



NEXUS Gains:
Realizing Multiple Benefits
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and Ecosystems



Assessing Sustainability of Expanding Groundwater Irrigation in Sub-Saharan Africa Using SWAT: Progress and Challenges

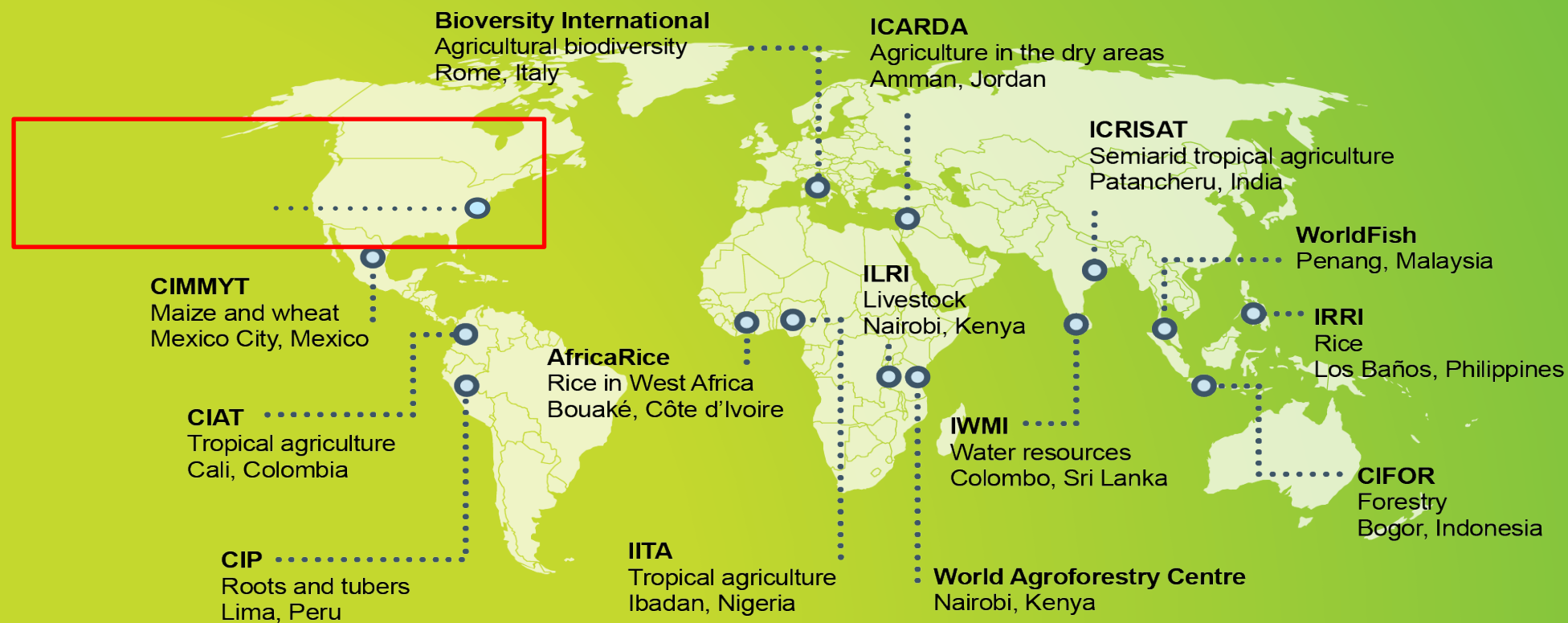
Hua Xie

International Food Policy Research Institute

