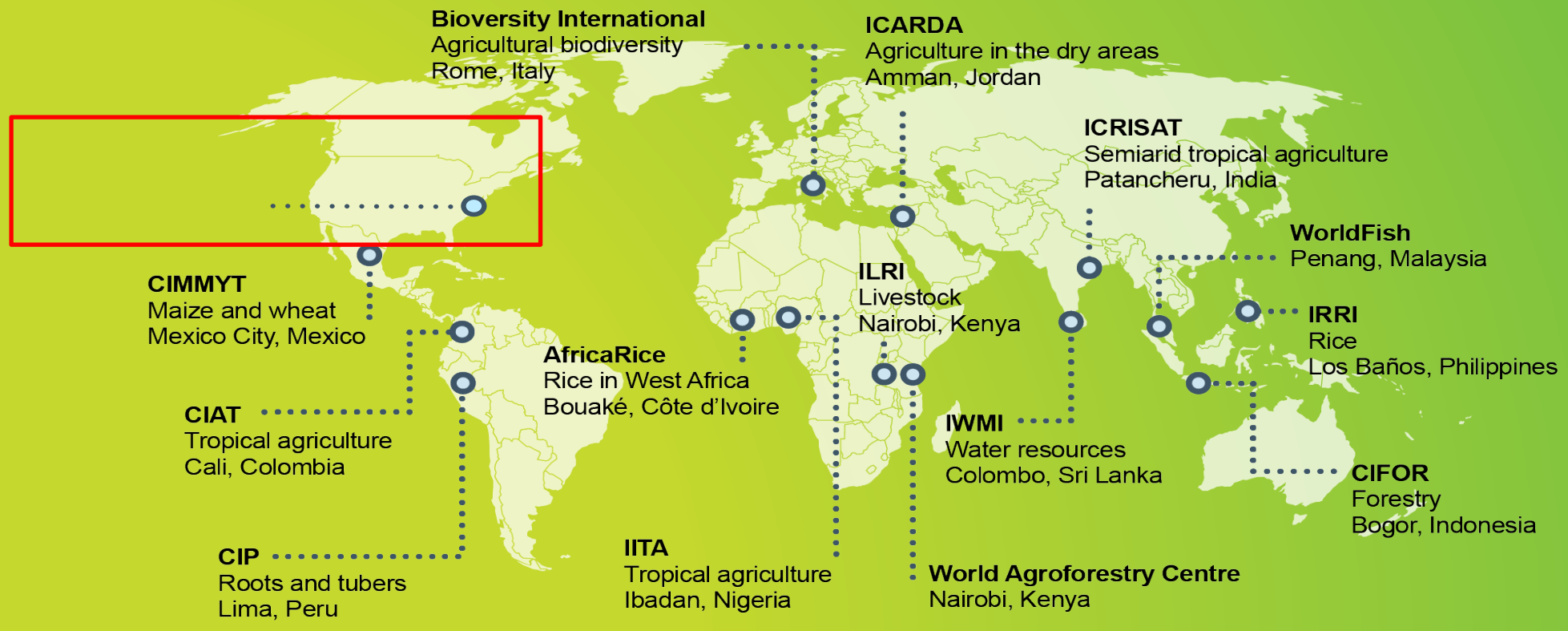
NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

