Developing a physically-based groundwater model to simulate regional groundwater hydrology in Sub-Saharan Africa – A SWAT approach

Hua Xie
International Food Policy Research Institute

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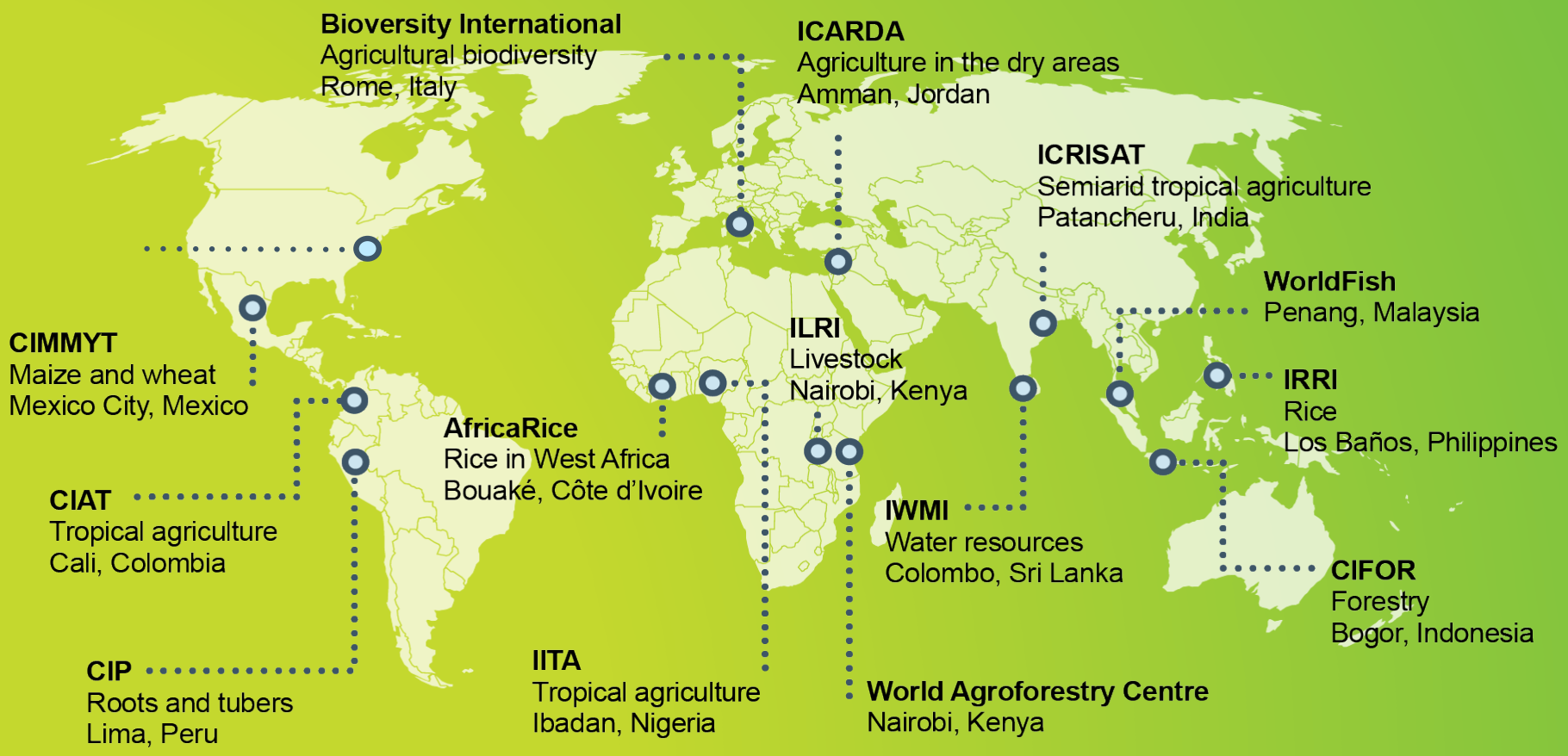
Bioversity International
Agricultural biodiversity
Rome, Italy
ICARDA
Agriculture in the dry areas
Amman, Jordan
ICRISAT
Semiarid tropical agriculture
Patancheru, India
WorldFish
Penang, Malaysia
CIMMYT
Maize and wheat
Mexico City, Mexico
ILRI
Livestock
Nairobi, Kenya
IRRI
Rice
Los Baños, Philippines
AfricaRice
Rice in West Africa
Bouaké, Côte d'Ivoire
IWMI
Water resources
Colombo, Sri Lanka
CIAT
Tropical agriculture
Cali, Colombia
CIFOR
Forestry
Bogor, Indonesia
CIP
Roots and tubers
Lima, Peru
IITA
Tropical agriculture
Ibadan, Nigeria
World Agroforestry Centre
Nairobi, Kenya