SWAT International Conference, July 12th 2024, Strasbourg



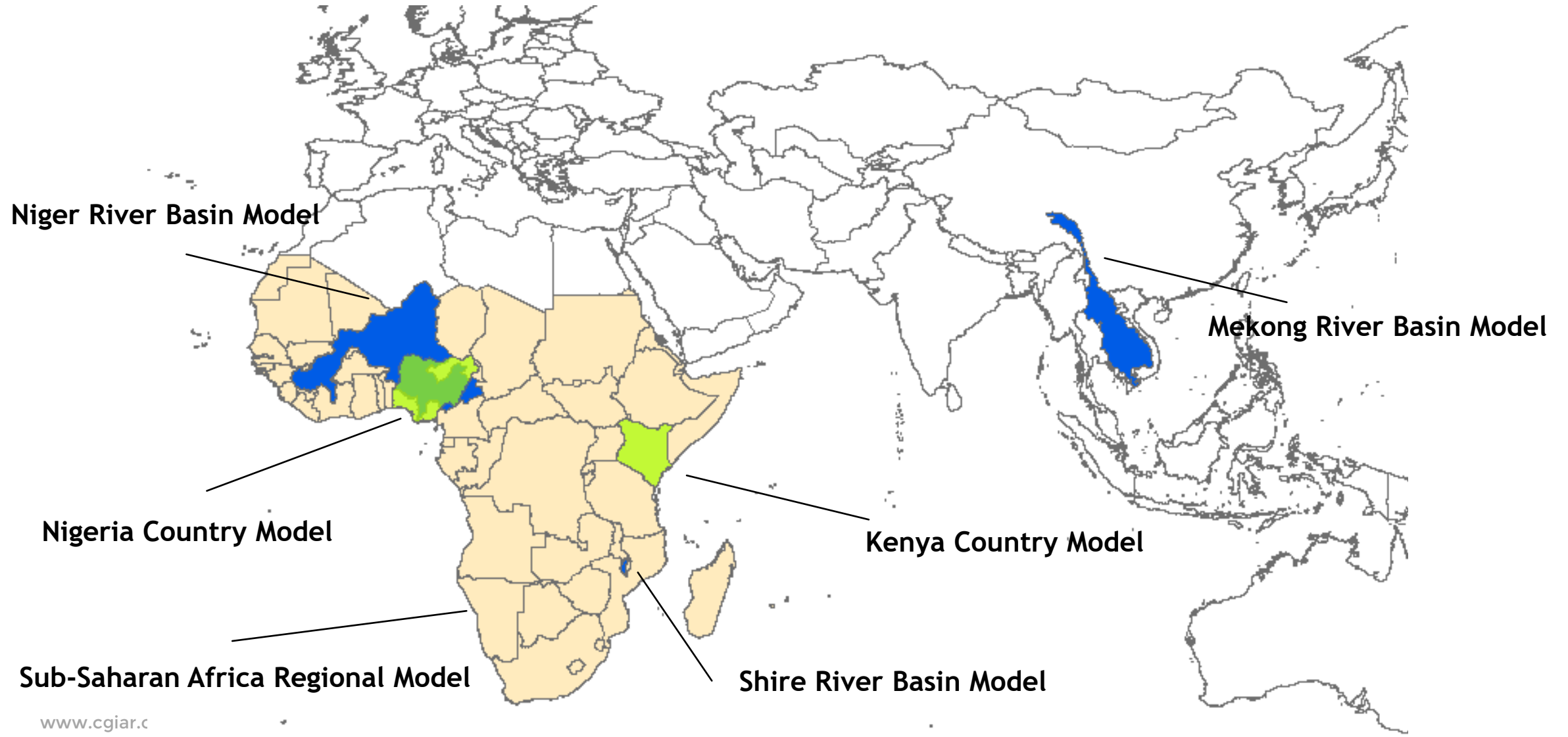
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SWAT modeling at IFPRI



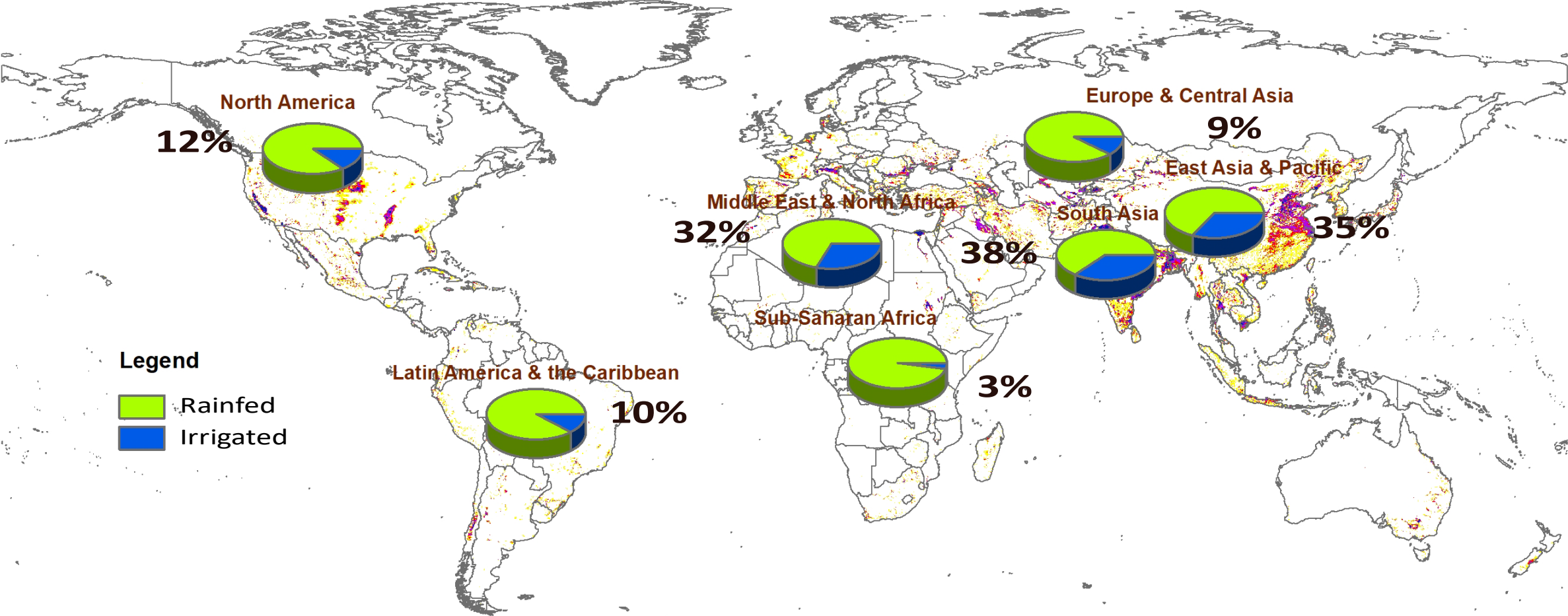
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Motivation

