



# InterACTWEL Cyberinfrastructure

## Enabling Long-term AI-driven Decision Support for Adaptive Management of Water, Energy, and Land Resources in Watershed Communities

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Cyberinfrastructure Integration Research Center (CIRC): Suresh Marru, Eroma Abeysinghe



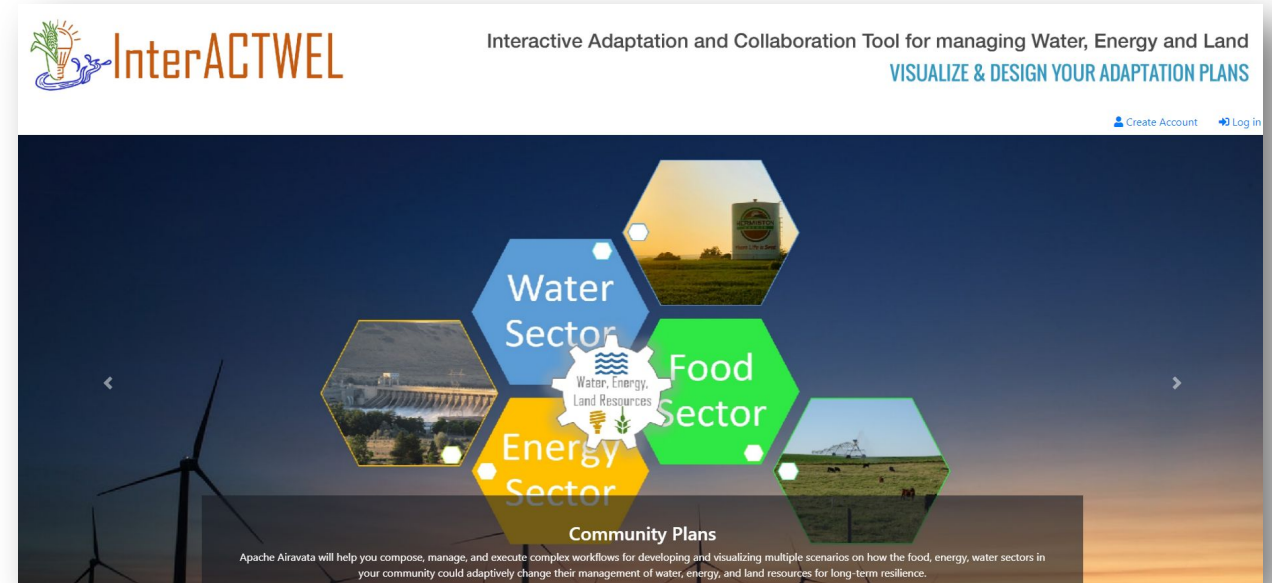
AWARD NUMBER:  
2017-67003-26057



AWARD NUMBERS:  
#1547611, #1339774.

# Outline

1. Overview of InterACTWEL
2. Description of Data, Data Parsers and Computations Involved
3. UX Approach
4. Gateway Development and Integration Plan
5. Future Work





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# **Overview of InterACTWEL**

**(Interactive Adaptation and Collaboration Tool for managing  
Water, Energy and Land)**

**Dr. Meghna Babbar-Sebens**

# InterACTWEL: Web-based Decision Support for Adaptation Scenario Planning in Local Communities

## Who?

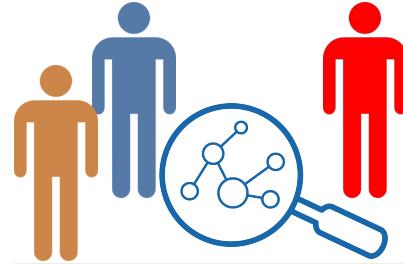
- InterACTWEL aims to empower communities in watersheds

## Do What?

- To coordinate and plan adaptation strategies for responding to stresses and changes to water, energy, and land resources.

## How?

- By providing data-driven services for planners and managers to simulate, visualize, evaluate, and share scenarios of multi-sectoral adaptation actions that reduce their community's vulnerability to stresses