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

Hua Xie

International Food Policy Research Institute

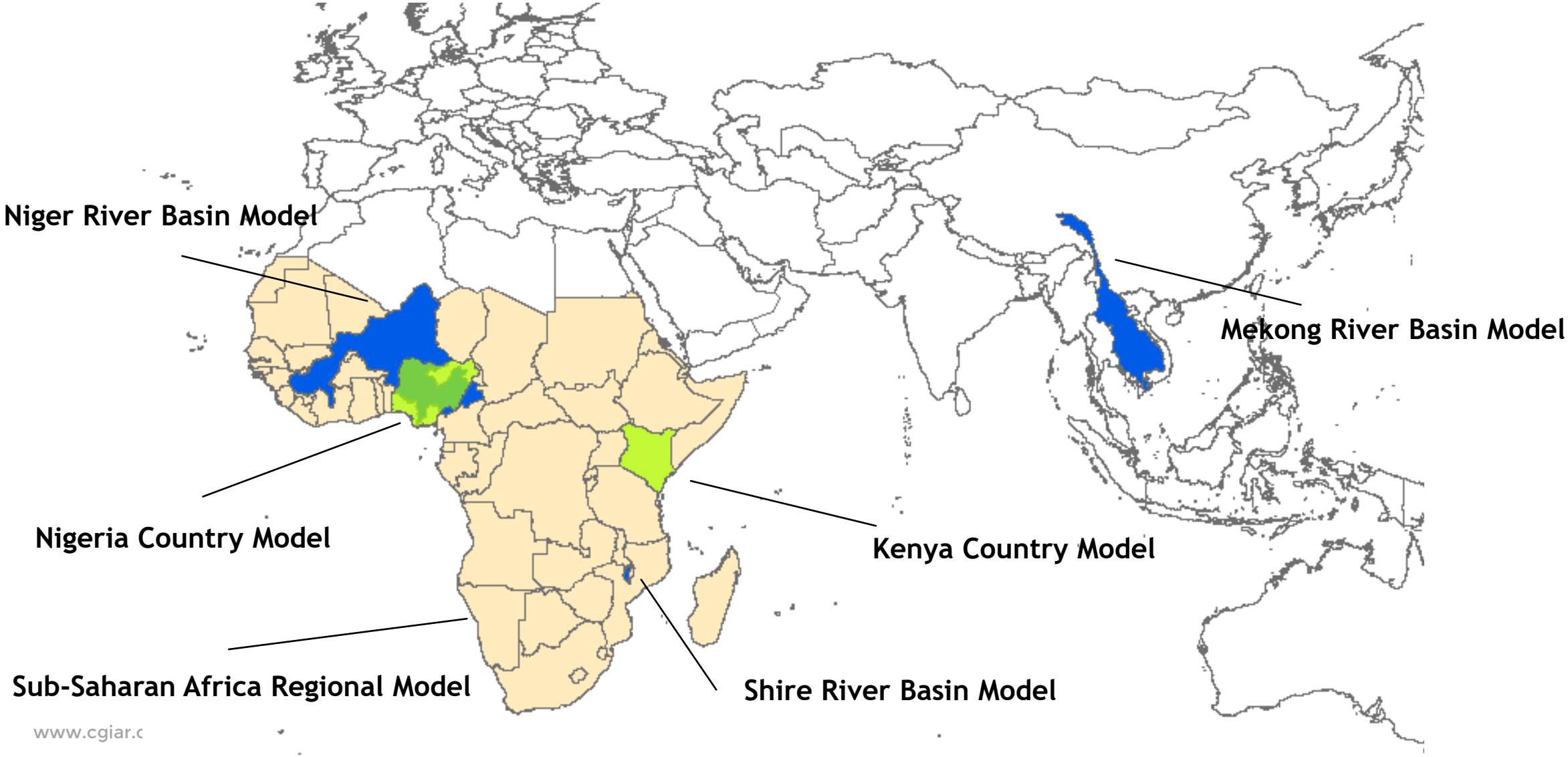
SWAT International Conference, July 12th 2024, Strasbourg


