Groundwater Risk Management for Growth and Development (Gro for GooD)

FINAL STAKEHOLDER WORKSHOP
Leopard Beach Hotel, Kwale County, Kenya
22nd November, 2018

TIME	TOPIC	SPEAKER/CHAIR
09h00	Introduction and Objectives	Eng. Mike Thomas (RFL)
	Opening Remarks	Hon. Mwabudzo, CEC Water, Kwale County Government
	Policy recommendations	Prof. Rob Hope (Oxford)
09h30 – 10h00	New knowledge on potential of Msambweni Aquifer.	Prof. Dan Olago (UoN)
10h00 – 10h30	Groundwater modelling for groundwater resource management	Dr. Albert Folch (UPC)
10h30 – 11h00	Improving rural welfare.	Jacob Katuva (Oxford)
Tea Break		
11h30 – 12h30	Plenary Discussion of findings	Prof. Bancy Mati (JKUAT)
12h30-12h45	Summary of Discussion	Prof. John Gathenya (JKUAT)
12h45-13h00	Priorities Exercise	Eng. Patrick Thomson (Oxford)
Lunch Break		
14h15-15h45	From Research into Action	Prof. Dan Olago (UoN)
15h45-16h00	Closing Remarks	Prof. Rob Hope (Oxford)

UPGro is a seven-year international research programme (2013-2020) focused on improving the evidence base around groundwater availability and management in Sub-Saharan Africa (SSA) to enable developing countries and partners in SSA to use groundwater in a sustainable way in order to benefit the poor.

The UPGro Programme has two phases.

The **Catalyst Phase** (2013-2015) comprised 15 one-year projects, undertaken in 14 countries.

The **Consortium Phase** (2015-2019) comprises five projects working across nine countries.

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

Gro For GooD
Groundwater Risk Management for Growth and Development

GroFutures
Groundwater Futures in Sub-Saharan Africa

Hidden Crisis
Unravelling current failures for future success in rural groundwater supply

T-GroUP
Experimenting with practical transition groundwater management strategies for the urban poor in Sub-Saharan Africa

NERC SCIENCE OF THE ENVIRONMENT

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

UKaid from the British people

Project Overview

2015-19, Kwale County, Kenya

Project hypothesis:

Competing groundwater use (commercial, community, ecosystem) requires new tools to understand risks from natural and human-induced changes. Kwale's rapid growth in mining and irrigated agriculture present opportunities for growth if government can evaluate groundwater risks to respond at scale.

Project outputs

The project aimed to support interdisciplinary science and governance of managing groundwater risks for growth and development in Africa:

1. A new Groundwater Risk Management Tool to support government regulation and management in Kenya.

2. An automated, daily monitoring network for shallow groundwater levels.

3. Improved theory and evidence linking groundwater governance to poverty and health dynamics and outcomes.

Project Partners

Study Area

UNDERSTANDNG GW & WELFARE

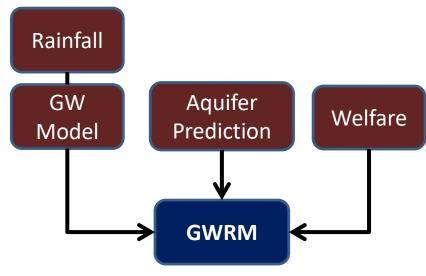| Rainfall & Climate	• Rainfall TS • Climate TS
Hydrological Model	• River Flow TS • Land use / Soils • Abstractions
Geophysics	• VES survey • ERT Surveys • Geological survey
GW Model	• Aquifer WL TS • Abstractions
GWQ Model	• WQ surveys
Welfare	• HH Surveys • Mobile surveys
Health	• Disease incidence
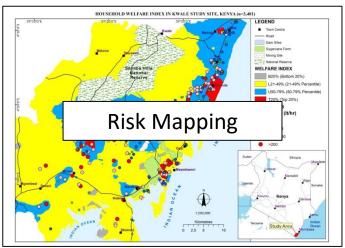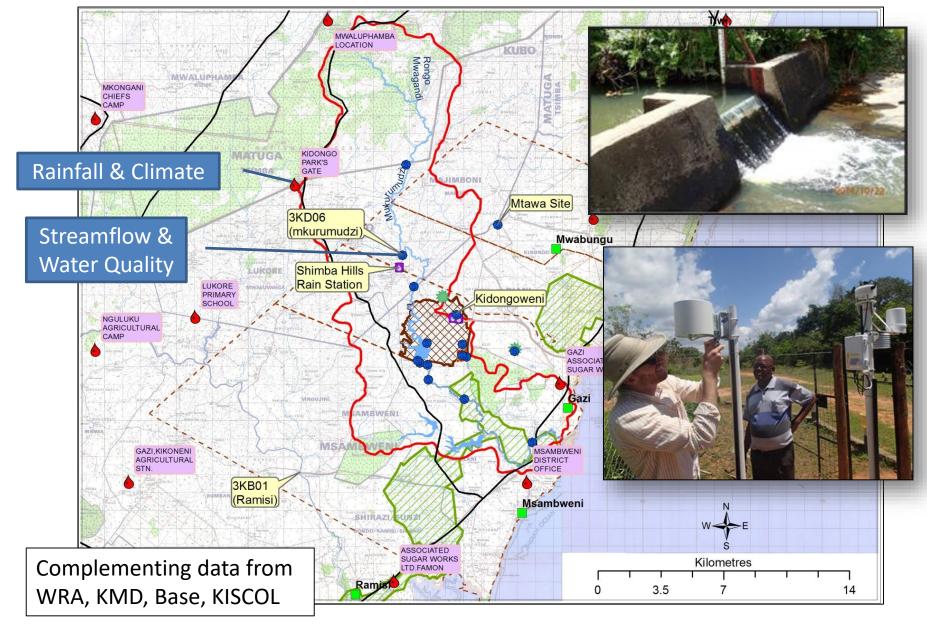
GROUNDWATER RISK MANAGEMENT