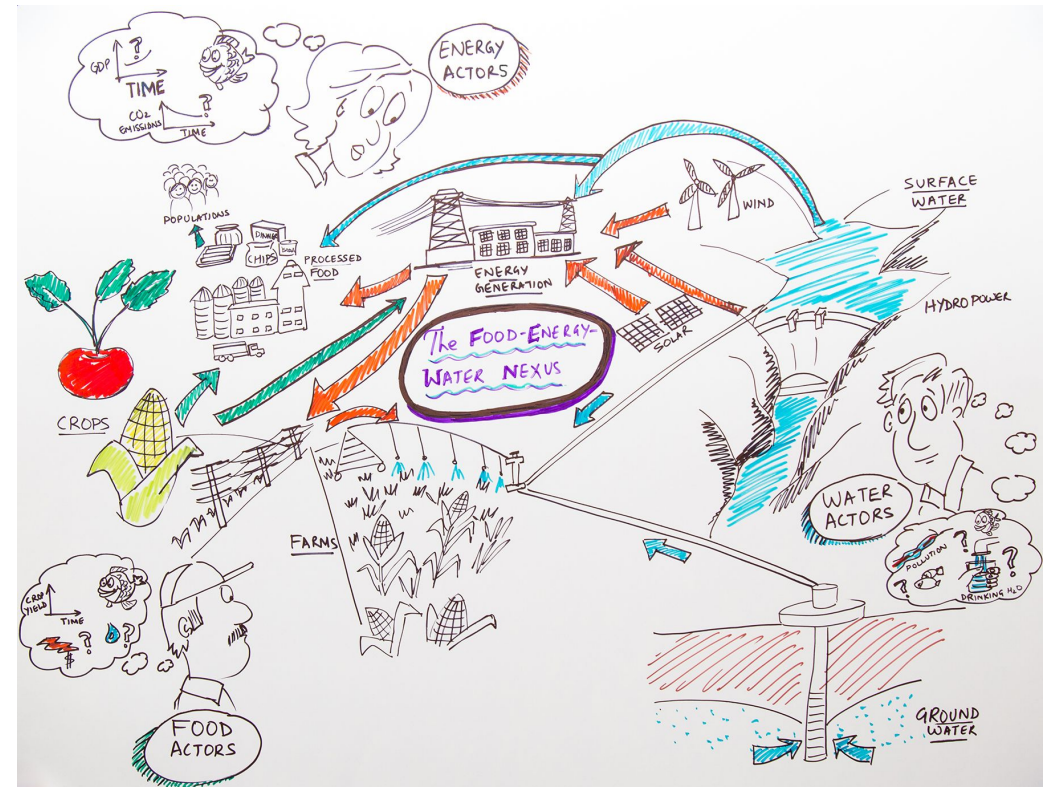
Researchers



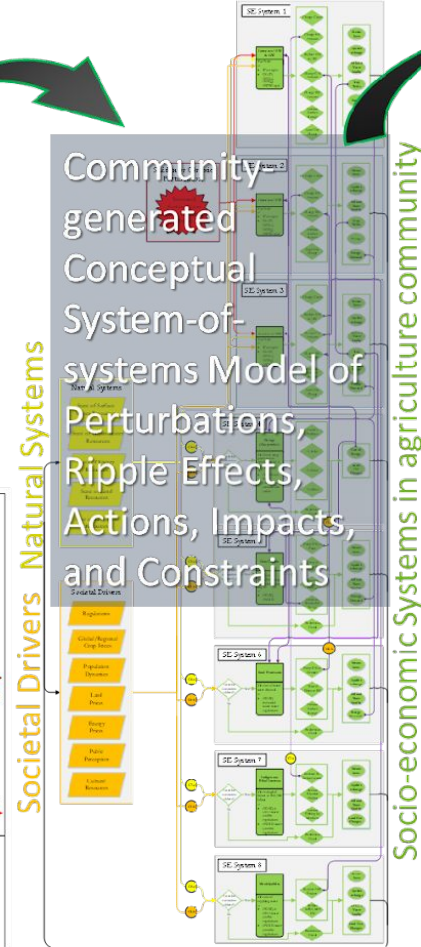
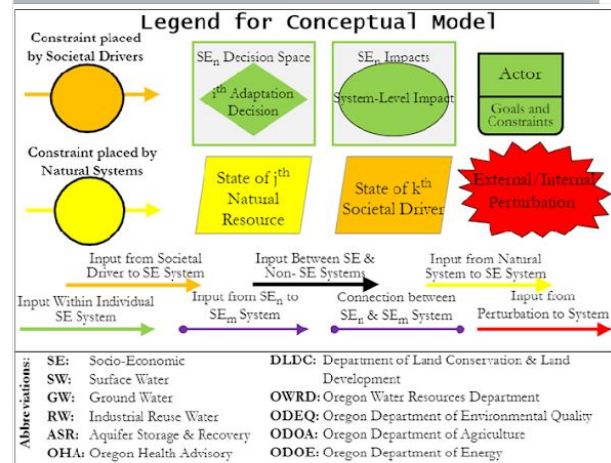
Managers & Agencies



