NSF PIRE Annual Meeting 2022

Assessment and Sustainable Utilization Groundwater Resources Under Different Management and Climate Change Scenarios

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Outline

- Motivation for joining PIRE
- GW Modeling Research
- Inter-disciplinary Aspects
- Broader Impacts and Way Forward

Motivation

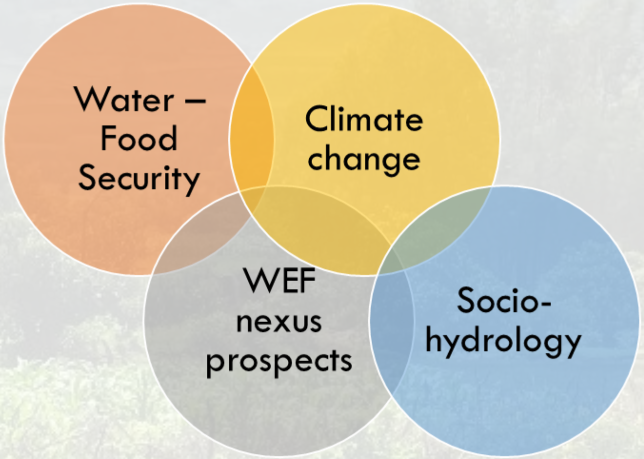
ISSUES

- Annual GW recharge in Ethiopia: 36 billion m^3
- In Tana, 2M people use potable GW; but limited use for irrigation.
- Rainfed irrigation, affecting 85% population
- GW could be considered for Regional growth, and Buffer climate vulnerability

Limited number of GW modeling efforts in the Blue Nile region

- Surface water and energy-based models
- Data scarcity is prominent for GW simulations
- Hydrogeological complexities