Rainfall

GW Model → GWRM ← Aquifer Prediction

Welfare → GWRM

Risk Mapping
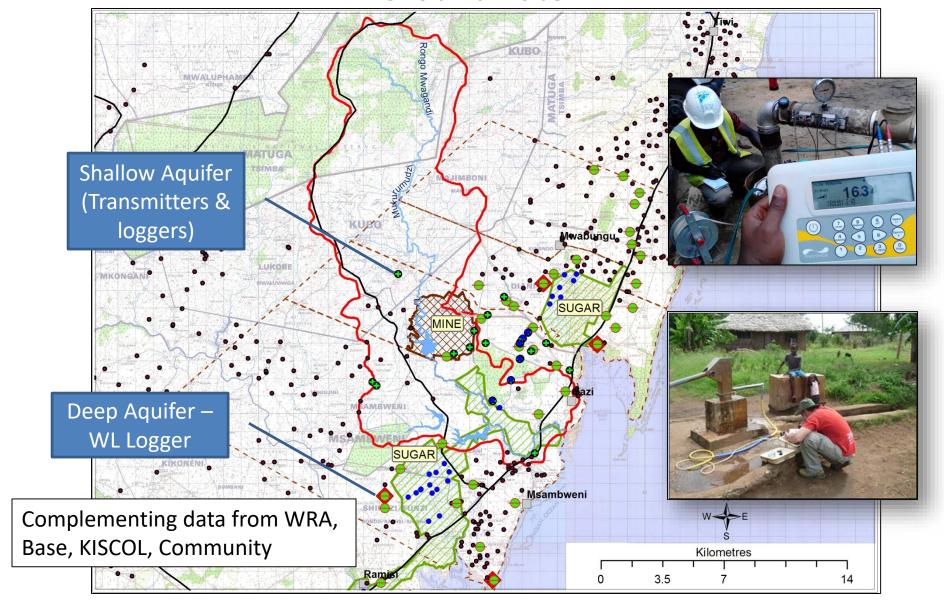
Environmental Monitoring Network
– Surface Water & Climate

Rainfall & Climate

Streamflow & Water Quality

MWALUPHAMBA LOCATION

MKONGANI CHIEFS CAMP

KIDONGO PARK'S GATE

3KD06 (mkurumudzi)

Mtawa Site

Mwabungu

Shimba Hills Rain Station

LUKORE PRIMARY SCHOOL

Kidongoweni

NGULUKU AGRICULTURAL CAMP

GAZI ASSOCIAT SUGAR W

Gazi

GAZI,KIKONENI AGRICULTURAL STN.

MSAMBWENI DISTRICT OFFICE

3KB01 (Ramisi)

Msambweni

ASSOCIATED SUGAR WORKS LTD.FAMON

Ramisi

Complementing data from WRA, KMD, Base, KISCOL

Kilometres

0   3.5   7   14

Environmental Monitoring Network
- Groundwater

Shallow Aquifer (Transmitters & loggers)

Deep Aquifer – WL Logger

Complementing data from WRA, Base, KISCOL, Community

New Knowledge on the Potential of the Msambweni Aquifer: Paleochannels and Fractured Sandstones

D. Olago, J. Odida, M. Lane and Others

KEY RECOMMENDATIONS

- Investing in groundwater studies avoids costly investment mistakes

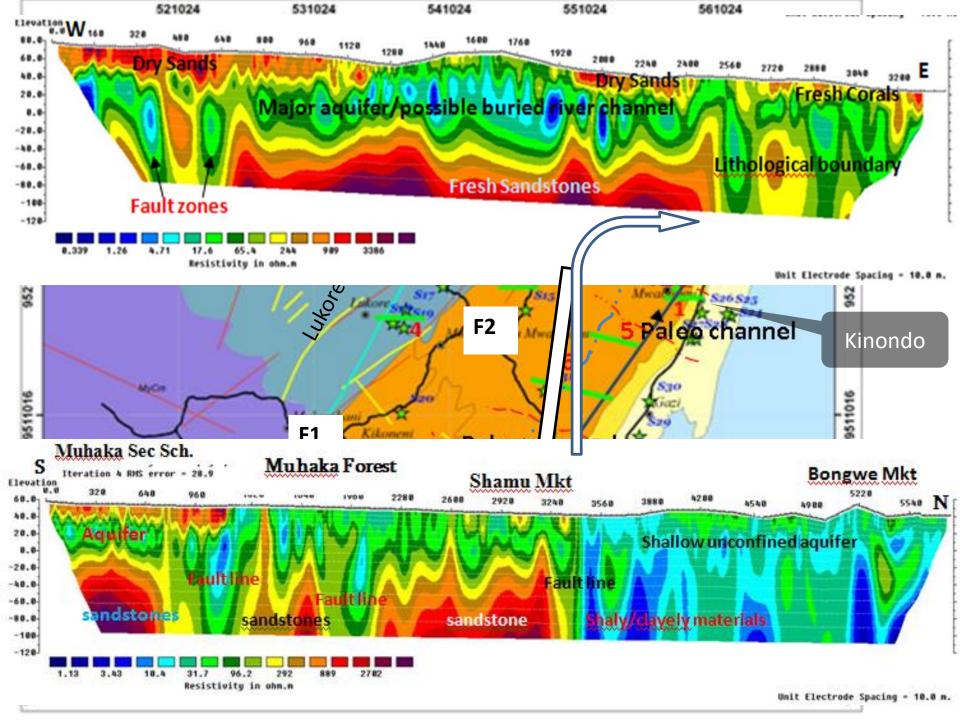- The palaeochannel aquifers can make a significant contribution to local water supplies