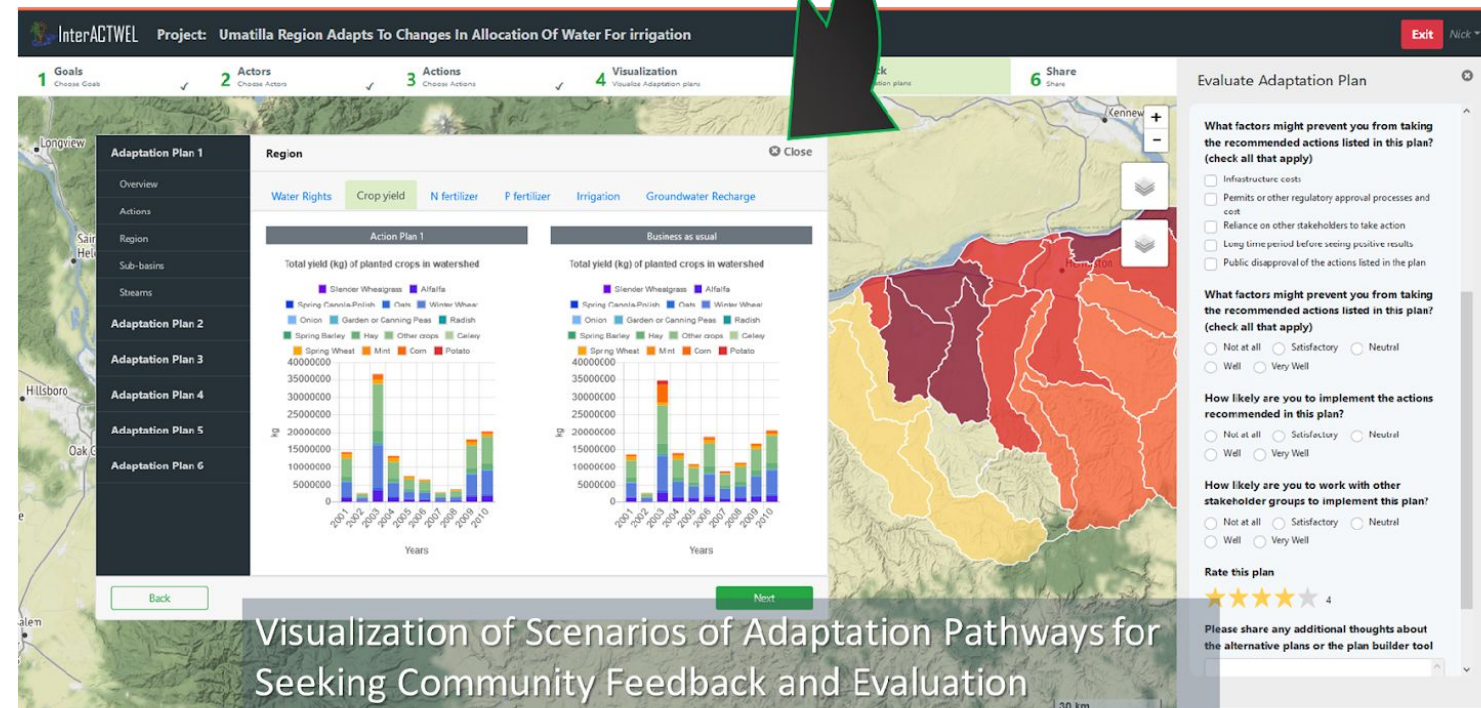
Watersheds



# InterACTWEL: Overall Vision

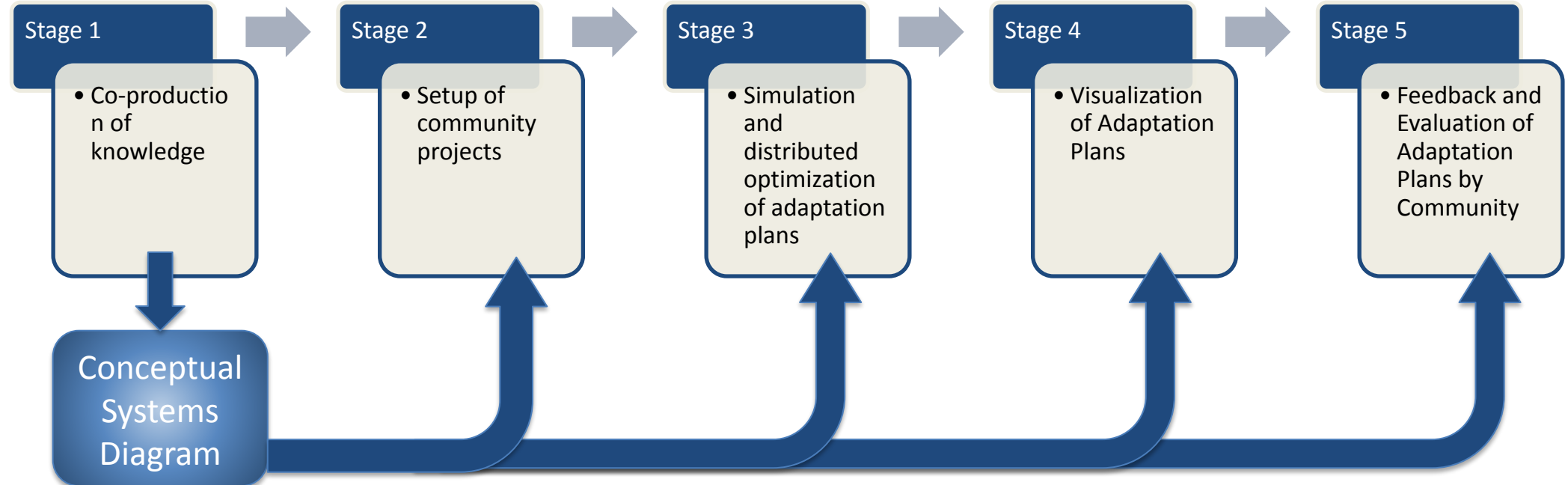


Development of Scenarios of Adaptation Pathways for Community-generated Model of System-of-systems



Visualization of Scenarios of Adaptation Pathways for Seeking Community Feedback and Evaluation

# InterACTWEL: Workflow Stages for Stakeholder-Driven Adaptation Planning





InterACTWEL Gateway

Home Projects Plans Community Help

### Learn

Learn about how adaptation can help FEW actors in watershed communities be resilient

- Instructional Videos
- Adaptation Stories
- Documentation
- Support

### Prepare

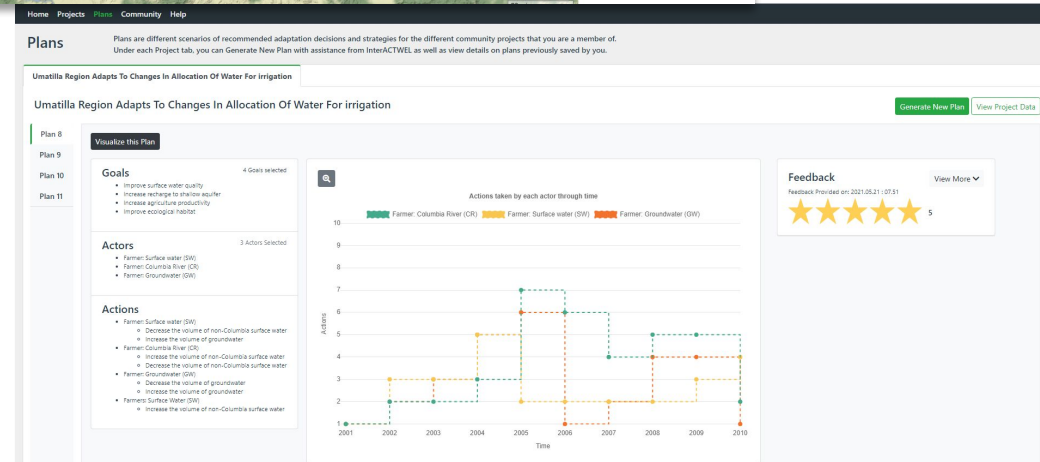
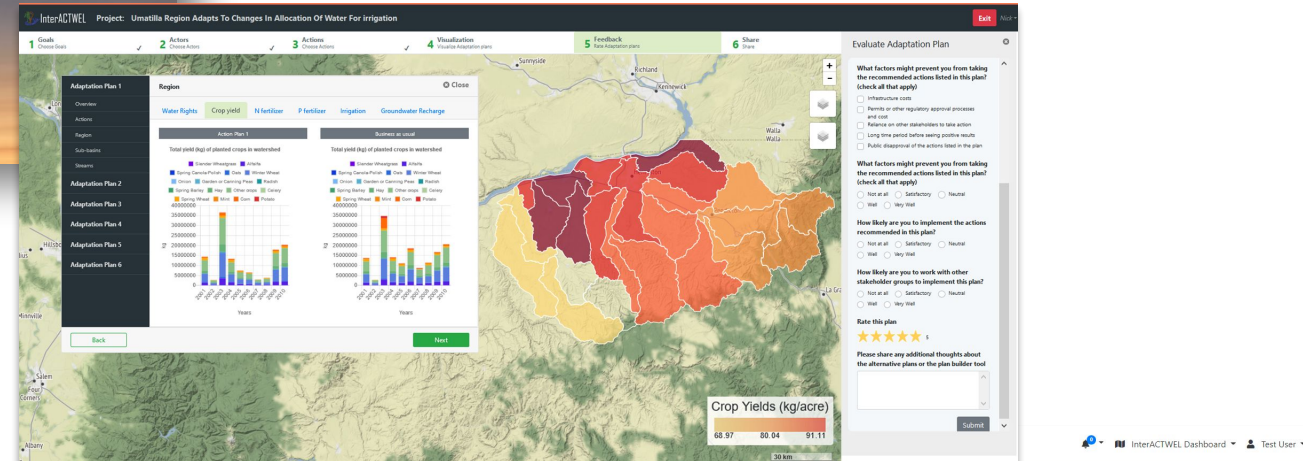
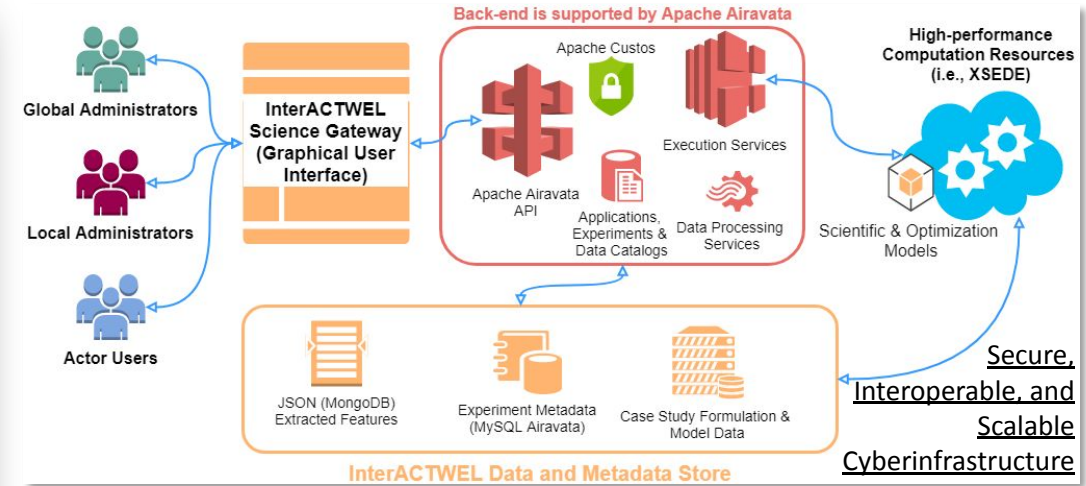
Create portfolios of community wide adaptation strategies using advanced scientific models and machine learning