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

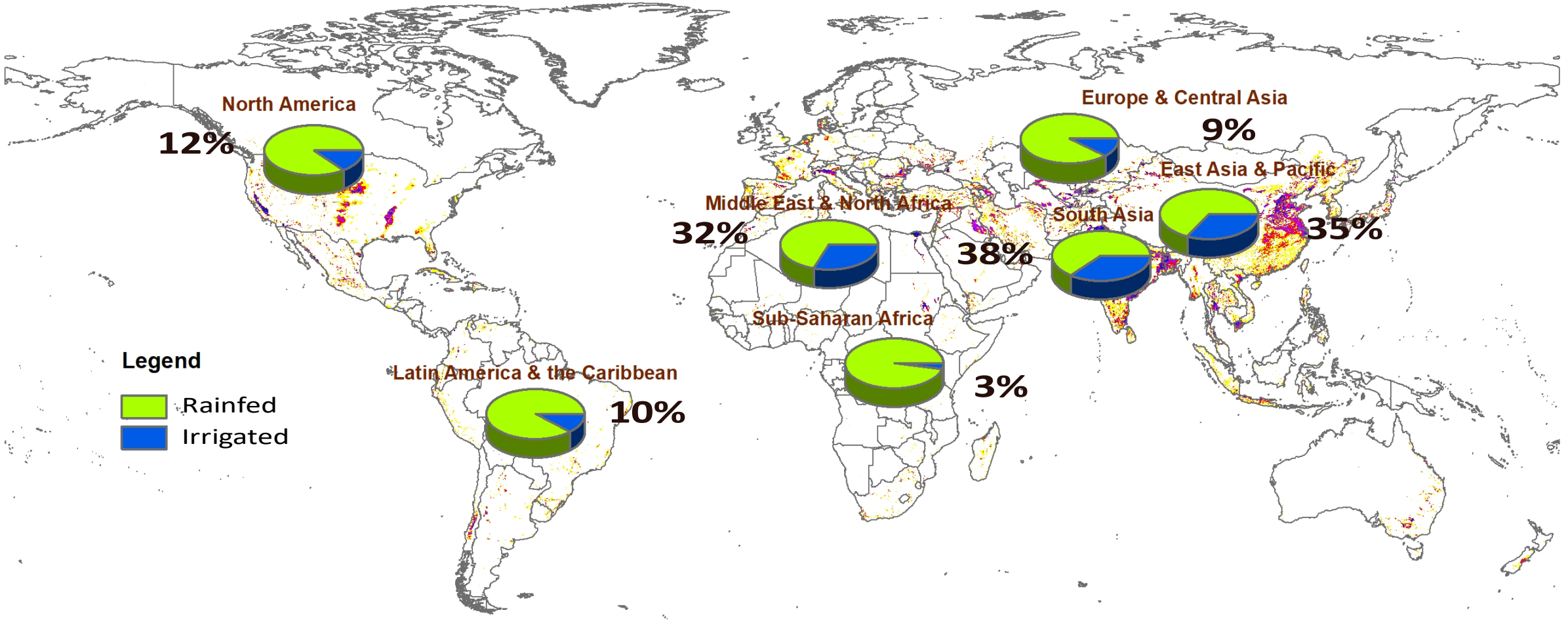
SWAT modeling at IFPRI

CGIAR

NEXUS Gains:
Realizing Multiple Benefits
Across Water, Energy, Food
and Ecosystems

