IM3

INTEGRATED MULTISECTOR MULTISCALE MODELING

FROM DATA TO DECISIONS: MACHINE LEARNING FOR WATER ALLOCATION AMID HYDROLOGIC EXTREMES

Presenter: Nicole D. Jackson

Team: Kirk Bonney, Thushara Gunda, Stephen Ferencz

EESM PI Meeting

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Pacific Northwest National Laboratory · Berkeley Lab · Oak Ridge National Laboratory · Sandia National Laboratories · Baylor University · Boston University · Cornell University · NC State University · The University of North Carolina at Chapel Hill · UC Davis University of California · PennState

Texas uses the closed source Water Rights Analysis Package (WRAP) for basin-scale water management modeling

Naturalized flows

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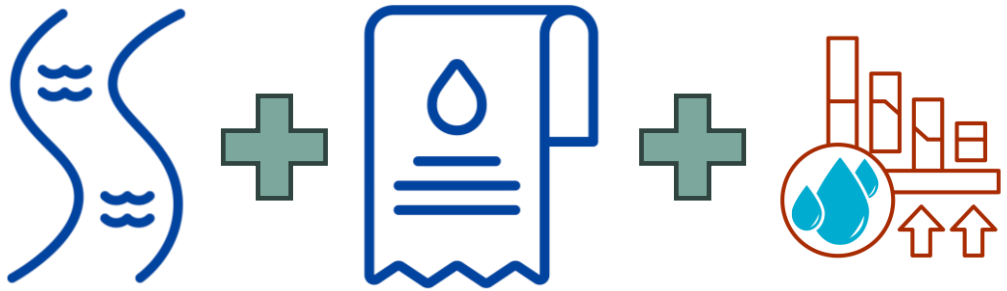

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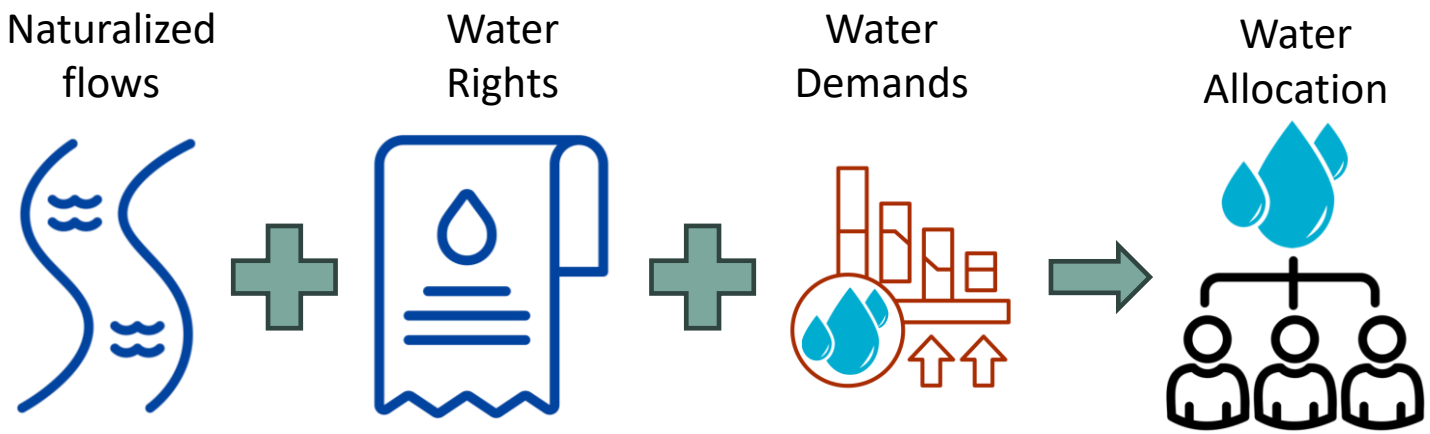

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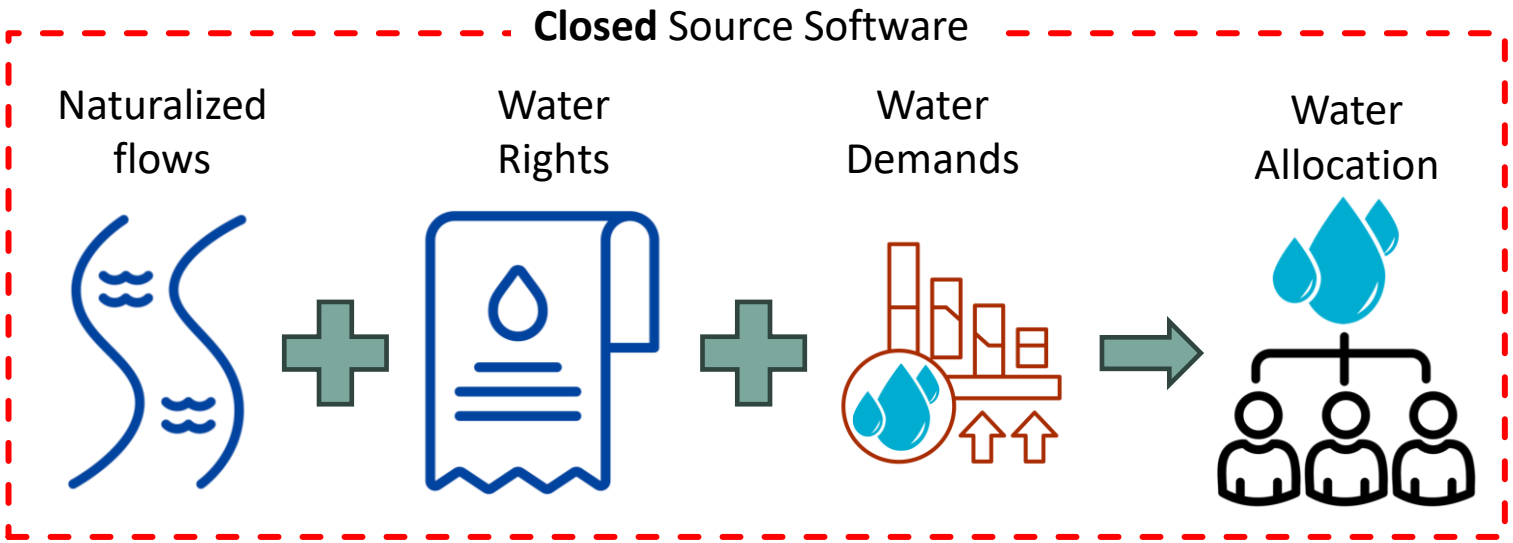