- Join a New Project
- Generate New Plans
- Review Saved Plans

### Act

Visualize, evaluate, recommend, identify and adopt community preferred adaptation plans

- Share Plans
- Participate in Group
- Participate in Events





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# Description of the data, data parsers and computations involved & UX approach

Dr. Samuel J. Rivera



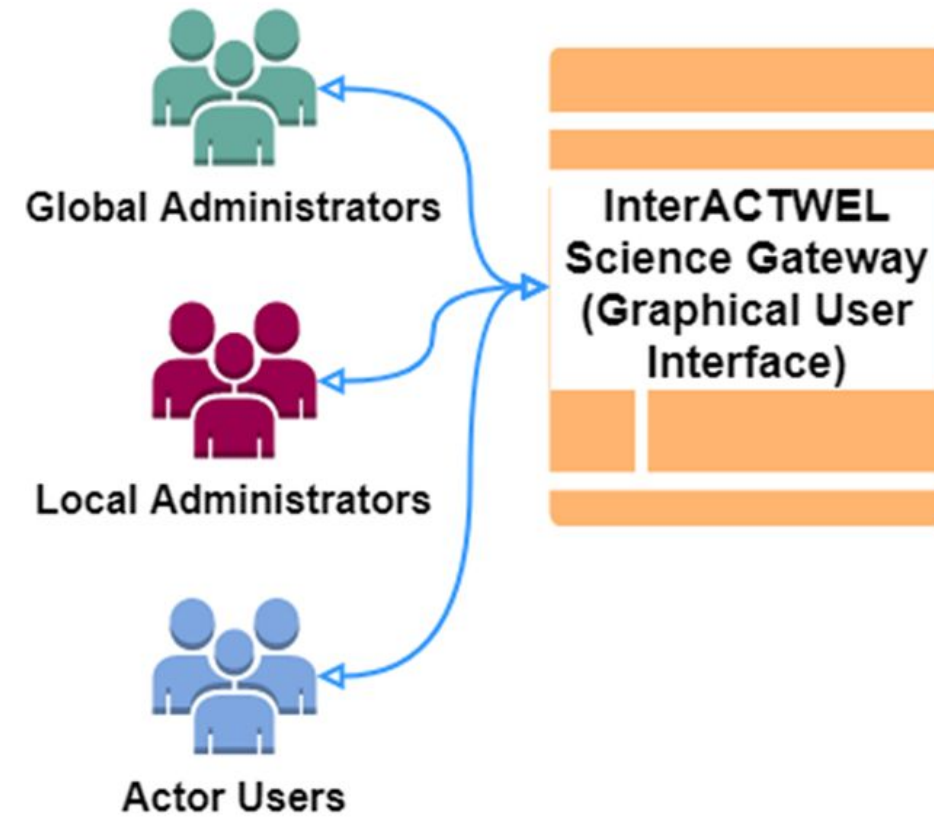
# End users of InterACTWEL and their Roles

## □ Global Administrator (GA)

- Set up InterACTWEL Project
- Identify and invite Local Administrators (described below)
- Complete control of the project, the data and models, and the members of the project

## □ Local Administrators (LA)

- Sector technical leads or managers in one or more individual FEW sectors of a local community
- Provide relevant data, models, decision strategies, and cost-benefit goals and constraints that represent their FEW sector
- Have complete control over their data (e.g, sharing privileges, visibility and use restrictions, etc.)
- Can run “pre-setup” simulations/experiments using a different parameters