Rising concerns over

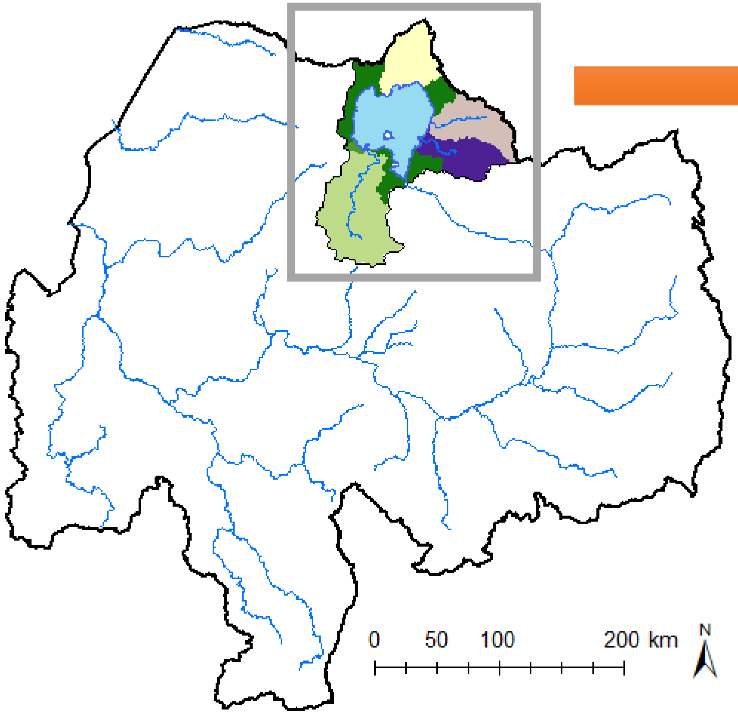


Groundwater Modeling

AREAS OF INTEREST

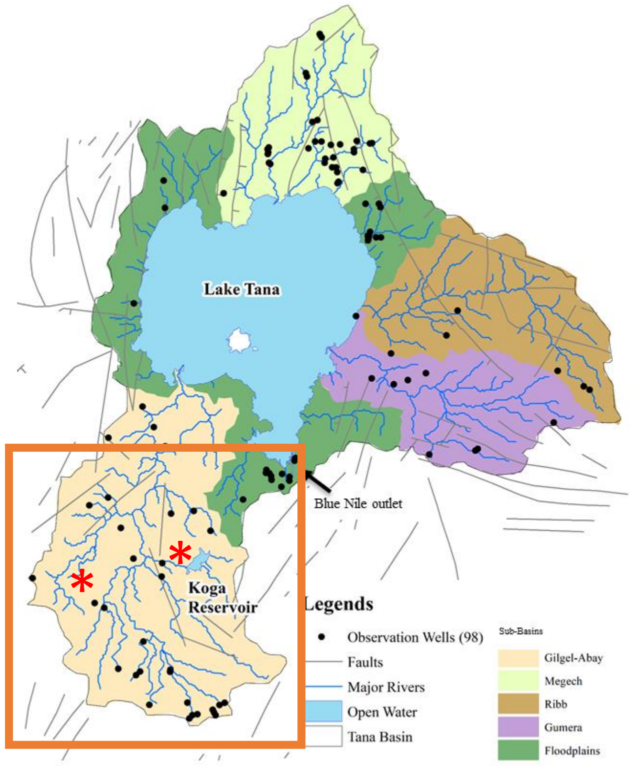
Nile River

Upper Blue Nile Basin (BNB) - Abay Basin



202,506 km²

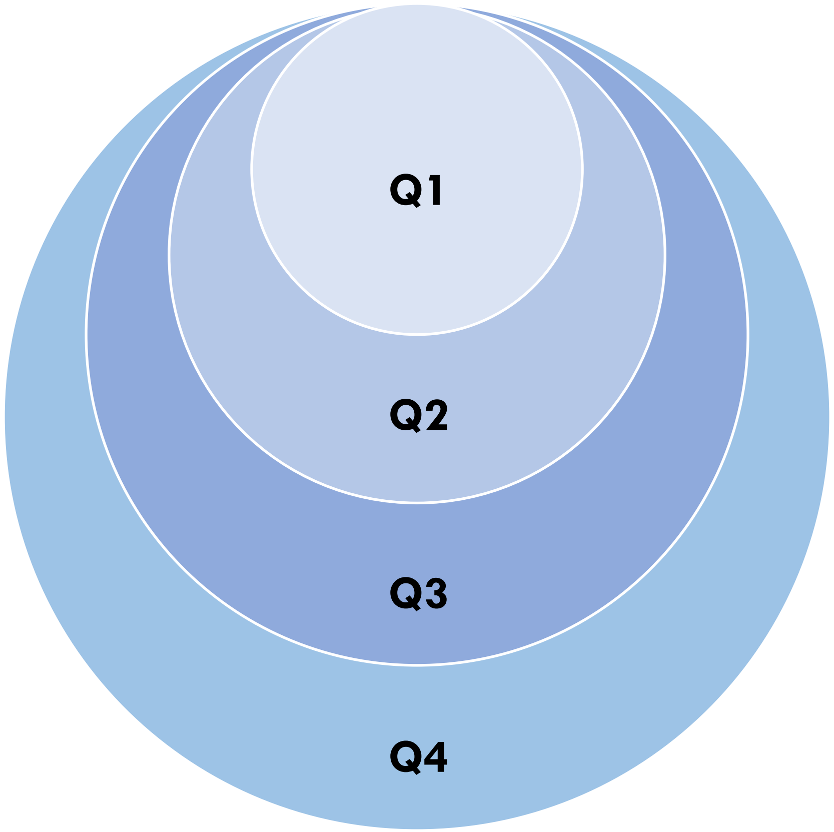
Tana Basin



15,096 km²

Research Questions

Assess the availability of GW resources to address ongoing challenges of water-food security, climate change impacts, and socio-hydrological stresses