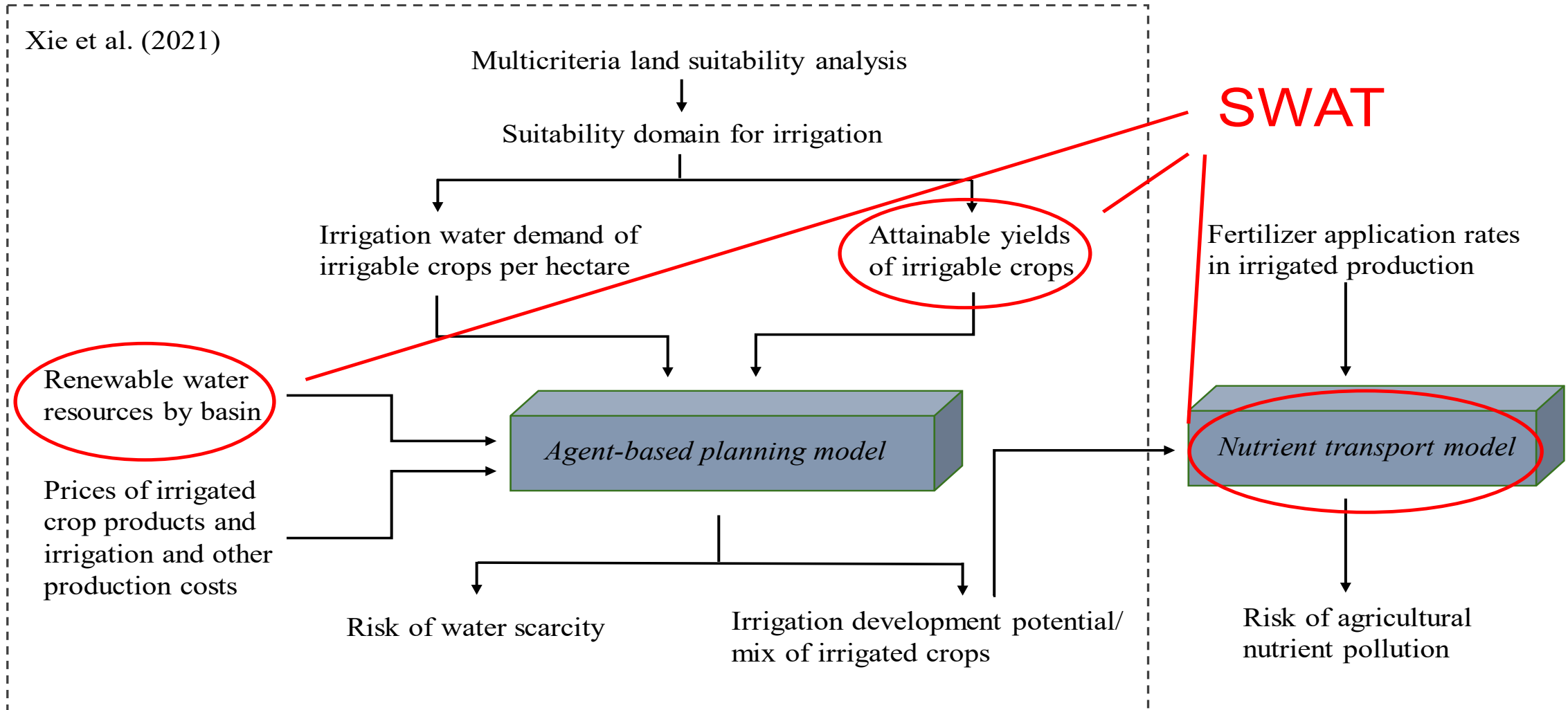


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Data source: IFPRI&FAO

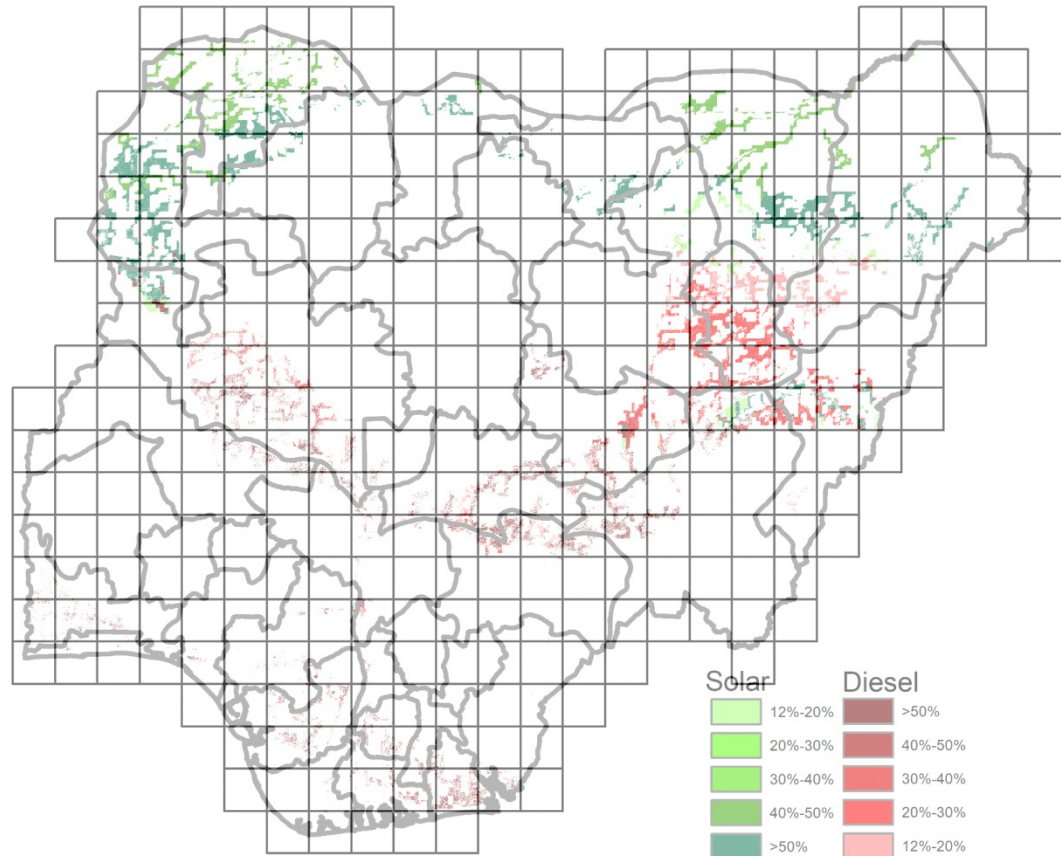
A modeling framework for irrigation investment planning analysis