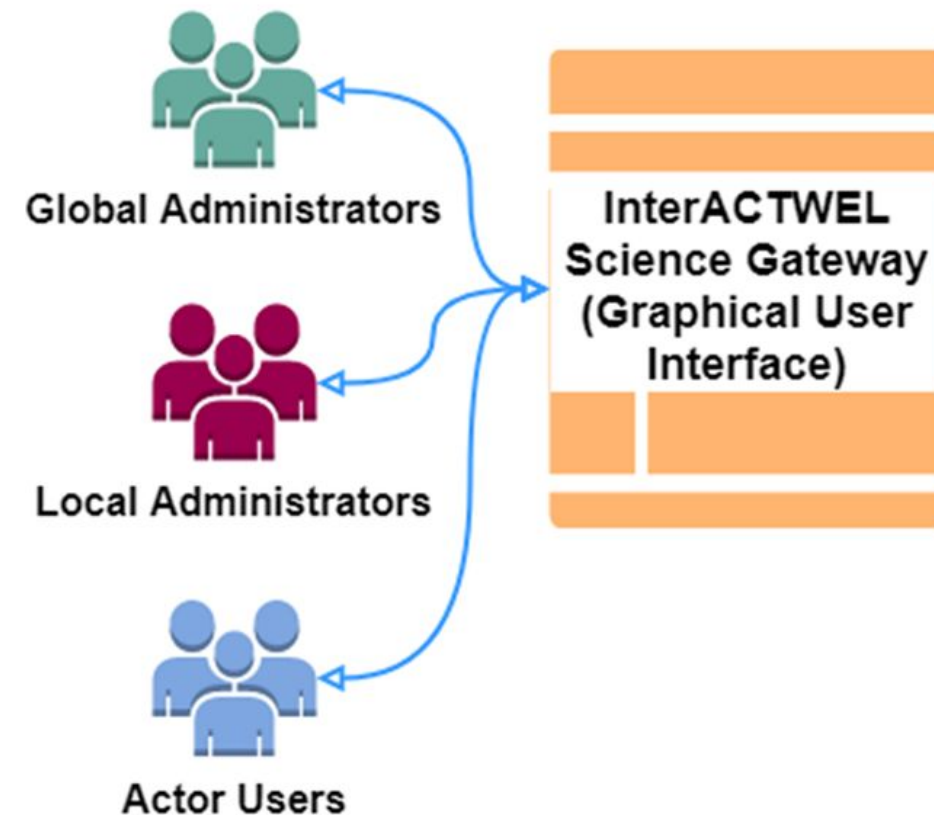
# End users of InterACTWEL and their Roles

□ **Global Administrator (GA)**

□ **Local Administrators (LA)**

□ **Actor Users (AU)**

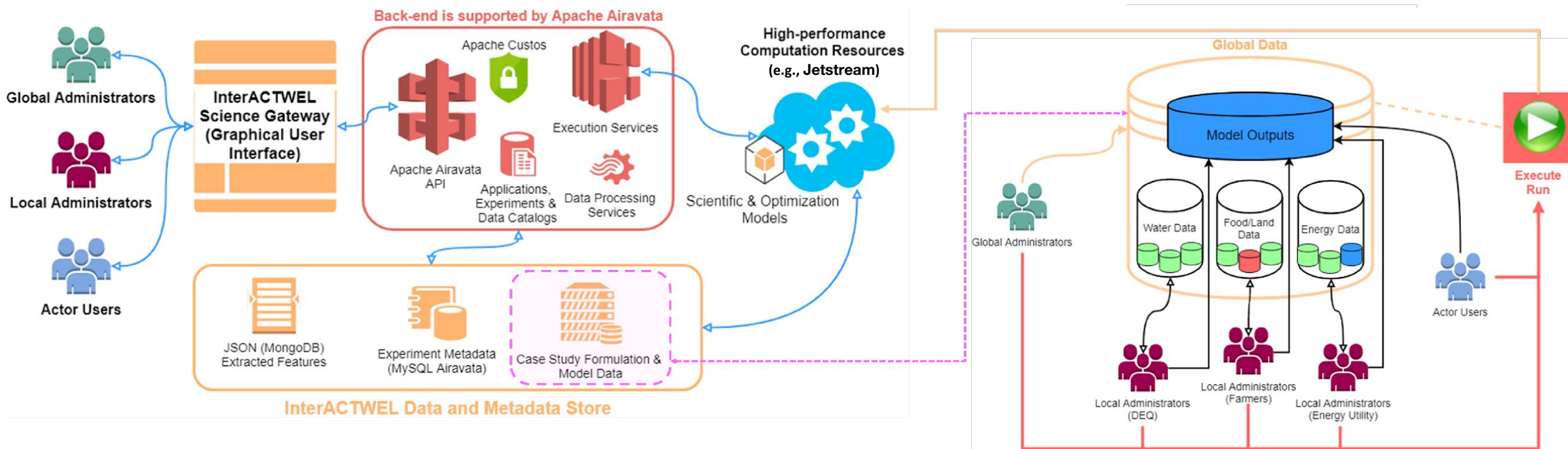
- End users are most closely related to the impacted community members (e.g., residents of the watershed, tribal communities), actors in each of the FEW sectors (i.e., farmers, water utilities) and other interested actors from the public (e.g., researchers, students).
- Interaction with the ScG is limited to the visualization and evaluation of the model results from the experiments through a visualization GUI.



# Overview of technology components and computational resources



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# Simulation and Optimization of Adaptation Plans

□ Plug-n-play modeling platform to simulate Impacts of actors, decision and perturbations in systems diagram

- Land and water management model: Soil and Water Assessment Tool (i.e., **SWAT**; Neitsch et al. (2011))
- Energy model: Energy portfolio planning model (Northwest Power & Conservation Council)
- Economic model: Input / Output Economic Model (OSU)

□ An open-source and decentralized multi-disciplinary design optimization (**MDO**) framework was used to develop a multi-objective optimization formulation of the conceptual model

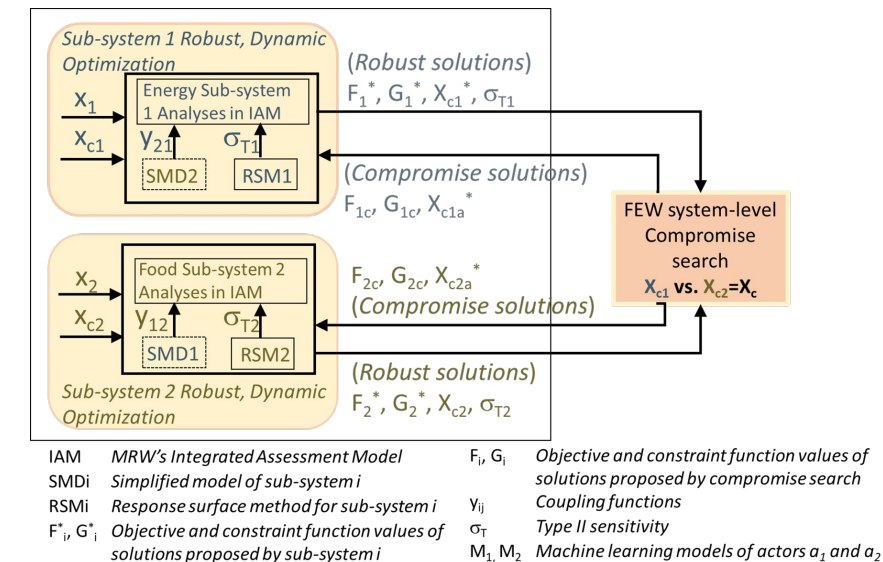
- Models of different spatial and temporal resolutions are coupled by using a dynamic planning approach
- A top-bottom approach is used to combine different optimization approaches (i.e., NLP, Evolutionary algorithms) are used to find near optimal solutions