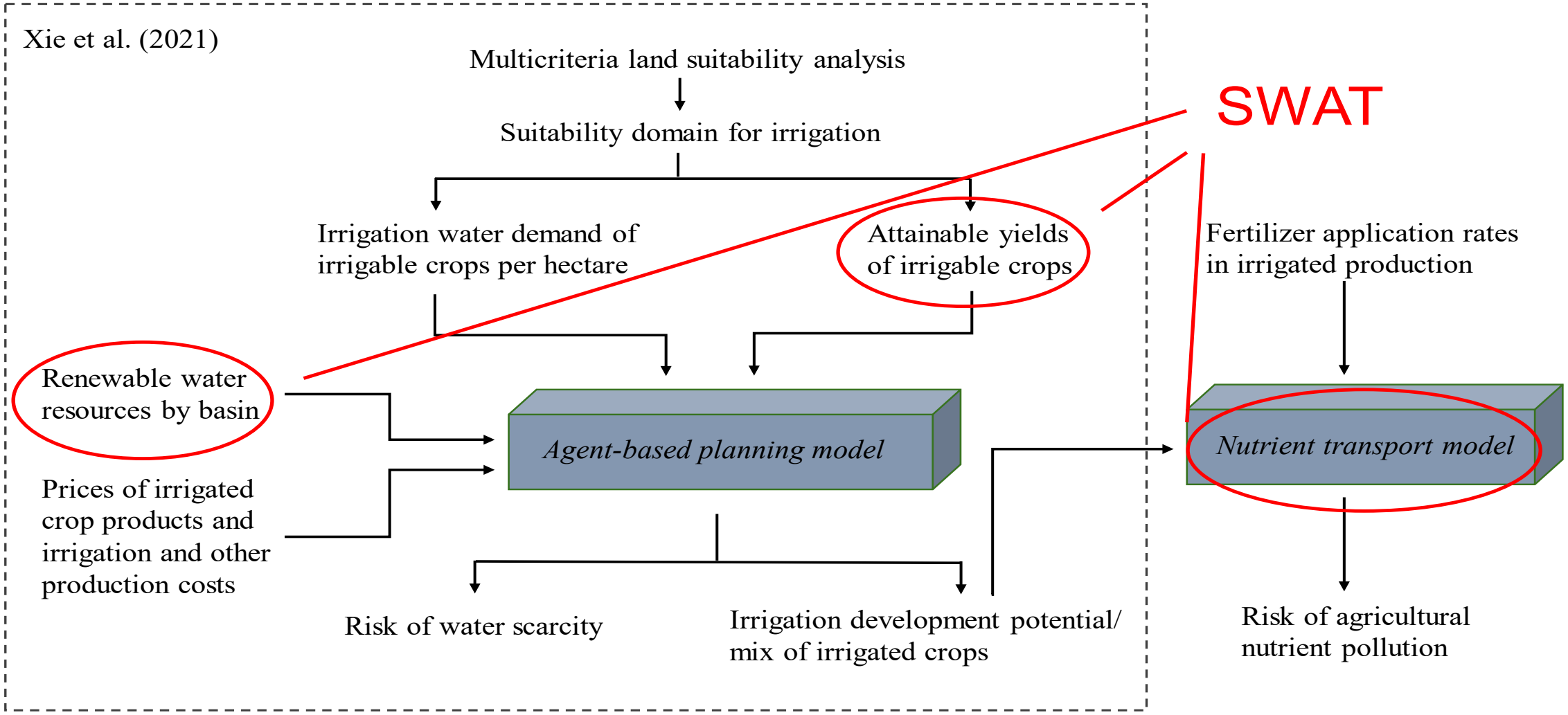


Motivation



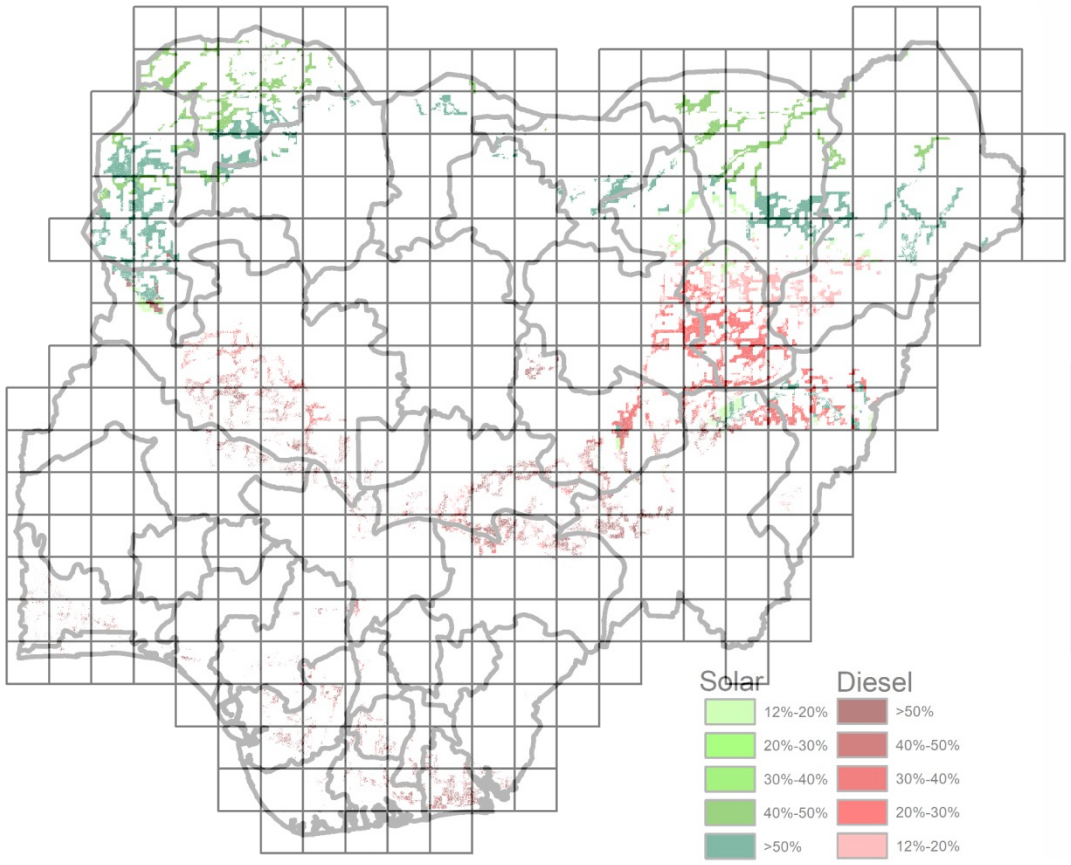
Data source: IFPRI&FAO