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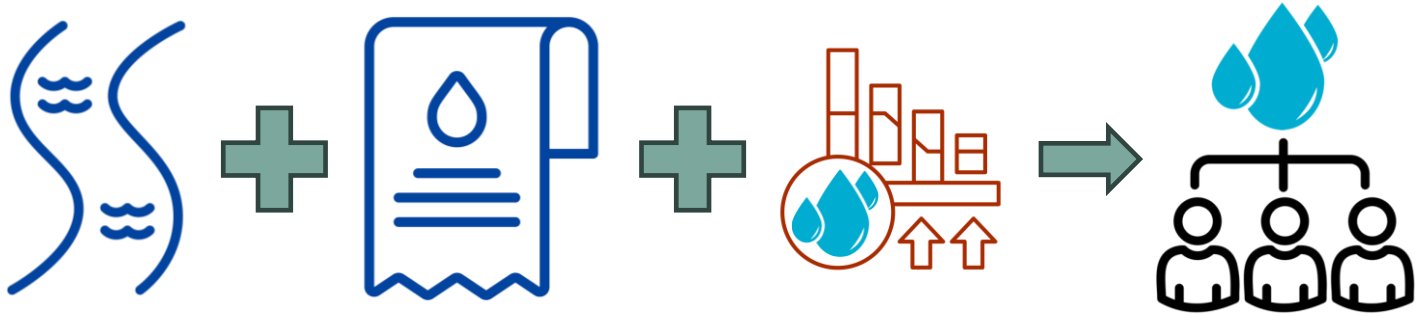

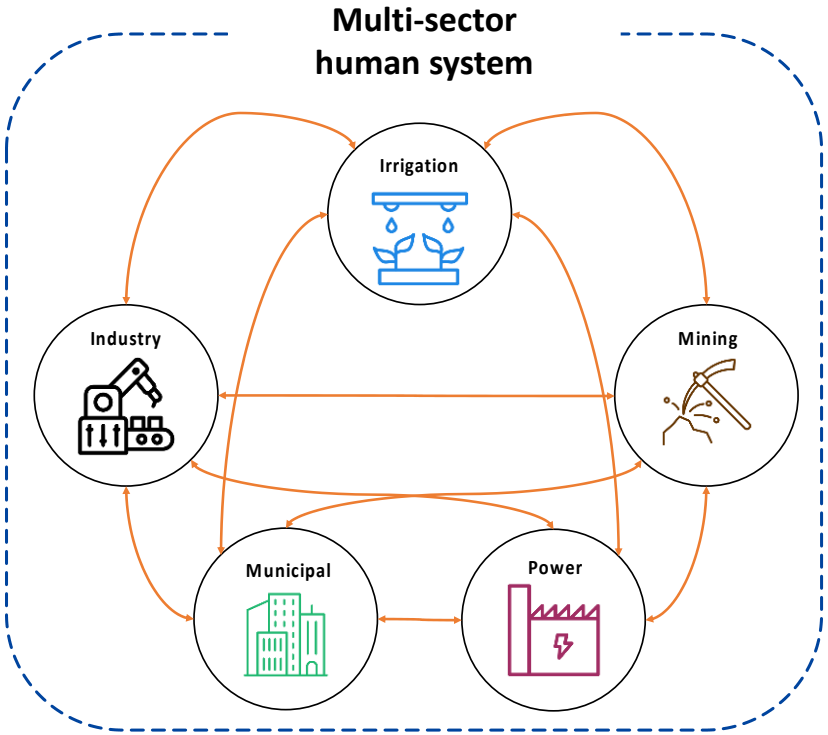

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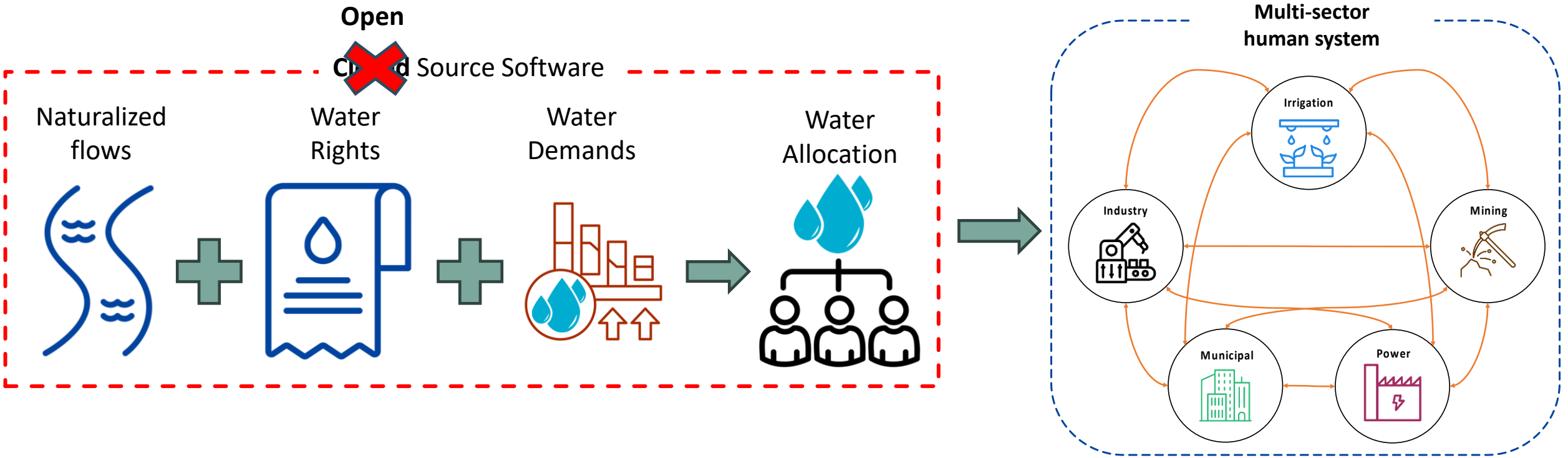