Geology

- **Typical approach:**
- Limited literature review
- Assess old geological maps for rock type and structures
- Preliminary determination of aquifer potential
- Mobilise geophysical equipment

- **Project approach:**
- Detailed literature review
- Assess geological map for rock type, structures
- Carry out detailed field mapping
- Update geological map
- Assess rock properties
- Evaluate observable geographical and soil features
- Assess the regional-local geo-evolutionary trend
- Determine aquifer potential & inform on geophysics sites
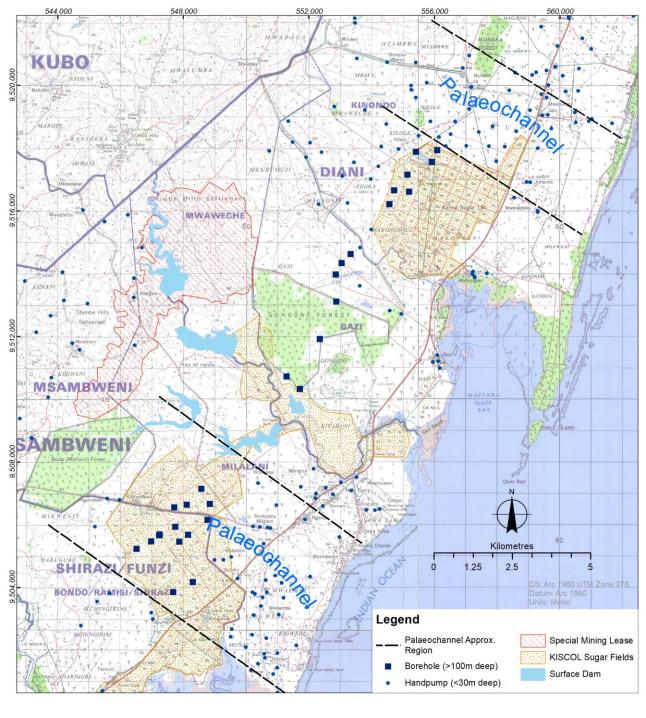
Geophysics

- Typical approach:
- Mobilise geophysical equipment
- Carry out VES / ERT at a point location
- Data interpretation
- Reporting

- Project approach:
- Mobilise geophysical equipment
- Carry out VES in spatial grid pattern
- Carry out long ERT transects (E-W and N-S profiles)
- 1-D and 2-D data interpretation
- Synthesise with geology findings

Findings

Southern Palaeochannel:
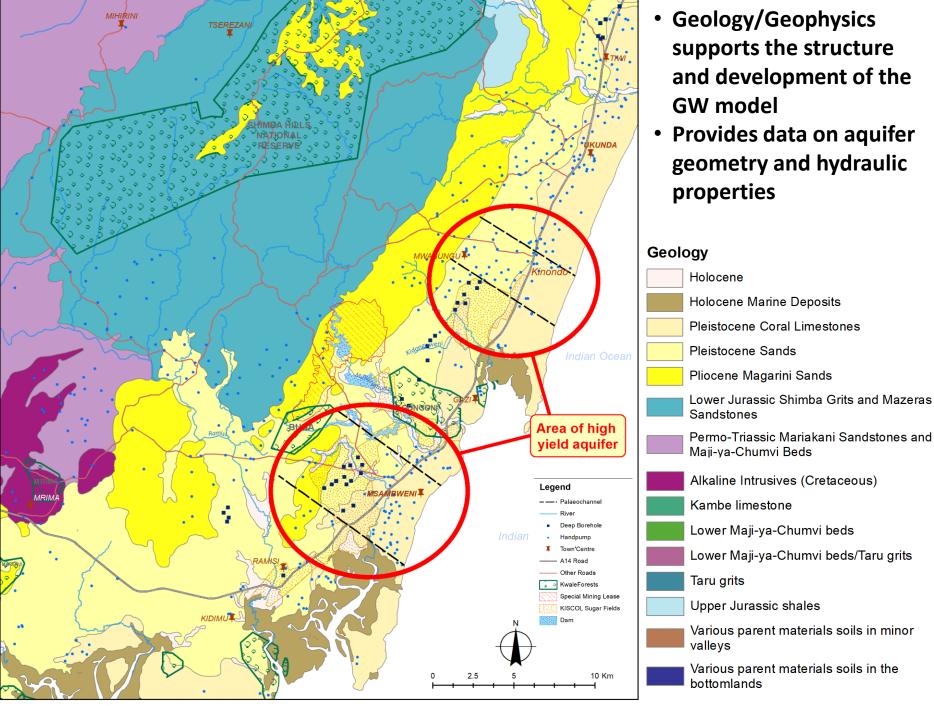- Milalani wellfield
- High yielding boreholes

Northern Palaeochannel:
- Kinondo area
- Large no. of shallow wells
- Need a deep test borehole

Between palaeochannels:
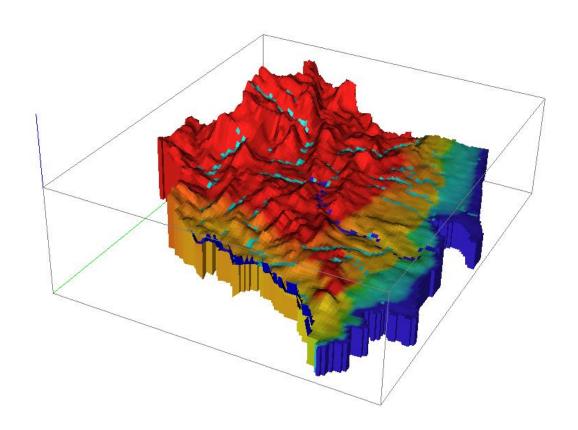- Base boreholes
- Productive fractured sandstones