A modeling framework for irrigation investment planning analysis

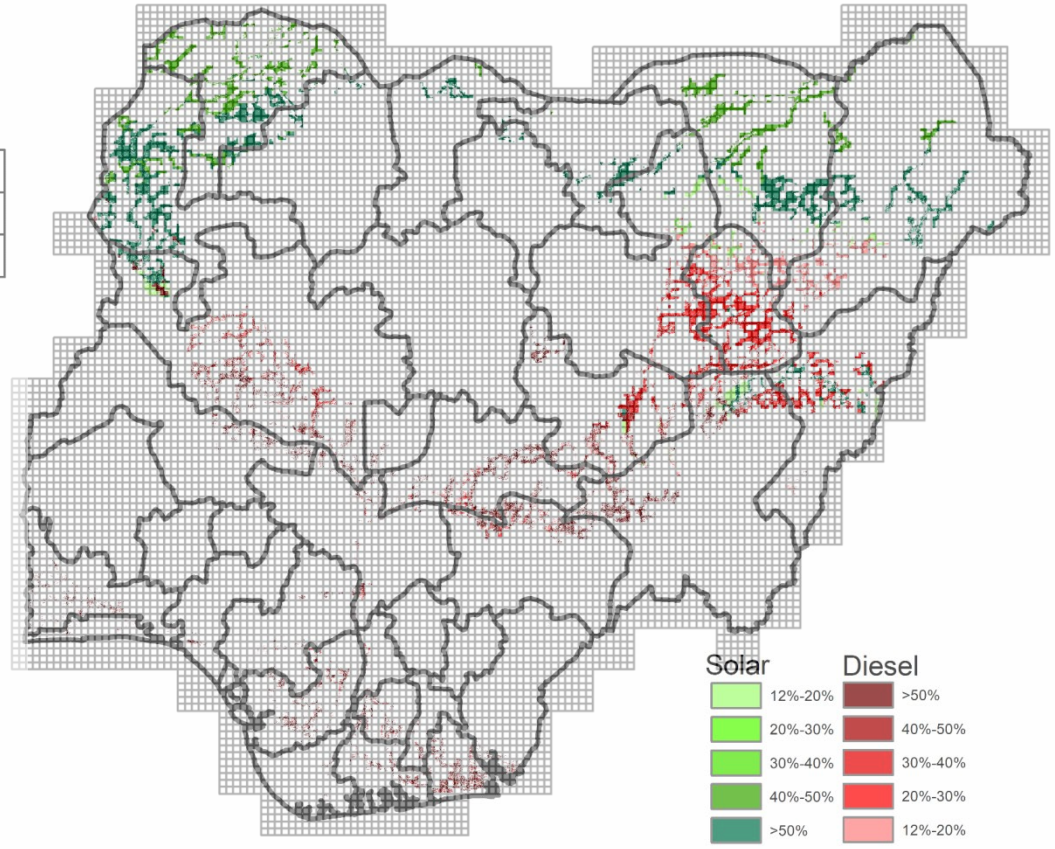


Xie et al. (2023)