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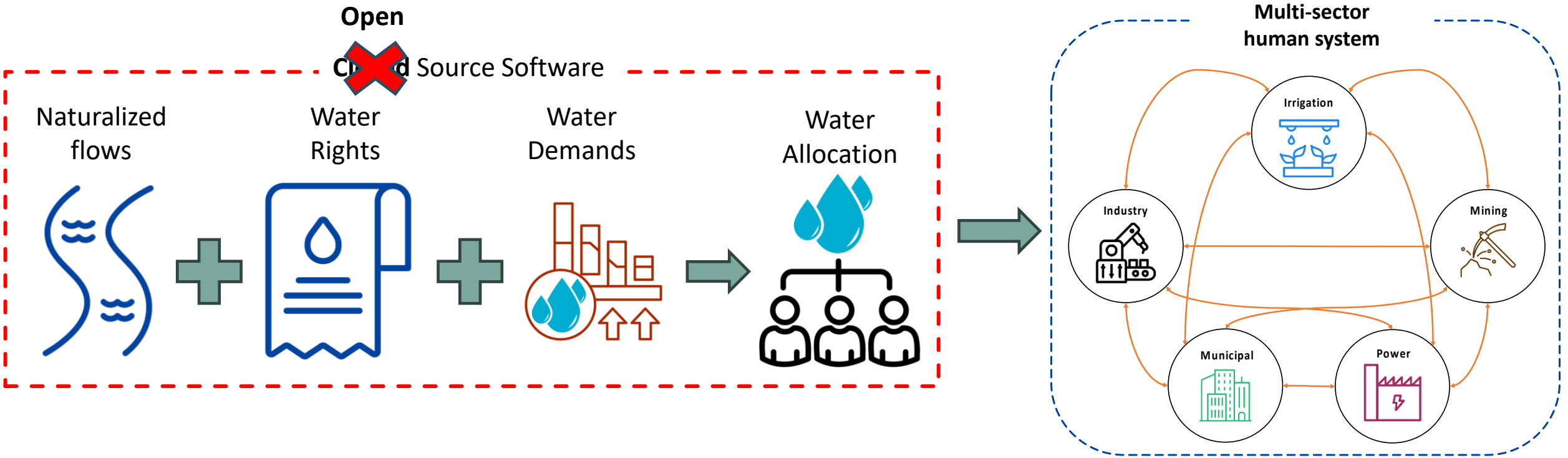

OVERARCHING GOAL

Use the Colorado River basin to develop an **open-source emulator** of WRAP to facilitate numerical experiments under diverse climate and operating conditions

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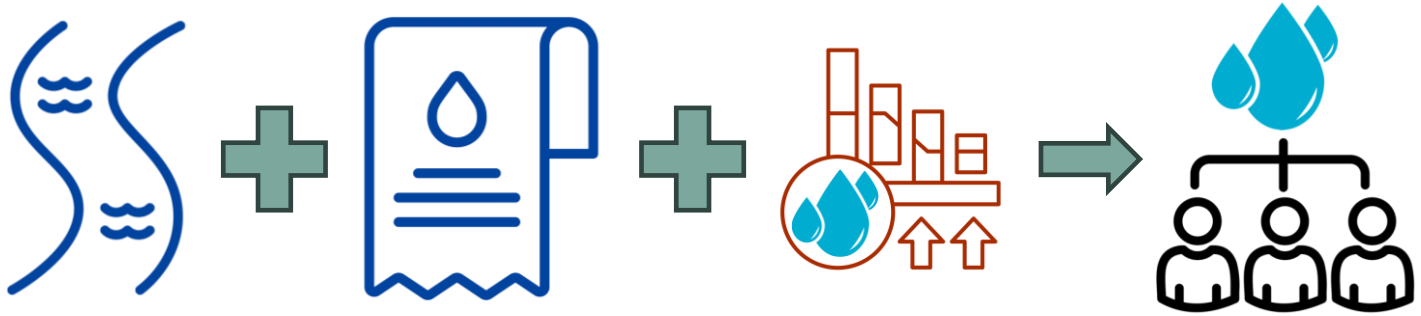
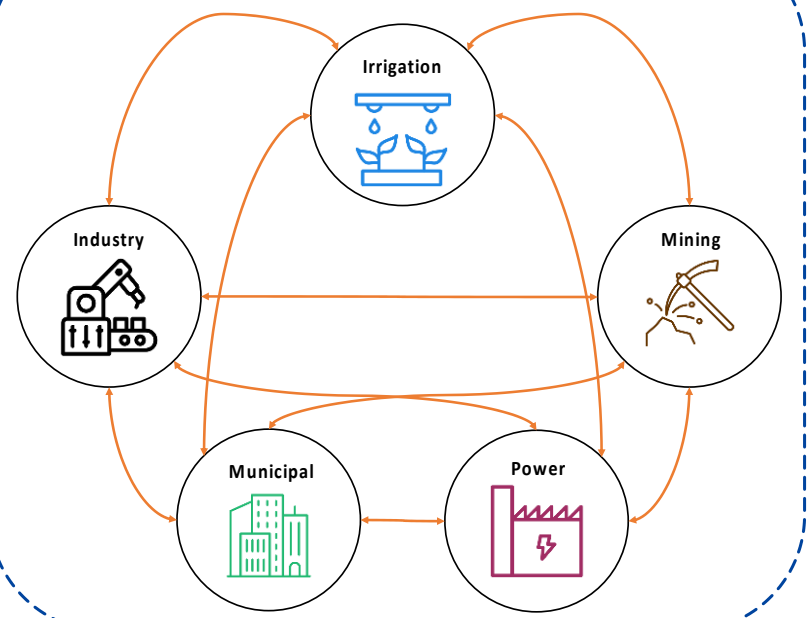


