Sourcing of sustainable groundwater supplies: An assessment of a weathered crystalline rock aquifer system, southwest-central Uganda

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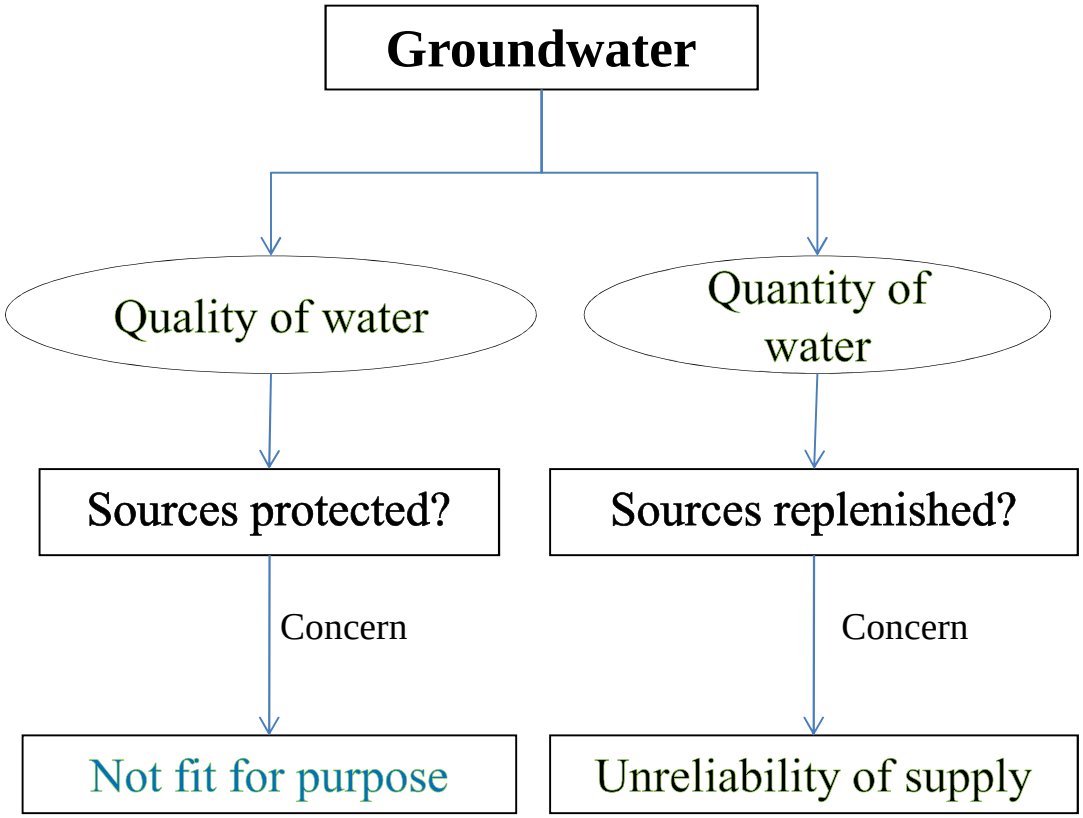
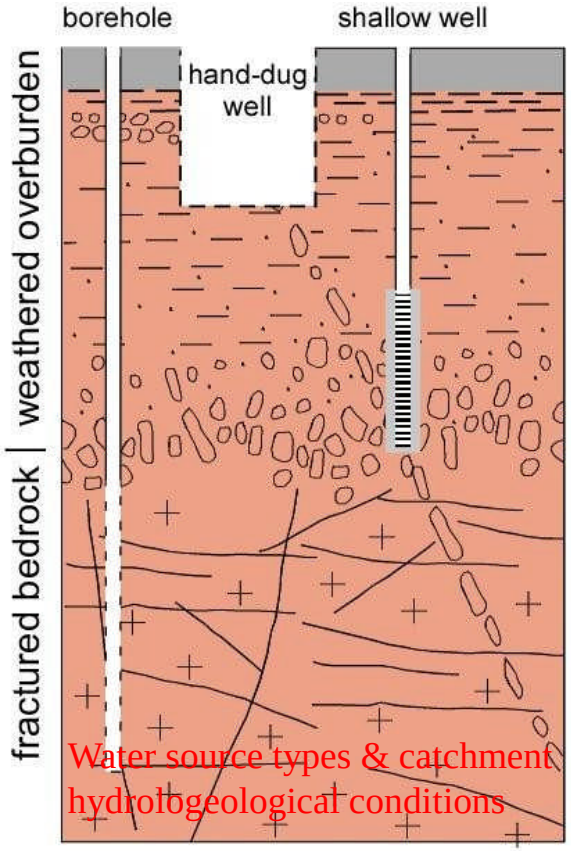
Research overview-Key words

- Sustainability issues



- Groundwater supplies



- Remember ≈79 percent of 27.6 million people in rural Uganda depend on groundwater source types and most of them shallow.

Groundwater quantity-Introduction

➢ Aim

❑ The study is to calculate a water balance for a weathered crystalline rock aquifer system under current and future climatic conditions

➢ Specific objectives

❑ To install field instrumentation and undertake monitoring

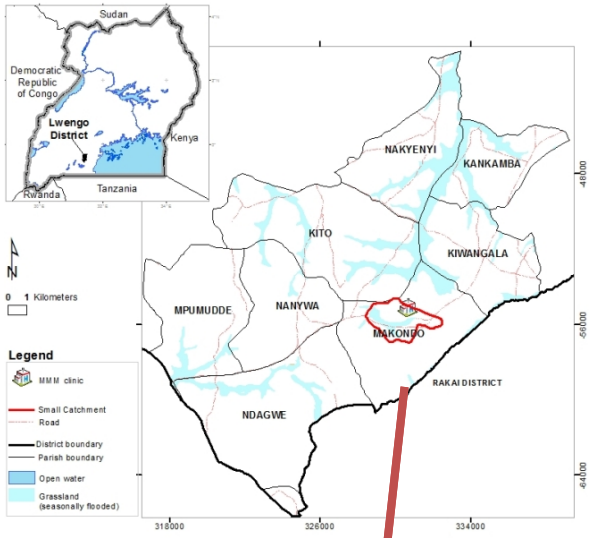
❑ To select an appropriate hydrological model for use

