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Assessing the Application Potentials of Motor Pump Irrigation Technology in Sub-Saharan Africa

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Agricultural Water Management Solutions

- Identify promising investment options for smallholder irrigation in Sub-Saharan Africa and South Asia

Smallholder Irrigation

- Treadle pump
- Motor pump
- Small reservoirs
- Inland-valley
- Agricultural Conservation (in-situ water harvesting)
- River diversion

Assessment Framework

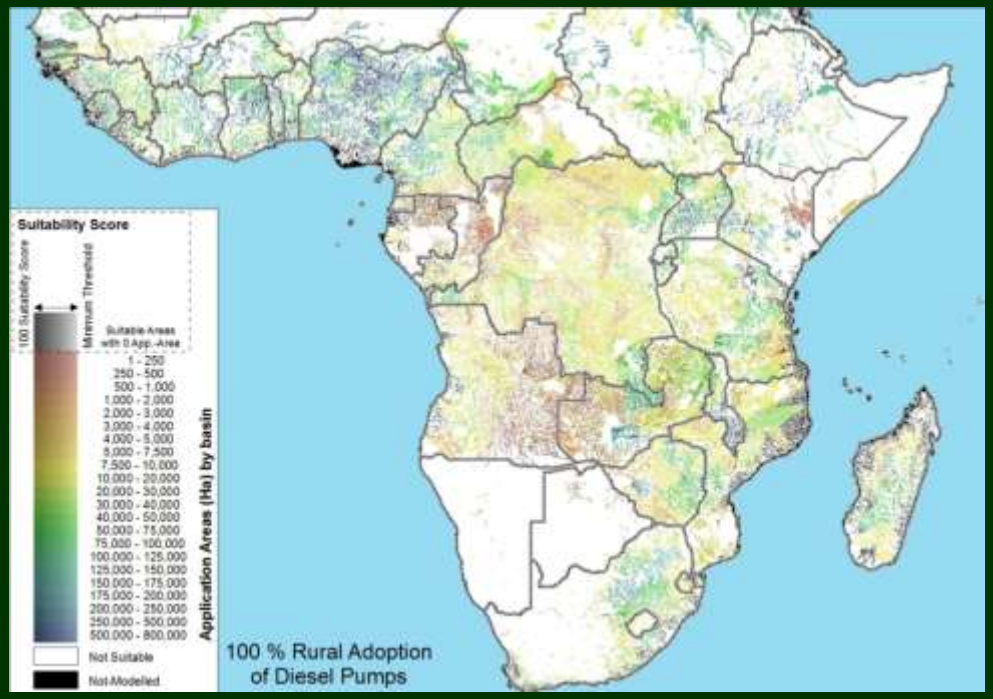
Data analysis & modeling Tools

- GIS
- Soil and Water Assessment Tool (SWAT)
- Dynamic Research EvaluAtion for Management (DREAM)

Key steps

1. Ex-ante analysis
   — criteria-based and by pixel
2. Predictive modeling
   — cost-benefit
   — environmental indicators

GIS ex-ante Analysis



Criteria for Diesel-Pumps:	Criteria Weights
Fluvisols (FAO)	False = 0 1 - 15 % = 11 16 - 50 % = 22 51 - 100 % = 33
Market Access (Nelson Travel Time)	5km = 10 minutes = 33.33 10km = 20minutes = 22.22 20km = 40 minutes = 11.11 30km = 60 minutes = 0 60km = 120 minutes = 0
Distance to Surface Water	< 0.5 km = 33.333 > 0.5 km = 0
Excluded Areas	True = Excluded
Minimum Suitability Threshold	55 / 100

AWM Technology	Application Area per Household	Household Member Participation	Application Area per Individual
Diesel Pumps	0.8 Ha/Household	1 household members adopting	0.8 Ha/person

Scenario building

- *What*

— tomatoes, onions, peppers, cabbages, beans, peas, potatoes, sweet potatoes, wheat, maize, rice, sugar cane, groundnuts

- *When*

— add a growing season in dry season

- *Where*

— farming land expansion is allowed, constrained by the potential areas identified in GIS ex-ante analysis

Crop mix optimization & environmental impact indicators

Water use-runoff ratio

$$r_1 = \sum_r \sum_c (w_{rc} \cdot A^*_{rc}) \Big/ \sum_r Q_r$$

Abstraction rate-GW recharge rate ratio

$$r_2 = \sum_r \sum_c (w_{rc} \cdot A^*_{rc}) \Big/ \sum_r \sum_c (GR_r \cdot A^*_{rc})$$

w_{rc} — ***water use intensity (m^3H_2O/ha-yr)***

A^*_{rc} —***optimal planting area (ha)***

Q_r — ***runoff during the dry (growing) season (m^3H_2O/ yr)***

P_c — ***crop price ($/ton)***

GR_r —***groundwater recharge rate (m^3H_2O/ha-yr)***

Crop mix optimization & environmental impact indicators

$$\max_{A_{rc}} \text{NetRevenue}(\$/\text{yr}) = \sum_r \sum_c \left[Y_{rc} \cdot A_{rc} \cdot P_{rc} - (IC_{rc} + PC_{rc}) \cdot A_{rc} \right]$$