- **Geology/Geophysics supports the structure and development of the GW model**
- **Provides data on aquifer geometry and hydraulic properties**

Area of high yield aquifer

Geology

- Holocene
- Holocene Marine Deposits
- Pleistocene Coral Limestones
- Pleistocene Sands
- Pliocene Magarini Sands
- Lower Jurassic Shimba Grits and Mazeras Sandstones
- Permo-Triassic Mariakani Sandstones and Maji-ya-Chumvi Beds
- Alkaline Intrusives (Cretaceous)
- Kambe limestone
- Lower Maji-ya-Chumvi beds
- Lower Maji-ya-Chumvi beds/Taru grits
- Taru grits
- Upper Jurassic shales
- Various parent materials soils in minor valleys
- Various parent materials soils in the bottomlands

Legend

- Palaeochannel
- River
- Deep Borehole
- Handpump
- Town'Centre
- A14 Road
- Other Roads
- KwaleForests
- Special Mining Lease
- KISCOL Sugar Fields
- Dam

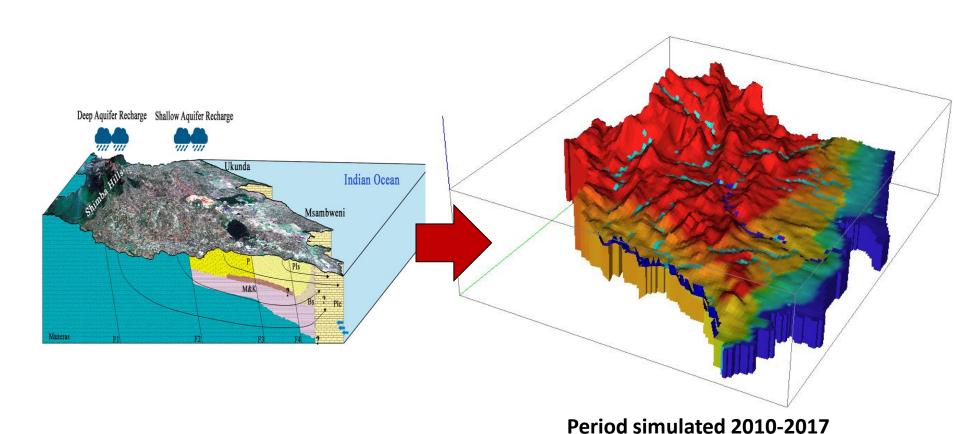# Groundwater modelling

Barcelona and Kenyan team

Why you need a groundwater model?

Sustainable allocation of the Msambweni aquifer requires a groundwater model. These can answer questions such as the following:

- ✓ How will pumping affect groundwater levels in the future?
- ✓ Can deep aquifer pumping affect shallow aquifer levels?
- ✓ How will land use change affect groundwater levels and discharge in to streams and the sea?
- ✓ How will water management decisions related to water diversions affect groundwater levels?
- ✓ How will climate change affect groundwater levels and groundwater discharge?
- ✓ What is the capture area of a new community borehole?
- ✓ …
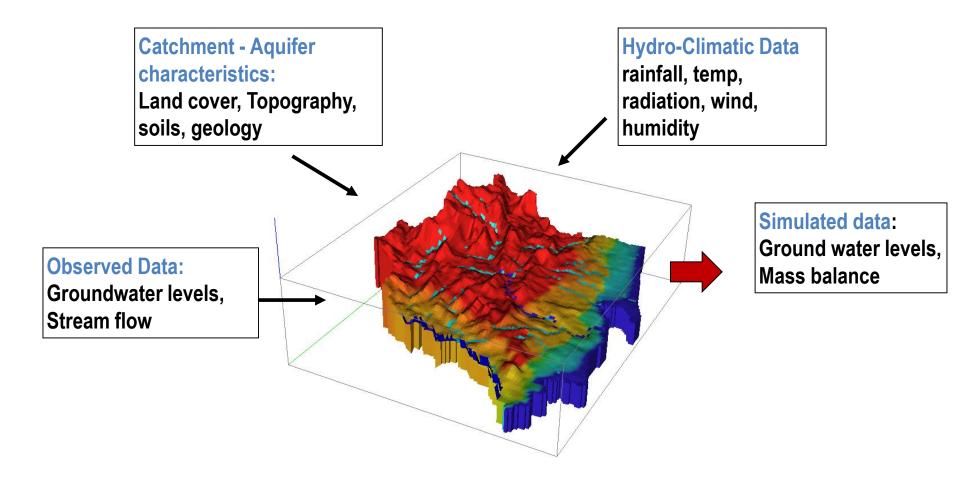
This are only some examples of the **many questions that can be answered** with a good groundwater model

What is a groundwater model?