Multi-sector human system



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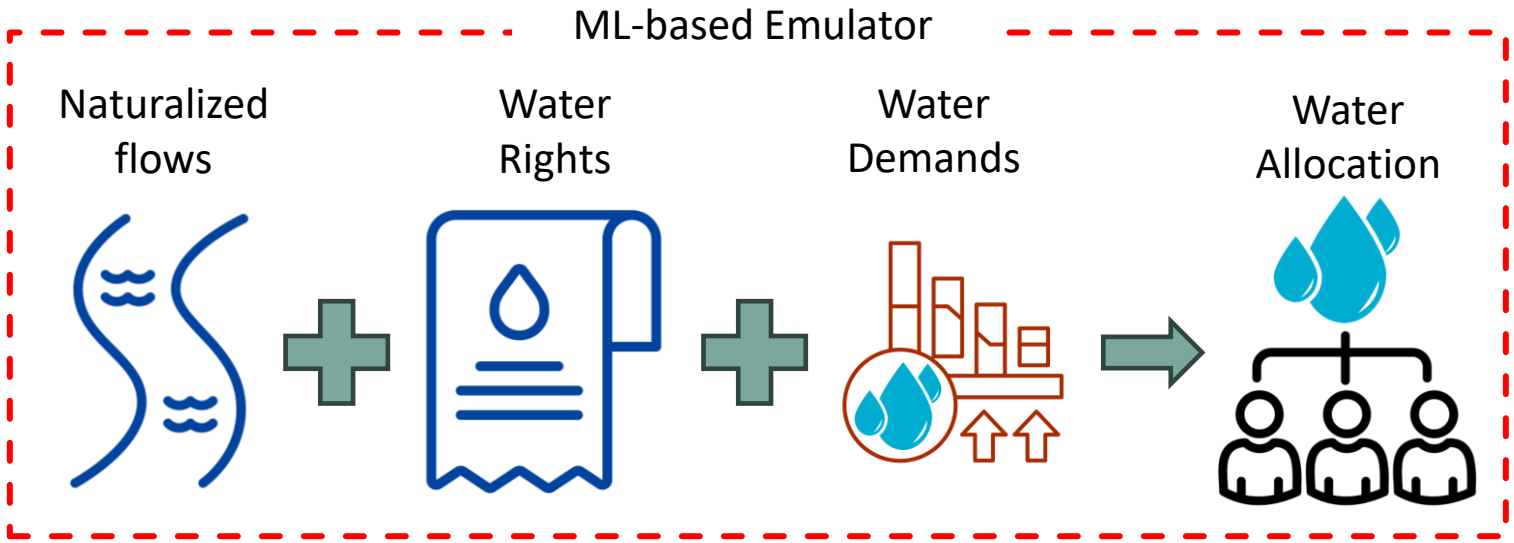
Use the Colorado River basin to develop an **open-source emulator** of WRAP to facilitate numerical experiments under diverse climate and operating conditions

Key knowledge gap

Understanding the efficacy of using long short-term memory (LSTMs) neural network as a surrogate