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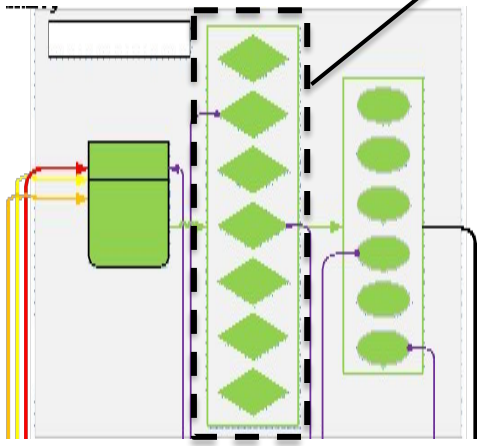


Northwest Power and  
Conservation Council



## Conceptual Socio-economic system's Actions/Decisions

Potential actions for an individual/group



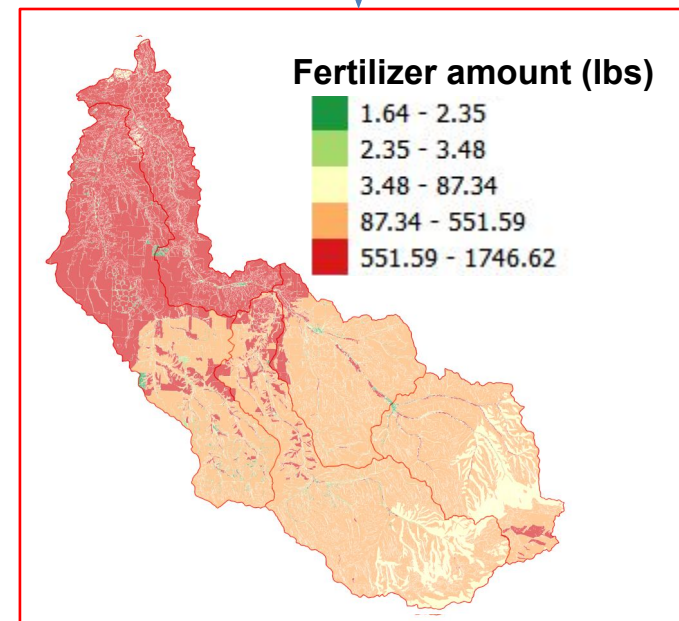
## Modeling of decisions and impacts (i.e., Model Inputs/Outputs)

*How much? When? What type?*

op_type	mon	day
autoirr_str.8		
till	4	30
fert	4	30
plnt	5	30
hvkl	10	30
skip	12	30

1	fertilizer.frt:
2	name
3	elem_n
4	elem_p
5	anh_nh3
6	urea
7	46_00_00
8	33_00_00
9	31_13_00
10	30_80_00
11	30_15_00
12	28_10_10
13	28_03_00
14	26_13_00
15	25_05_00
16	25_03_00
17	24_06_00
18	22_14_00
19	20_20_00
20	18_46_00

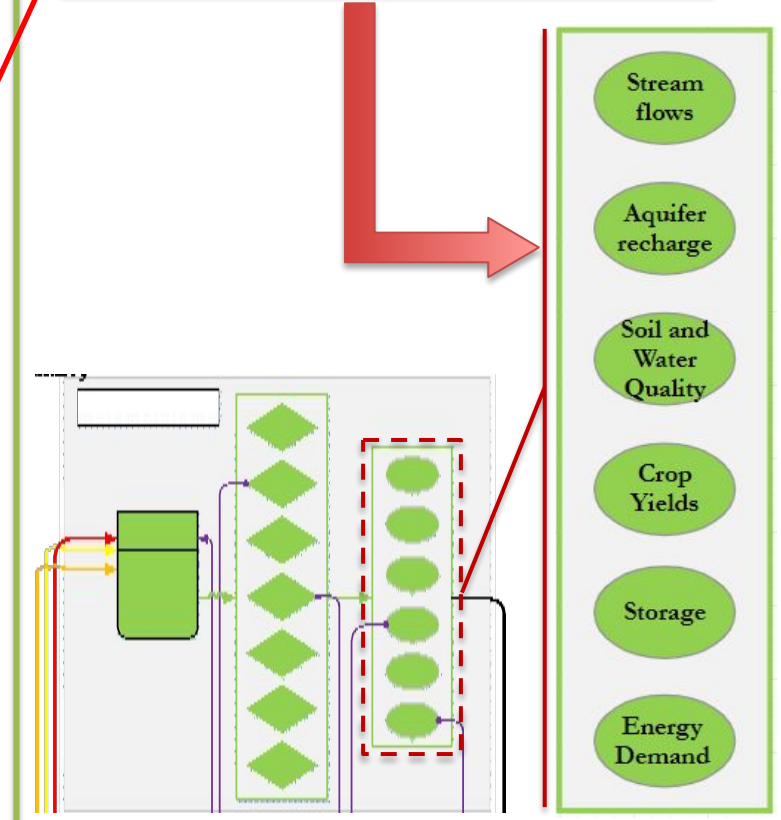


## Quantification of an Actor's Impacts

SWAT+ Aug 14 2018				MODULAR Rev 2018.55		
jday	mon	day	yr	unit	PLANTNM	YIELD
365	12	31	1983	1	corn	1699.888
365	12	31	1983	2	onin	1710.660
365	12	31	1983	3	wwht	1714.649
365	12	31	1983	4	swht	1743.294
365	12	31	1983	5	scrn	1771.090
365	12	31	1983	6	alfa	1683.579