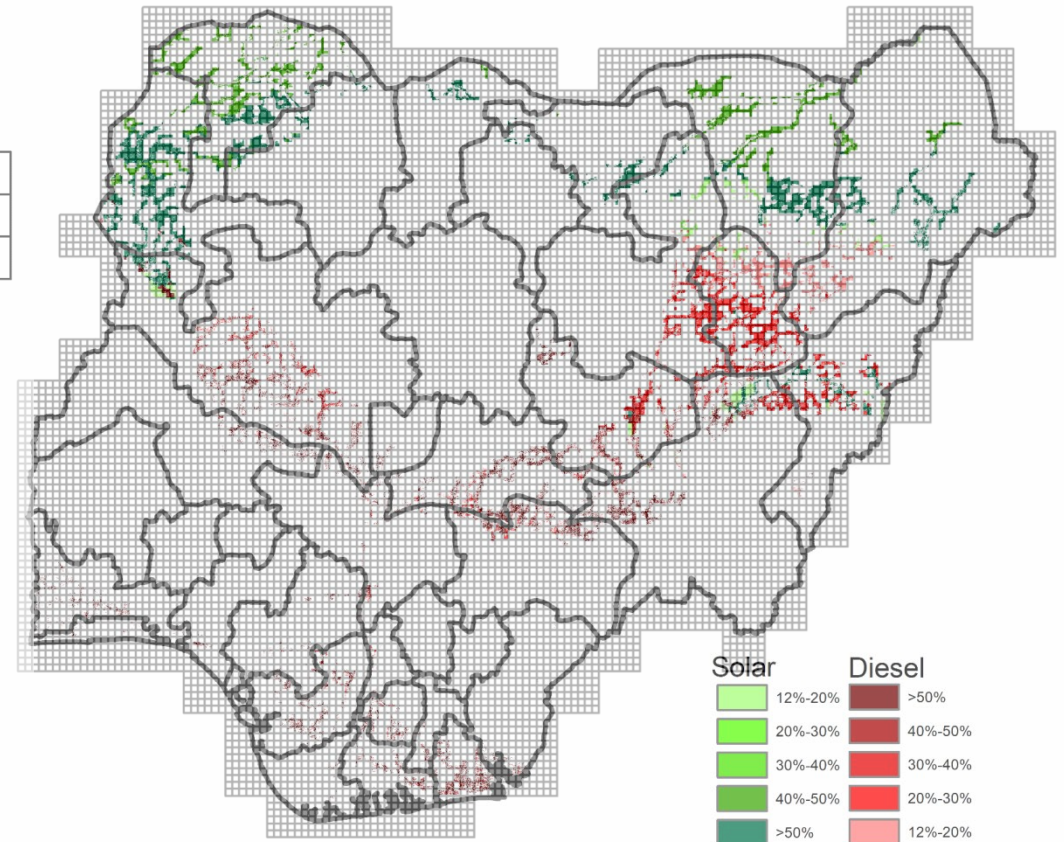
Challenges in assessing groundwater sustainability: An illustration from a study in Nigeria



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2.2 million hectares



1 million hectares

Large-scale groundwater modeling – an emerging research area



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- de Graaf, I.E., van Beek, R.L., Gleeson, T., Moosdorf, N., Schmitz, O., Sutanudjaja, E.H. and Bierkens, M.F., 2017. A global-scale two-layer transient groundwater model: Development and application to groundwater depletion. *Advances in water Resources*, 102, pp.53-67.
- Reinecke, R., Foglia, L., Mehl, S., Trautmann, T., Cáceres, D. and Döll, P., 2019. Challenges in developing a global gradient-based groundwater model (G3M v1. 0) for the integration into a global hydrological model. *Geoscientific Model Development*, 12(6).