model for water allocation processes and the appropriate conditions for using a training model

Developing an LSTM for WRAP requires minimal information about the system



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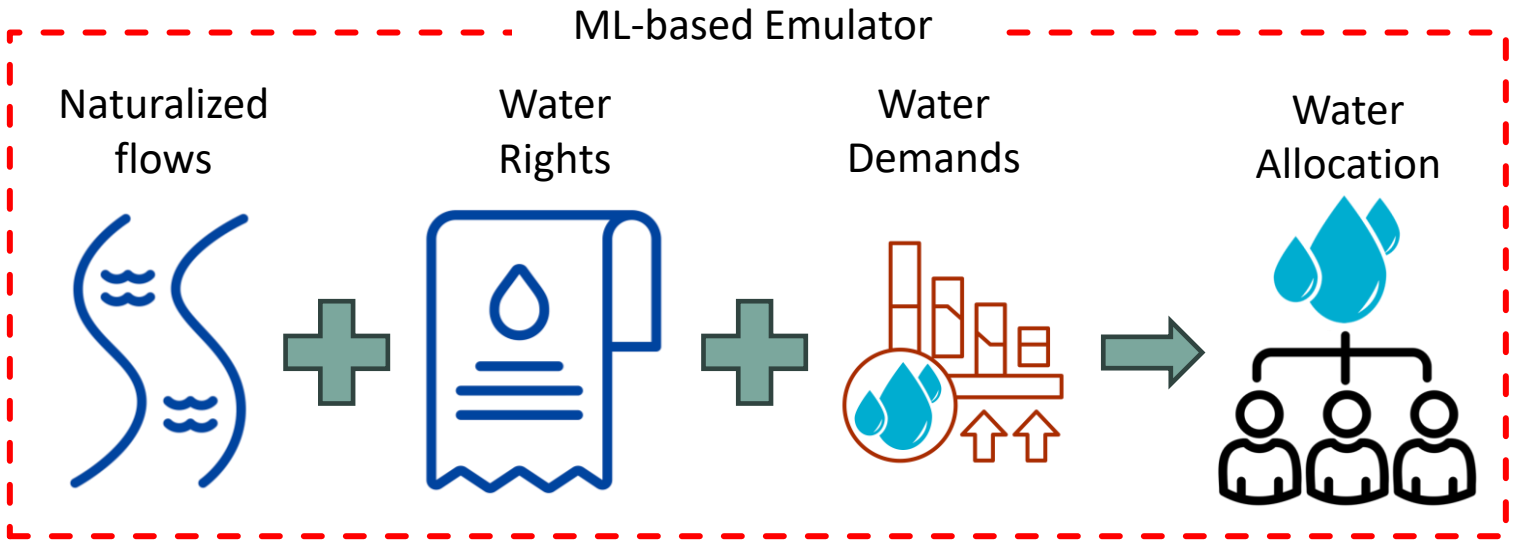
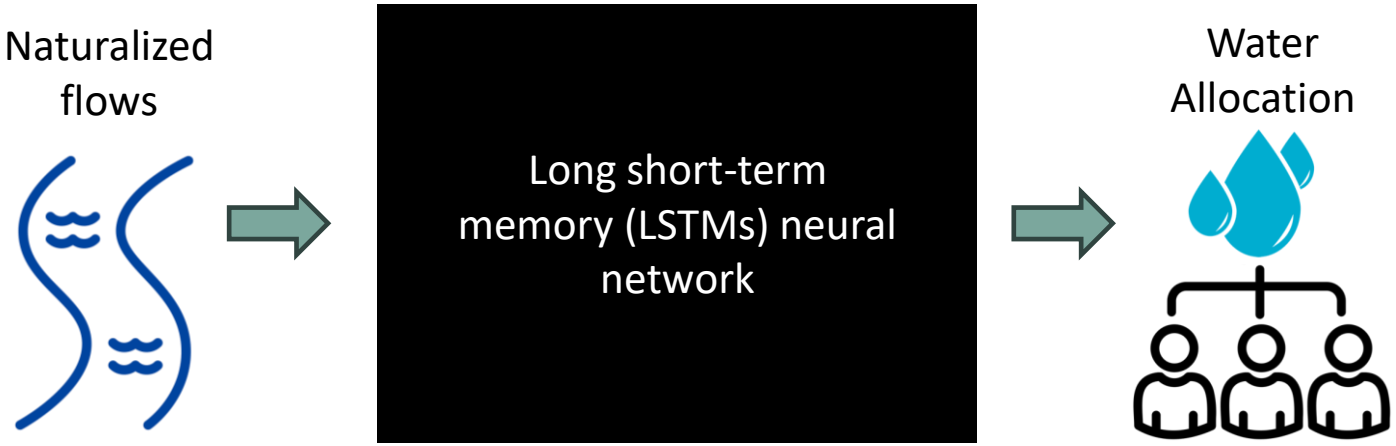
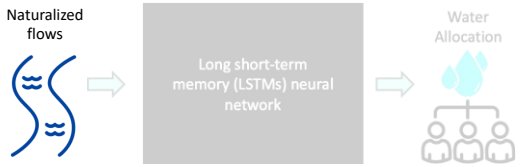
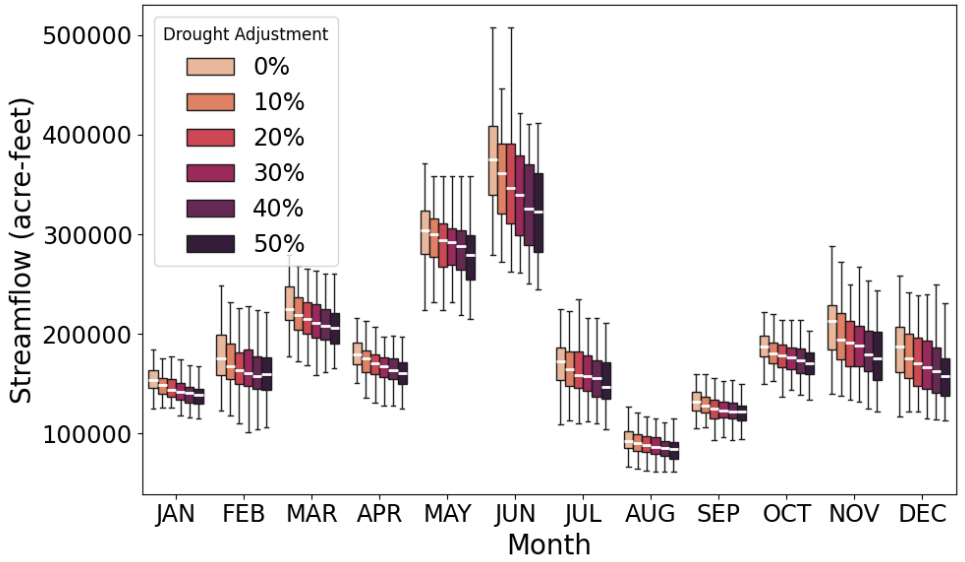