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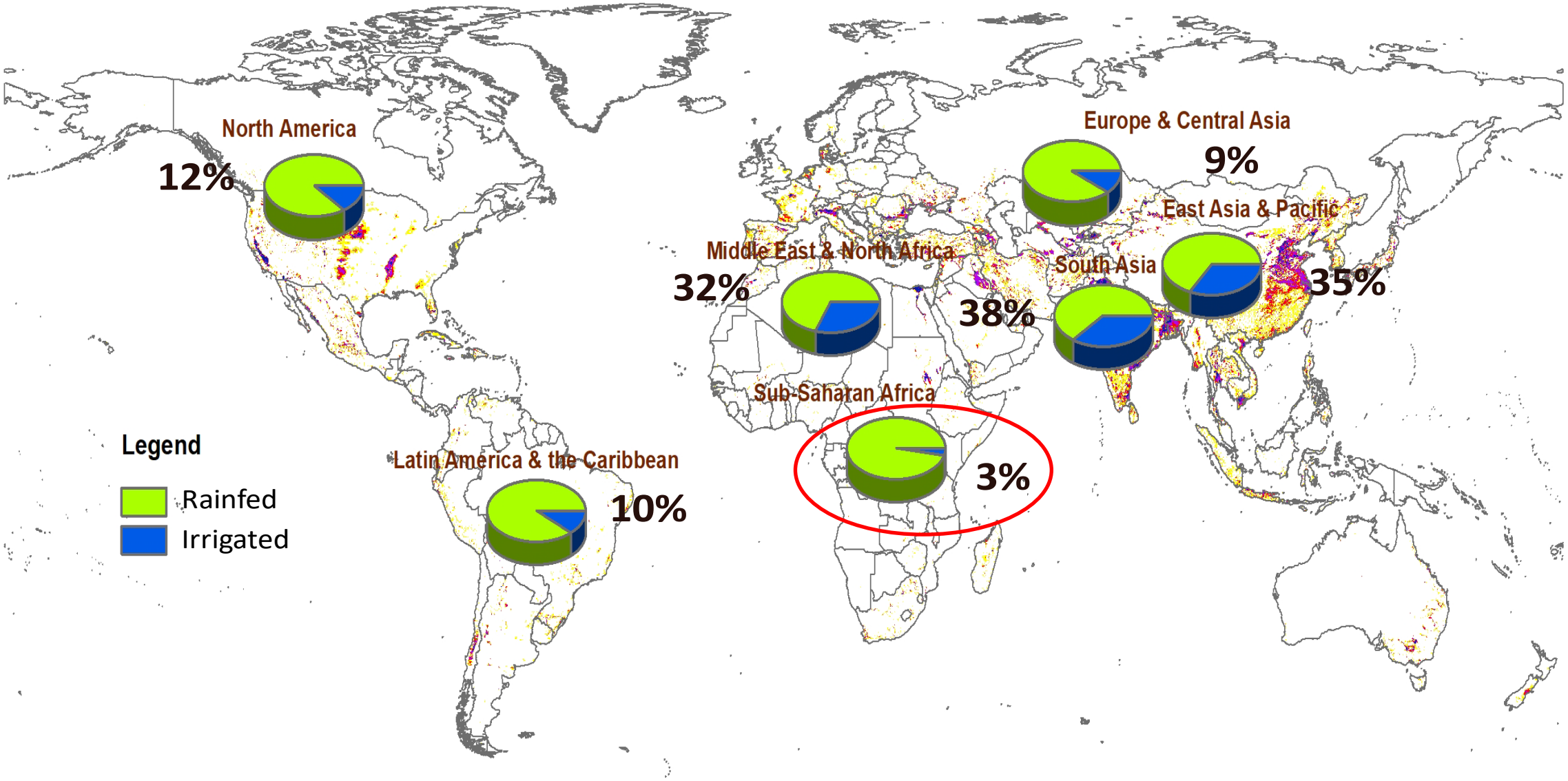