SWAT Soil & Water
Assessment Tool

Software Docs Data Workshops Conference

SWAT / Software / SWAT-MODFLOW

SWAT-MODFLOW

SWAT-MODFLOW is an integrated hydrological model that couples SWAT land surface processes with spatially-explicit groundwater flow processes. QSWATMOD is a QGIS-based graphical user interface that facilitates linking SWAT and MODFLOW, running SWAT-MODFLOW simulations, and viewing results.

Download SWAT-MODFLOW 

The zip file contains: tutorial with example dataset, source code, and compiled executable

Download QSWATMOD

QSWATMOD is a QGIS-based graphical user interface that facilitates linking SWAT and MODFLOW, running SWAT-MODFLOW simulations, and viewing results. The repository linked above contains source codes and an executable for the new version of QSWATMOD.

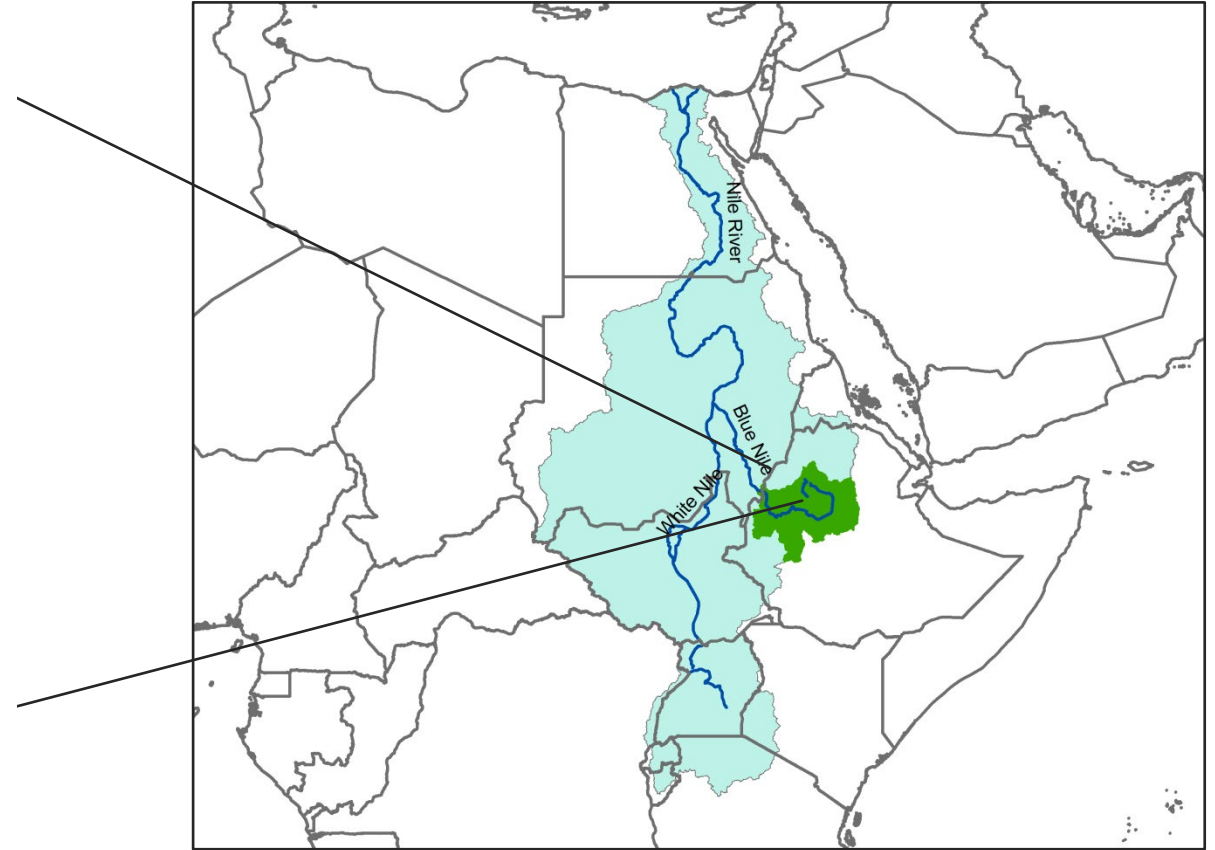
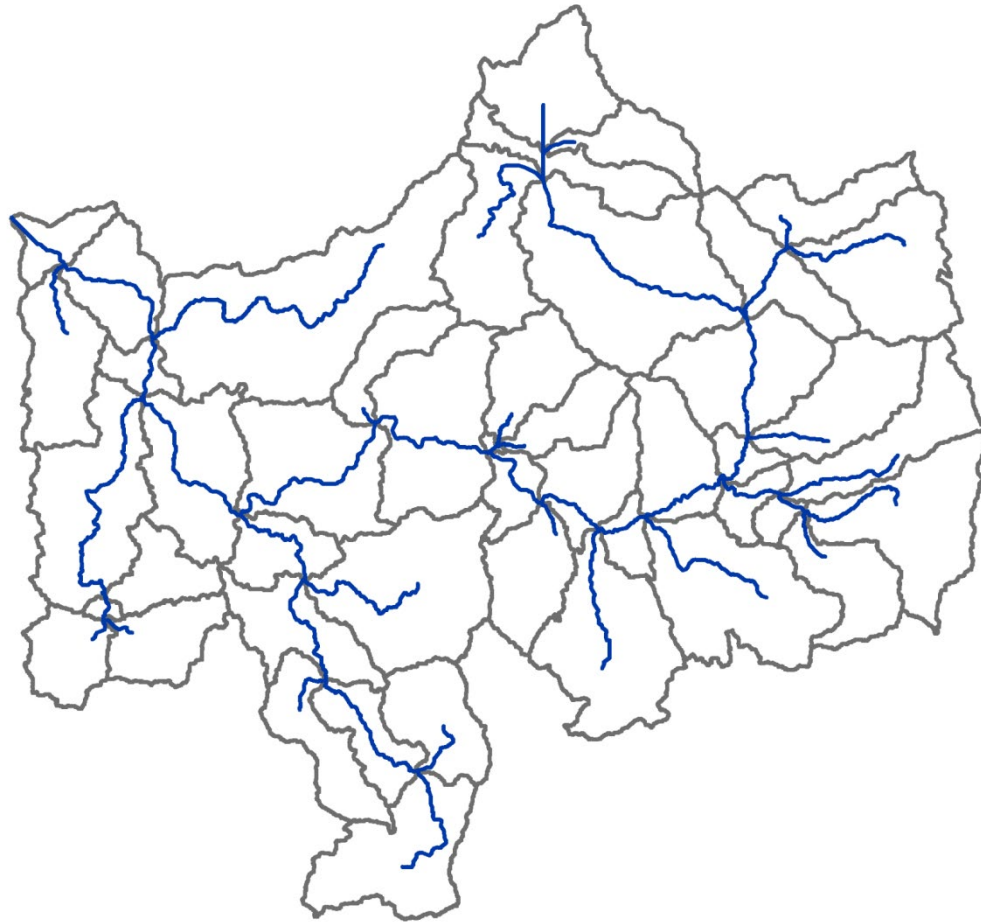
SWAT-MODFLOW is a public domain model, and as such may be used and copied freely. The model links SWAT with the newest version of MODFLOW, MODFLOW-NWT. Recharge rates are passed from SWAT HRUs to the MODFLOW grid, and groundwater-surface water interactions simulated by MODFLOW are passed to SWAT subbasin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