Data gap filled using Hidden Markov Models to generate synthetic streamflows across a variety of drought conditions





Purpose	Drought adjustment parameter (a)	Number of realizations
LSTM training	0	1,000
LSTM testing	0	100
Drought testing	[0.1, 0.5]	100 for each a

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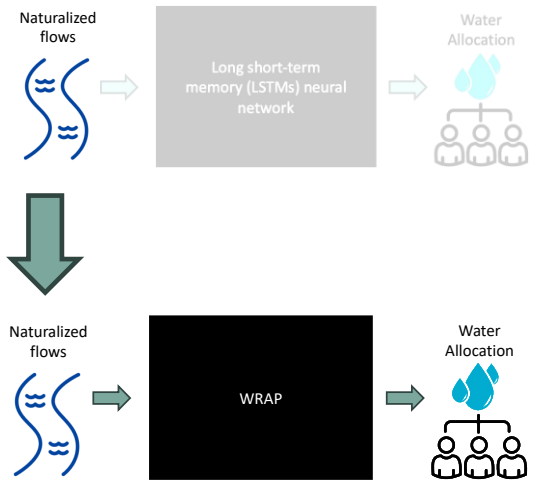

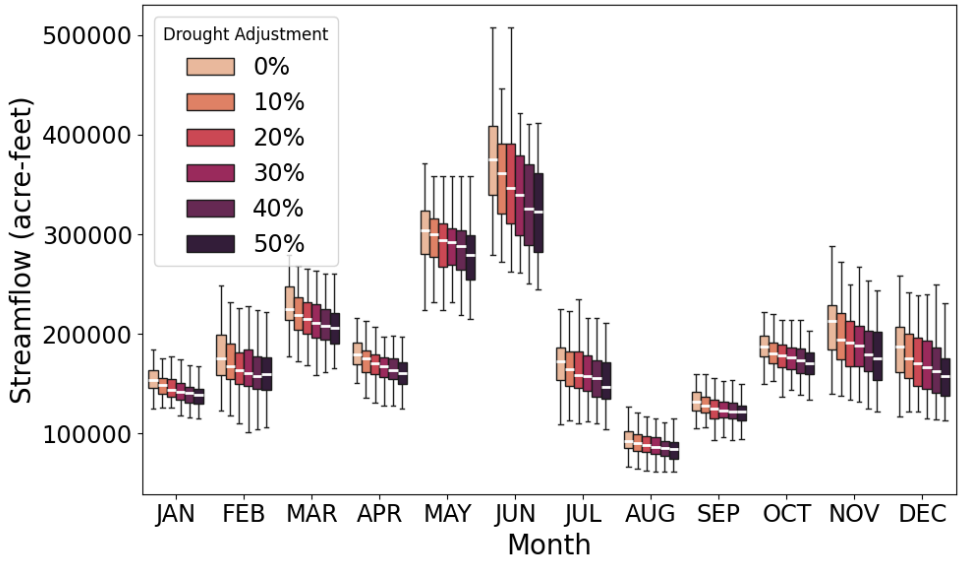

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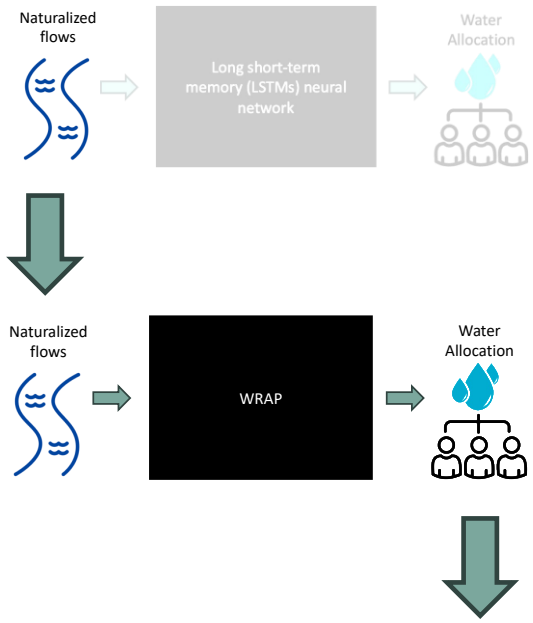
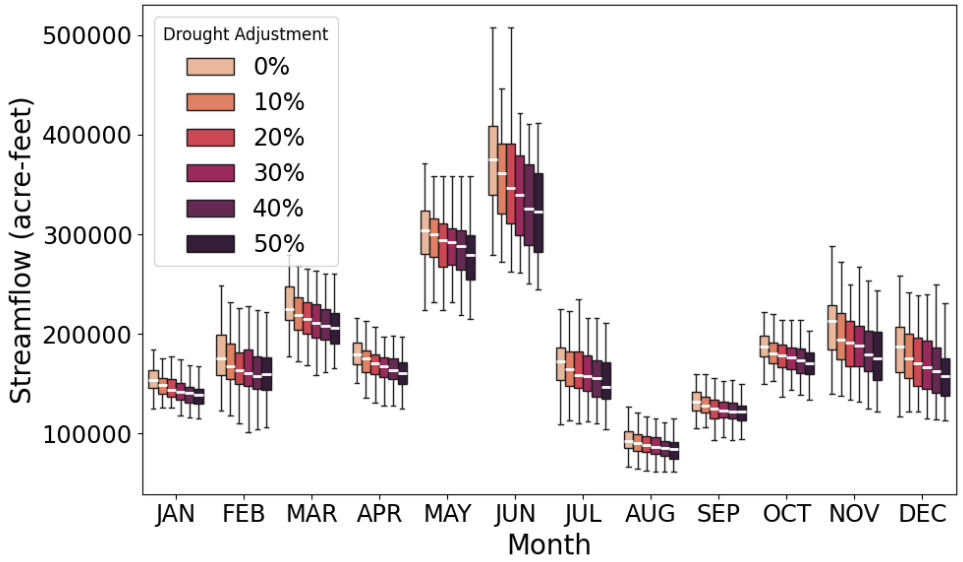


$$shortage\ ratio = \frac{allocation\ shortage}{allocation\ target}$$



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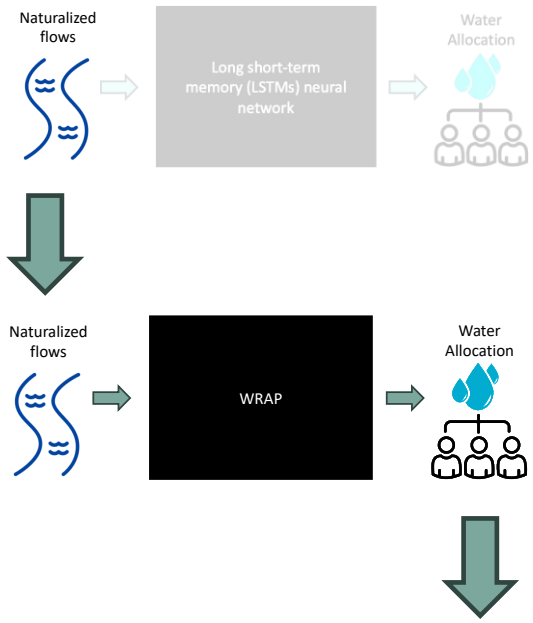

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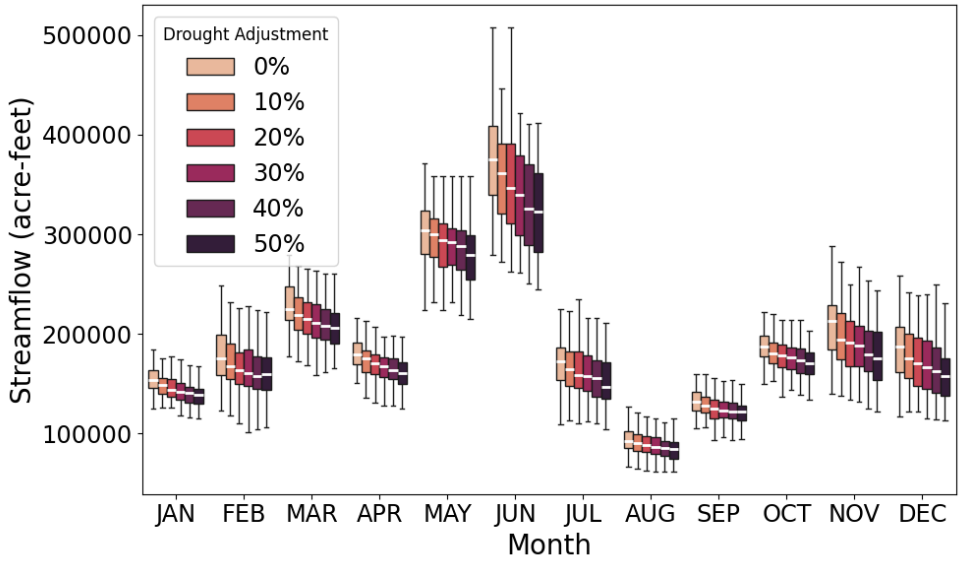