Subj. to: $\sum_c A_{rc} < A_{r,max}$

$A_{rc} \geq 0$

Y_{rc} — ***crop yield (ton/ha-yr)***

A_{rc} — ***planting area (ha)***

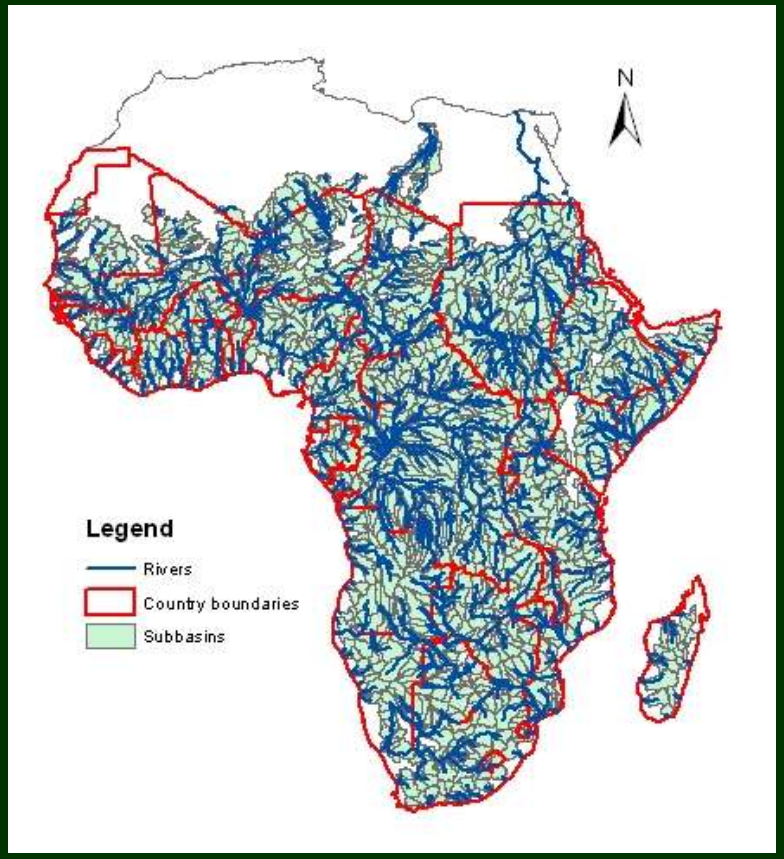
$A_{r,\max}$ — ***maximum area with irrigation potentials (ha)***