❑ To compare the use of different evapotranspiration calculation methods on water balance outputs under current climatic conditions

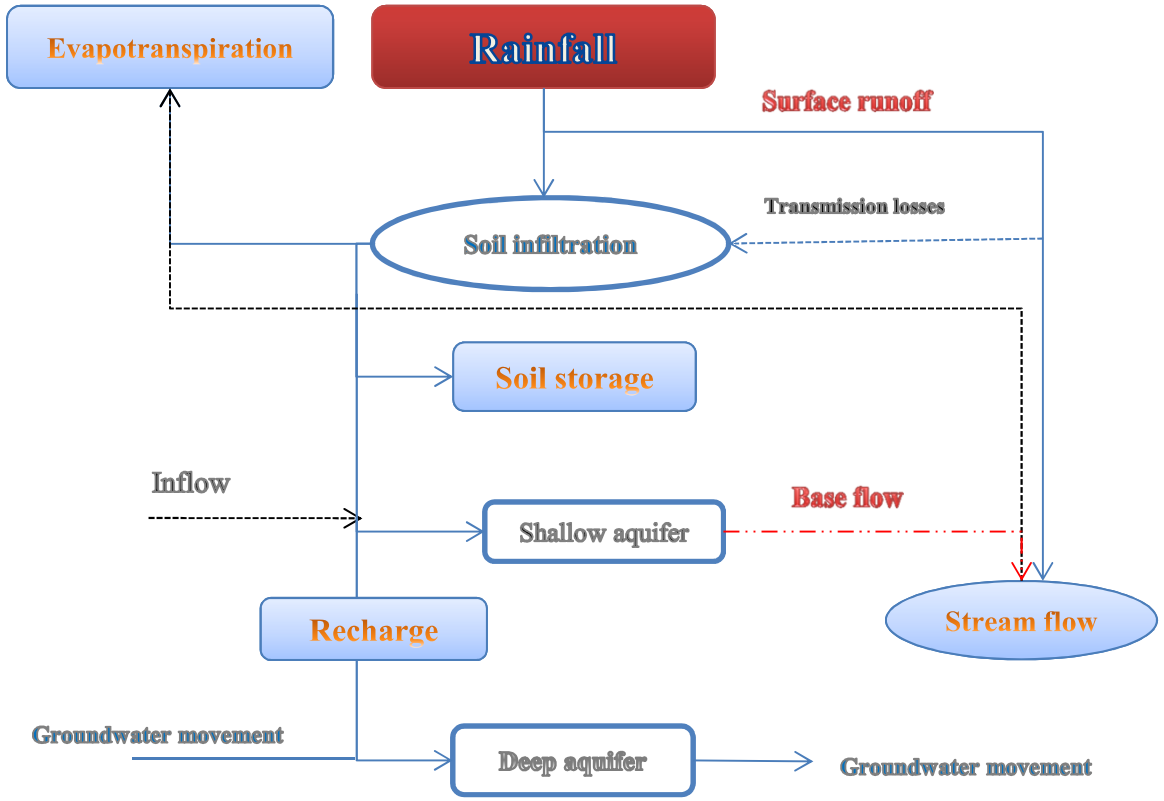
❑ To assess the sensitivity of catchment hydrology to future temperature and rainfall variations under projected climatic change