Data source: IFPRI&FAO

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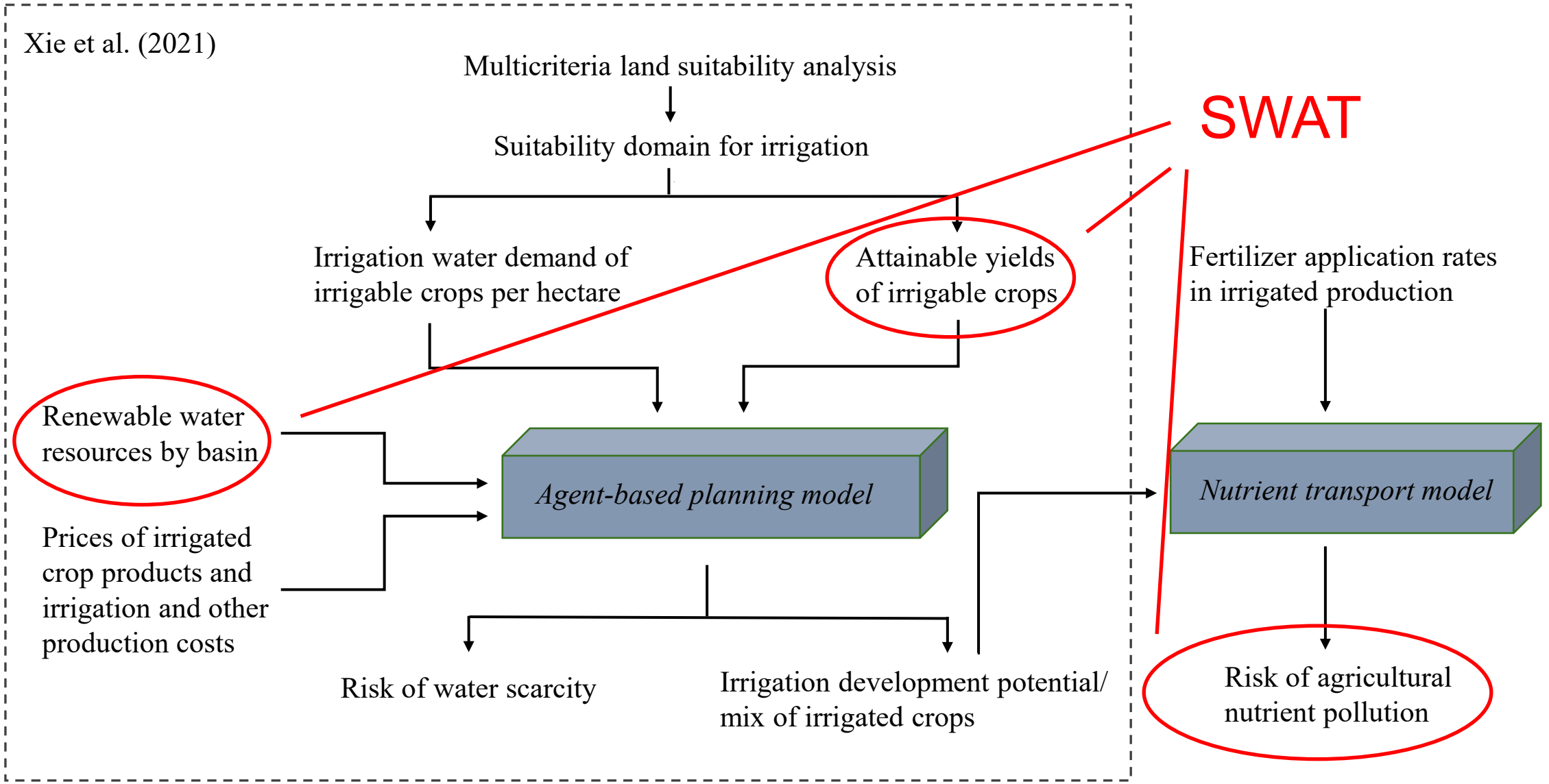