P_{rc} — ***crop price ($/ton)***

IC_{rc} —***irrigation costs ($/ha)***

PC_{rc} —***other production costs ($/ha)***

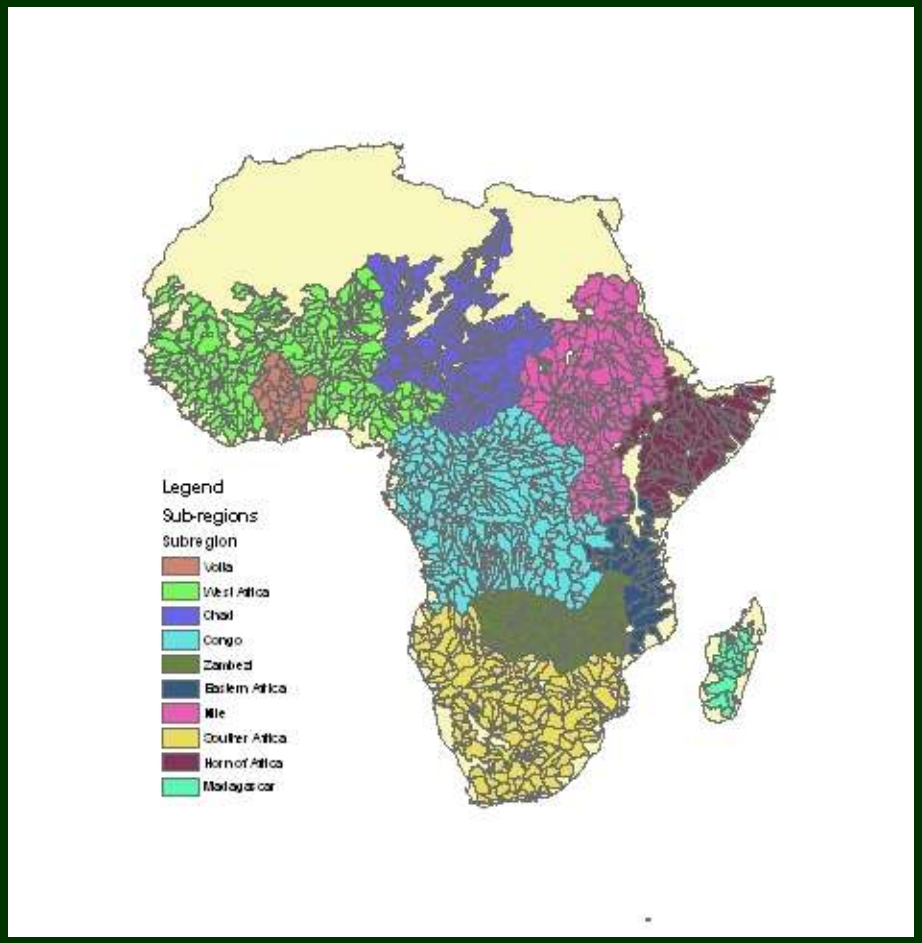
The setup of the SWAT-SSA model



1,488 subbasins with dominant land use and soil

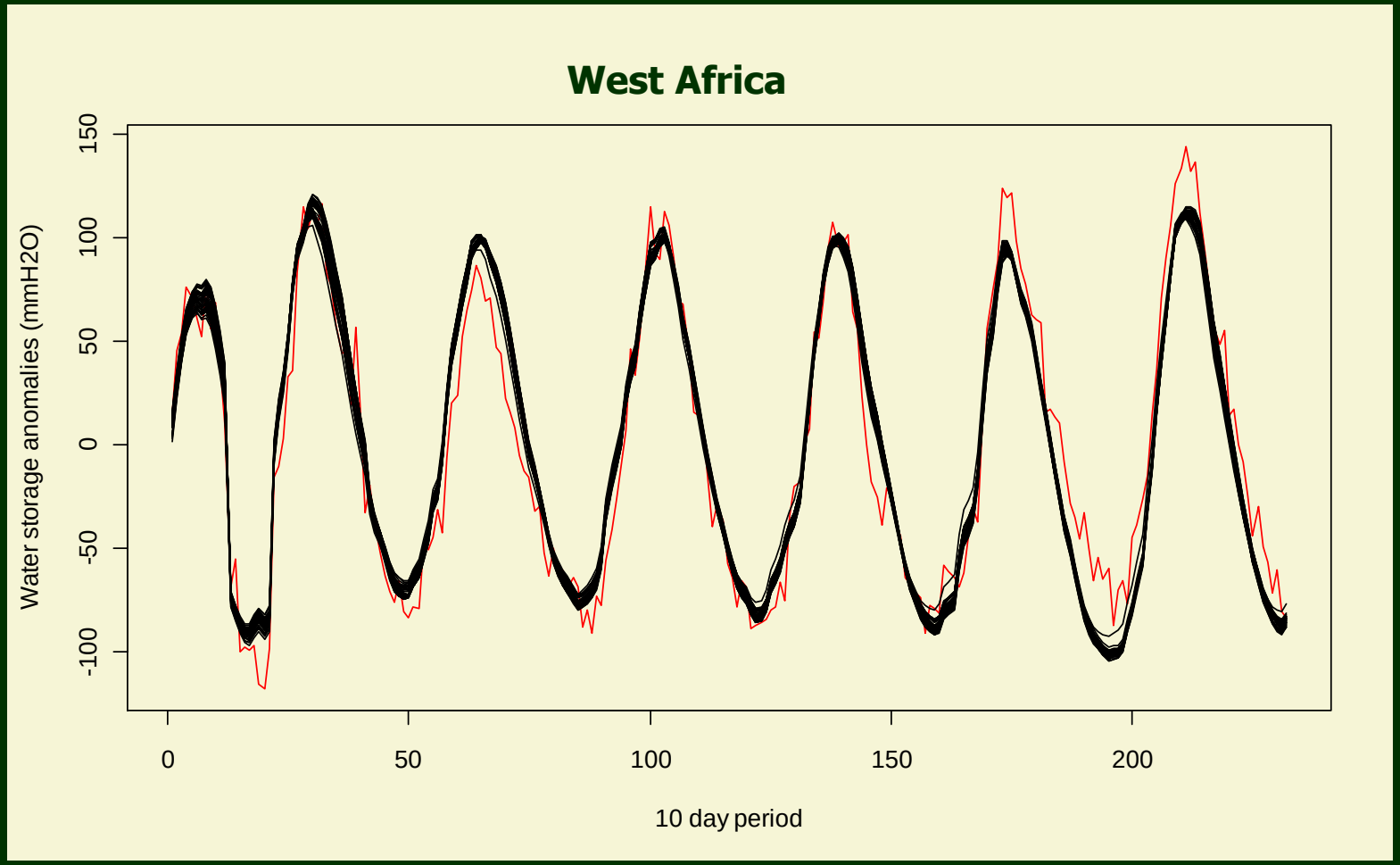
Category	Source
Elevation	HydroSHEDS
Soil	Harmonized world soil database (HWSD)
Land cover	Global land cover (GLC) 2000
Lakes & reservoirs	Global lake and wetland database (GLWD)
Climate	Surface meteorology and Solar Energy (SSE) Release 6.0 — Global Precipitation Climate Project (GPCP)

Model calibration and evaluation — Hydrology

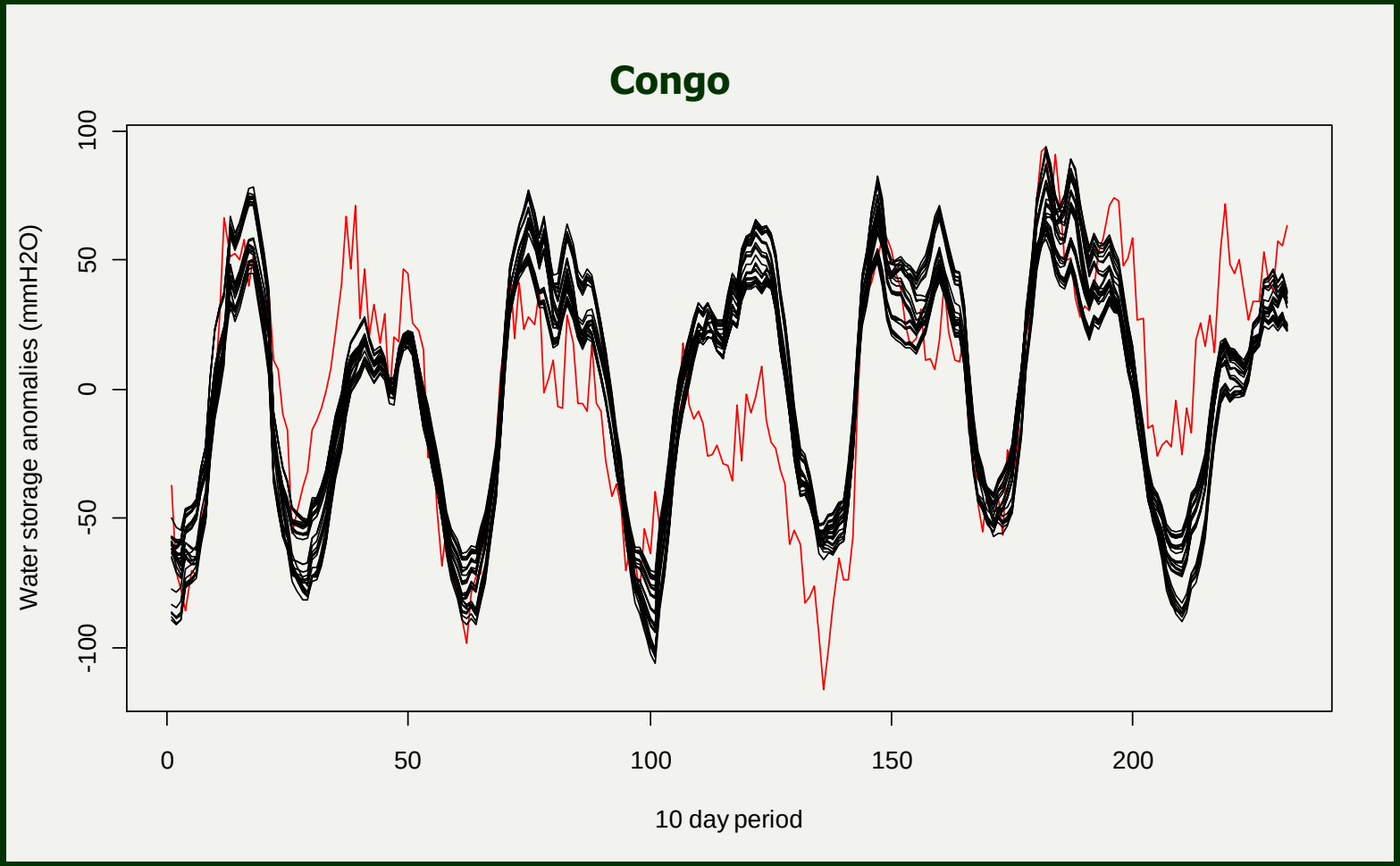


- *Division of sub-regions*
  - *— SWAT model for each sub-region was calibrated and evaluated separately*
- *Multi-criteria calibration*
  - *— GRDC (Global runoff data centre)*
  - *— GRACE (Climate and Gravity Recovery Experiment)*