Groundwater quantity-Study approach

- Catchment location



- Conceptual model

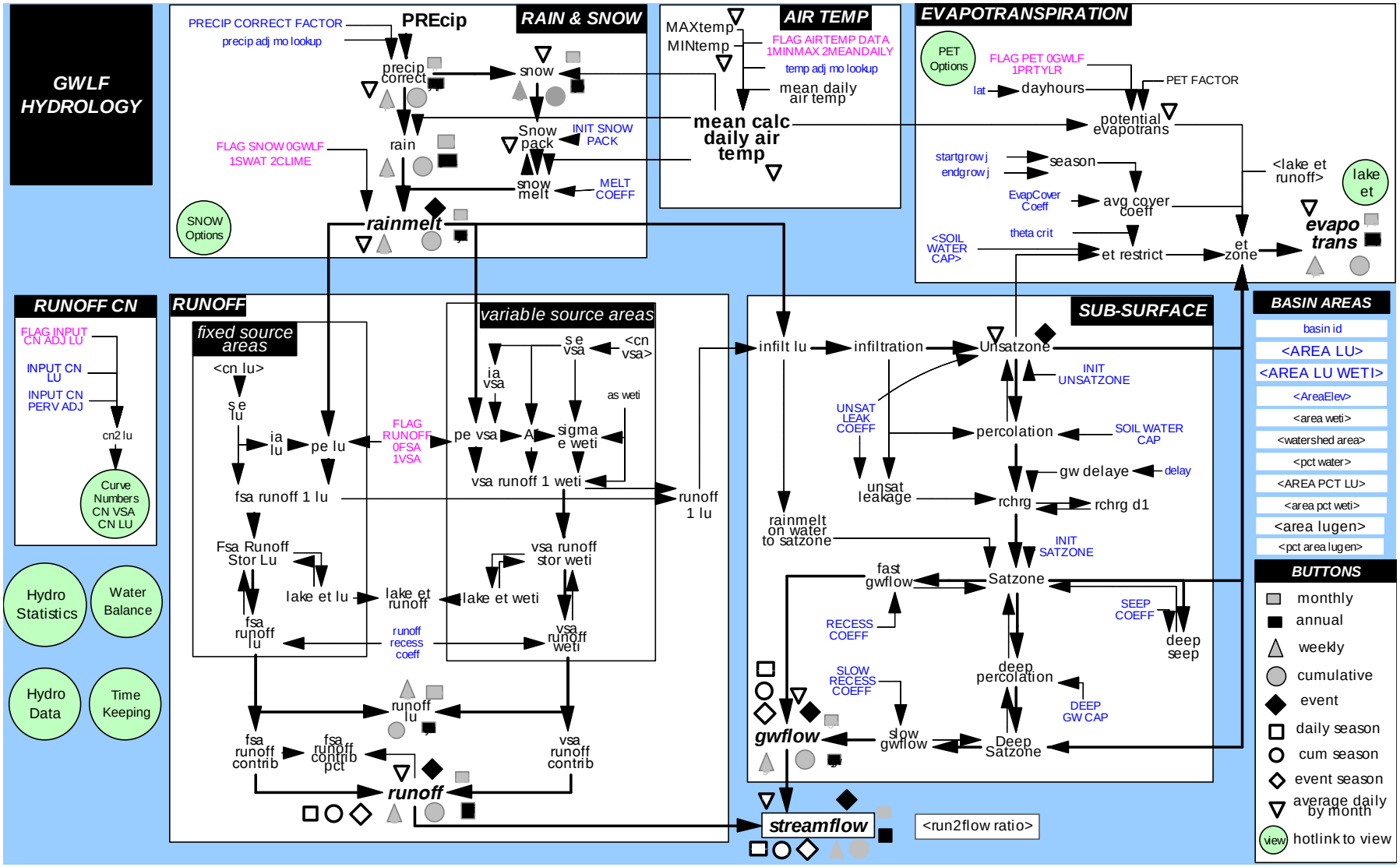


- Based on Soil Moisture Balance Model

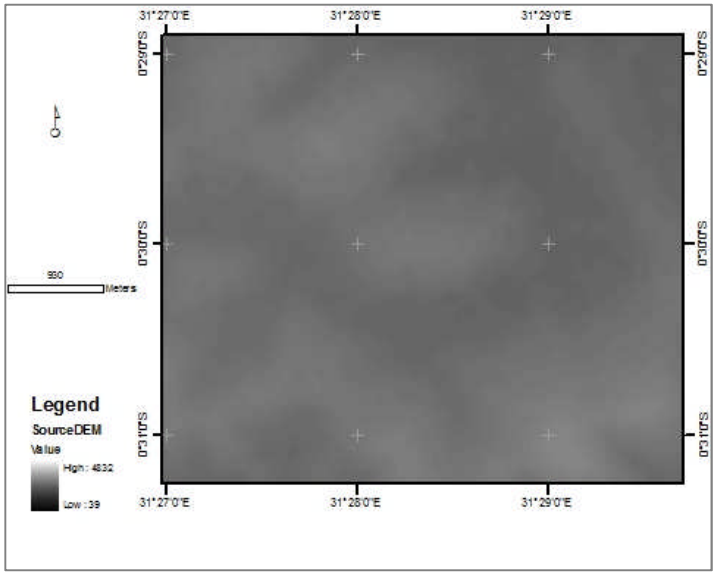
$$SW_t = SW_0 + \sum_{i=1}^{t} (R_{day} - Q_{surf} - E_a - w_{seep} - Q_{qw})$$

Groundwater quantity-Model application

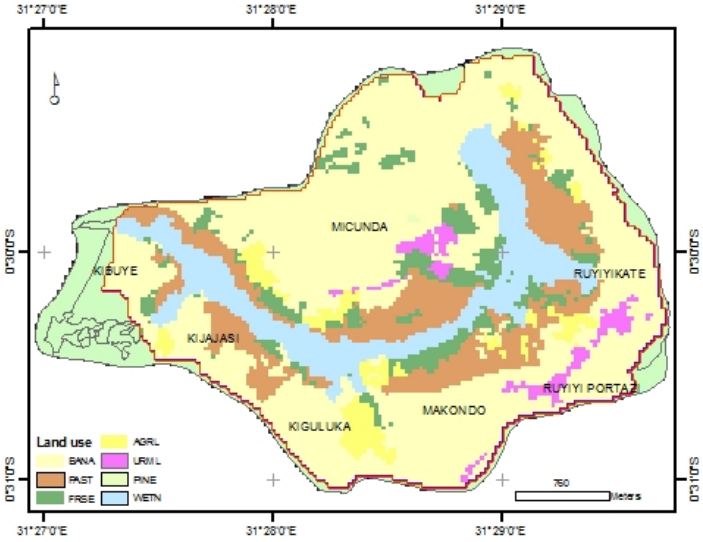
- GWLF hydrology Model



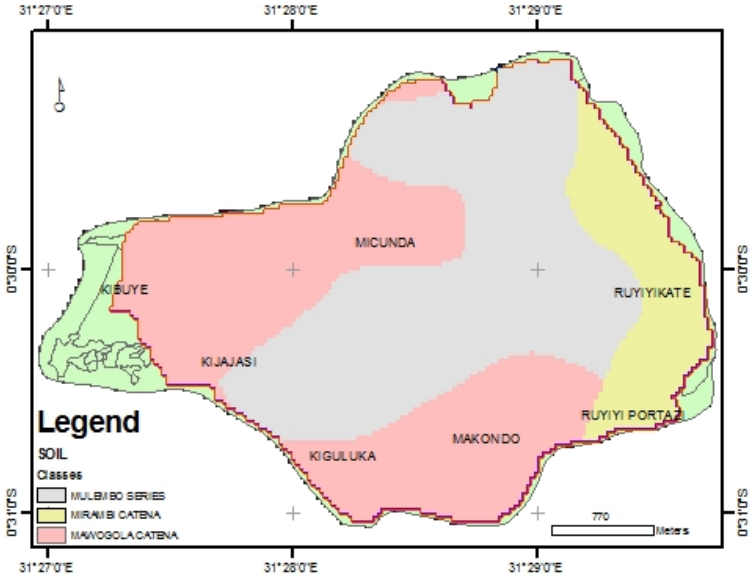
Groundwater quantity-SWAT and data requirements