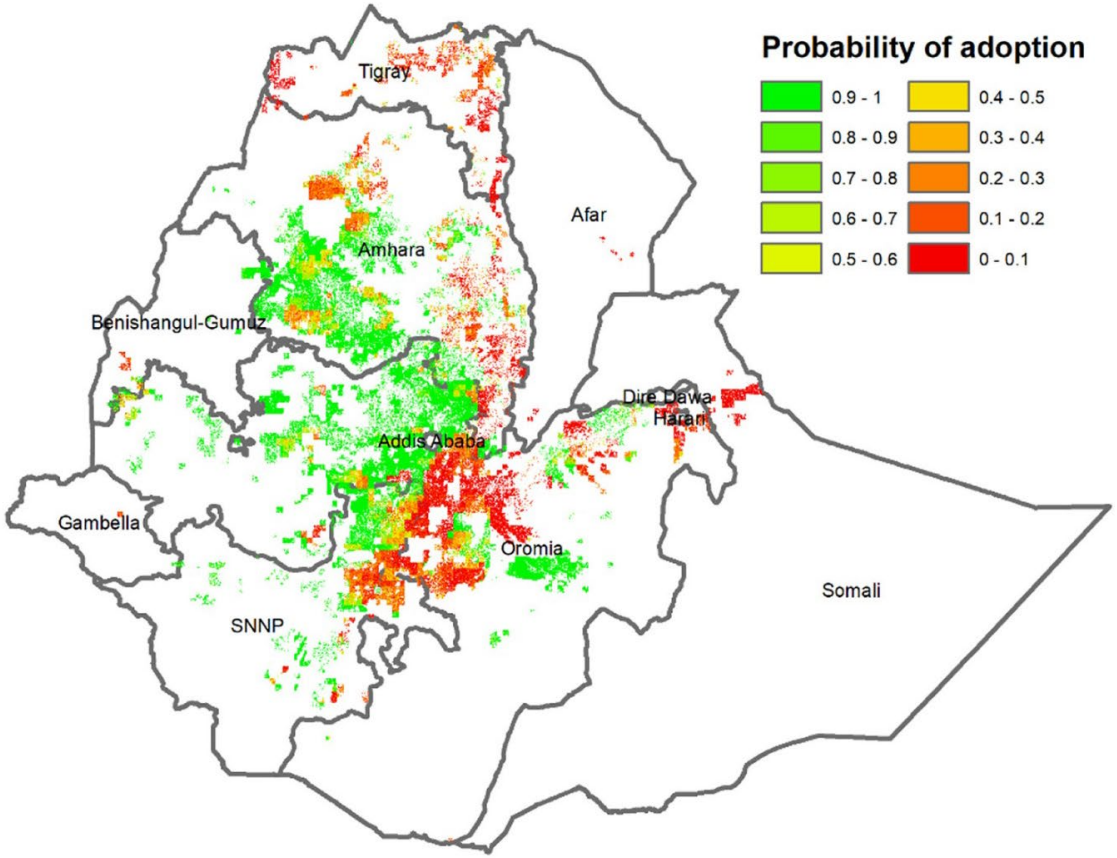
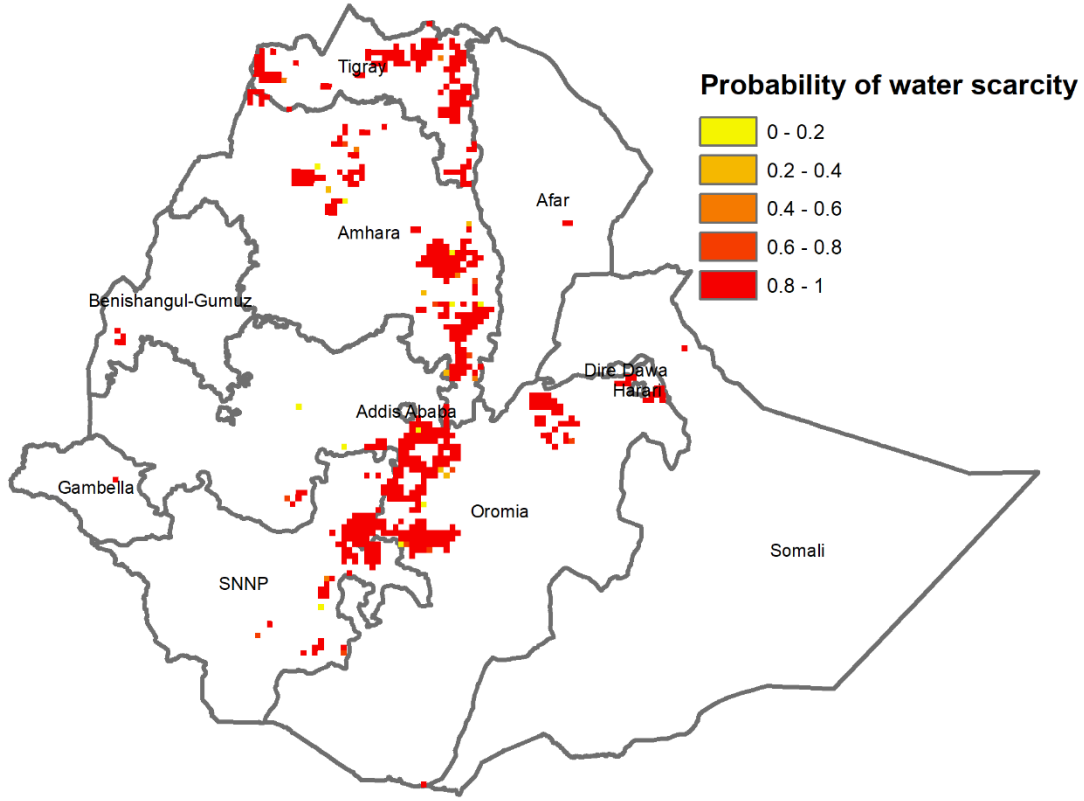