Study area: Upper Blue Nile Basin in Ethiopia



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182 thousand km²

Key input data



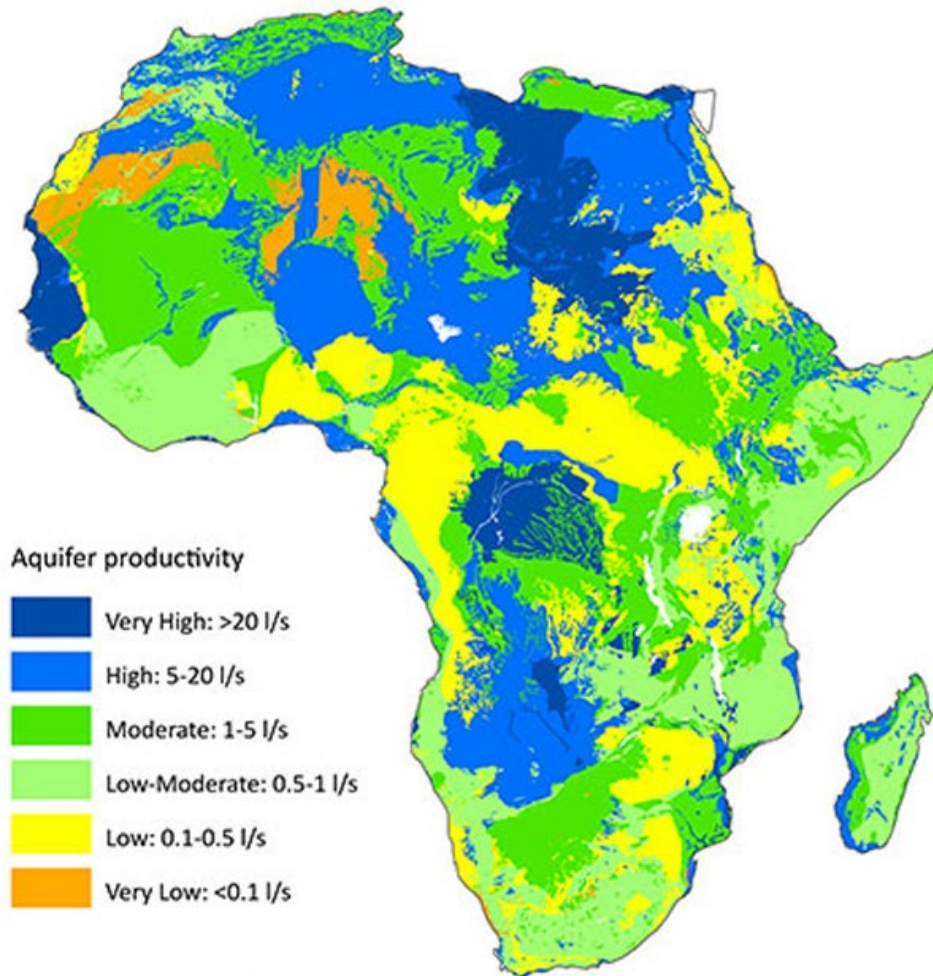
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Category	Source
Elevation	HydroSHEDS (https://www.hydrosheds.org/)
Land use	MODIS (https://modis.gsfc.nasa.gov/data/dataproduct/mod12.php) & SPAM (https://mapspam.info/)
Soil	HWSD (https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/harmonized-world-soil-database-v12/en/)
Weather	CHIRPS (https://chc.ucsb.edu/data/chirps) and CSFR (https://swat.tamu.edu/data/cfsr)
Hydrogeology	BGS groundwater maps of Africa (https://www2.bgs.ac.uk/groundwater/shaleGas/home.html)