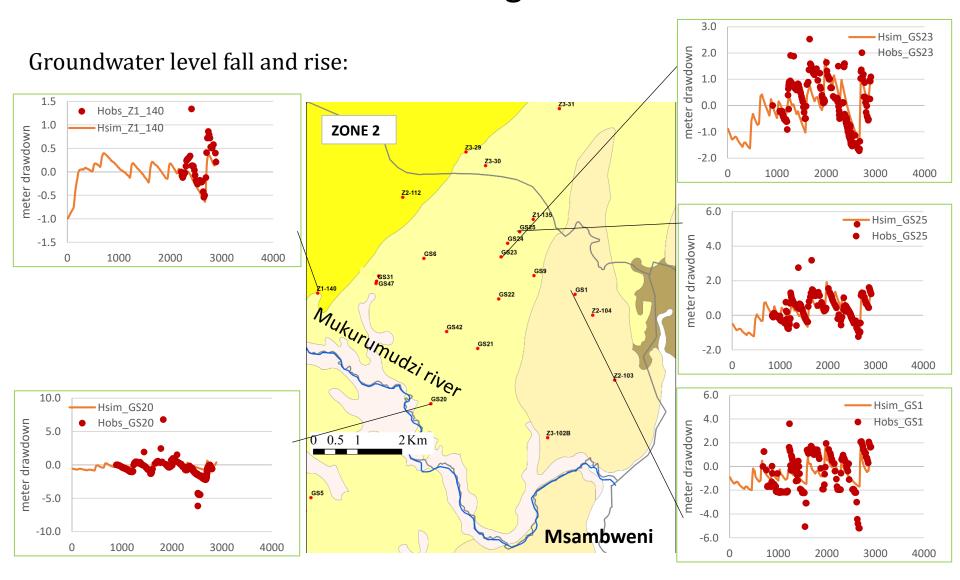**Period simulated 2010-2017**

We use different types of data to simulate the evolution of groundwater levels and the water balance (recharge, stream interaction, abstraction, etc.)
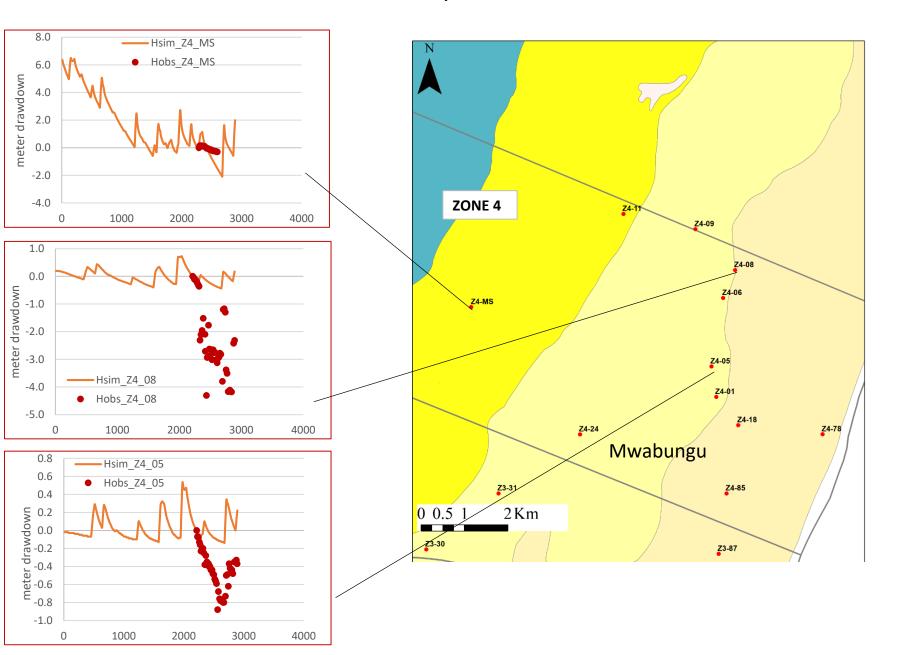
Models require data and monitoring

Catchment - Aquifer characteristics:
Land cover, Topography, soils, geology

Hydro-Climatic Data
rainfall, temp, radiation, wind, humidity

Observed Data:
Groundwater levels, Stream flow

Simulated data:
Ground water levels, Mass balance

Inter-agency collaboration on data collection and sharing is vital.

Models can simulate groundwater levels

Groundwater level fall and rise:

Model fits best in Zones 2 and 3 (where most abstraction occurs)

Where data are limited, models are less accurate

Model findings

1. Aquifer recharge is the most important variable affecting groundwater levels:

   - The lowest recharge is observed during the 2016 (La Niña) event, leading to the lowest groundwater water levels
   - Both rainfall distribution and intensity across wet seasons has an important impact on recharge

2. Current levels of groundwater abstraction represents between 1% (average year) and 4% (La Niña year) of recharge ⇒ under current climatic and abstraction conditions the system is sustainable.

3. More hydrogeological data are required in parts of Zone 1 (Magarini sands) and Zone 4 (both Kilindini and Margarini sands) to improve the model.

The model allows us to run future potential scenarios.

Scenario Development

Change Scenarios
- ❑ Nature and extent of change
- ❑ Plausible but significant change to test system response
- ❑ Persistence with GW system

Type of Change
- ✓ Extreme dry/wet rainfall
- ✓ Temperate Increase
- ✓ Increase in GW Abstraction
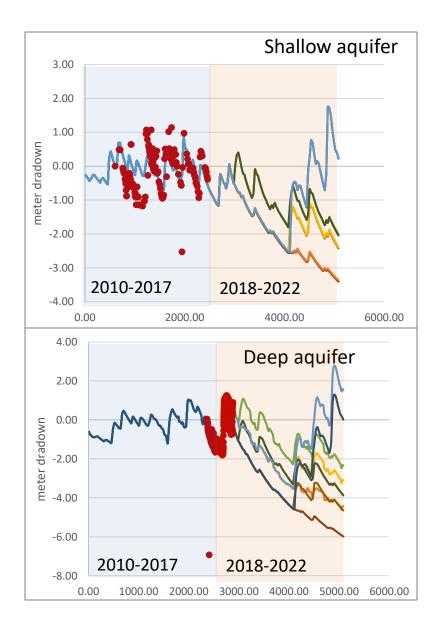- ✗ Sea level rise

Provides a range of different scenarios

Timeframe for Modeling Change Scenario

| 2010 - 2017 | 3 Yrs Change | 3 Yrs Recovery |

Findings of scenario modelling

Shallow aquifer

Deep aquifer

- Two successive very dry years cause a significant decline in groundwater level in the shallow aquifer ⇒ **Initiating a programme of deepening hand-dug wells which are at risk of going dry during drought periods.**

- Increased groundwater abstraction from the deep aquifer does not affect levels in the shallow aquifer .