Model calibration and evaluation — Hydrology



Model calibration and evaluation — Hydrology



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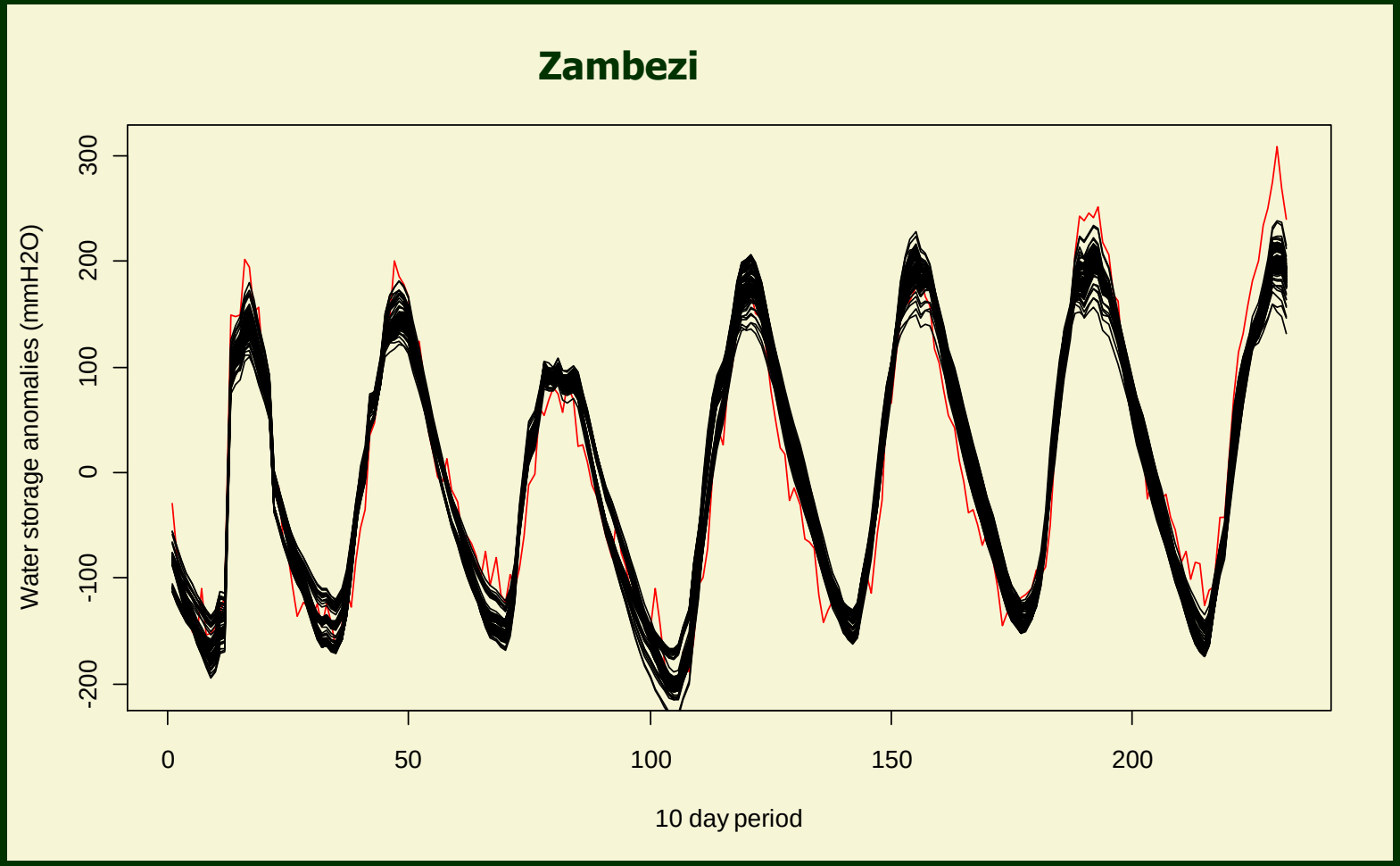