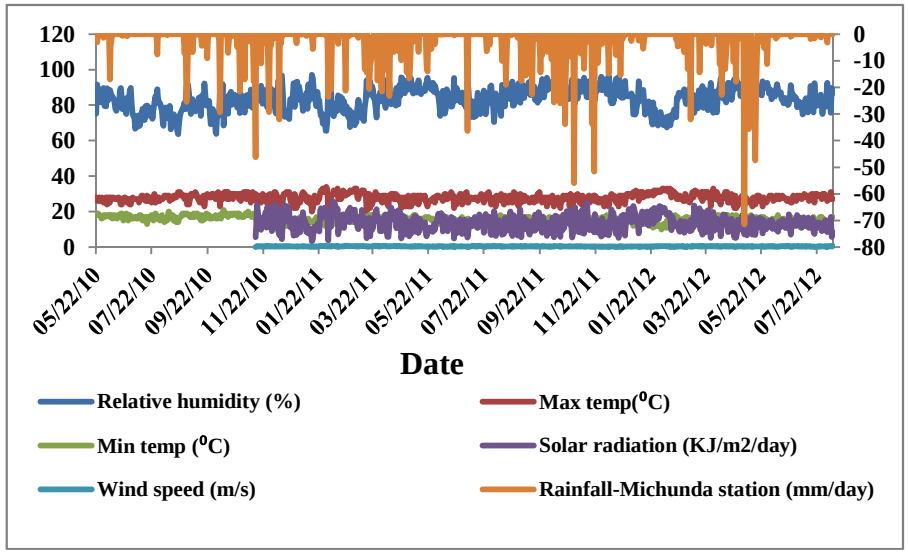
➢ DEM



➢Land cover/use map and basin slope



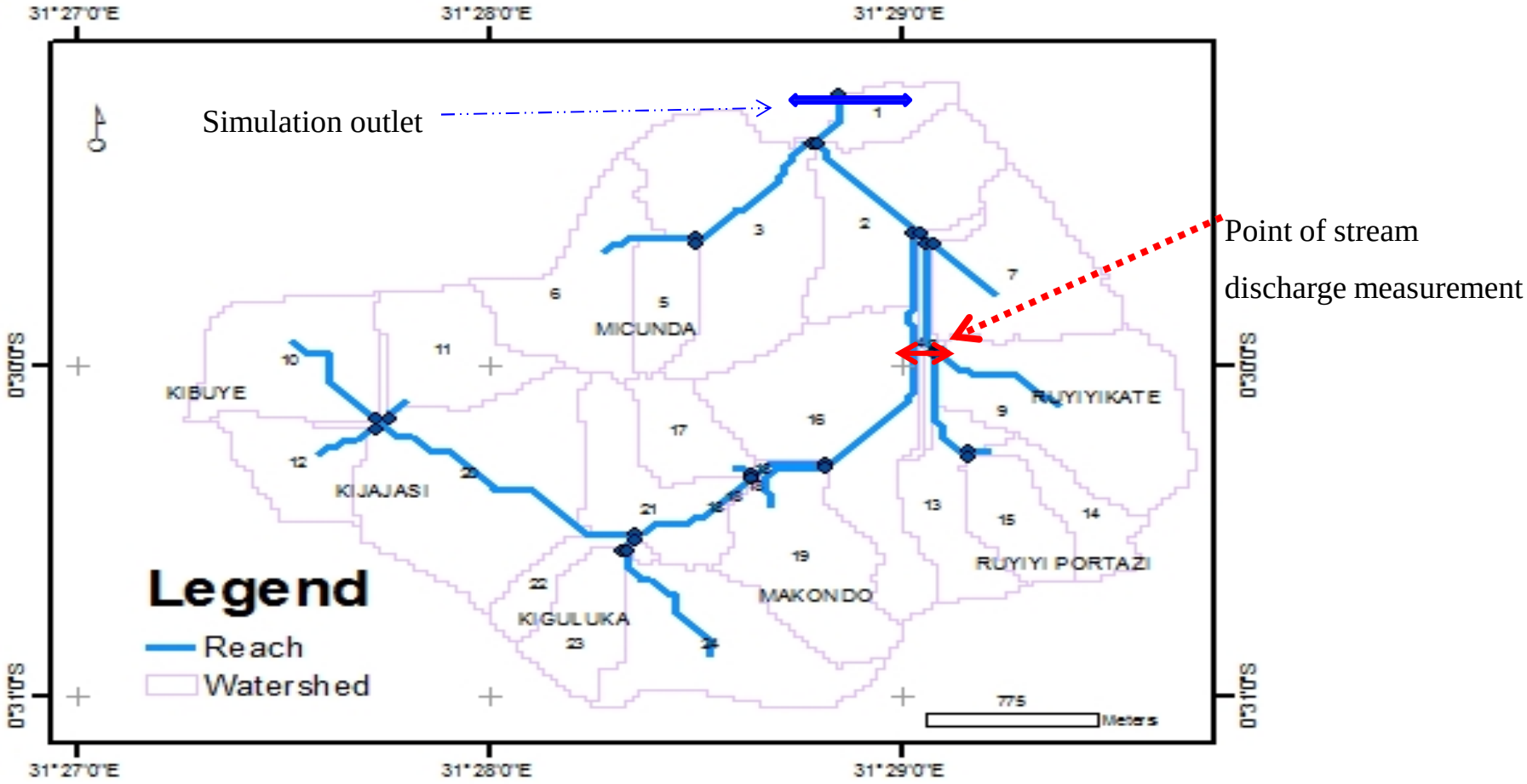
➢Soils map and physical properties



➢Stations location, climatic and weather generator data