Q1. Are there **enough** available GW resources in the Tana aquifer, and more specifically in the local irrigation communities of interest?

Q2. Is it environmentally **feasible** to use GW as supplemental irrigation during normal as well as dry and extremely dry years?

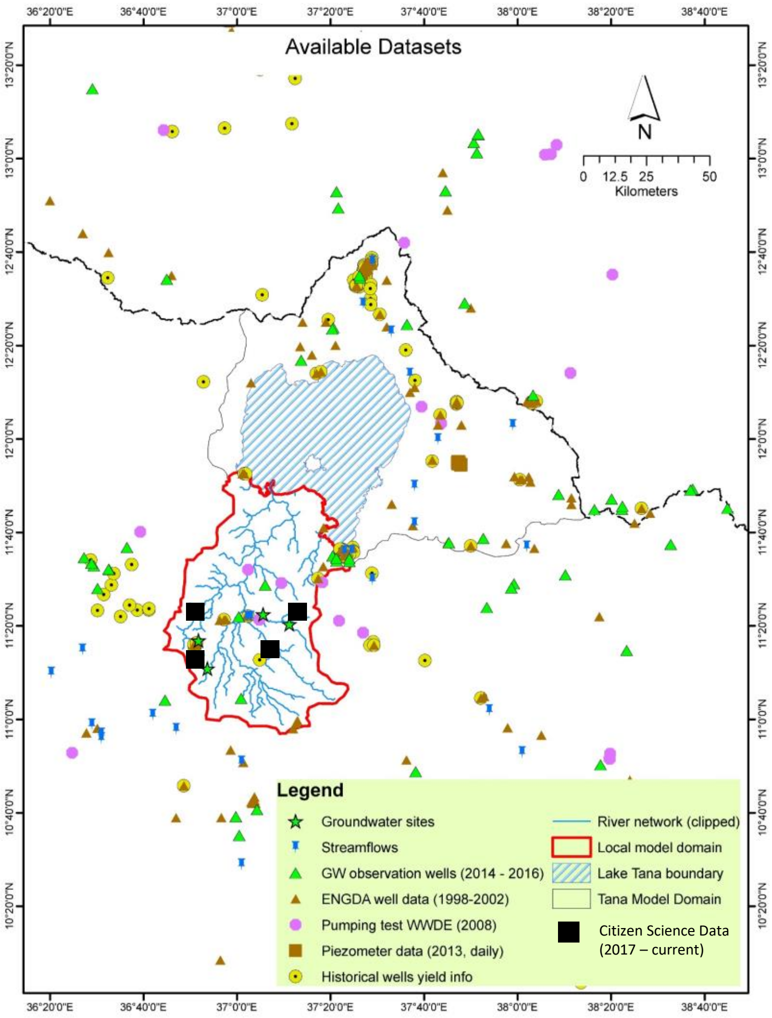
Q3. Is the existing irrigation infrastructure supportive of establishing a sense of **fair and equitable** water sharing in the local communities?