Uncertainty in hydrogeological input data



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Boundaries of surficial geology of Africa, courtesy of the U.S. Geological Survey.
Country boundaries sourced from ArcWorld © 1995-2011 ESRI. All rights Reserved

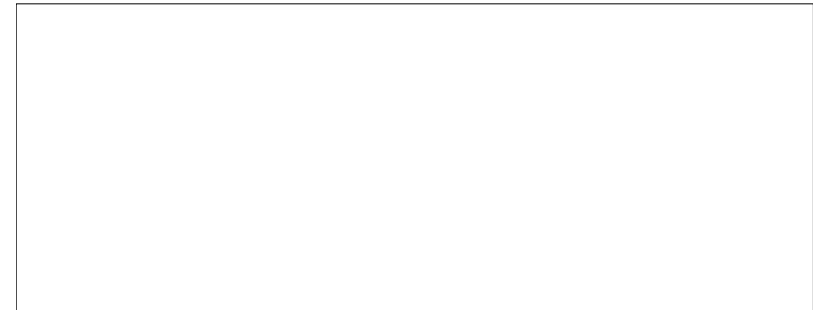
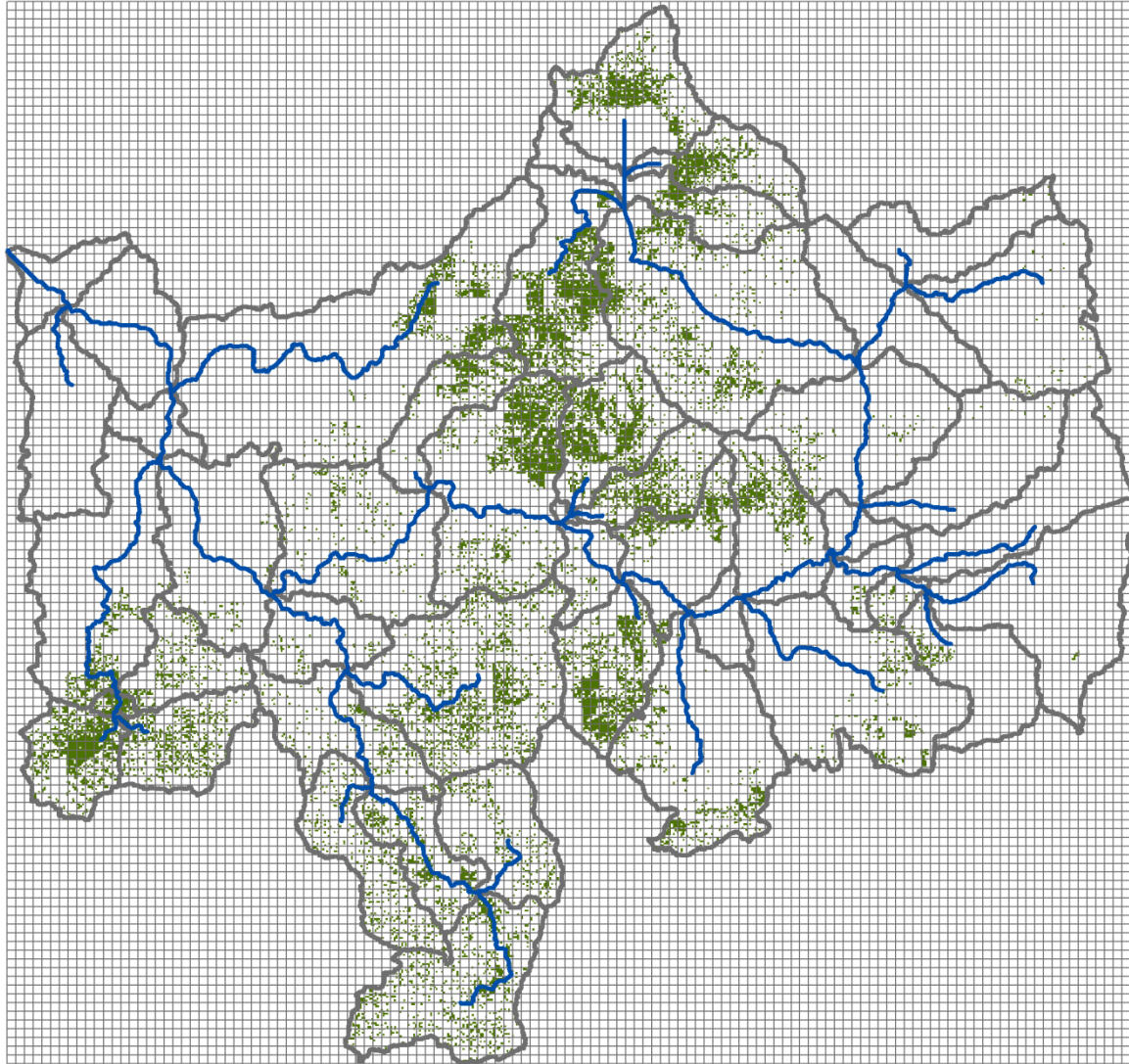
Aquifer productivity	Transmissivity (m ² /d)
Very high	500-1,000
High	50-500
Moderate	10-50
Low-moderate	5-10
Low	1-5
Very low	0.1-0.5