- A wet period shorter than a previous drought period leads to the recovery of the groundwater system.

- Abstraction from the deep aquifer delays water level recovery in the deep aquifer after a drought period.
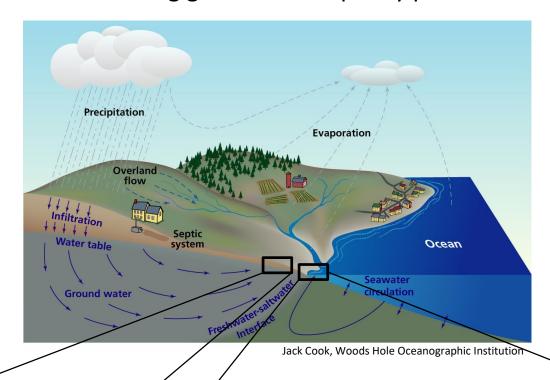
Recommendations to reduce impacts of drought

Managing future droughts periods requires planning now.

Ensuring inter-agency collaboration on data collection and sharing to improve drought early warning.

Groundwater quality

One of the areas showing groundwater quality problems is the coast

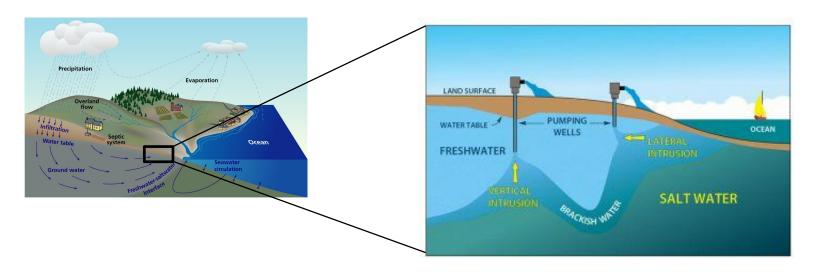Jack Cook, Woods Hole Oceanographic Institution
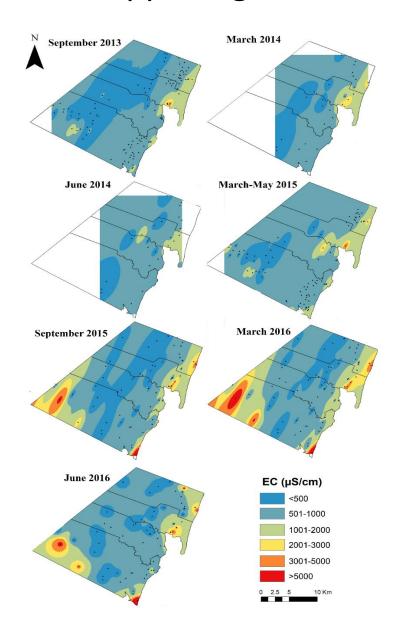
Water Resources

Submarine Groundwater Discharge (SGD)
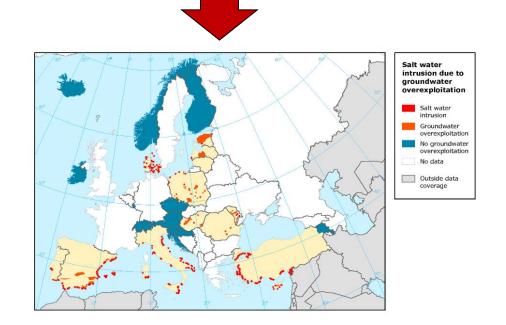
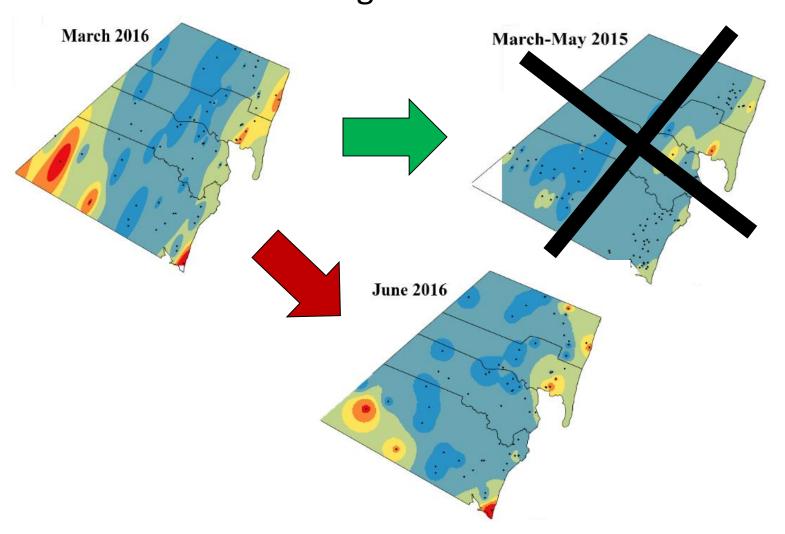# Pumping with no control areas can induce salinization