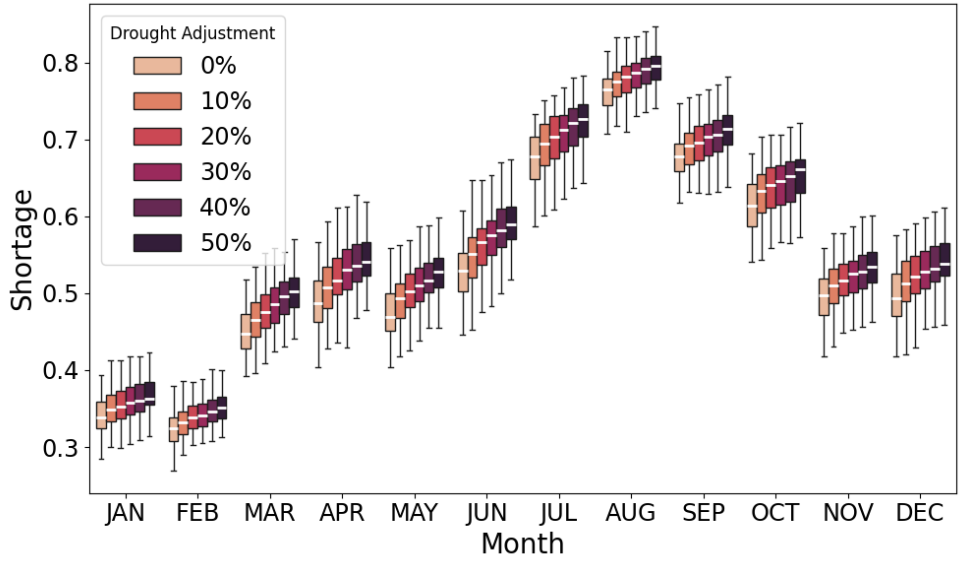

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LSTM performance as a WRAP emulator can be evaluated overall as well as across space, time, sector, and drought

Metric	Shortage Ratio Error	Volumetric Error (acre-feet)
MSE	0.034	40614.64
MAE	0.071	6.74
ME	-0.003	-0.55
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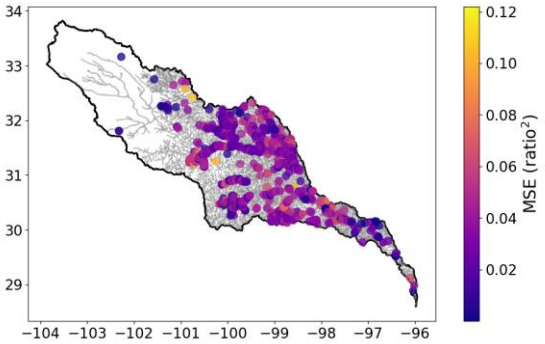

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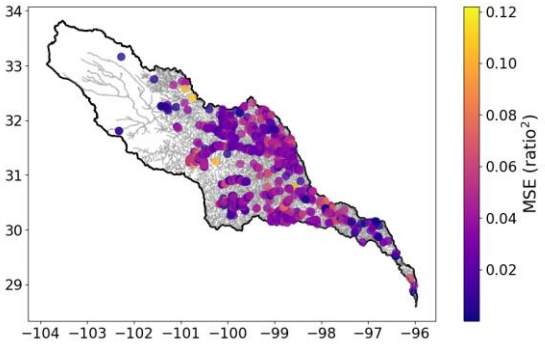

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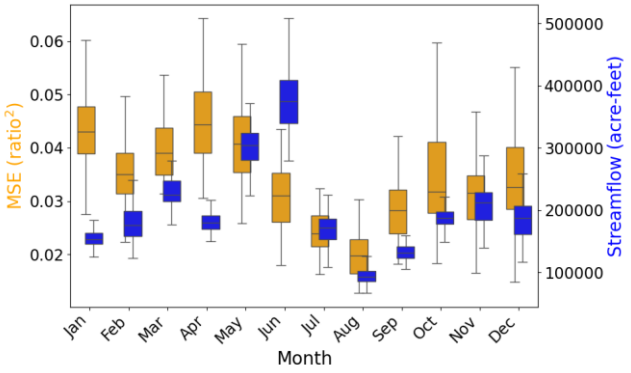

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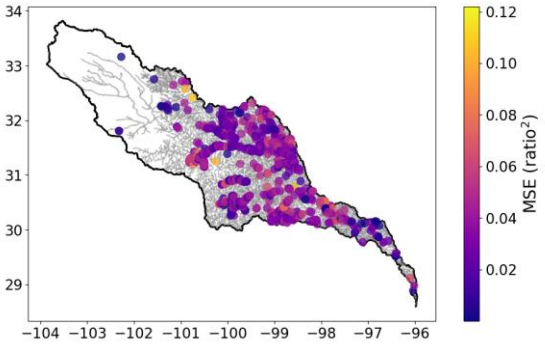

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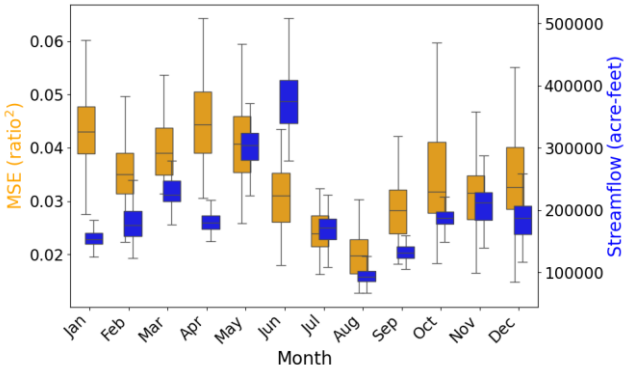

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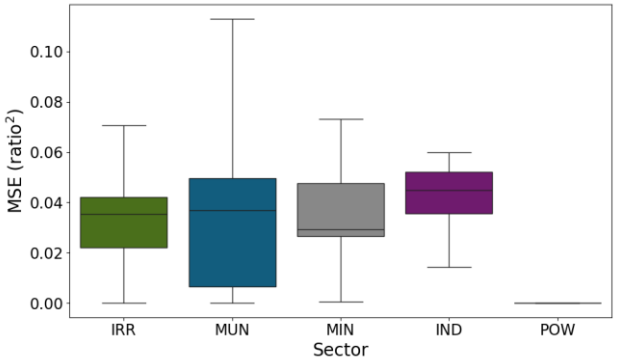

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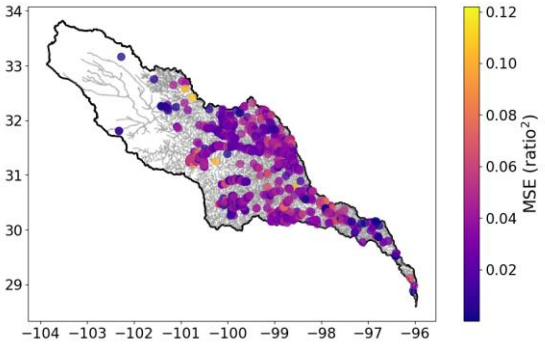