Groundwater quantity-Catchment delineation

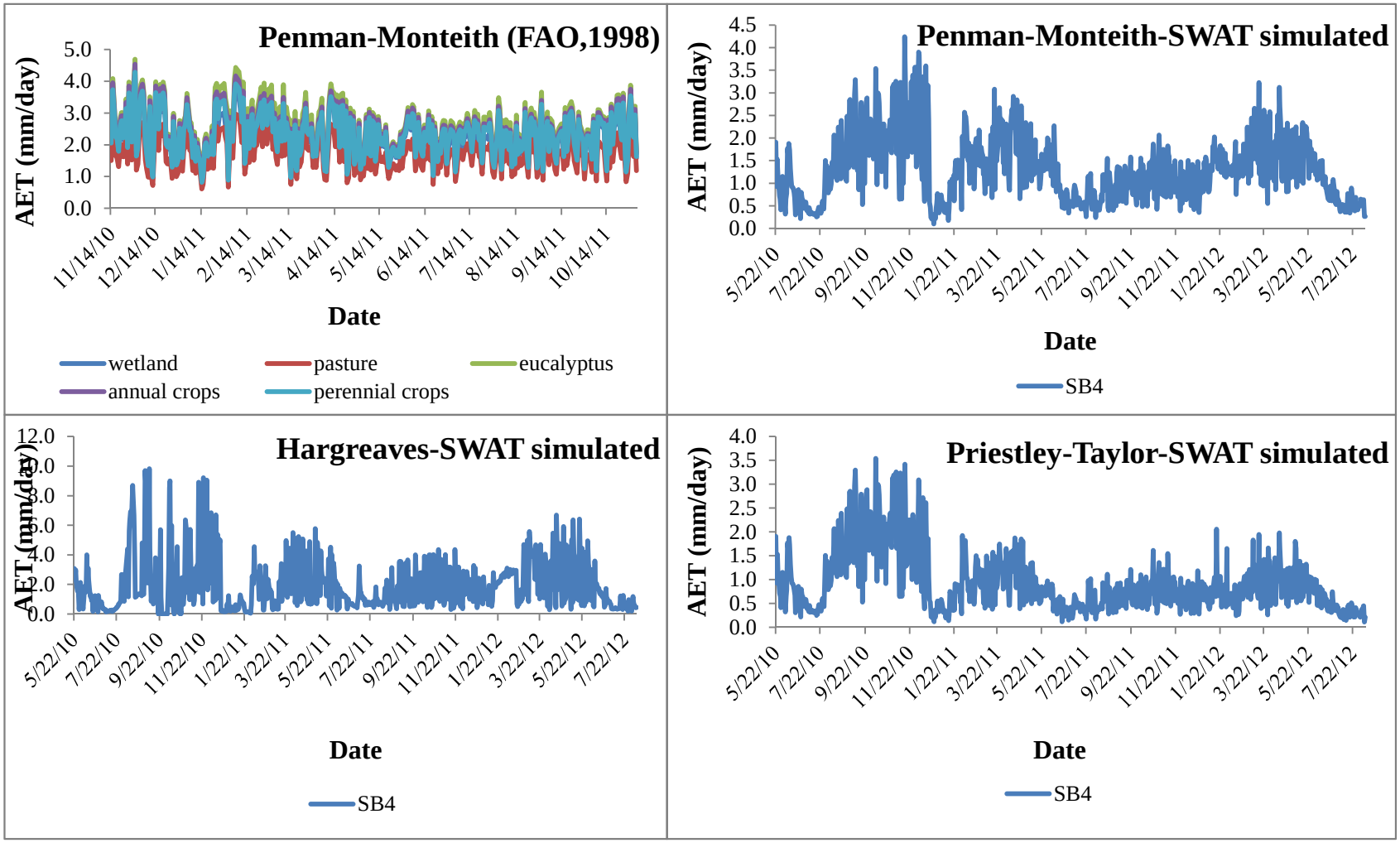
- SWAT Model (Area-19 Km^2 over 24 sub-basins)



- Sensitivity analysis based on OAT and LH
- Calibration against stream discharge