Saltwater intrusion is a global problem … (e.g. in Europe, left).
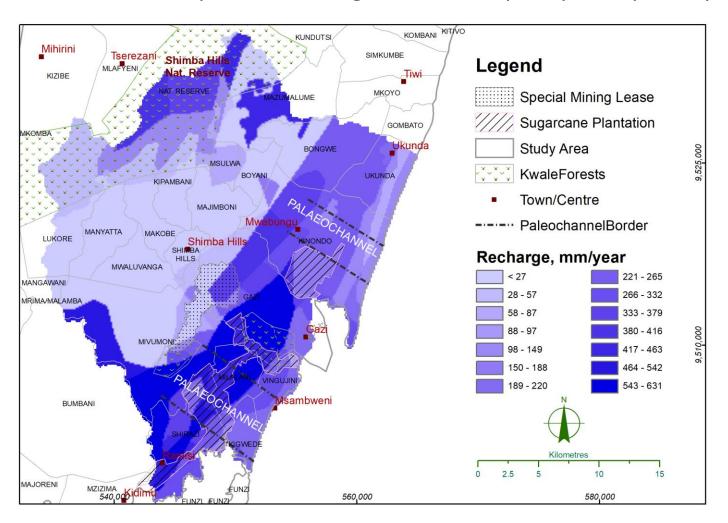
What's happening in Kwale?

Drought as la Niña does allow the system to recover during wet season

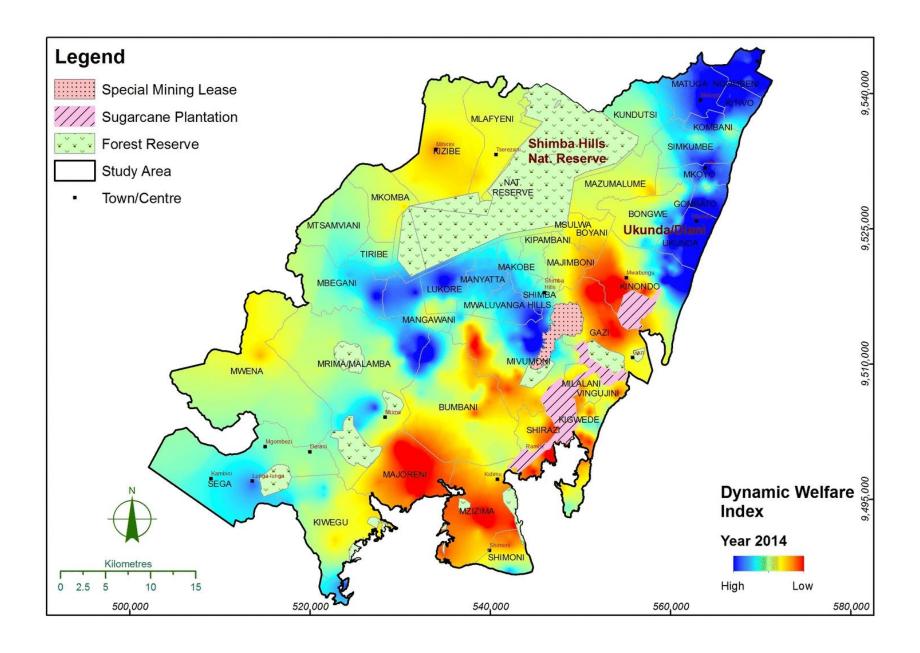**Unregulated groundwater use may lead to saline intrusion in the coastal aquifer.**

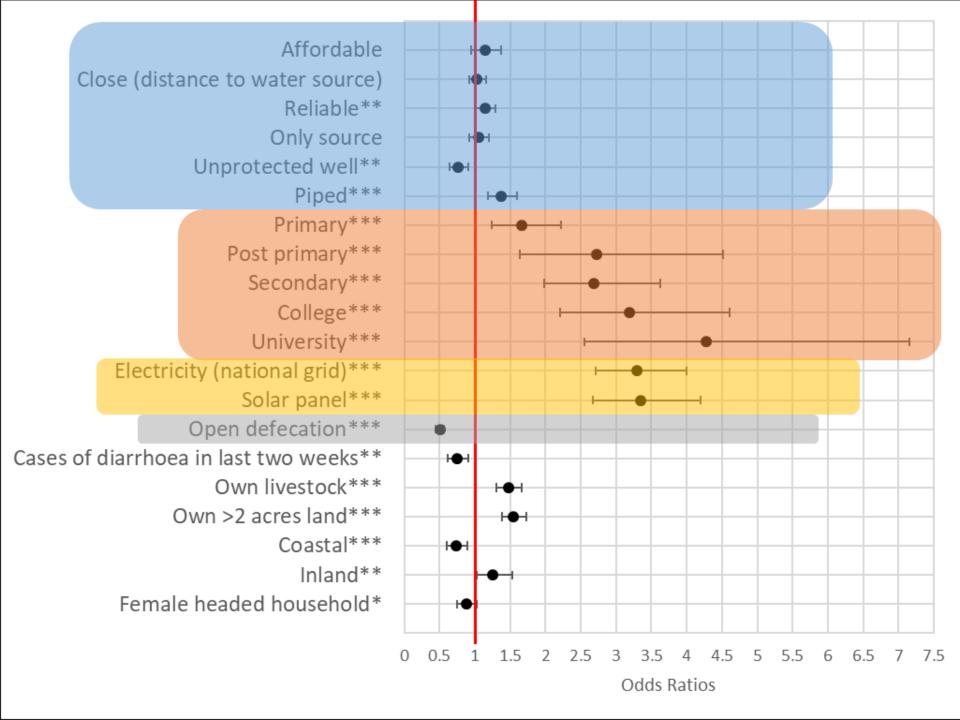# Groundwater recharge areas must be protected.