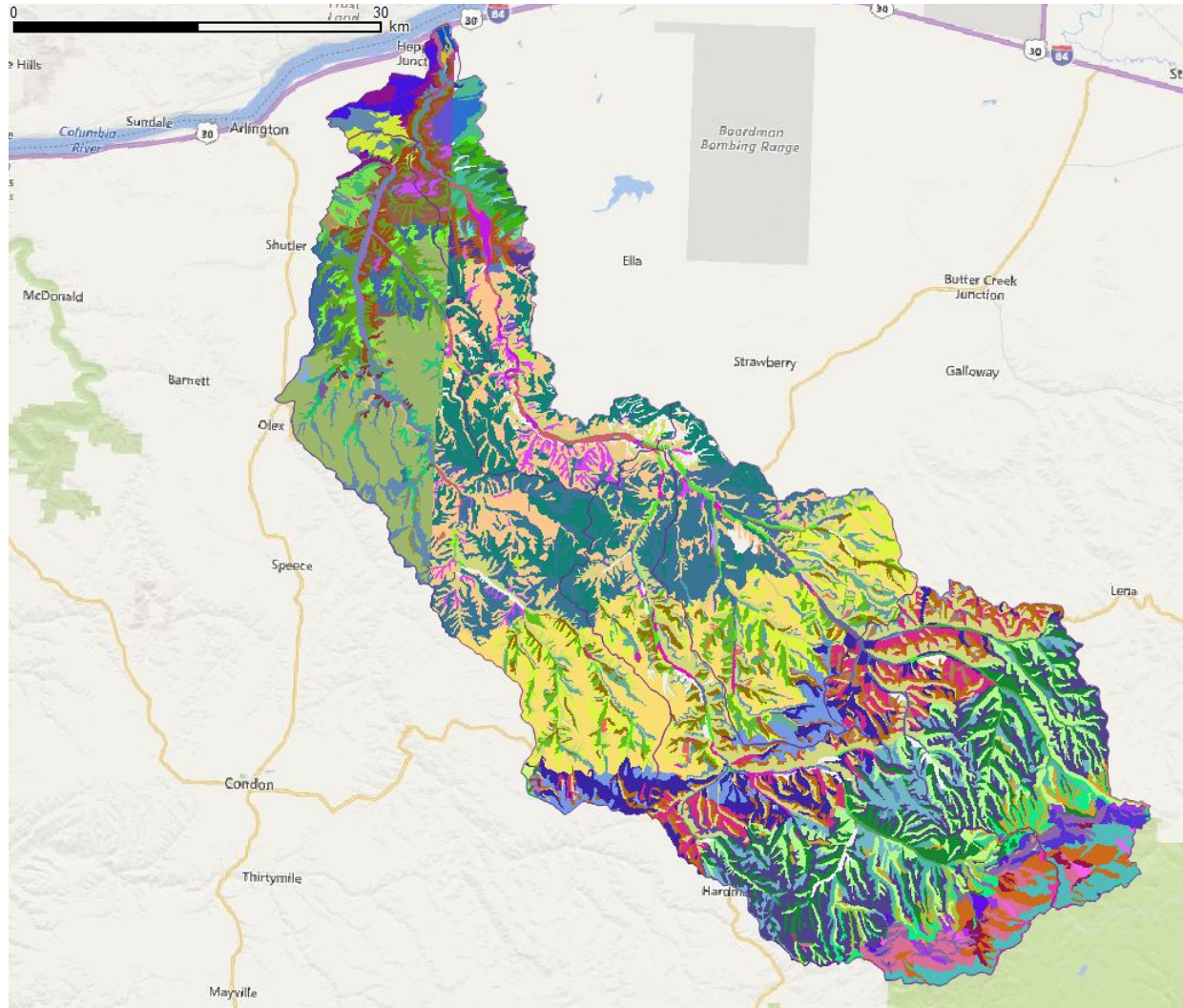
  

orgnin_kg	orgnout_kgN	no3in_kg	no3out_kg
0.5735E-01	0.3521E-01	0.1267E+07	0.0567E+00
0.5735E-01	0.5730E-01	0.1244E+07	0.1102E+00
0.5735E-01	0.0989E-01	0.1568E+07	0.0035E+00