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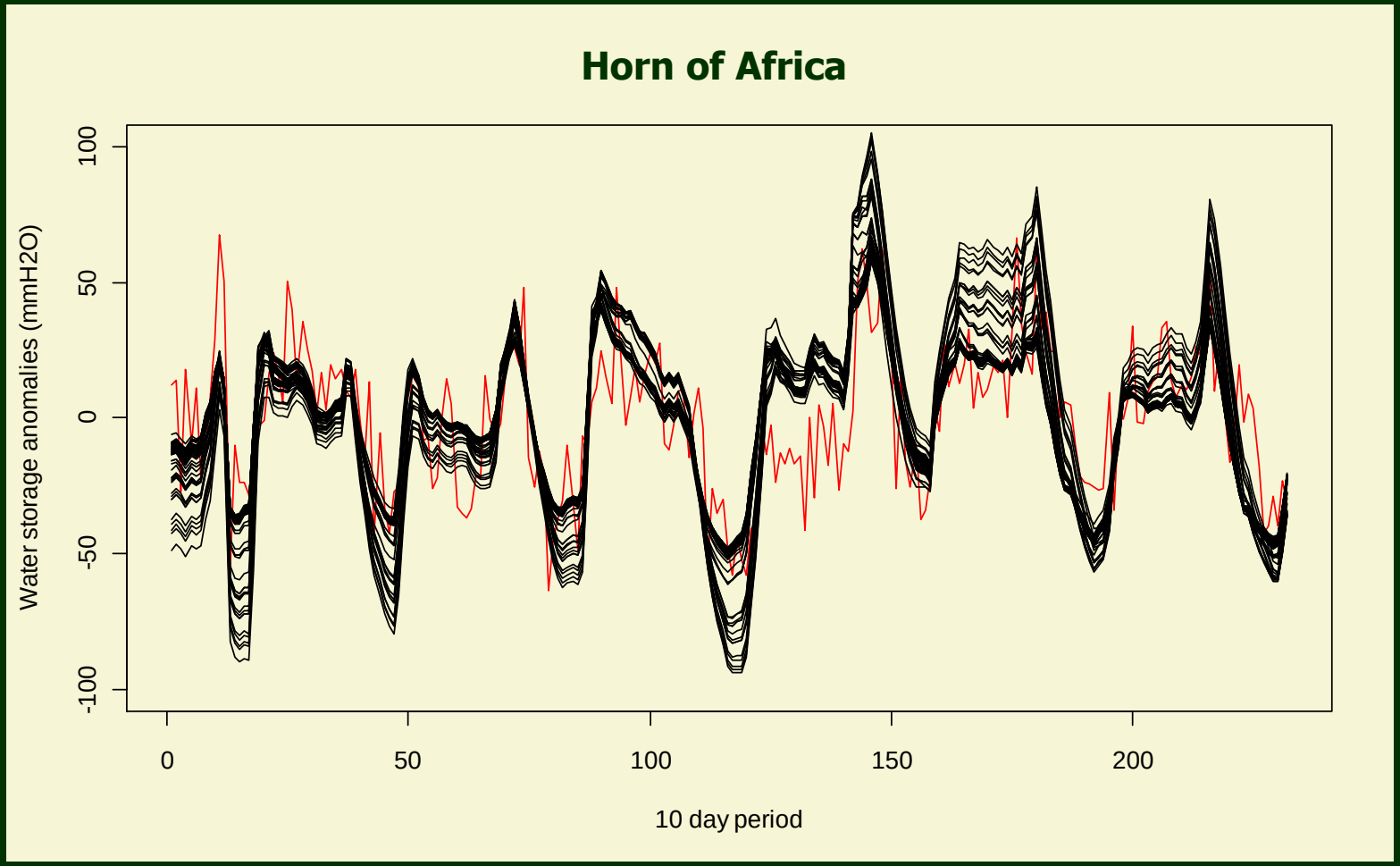
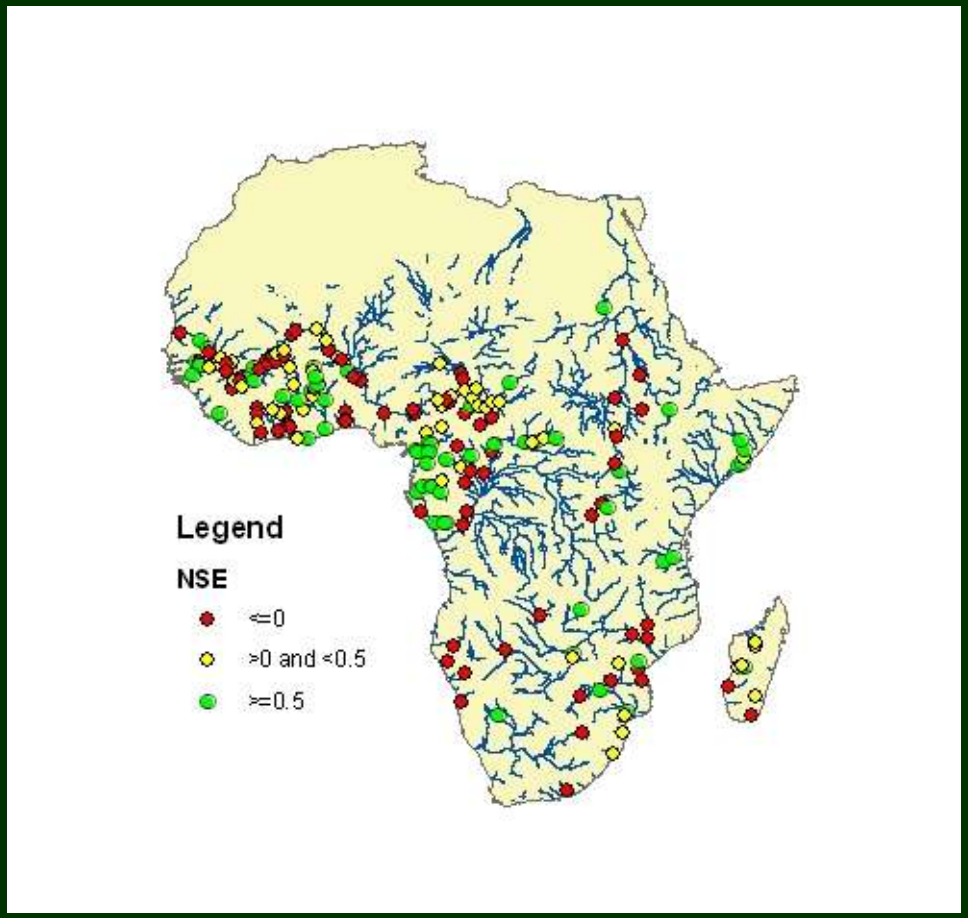