Groundwater quantity-Preliminary findings

- **Comparison of actual evapotranspiration outputs**

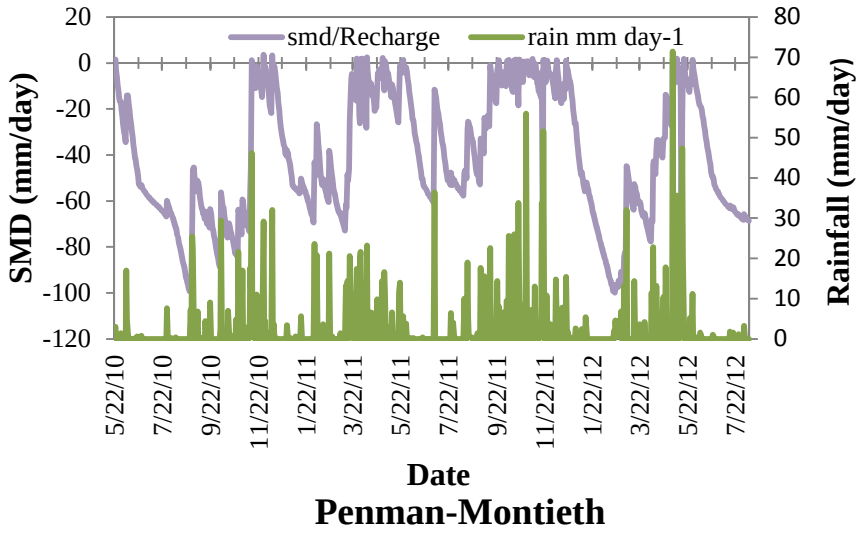


- AET outputs vary depending on the method of calculation

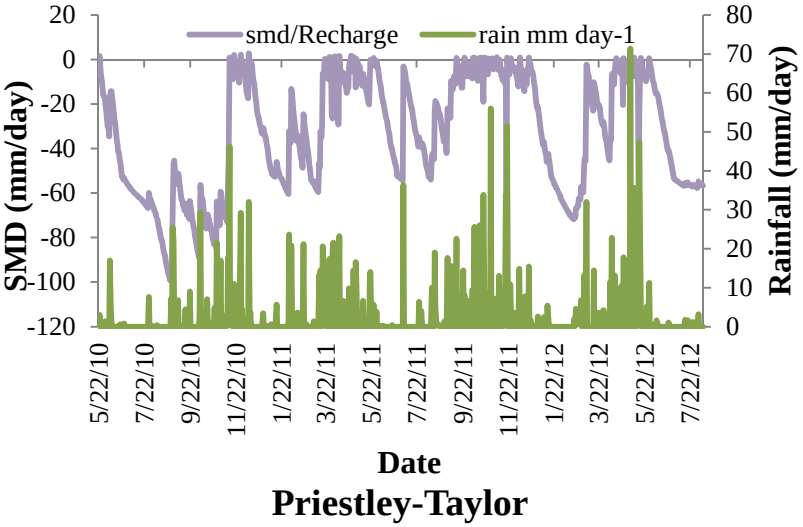
Groundwater quantity-Preliminary findings

➢ Soil Moisture Deficit /Recharge

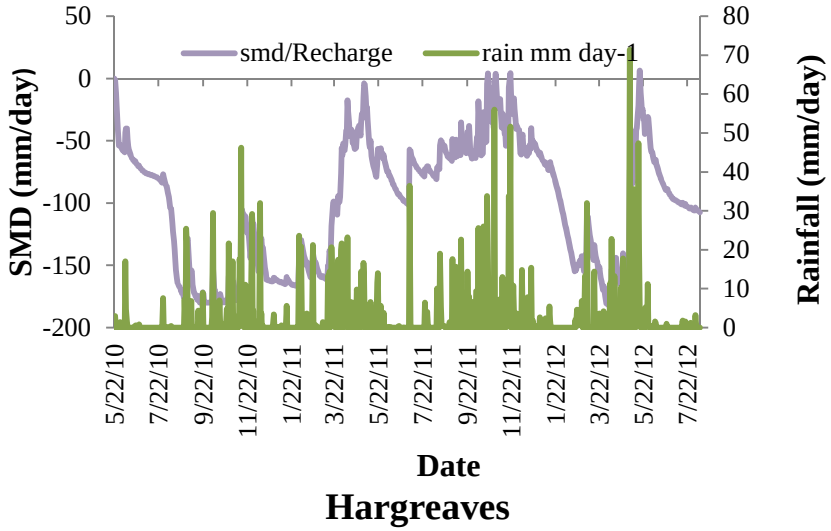
❑ Recharge (R) = 0 when SMD>0 (SB 4)



Penman-Montieth



Priestley-Taylor



Hargreaves

➢ High AET, increased SMD resulting in less Recharge

Groundwater quantity-Preliminary findings

➢ **Water balance** (SB's 4 and 10 as examples)

❑ Hargreaves method- AET rates (78-86 percent of incoming rainfall) resulting in low recharge rates (8 percent of in coming rainfall)

❑ Penman-Montienth method–AET rates (53-60 percent of in coming rainfall)

resulting in higher recharge rates (15-22 percent of in coming rainfall)

➢ **Impacts on Makondo hydrology**

Groundwater quality-Introduction

➢ Aim

❑ The study is to assess the community water needs and to evaluate existing groundwater sources in Makondo parish

➢ Specific objectives

❑ To establish baseline data on community water needs in selected villages

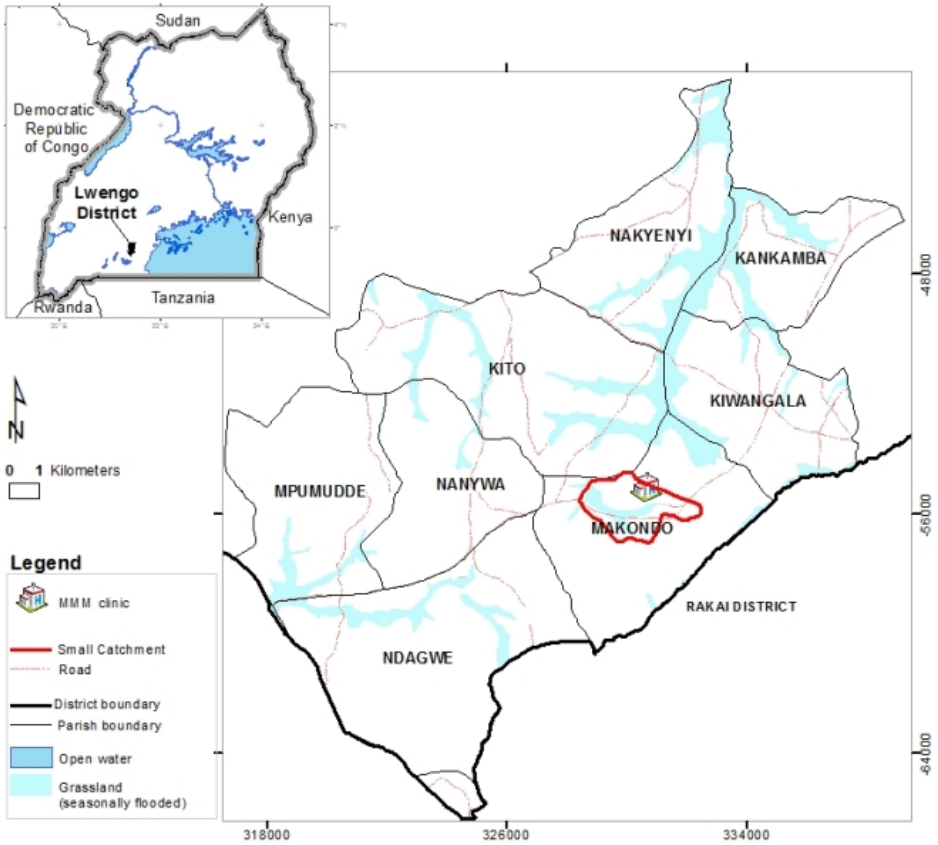
❑ To locate and determine the types of pollutants to groundwater sources in the selected villages