Xie et al. (2023)

Groundwater irrigation development potential in Ethiopia





Xie et al. (2021)

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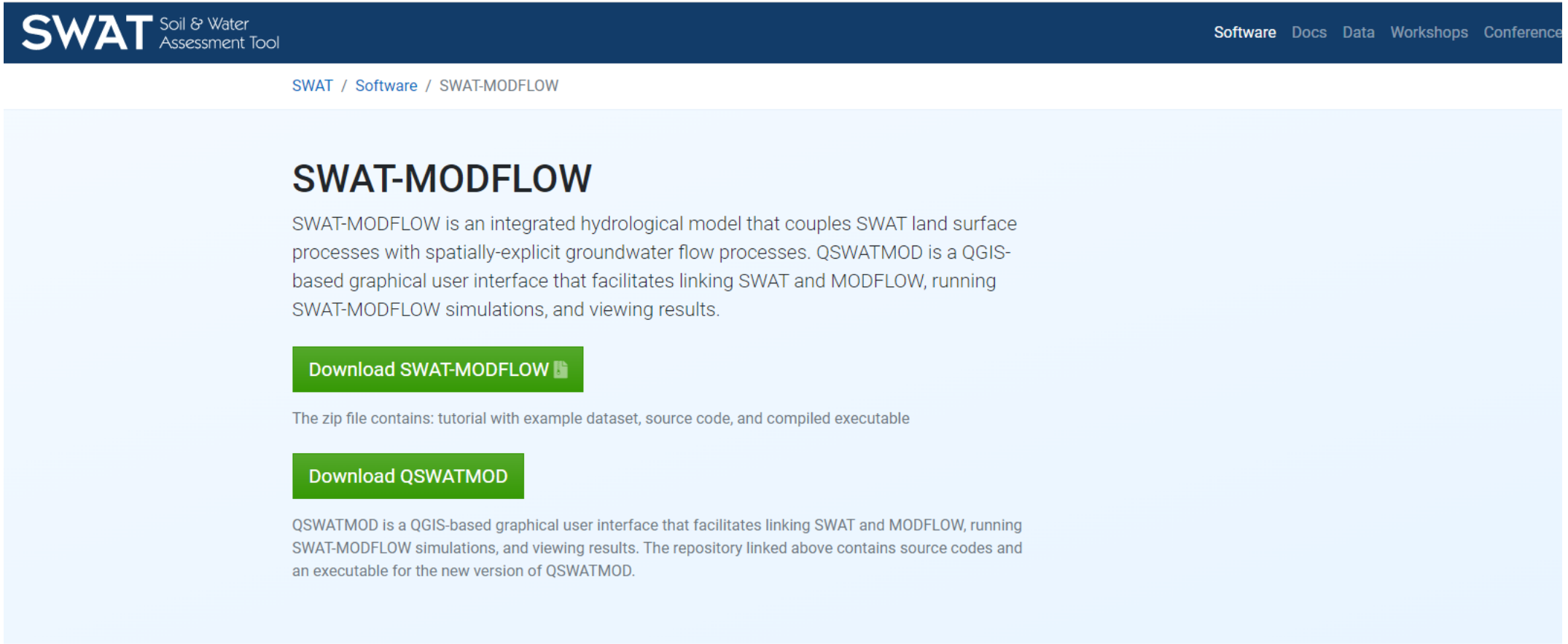
SWAT-MODFLOW coupling approach