Q4. What could be the **climate change** (up to 2100) impacts on,
a) GW resources in the Tana region, b) Lake Tana levels and releases, and c) local reservoir operations?

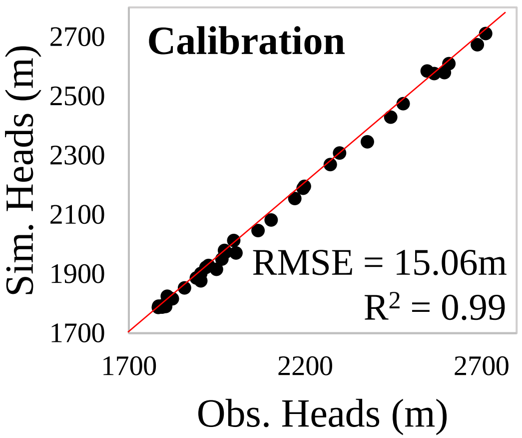
Methodology and Results

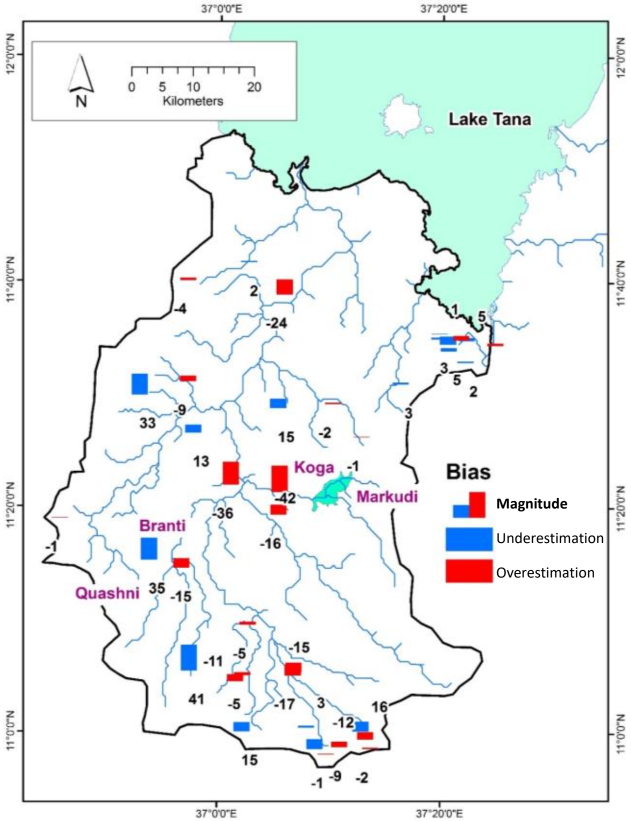
Data Used

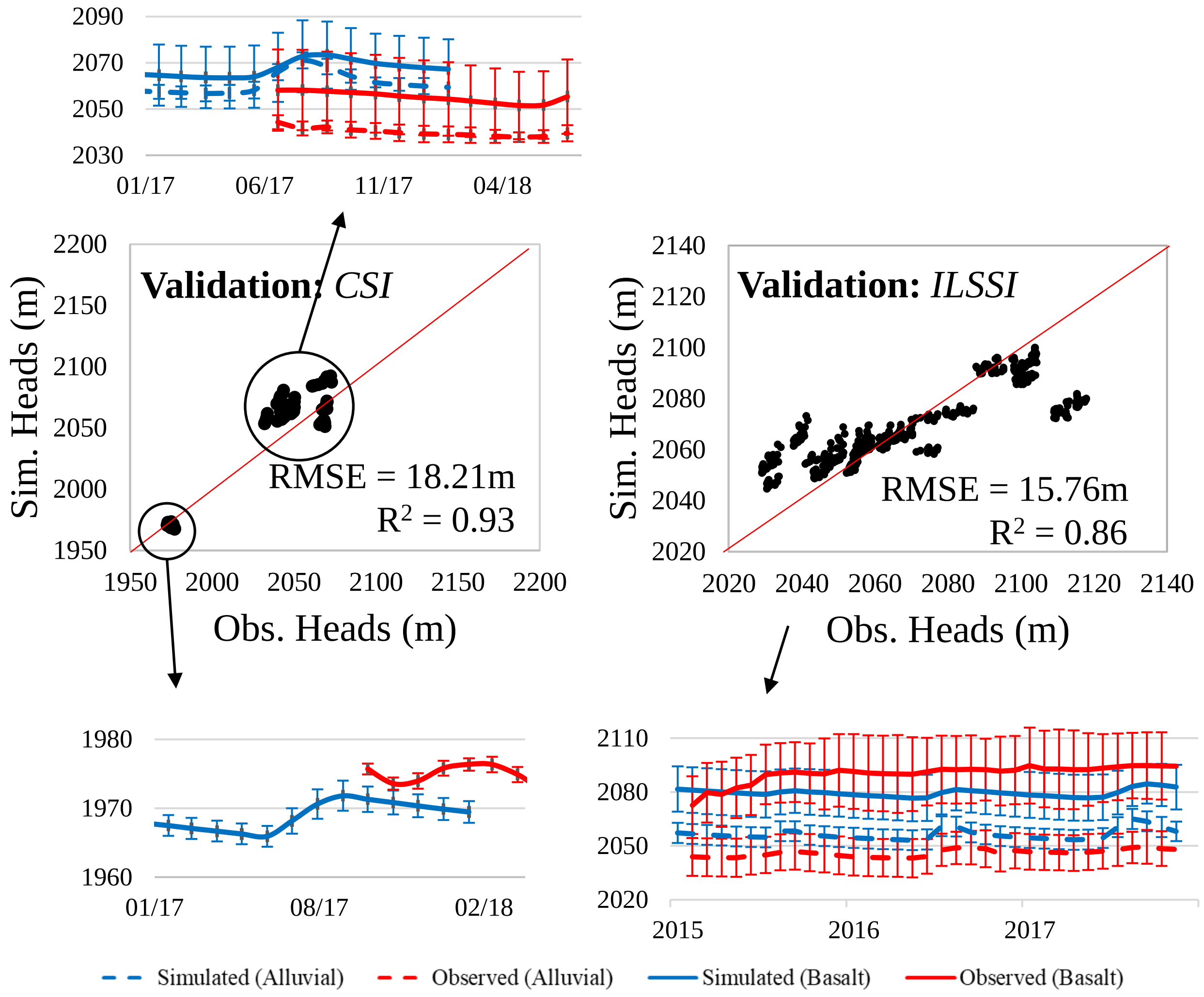
- Observed - Lake Tana water levels (1960 – 2005) (Boundary Condition);
- Historical GW well data (2013-16) (Calibration); and borehole data (1979-2002);
- Citizen Science data at four communities (GW level, TDR and MSMS soil moisture records) for validation (2017 - current)
- 41 years (1979–2020) of daily recharge and streamflow (from CREST) => forced with *T, Pa, Rad, H,* and *W* from ECMWF and GDAS, and *P* from MSWEP-v1, and IMERG.