❑ To assess the influences of rainfall on pollutant loadings into the shallow groundwater

❑ To assess specific risk factors on contamination of various source types and develop models for contamination.

Groundwater quality-Introduction

➢ Study location



➢ Methods

- ❑ Field studies
- ❑ Questionnaire study
- ❑ Literature review
- ❑ Field tests and measurements
- ❑ Laboratory analyses

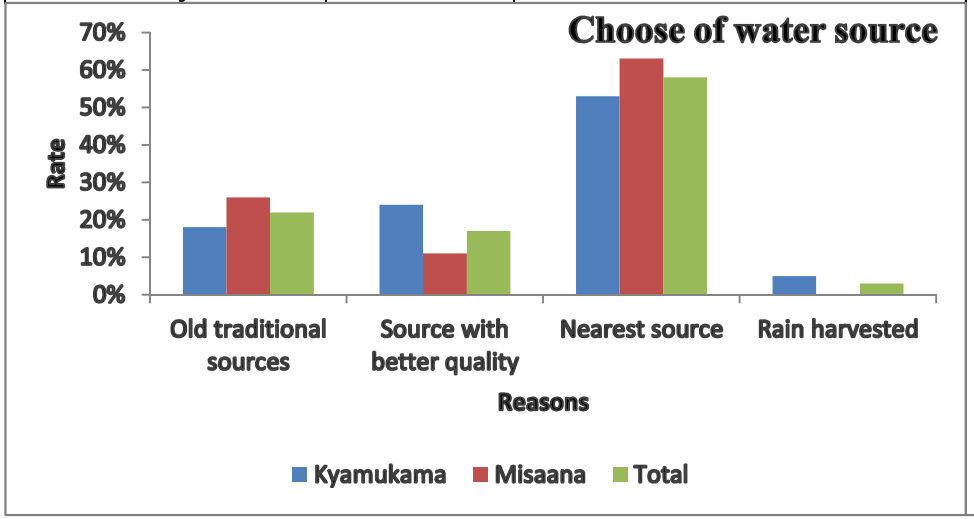
➢ Study extent

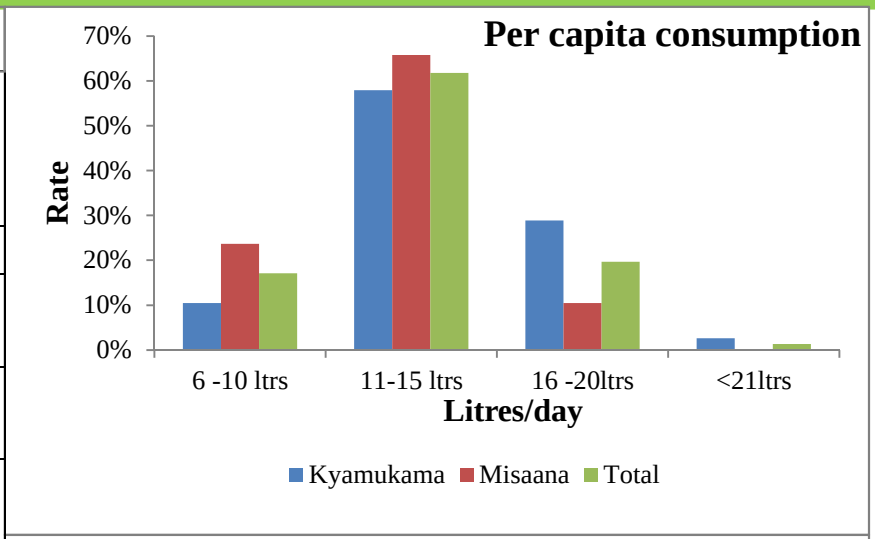
- ❑ Eight parishes: 35 water sources

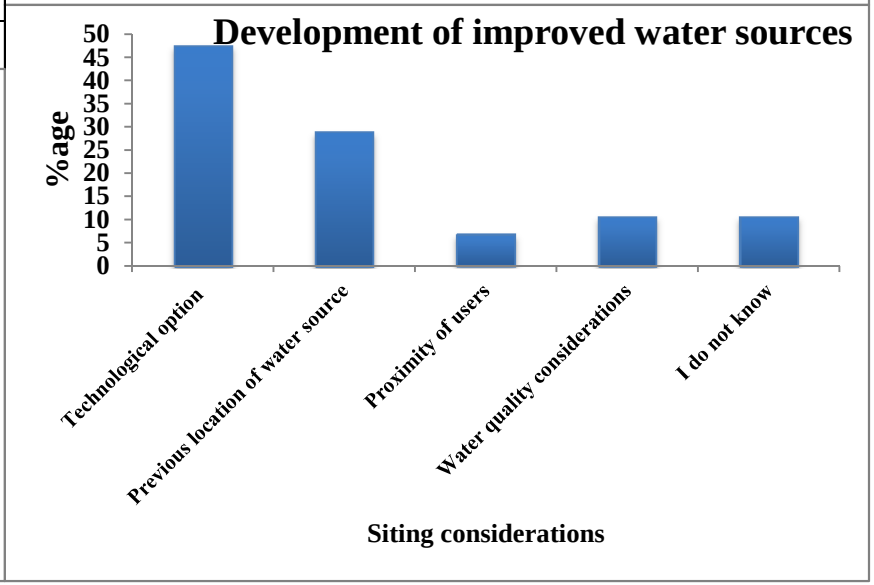
Groundwater quality-Key baseline data

Microbial & physico-chemical quality

Water source type	Turbidity range (NTU)	Mean feacal contamination (CFU/100ml)
Deep wells (n=10)	5	1 2
Improved shallow wells (n=18)	5-46	32 55
Protected springs (n=2)	5	1 1
Open dug wells (n=5)	33-100	482 505
Statutory limit	**5**	**0**