Model calibration and evaluation — Hydrology



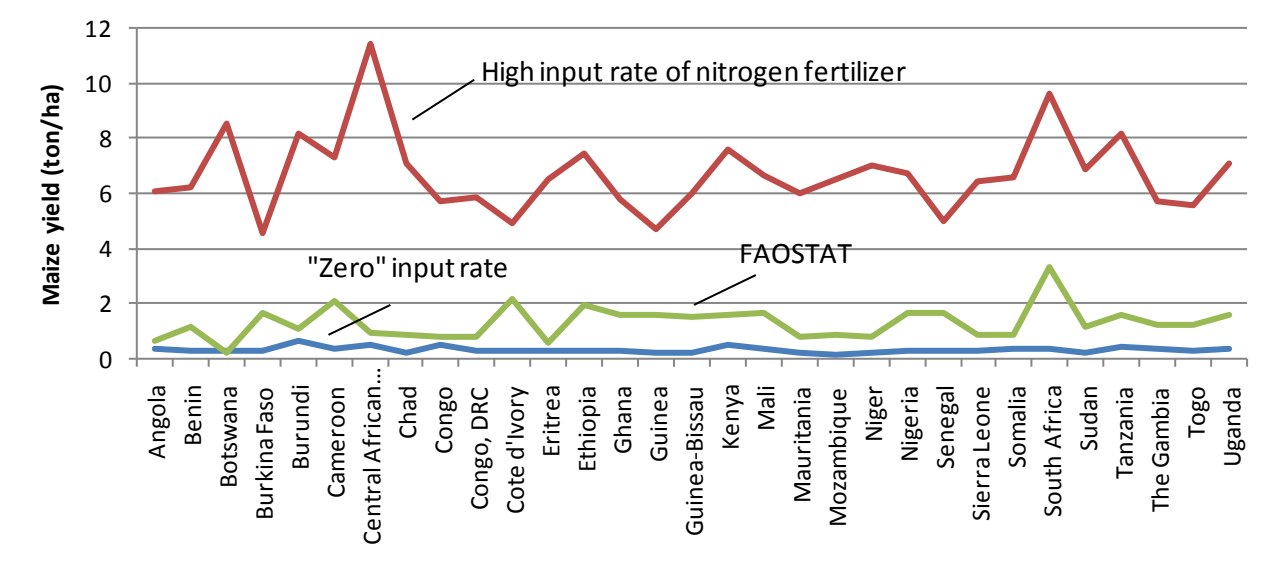
- *Runoff simulation*

— *evaluated against multi-year average monthly discharge data*

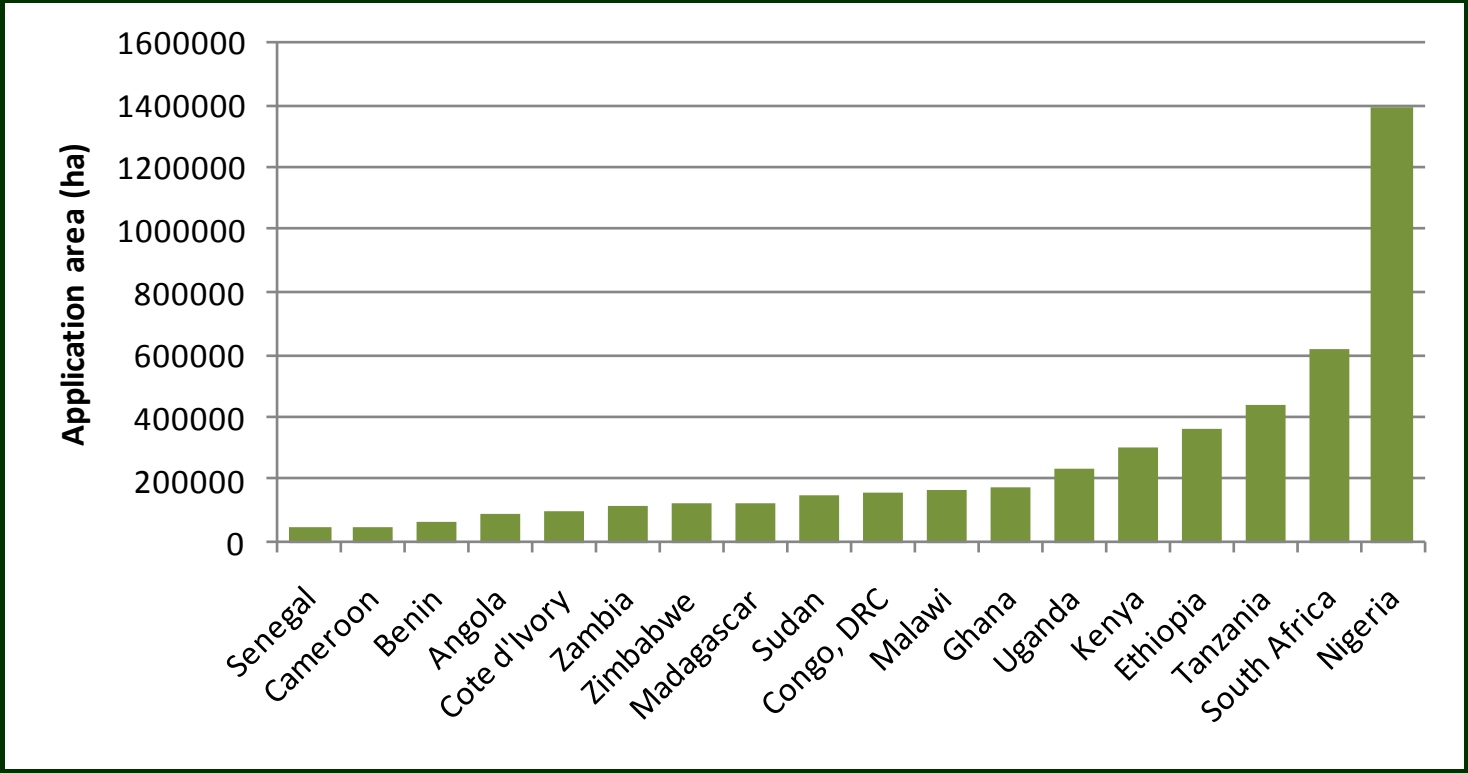
— *different time frames of GPCP, GRDC and GRACE data*