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



2.2 million hectares

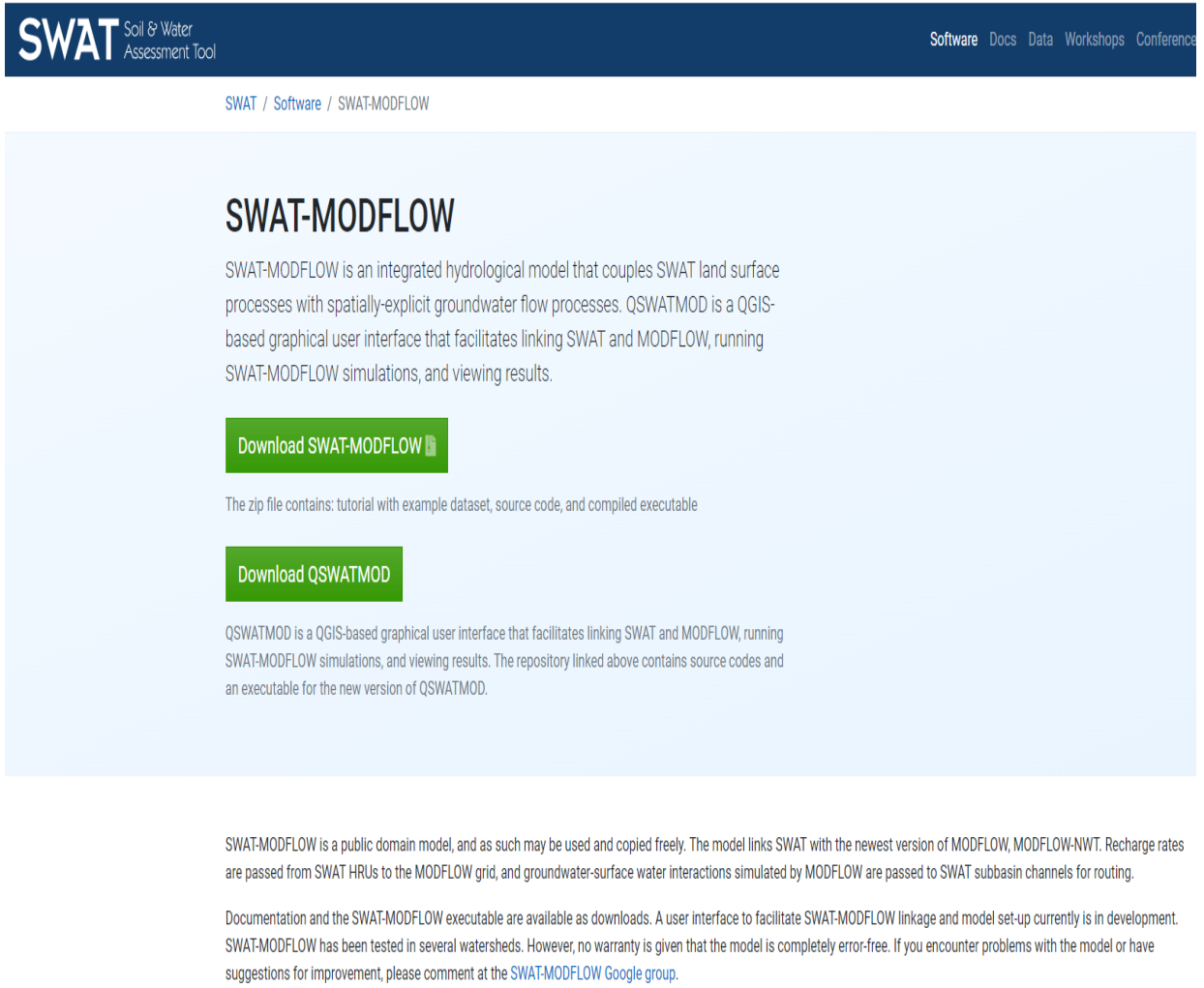


1 million hectares

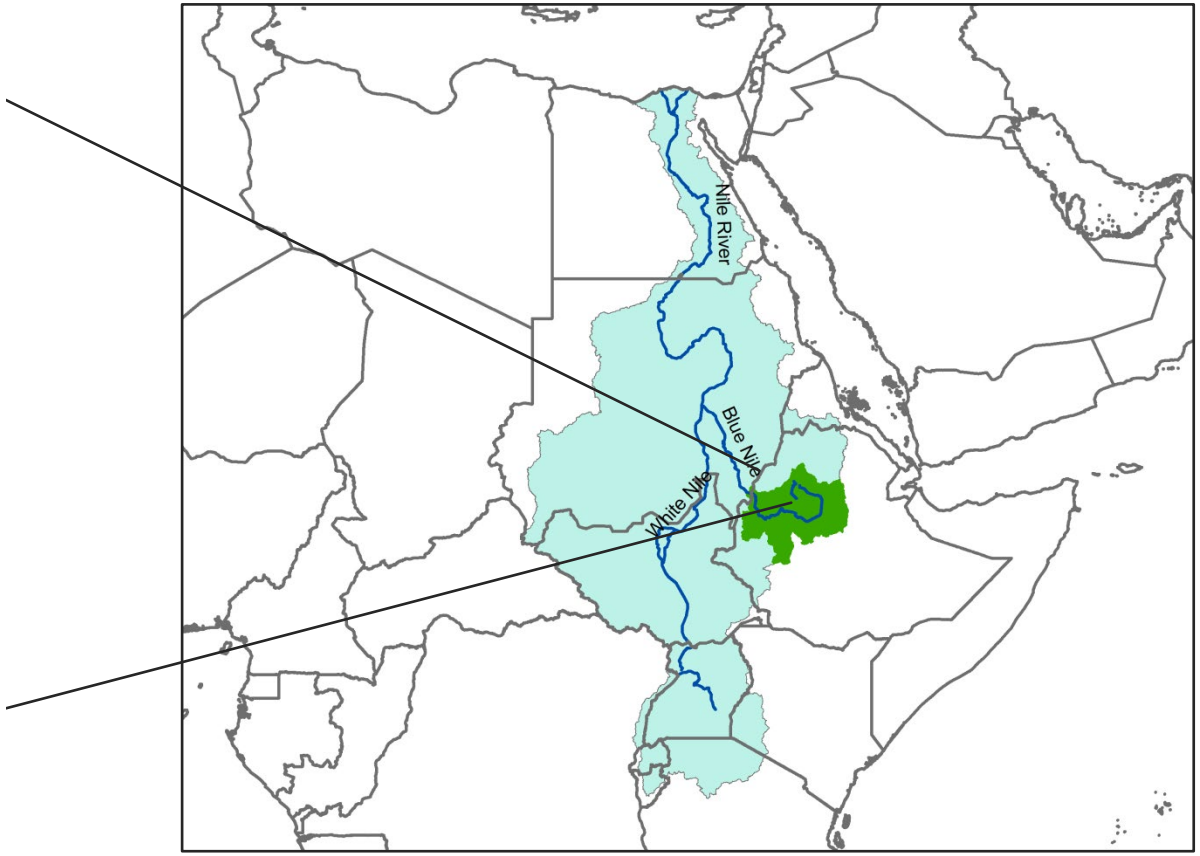
Large-scale groundwater modeling – an emerging research area

- 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).