Regional GW Model in Gilgel-Abay





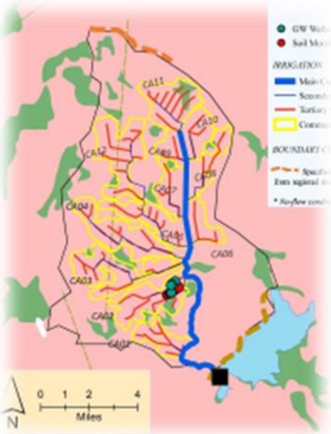


Local GW Model at Koga

Irrigation Scenarios and Crop Water Stress

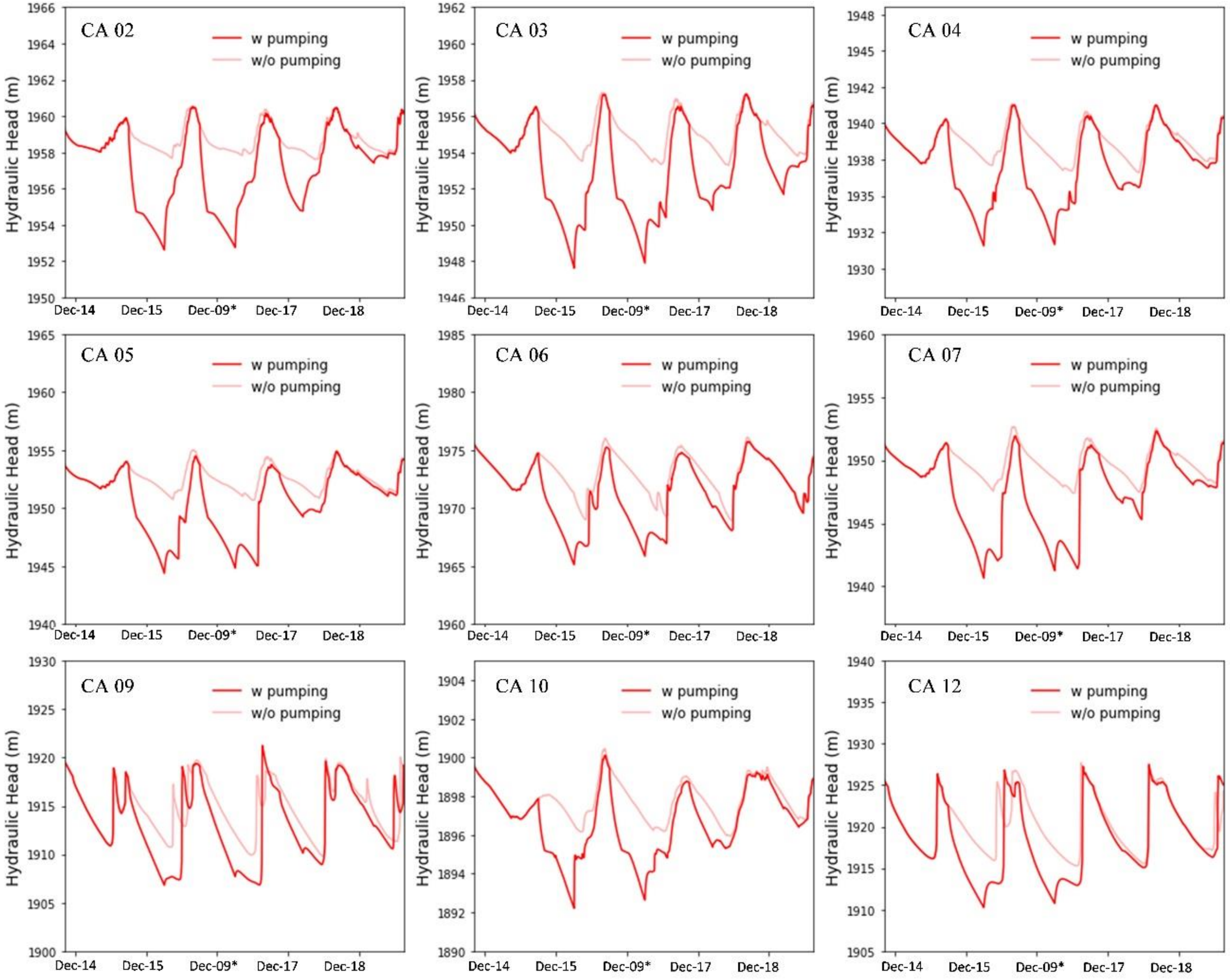
non-regulated (NREG)	regulated (REG)	regulated with groundwater pumping (REG+GW)
		

Specifically assessed a hypothetical dry spell consisting of 2015 and 2009 for the REG+GW scenario



Crop water stress =
[Potential Transpiration (DSSAT) –
Root water uptake (MODFLOW)]