SWAT-MODFLOW is a public domain model, and as such may be used and copied freely. The model links SWAT with the newest version of MODFLOW, MODFLOW-NWT. Recharge rates are passed from SWAT HRUs to the MODFLOW grid, and groundwater-surface water interactions simulated by MODFLOW are passed to SWAT subbasin channels for routing.

Documentation and the SWAT-MODFLOW executable are available as downloads. A user interface to facilitate SWAT-MODFLOW linkage and model set-up currently is in development. SWAT-MODFLOW has been tested in several watersheds. However, no warranty is given that the model is completely error-free. If you encounter problems with the model or have suggestions for improvement, please comment at the SWAT-MODFLOW Google group.

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Develop large-scale SWAT-MODFLOW model in Sub-Saharan Africa: Main challenges

- Scarcity of input data/parameters
  - *Aquifer properties*
  - *Well observations*

- High computational costs & solutions
  - *SWAT+ gwflow*
  - *Surrogate model*

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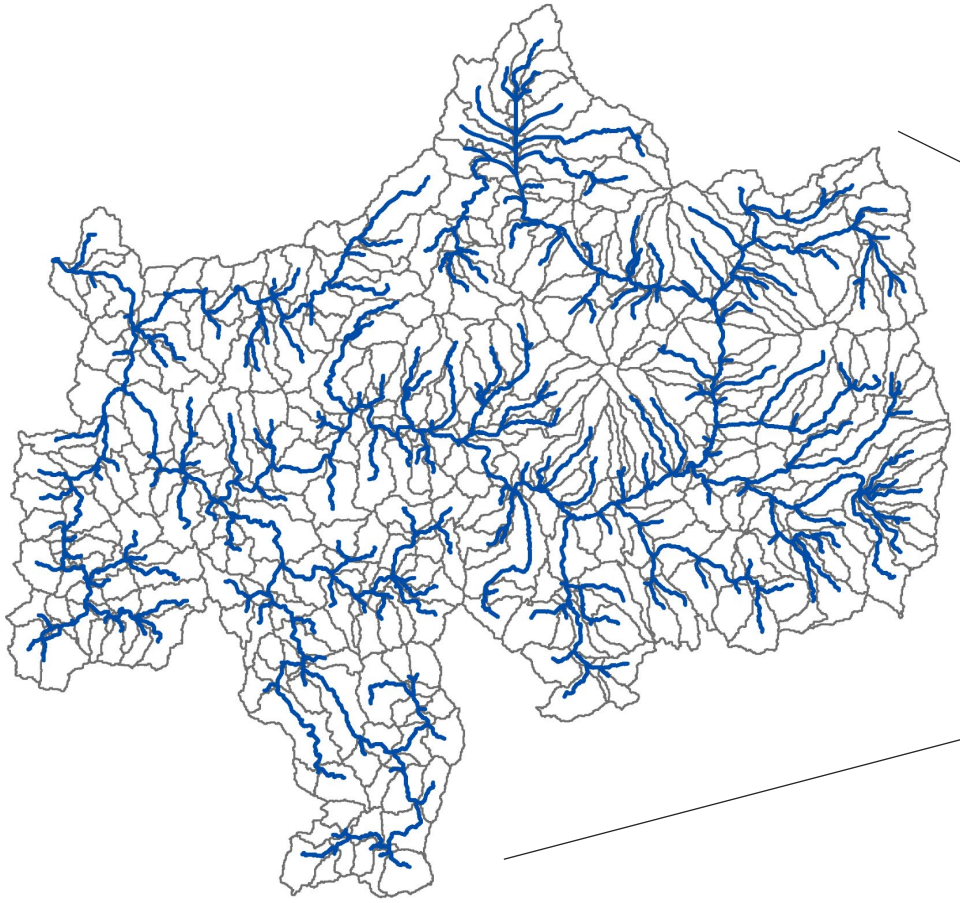
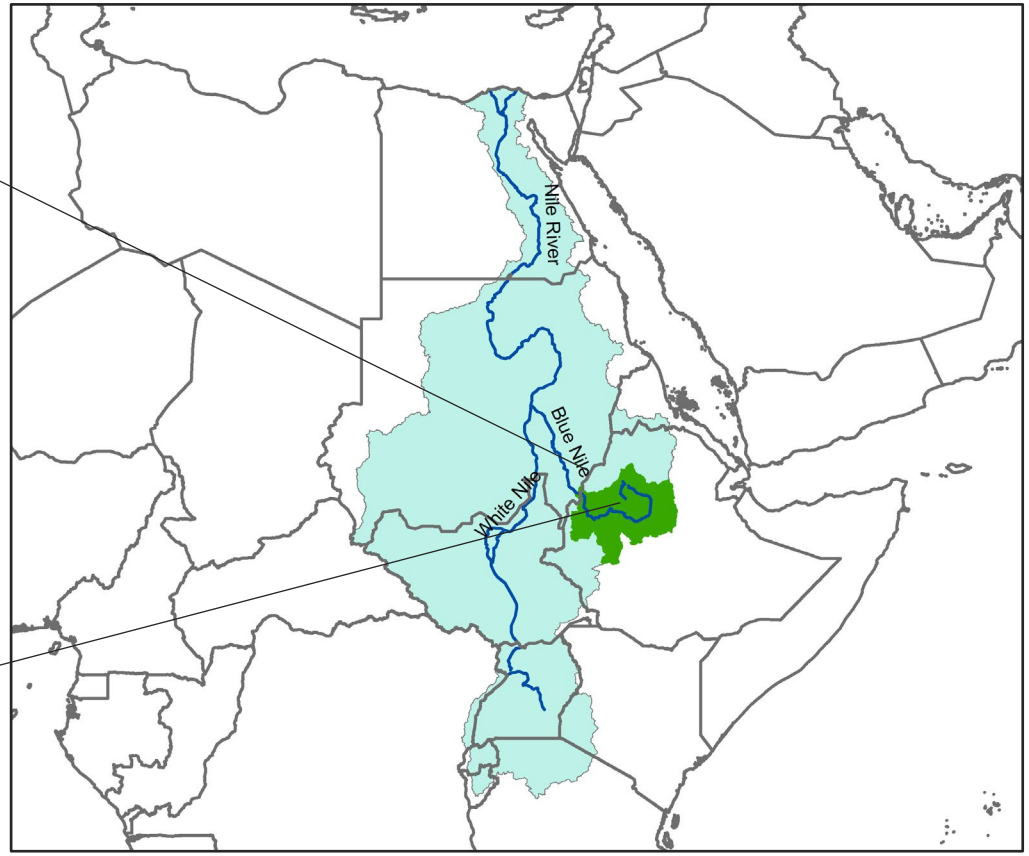
Study area: Upper Blue Nile Basin in Ethiopia