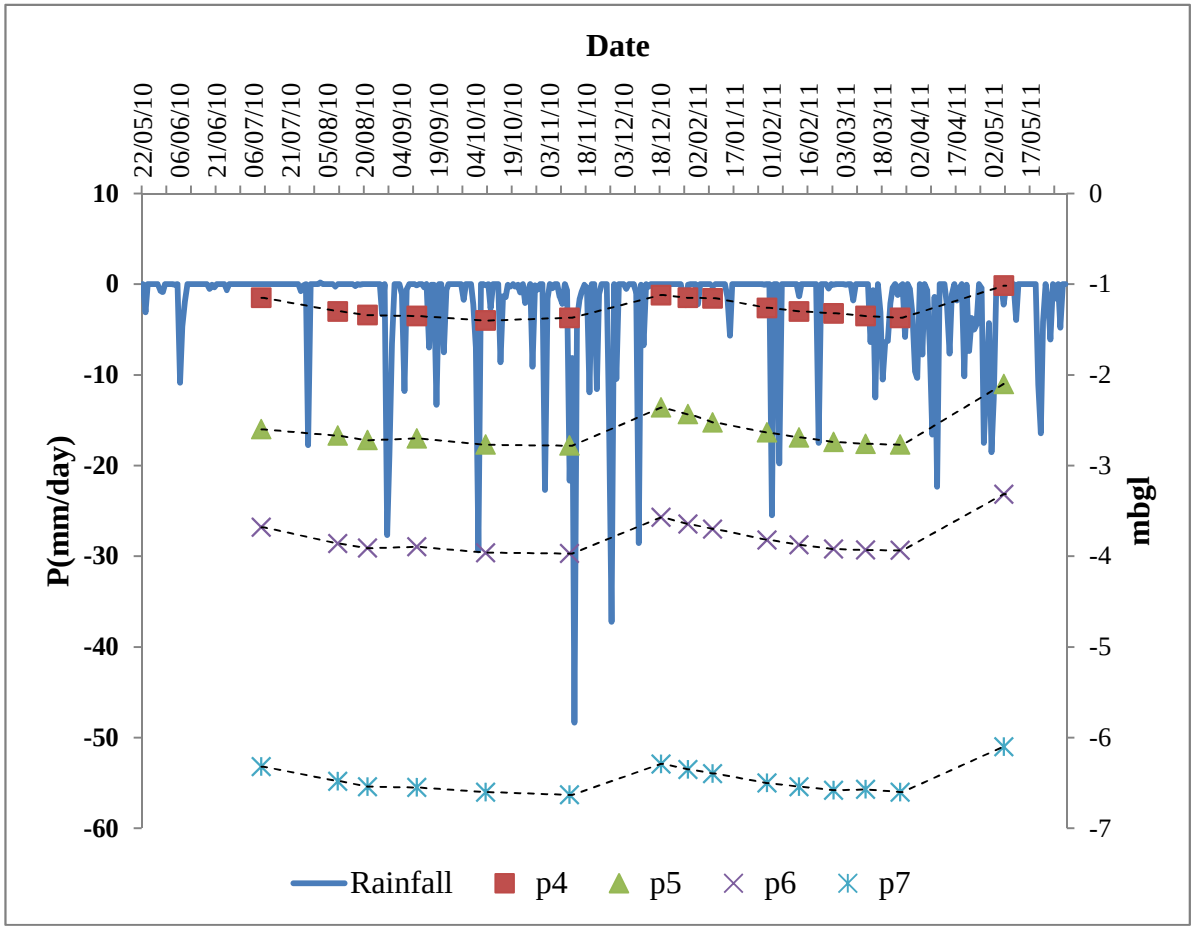




❑ Water chemistry meets statutory guideline requirements except for elevated levels of $Mn^{2+}$and Fe^{2+} in 11% and 46% of water sources respectively.

Groundwater quality-Contamination models

➢ Effect of changing seasons on water quality



❑ How do variations in groundwater levels affect water quality at sources?

➢ And finally, different risk factors will be related to water quality at various water sources to assess any relationship.

Contribution of WP1 to wider WIL

- Specifically, W1 project is informing WIL project on key sustainability issues of water quantity and quality

- Improved accessibility & availability of clean water helps in meeting the minimum quantity required for health & hygiene

- Improved health leads to saving on medical expenses, a better productive labour force and hence, breaking the poverty circle

- Improved access & availability of water reduces the burden on women & children who are responsible for fetching water in rural communities of Uganda

Impact of WP1 on rural communities

- A guideline document outlining siting, design, construction and maintenance of new sources shall be produced which will lead to:
  - Communities influencing decisions on development of groundwater sources in their areas
  - Better appreciation of water quality issues in respect to water source selection , treatment of drinking water & protection of sources
  - Planning adaptation measures during water scarcity under changing climatic conditions

Contribution of WP1 to the knowledge on sustainable water management in Uganda

- This research pulls together key groundwater aspects of a crystalline aquifer system with a view to informing future groundwater sourcing and developments.

Acknowledgements

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TCD

MMM Sisters

Makondo community

Fellow PhD students