This would help to conserve groundwater quality and quantity

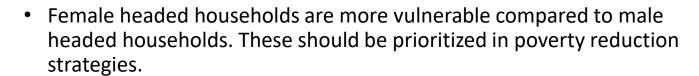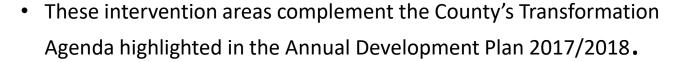A Kenyan example is the Lamu Water Catchment Area.

Social analysis to guide interventions to improve welfare

Legend

- ⬚ Special Mining Lease
- ▨ Sugarcane Plantation
- ⬚ Forest Reserve
- ▢ Study Area
- ■ Town/Centre

Shimba Hills Nat. Reserve

Ukunda/Diani

MATUGA NGOMBENI
KITIVO
KOMBANI
SIMKUMBE
KUNDUTSI
MLAFYENI
Mihirini
KIZIBE
Tserezani
NAT. RESERVE
MAZUMALUME
MKOMBA
MKOYO
GOMBATO
BONGWE
MTSAMVIANI
MSULWA BOYANI
UKUNDA
KIPAMBANI
MAKOBE
TIRIBE
MANYATTA
MAJIMBONI
Shimba Hills
Mwabungu
LUKORE
SHIMBA
KINONDO
MBEGANI
MWALUVANGA HILLS
MANGAWANI
GAZI
Gazi
MRIMA/MALAMBA
MIVUMONI
Mrima
MILALANI VINGUJINI
MWENA
KIGWEDE
Mgombezi
Derani
SHIRAZI
Ramisi
Kambini
SEGA
Lunga-lunga
BUMBANI
MAJORENI
Kidimu
KIWEGU
MZIZIMA
Shimoni
SHIMONI

Dynamic Welfare Index

Year 2014

High Low

Kilometres
0 2.5 5 10 15

500,000   520,000   540,000   560,000   580,000

9,540,000
9,525,000
9,510,000
9,495,000

Odds Ratios

Results highlight four interventions to improve welfare

- **Promote higher education attainment.**

- **Increase household energy access.**

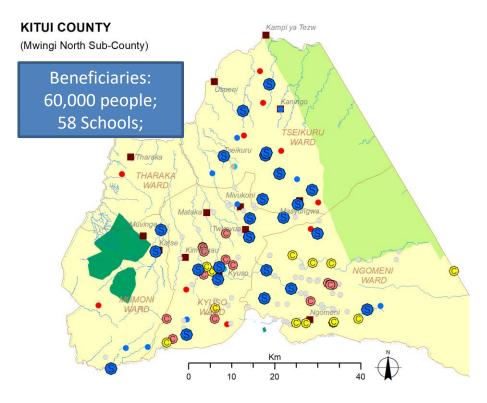- **Improve drinking water services.**

- **End open defecation.**

- Female headed households are more vulnerable compared to male headed households. These should be prioritized in poverty reduction strategies.

- These intervention areas complement the County's Transformation Agenda highlighted in the Annual Development Plan 2017/2018.
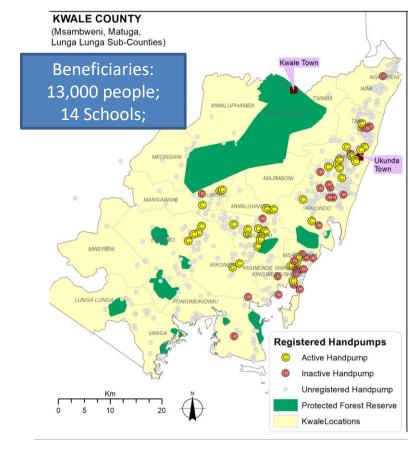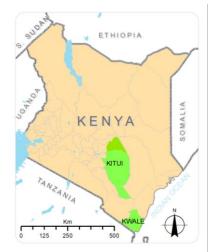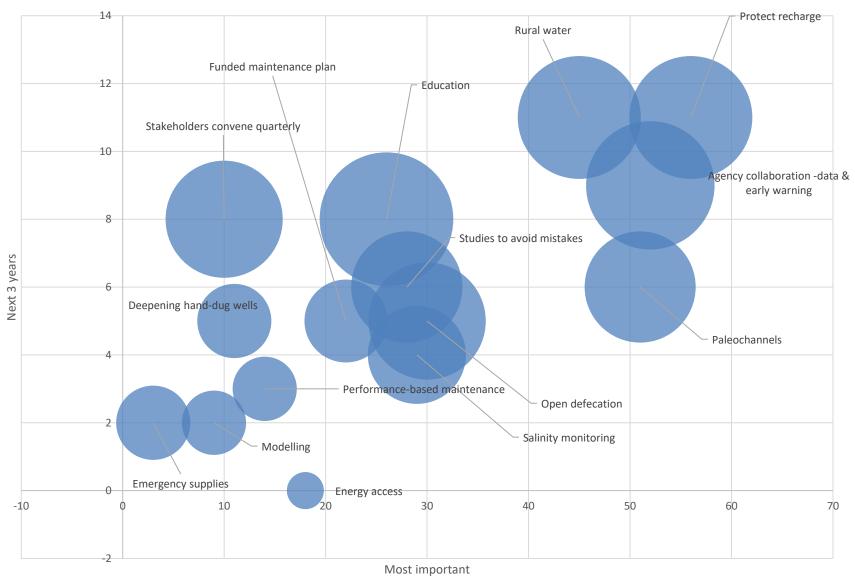
FundiFix – Local entrepreneurs powered by smart data

Stakeholder priorities to which of the 15 policy recommendations are most important versus achievable in next 3 years

Note – bubble size indicates priority by cumulative participant ranked score.
Participants were not representative of all thematic areas. Results are indicative only.

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