Crop simulation

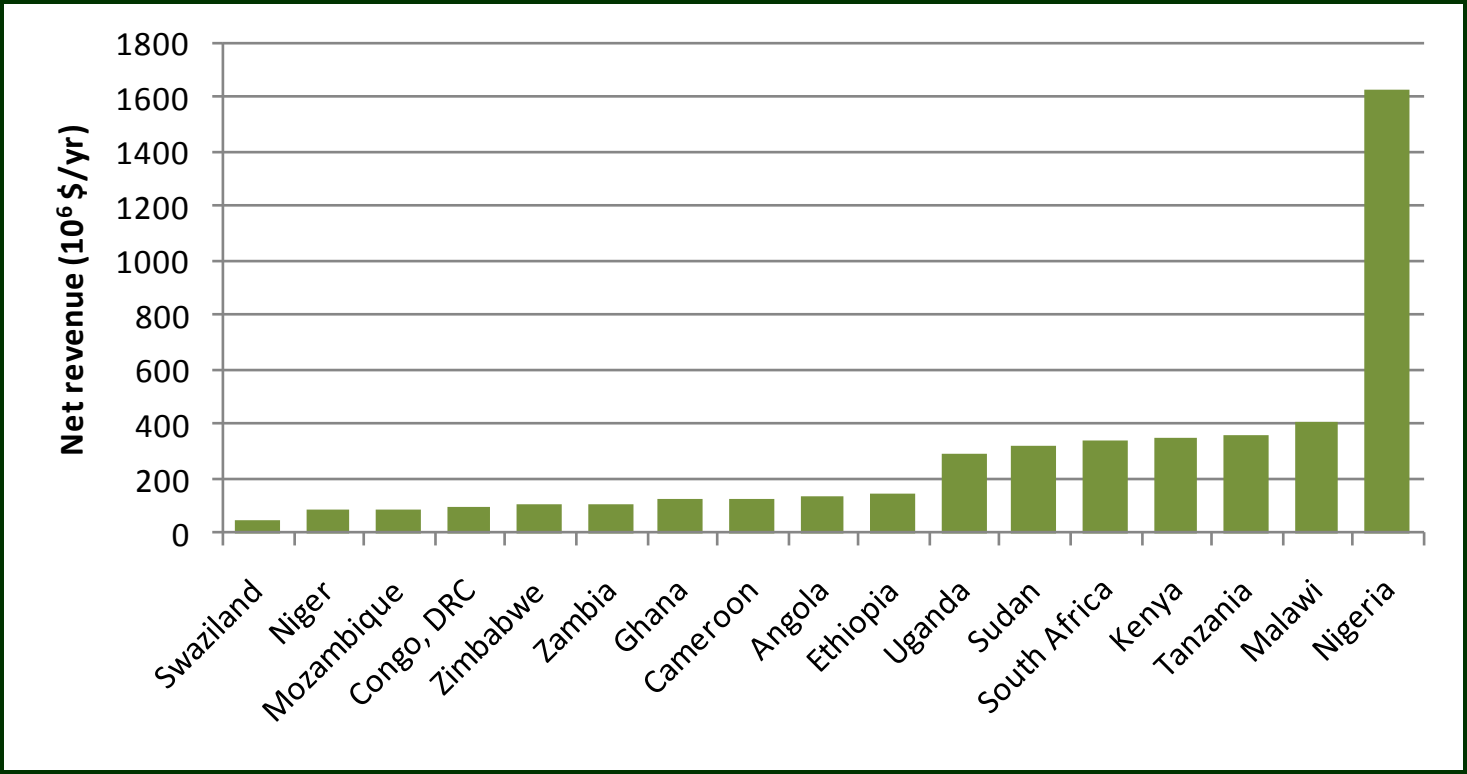
- *"Full irrigation" assumption*
  - no constraints on water availability during the simulation of irrigation
- *"High-input" assumption*



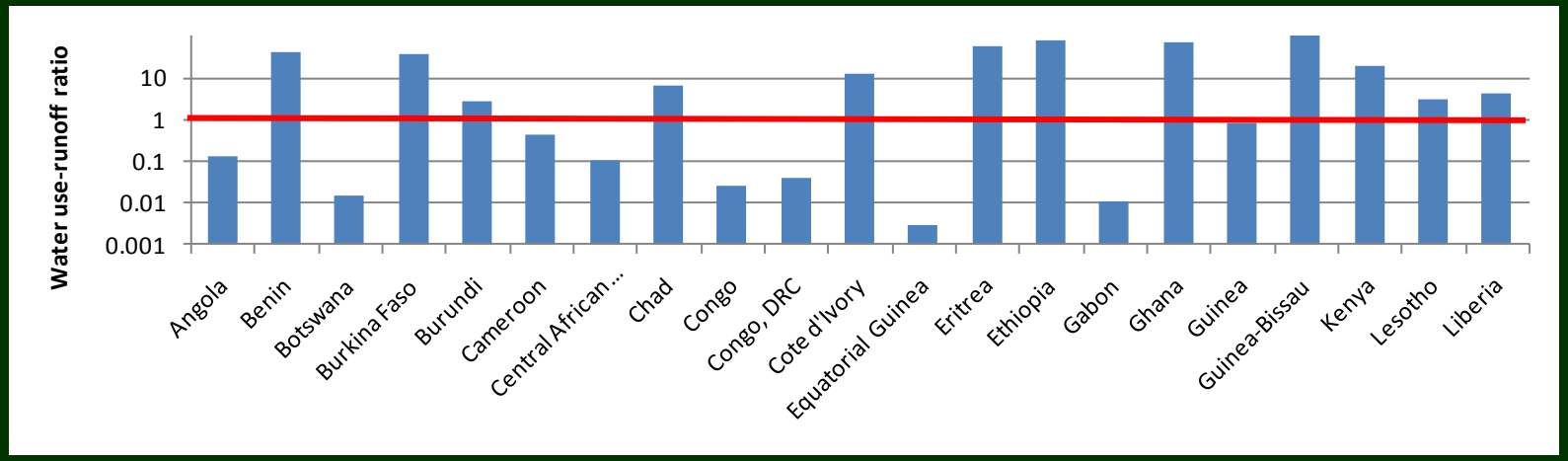
Results--Application areas > 50,000 ha, motor pumps, SSA