Study area: Upper Blue Nile Basin in Ethiopia

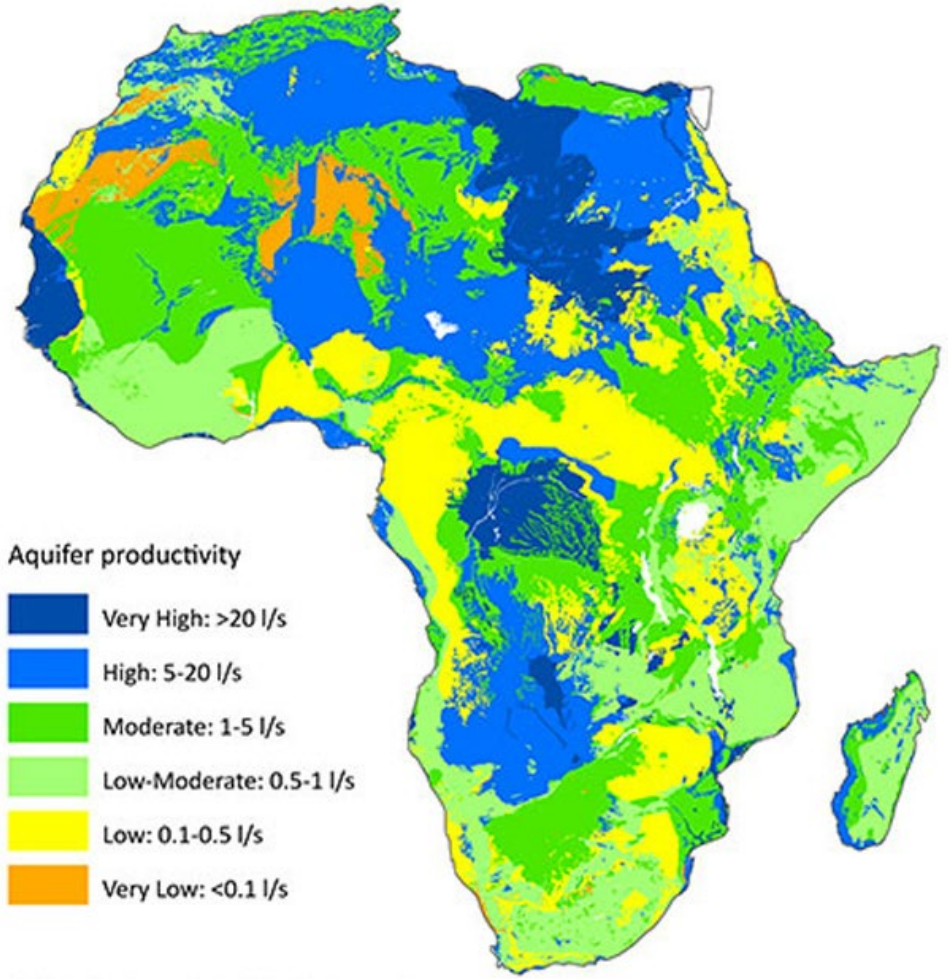


182 thousand km^2

Key input data

Category	Source
Elevation	HydroSHEDS (https://www.hydrosheds.org/)
Land use	MODIS (https://modis.gsfc.nasa.gov/data/dataprod/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)

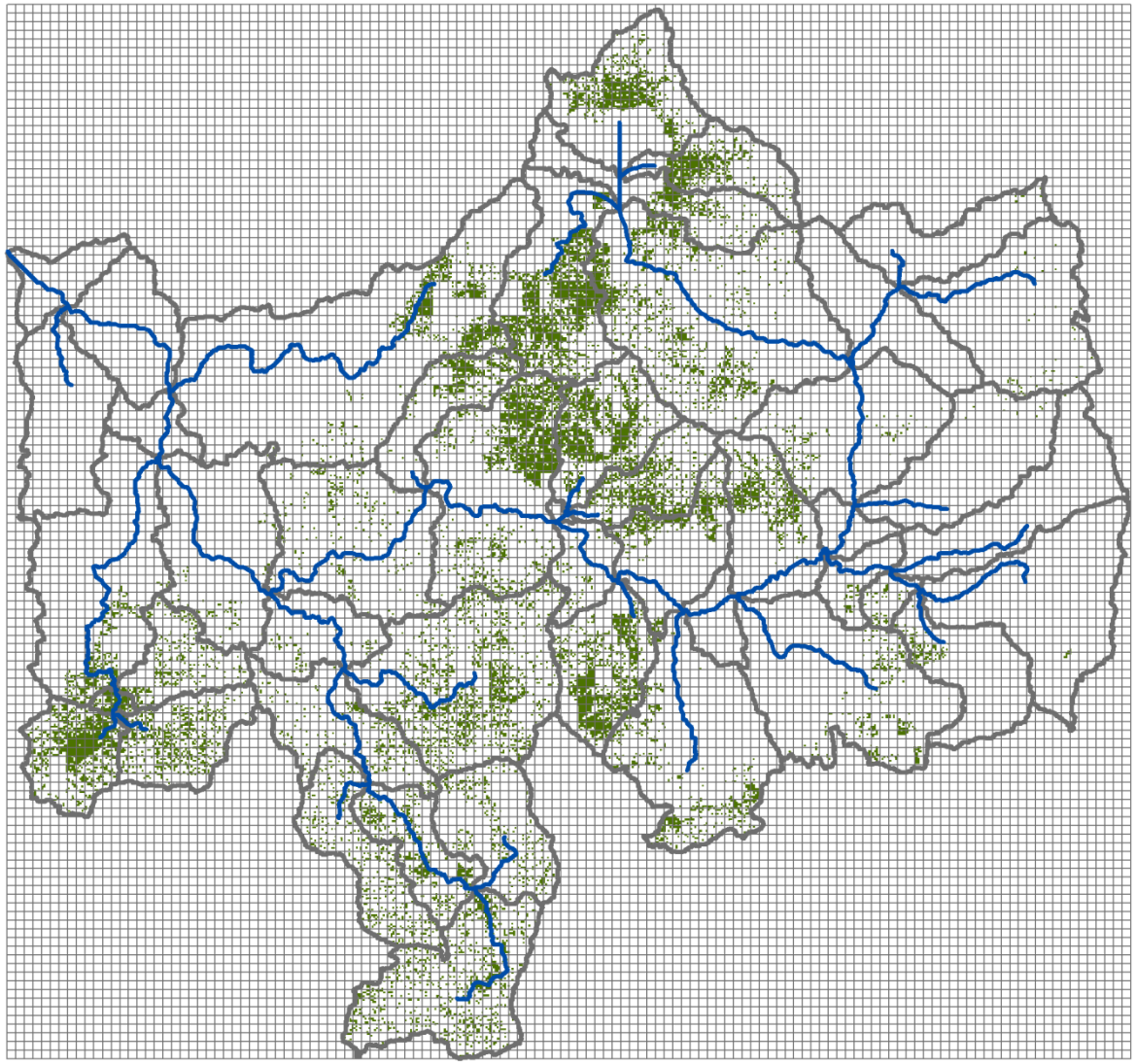
Uncertainty in hydrogeological input data