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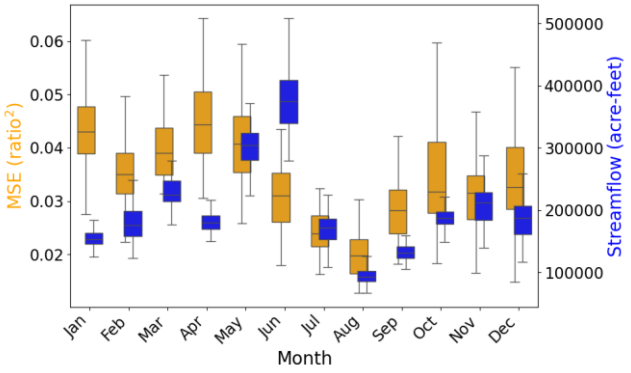

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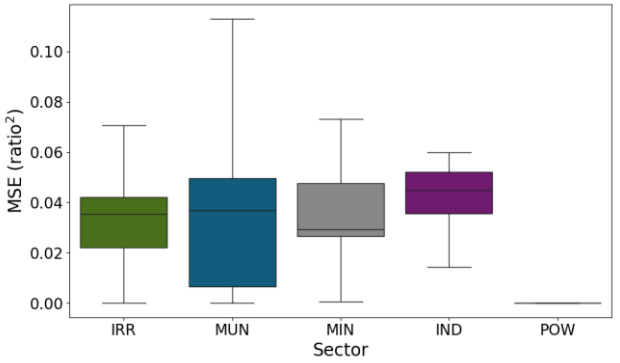
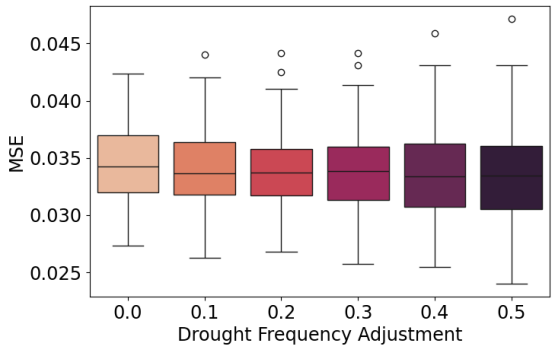
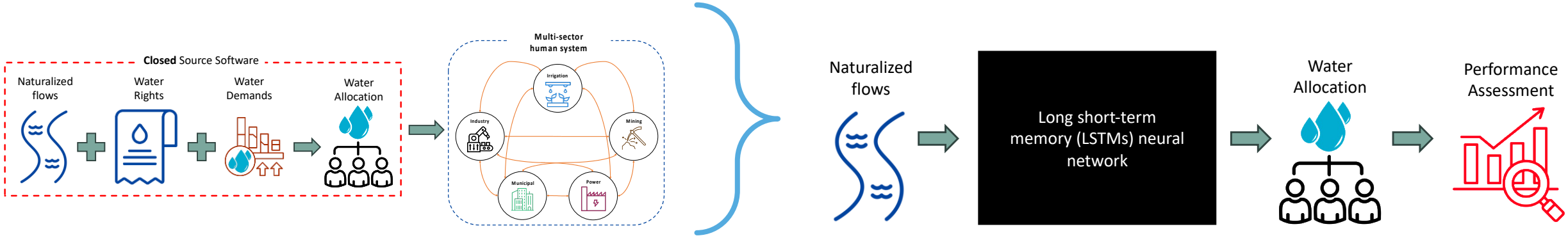


MSE by drought



In conclusion, a high performing water allocation emulator has been developed for the Colorado River Basin in Texas



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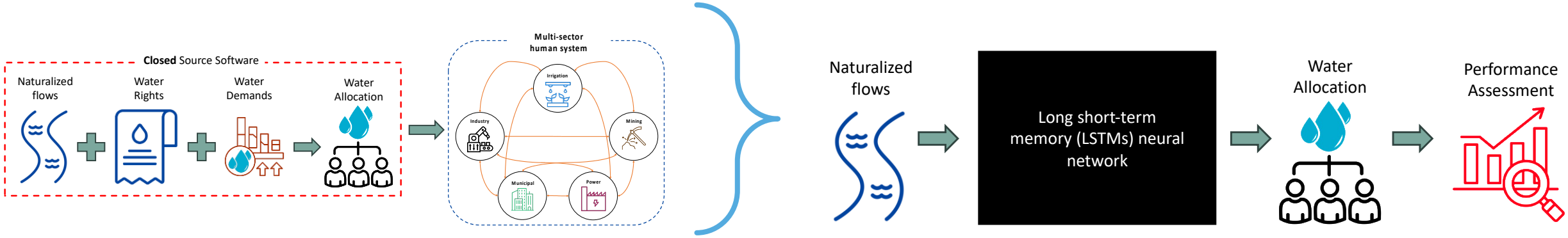

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- **Challenge**: No validation data of historical demands and allocations

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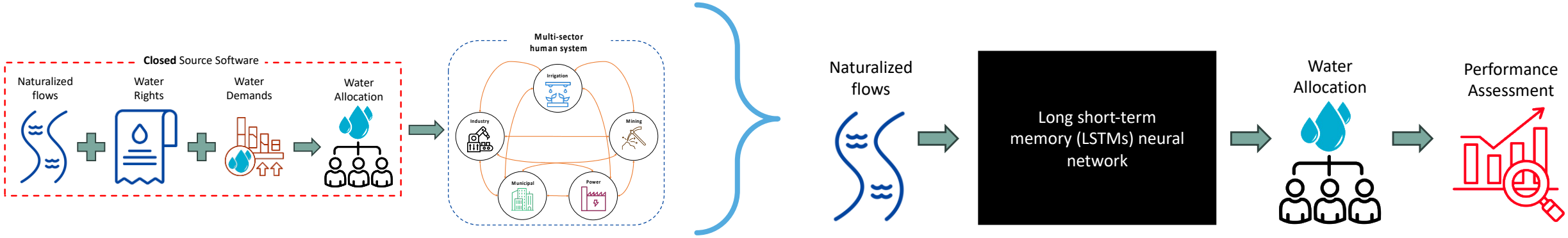

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Leveraging testbeds

- **How can the testbed framework be advanced to promote coordination across EESM and BER?**
  - Validated regionally refined models could be support test bed development and facilitate exposure to other types of extreme events
- **What role could other agencies play in facilitating the efficacy of testbeds in achieving our science?**
  - Data sharing, co-production of coupled human-natural systems models, development of new, relevant metrics