175,977 km^2

Input data for SWAT-MODFLOW setup and model configuration

Category	Source
Elevation	HydroSHEDS (https://www.hydrosheds.org/)
Land use	MODIS (https://modis.gsfc.nasa.gov/data/dataprod/mod12.php)
Soil	HWSD (https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/harmonized-world-soil-database-v12/en/)
Weather	SWAT weather generator
Aquifer properties	British Geological Survey (https://www2.bgs.ac.uk/africagroundwateratlas/index.html)

SWAT
– 486 subbasins with dominant land use and soil

MODFLOW
– 3 arc minute land grid
– one aquifer layer

Simulation scheme
– 20 years in total
– 10-year data for surrogate model training and 10-year data for model validation

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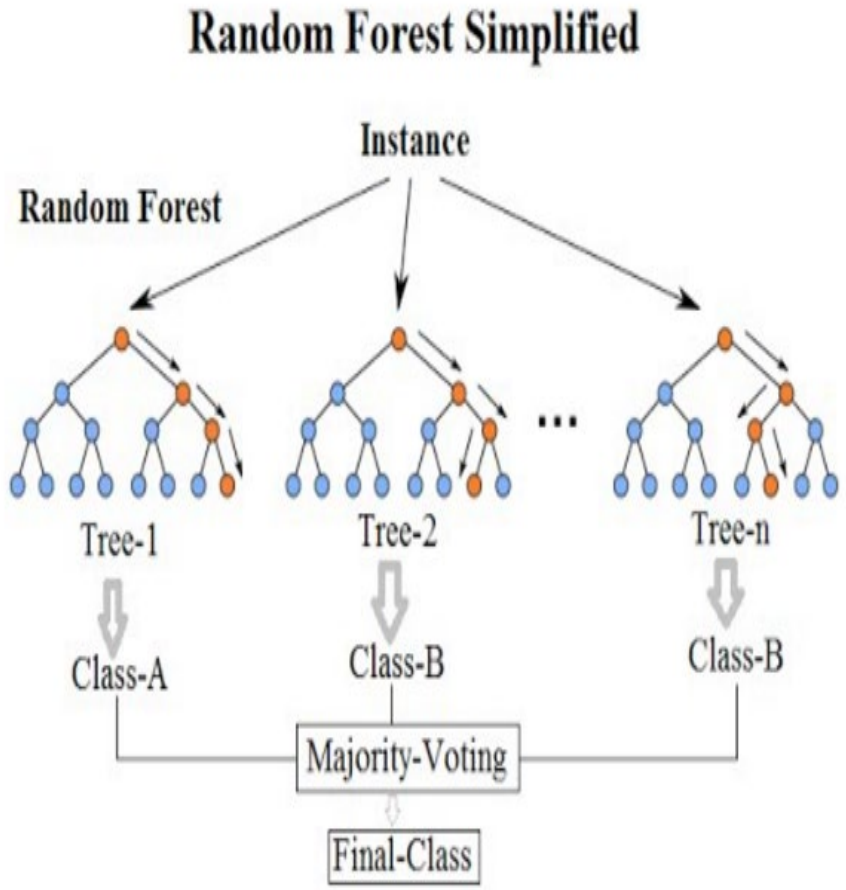
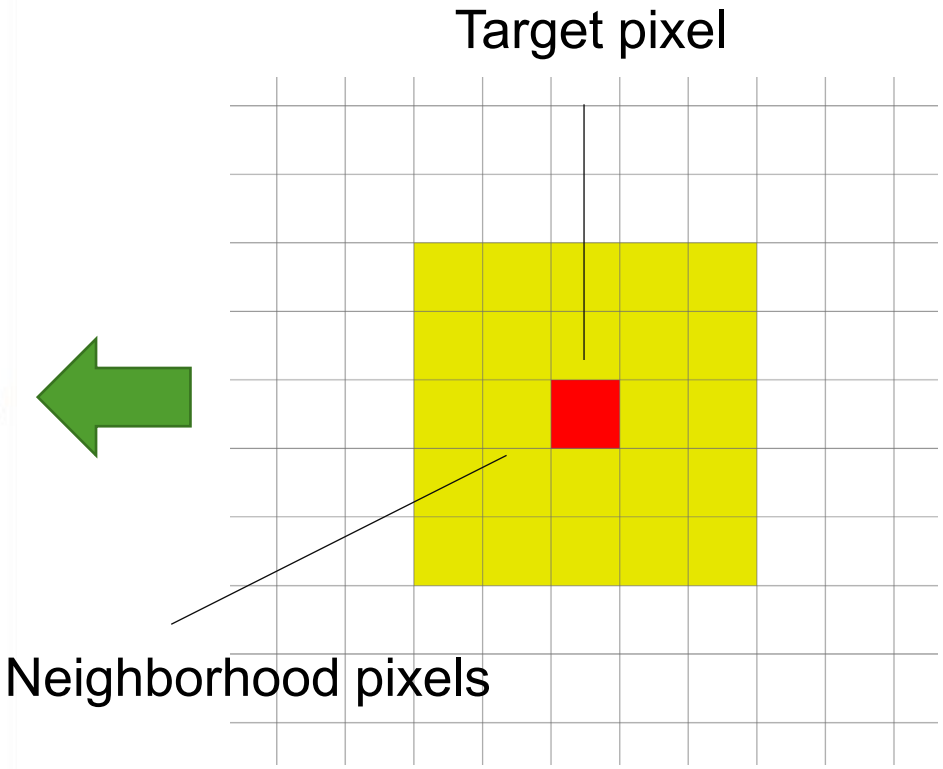
Surrogate model construction





❑ Predictors

- Recharge
- Groundwater table elevation on previous three days and in neighborhood pixels
- Unmet ET
- River stage

Source: Venkata Jagannath

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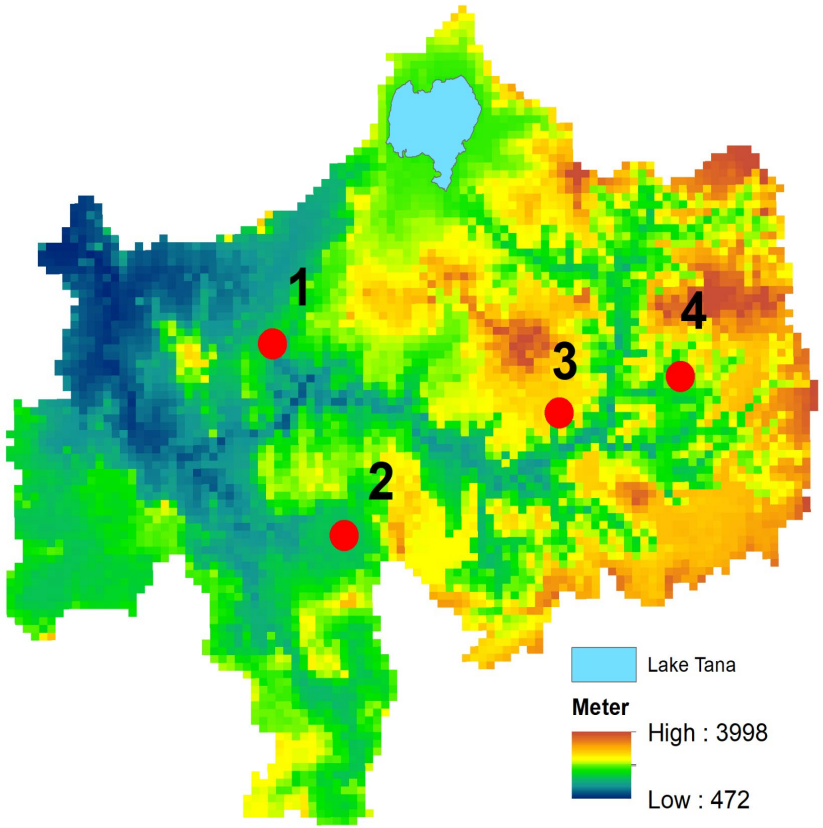
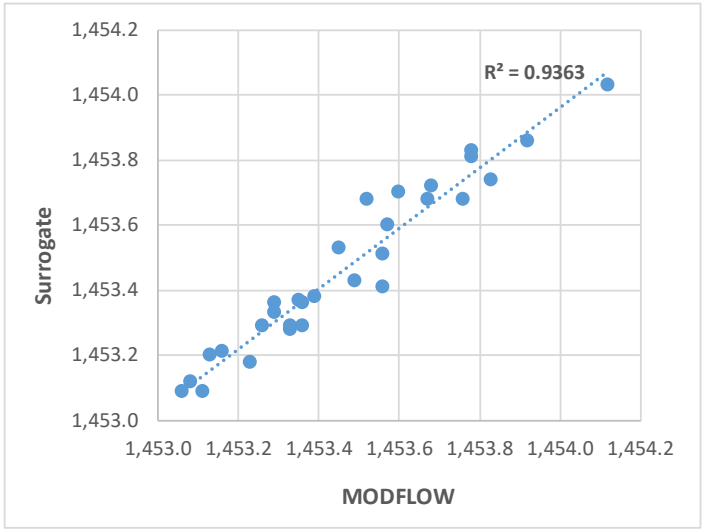
Results