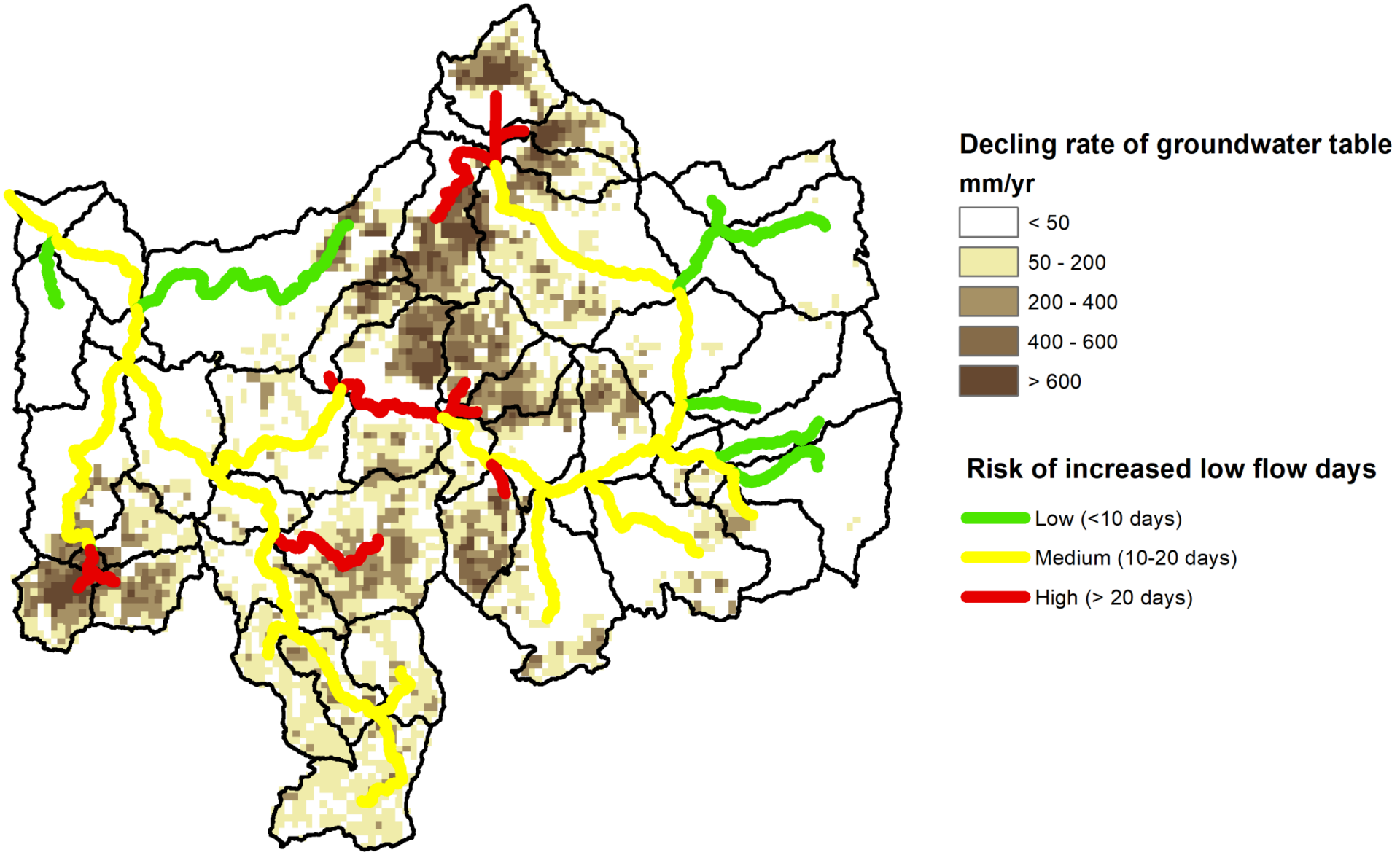
Aquifer productivity	Transmissivity (m^2/d)
Very high	500-1,000
High	50-500
Moderate	10-50
Low-moderate	5-10
Low	1-5
Very low	0.1-0.5

Source of data: British Geological Survey

MODFLOW grid



Initial results



Future work

- 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!