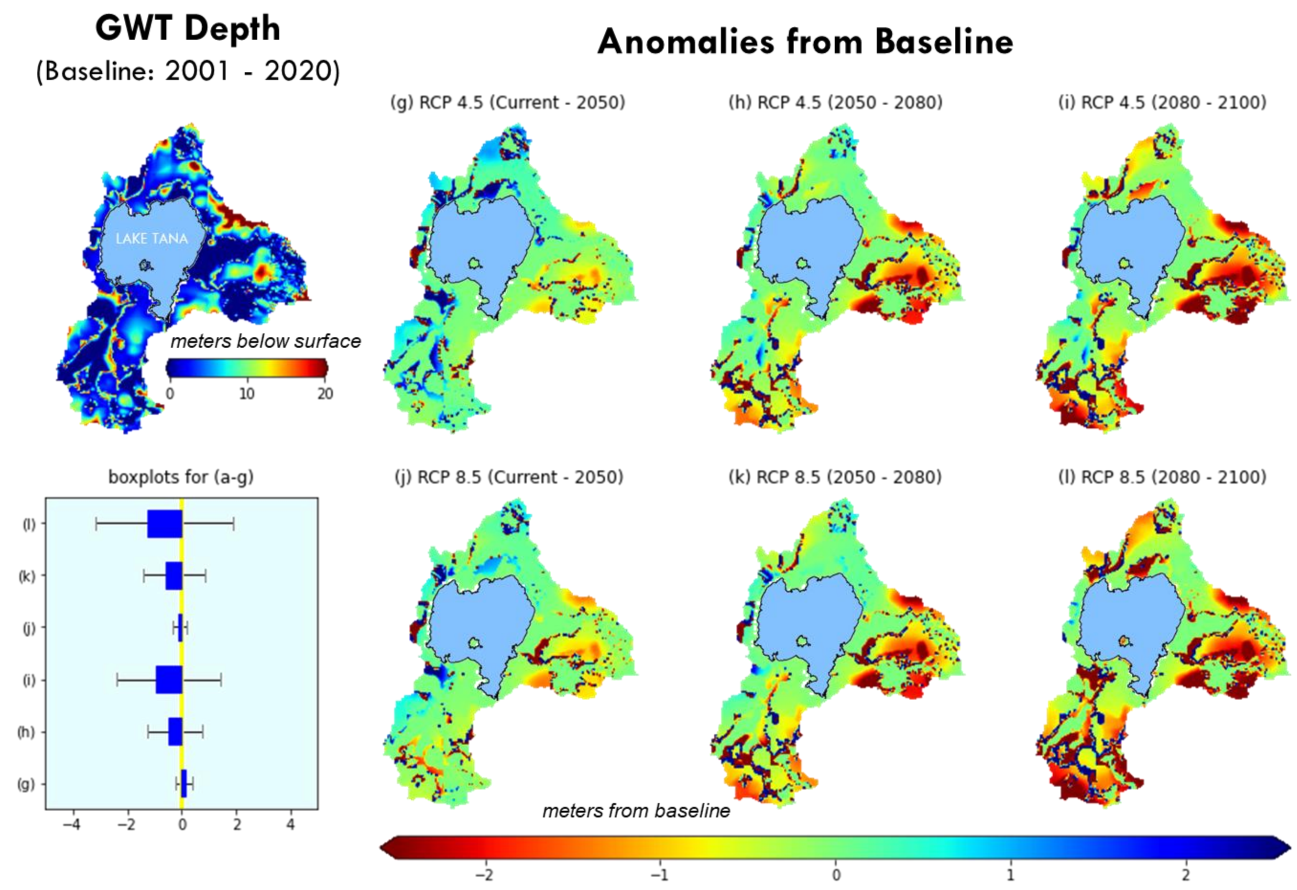
GW For Supplemental Irrigation



GW pumping for supplemental irrigation could be a potential solution for extreme droughts

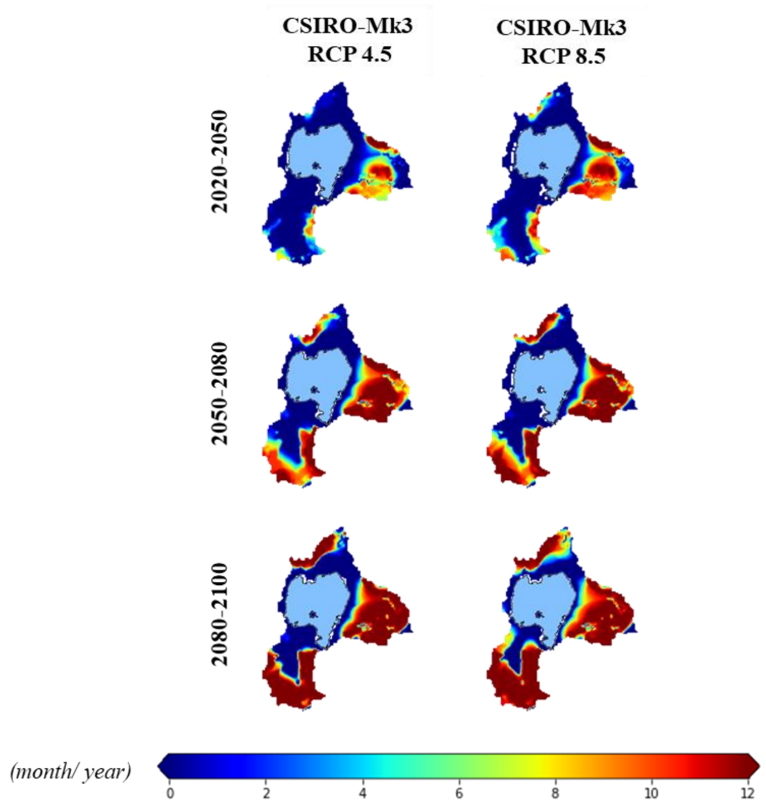
Interdisciplinary Aspects: Climate Change

