. G. , Thomson P., Hope, R., Clifton D. A. (2017) **Accidental infrastructure for groundwater monitoring in Africa**, *Environmental Modelling & Software* 91 (2017) 241 – 250

Unlocking the Potential of Groundwater for the Poor

**Groundwater risk management for growth and development**

**For feedback or follow up on any items in this newsletter, please contact:**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**Project partners**

Kwale County Government

Oxford University

Jomo Kenyatta University

University of Nairobi

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