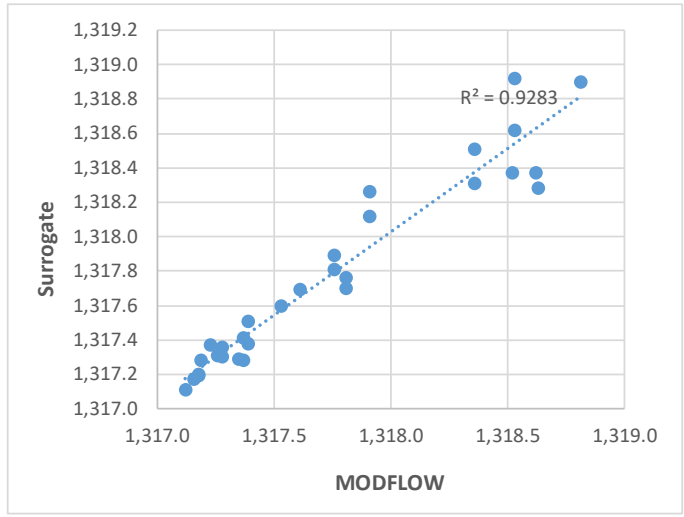


Groundwater table elevation (June, year 20)

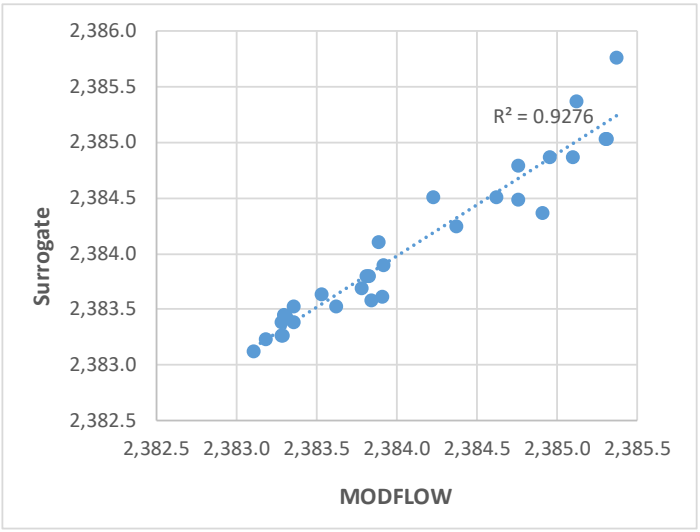
Location 1



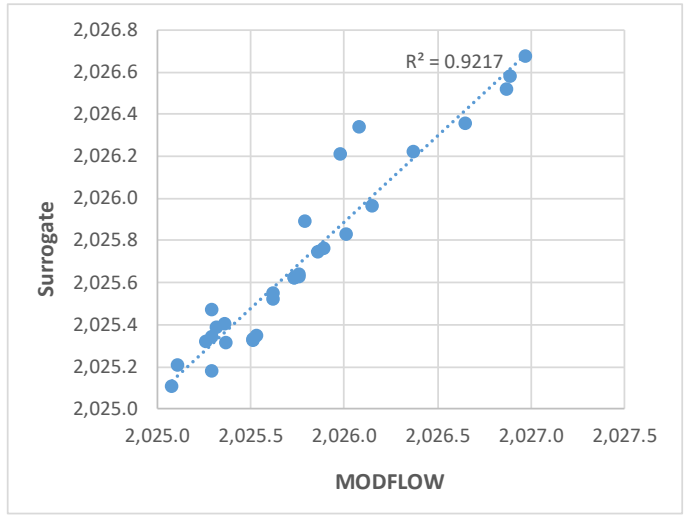
Location 2



Location 3



Location 4



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Future work

- Testing cases with more complex model configuration
  - *Additional layer for confined aquifer*
  - *Activate function for modeling irrigation water pumping*
  - *Increased spatial resolution of MODFLOW grid or local grid refinement*
- Model calibration, validation and uncertainty analysis
- SWAT+ gwflow

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Thank you!

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