Climate change impacts on GW: CSIRO-Mk3



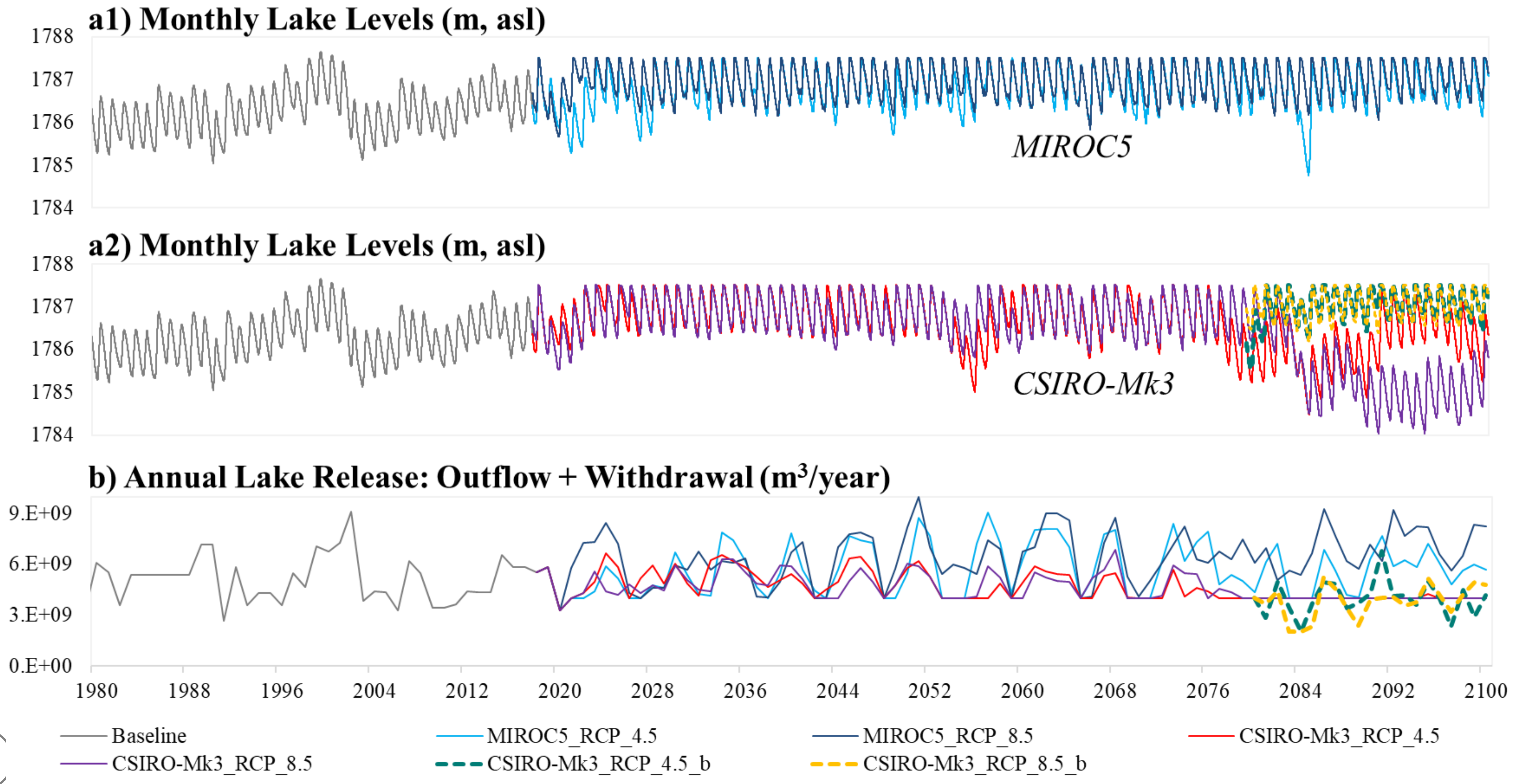
Mild GW Droughts

$0 < [SWI = (W_{i,T} - W_{i,t})/\sigma_{i,T}] < 1$



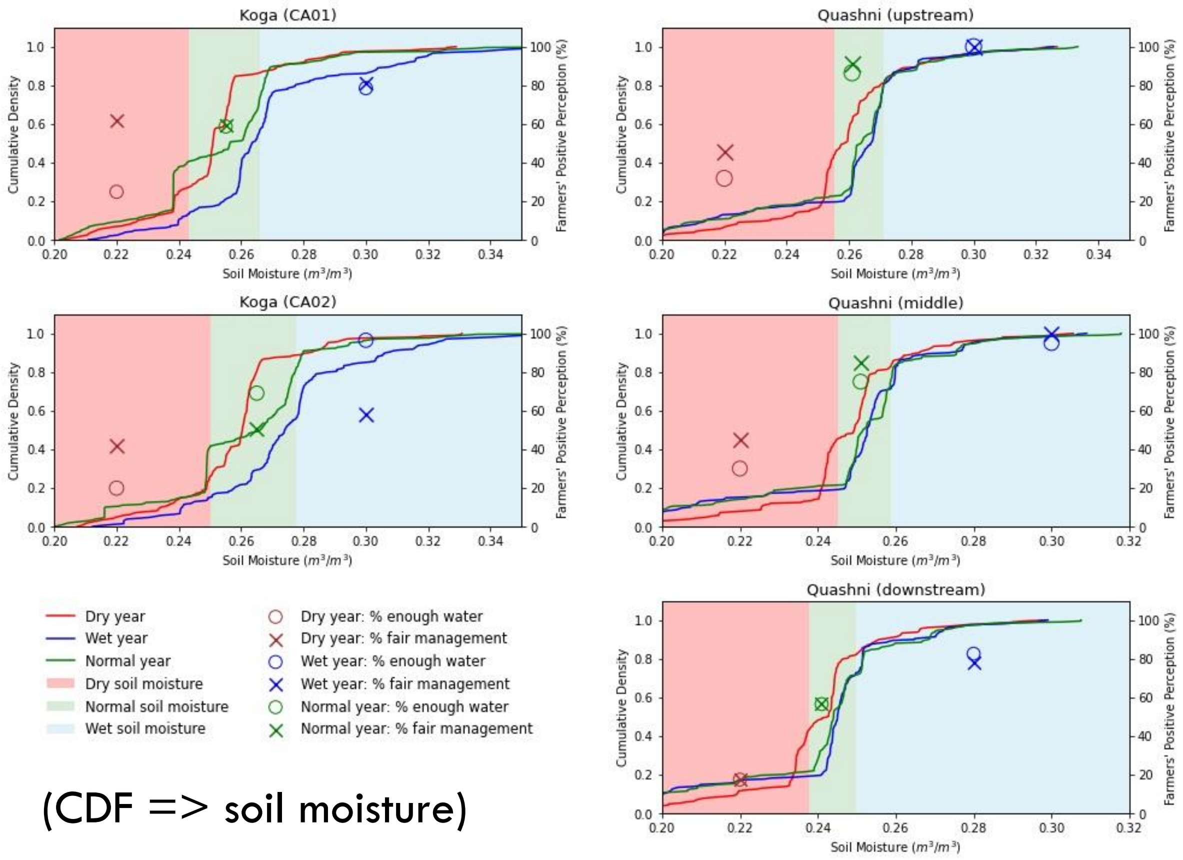
Interdisciplinary Aspects: Climate Change

Climate change impacts on Lake Tana



Interdisciplinary Aspects: Socio-Hydrology

Farmers Perceptions vs GW Model findings



(CDF => soil moisture)

Area	Dry	Normal	Wet
Koga	2015	2017	2018
Quashni	2015	2017	2014

Selection of Dry, Normal and Wet Years

- Total Precipitation
- Onset Precipitation (May and June)
- Number of Dry Spells (three consecutive dry days (<0.1 mm rain; or five consecutive days with <5 mm rain)

Broader Impacts and Way Forward

Leadership and Capacity Development

- ✓ Field visits in Summer 2018 and 2019
- ✓ Project Manager at UConn (2019-2022)

Perform State-of-the-Art research on water-food security and other interdisciplinary issues, helped me fulfill my PhD journey

Starting June 2022, I will be joining NASA as a postdoctoral fellow –

Research topic: *Using Remote Sensing to Predict Soil Salinity*

Potential Future Work…

- Study **climate change impacts on local irrigation**, focusing on recent agricultural emphasis on exotic plants/ crops.

- Climate change impacts on local **reservoir and irrigation operations** by adopting more detailed data-driven or process-based modeling effort.

- Take advantage of our **database** of model simulations (41 years of baseline + 80 years of climate change scenarios) for possible downscaling and data driven modeling applications

Acknowledgements

THANK YOU