Source of data: British Geological Survey

MODFLOW grid



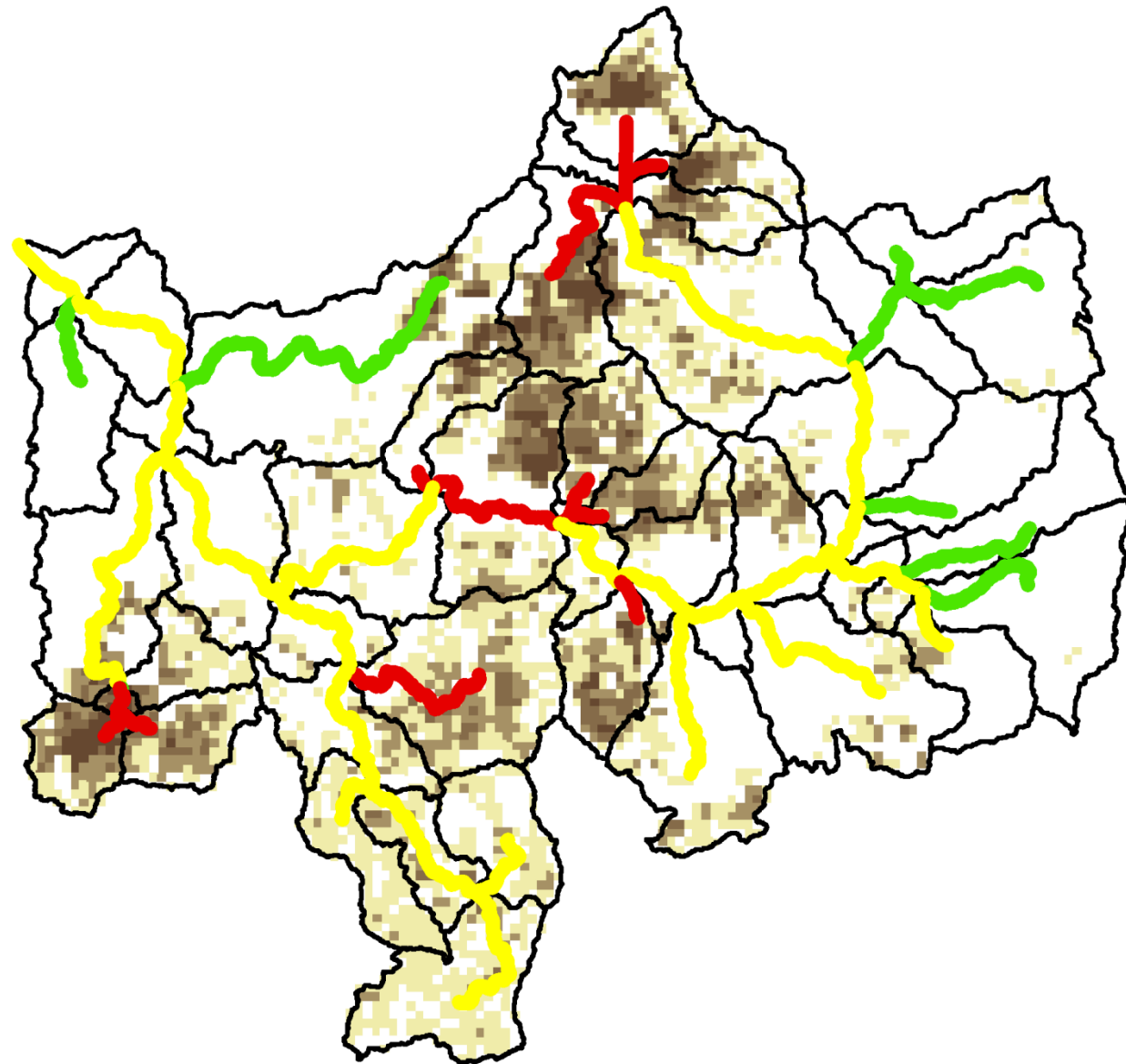
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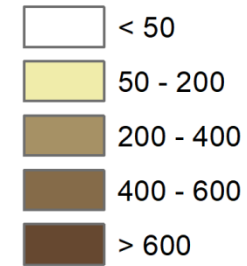
Initial results



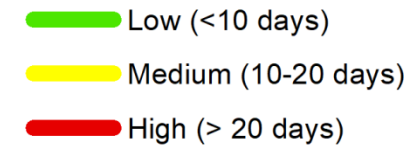
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Declining rate of groundwater table mm/yr



Risk of increased low flow days



Future work



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- Hydrogeological data collation (e.g., from national agencies)
- Seeking additional computational resources; testing an alternative version of MODFLOW
- Multivariate model calibration (e.g., using streamflow, GRACE, remote sensing-based ET, and well groundwater level data)
- New AI technique for groundwater modeling

Thank you!



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