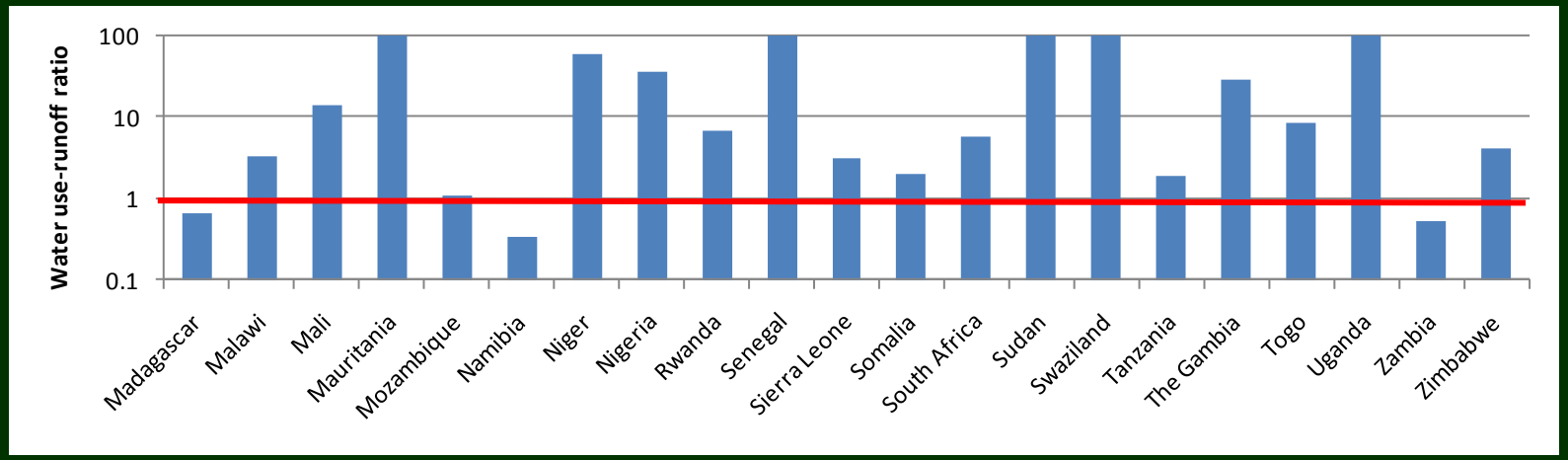


Results—Net revenues> 50 million $/yr, motor pumps, SSA

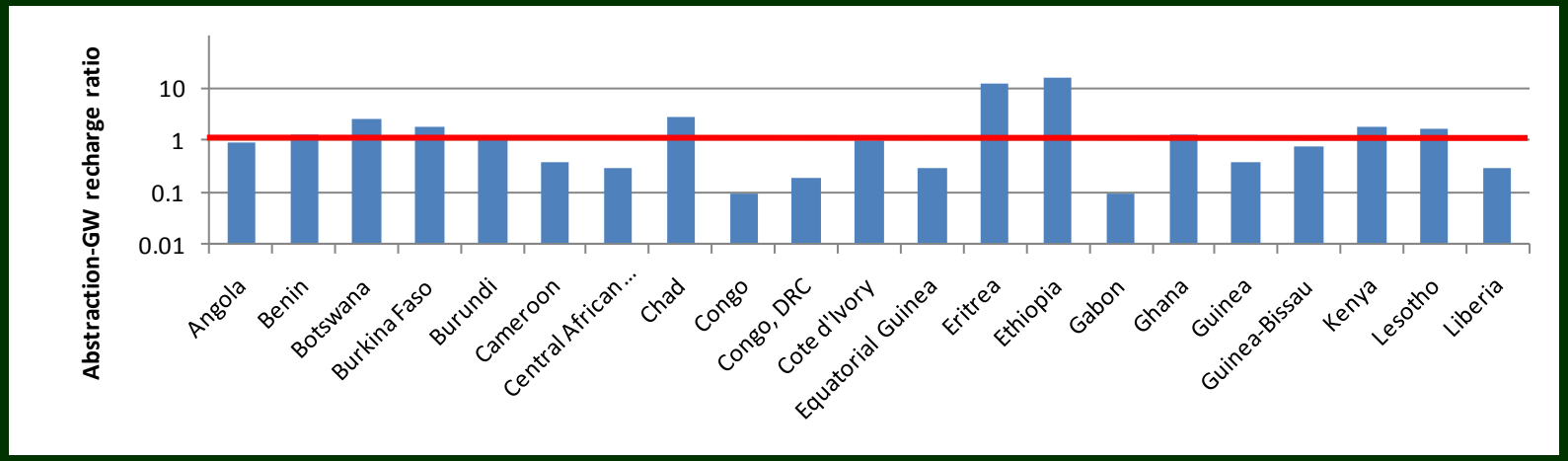


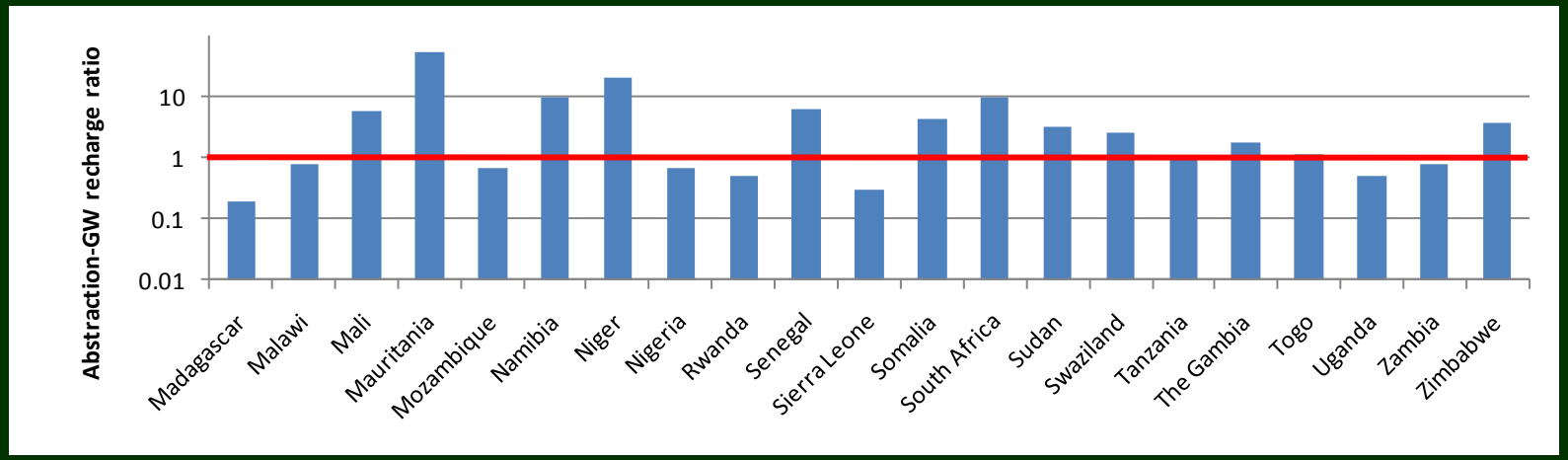
Results—water use –runoff ratio, motor pumps, SSA





Results—Abstraction –GW recharge, motor pumps, SSA





Thank you !