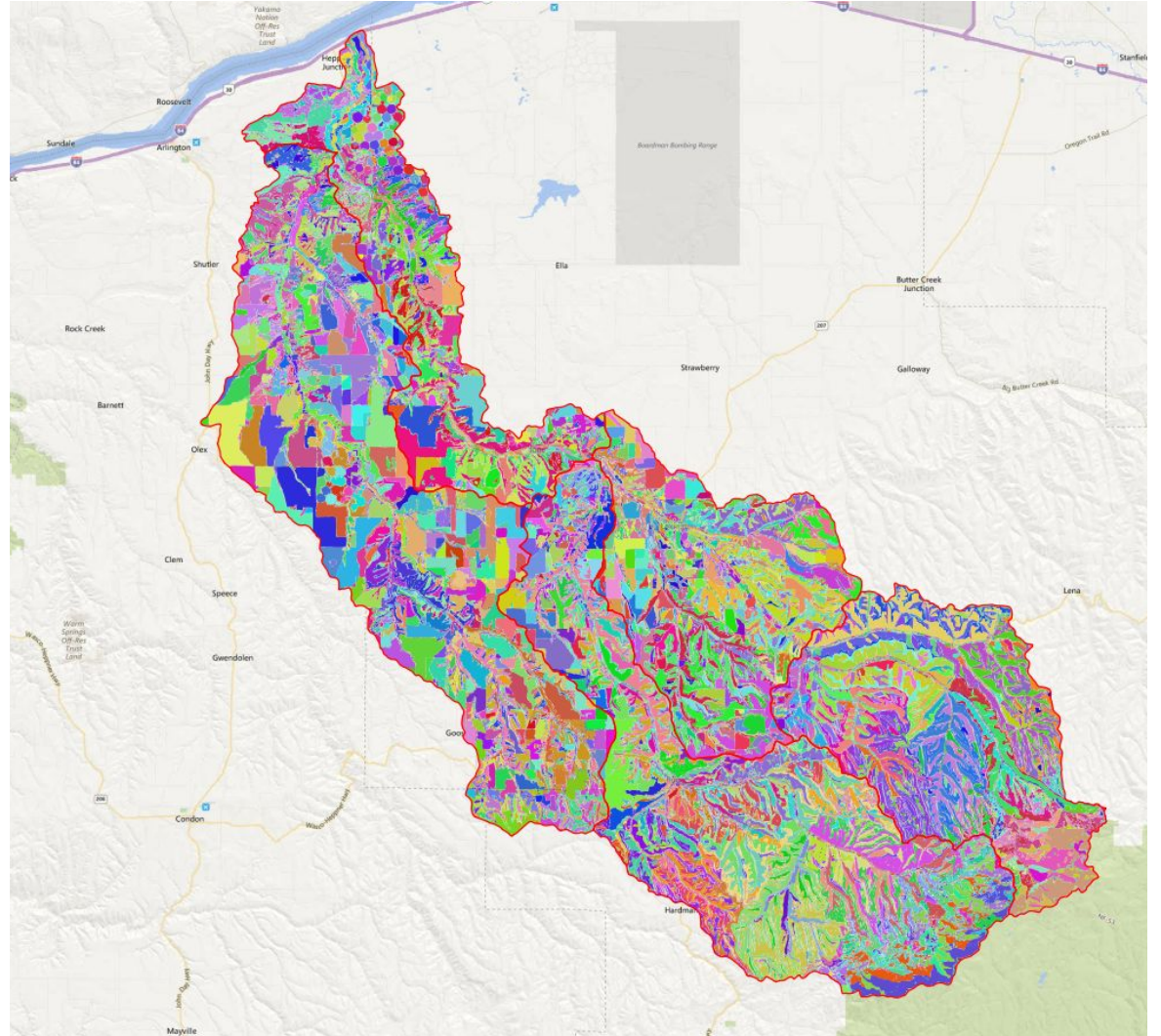
# InterACTWEL: SWAT Model

- **Model boundary**
  - Watershed Boundary Dataset (WBD) – USGS
- **Elevation**
  - Digital Elevation Model (DEM) – USGS
- **Streams**
  - National Hydrography Data (NDH) – USGS
- **Land use**
  - Cropland Data Layer (CDL) – USGS (NASS)
  - National Land Cover Dataset (NLCD) – USGS
- **Soil**
  - Soil Survey Geographic Database (SSURGO) – USGS (NRCS)
- **Many more types of data**
  - Water rights, crop yields, field management data, water quality/quantity, dam operations, etc.



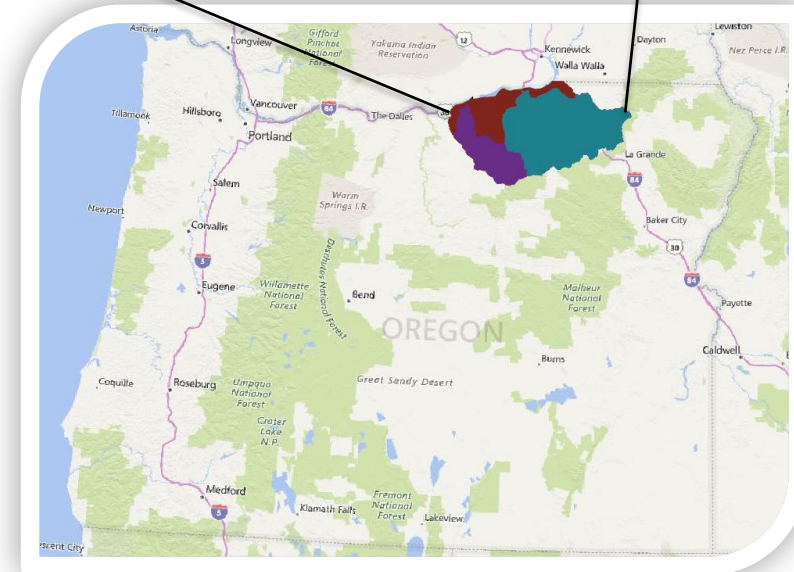
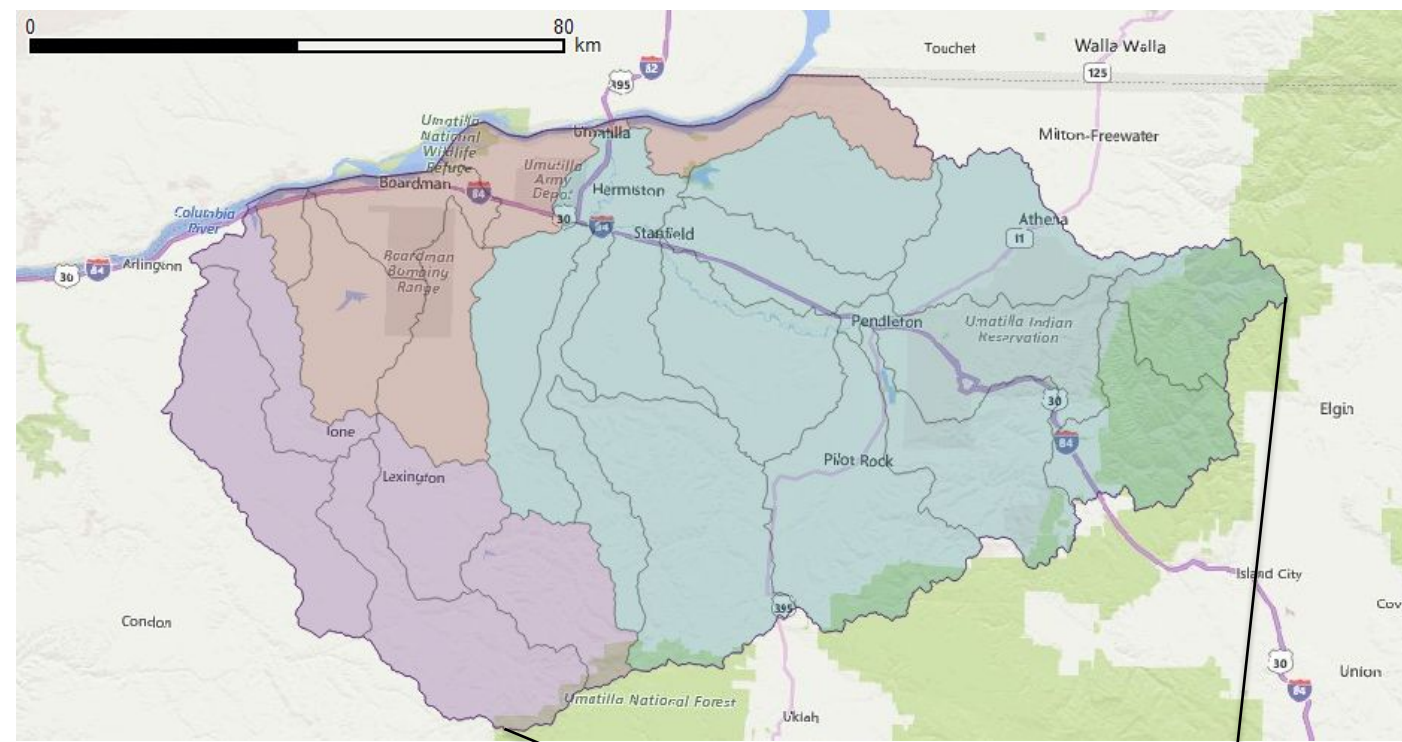
# InterACTWEL: SWAT Model

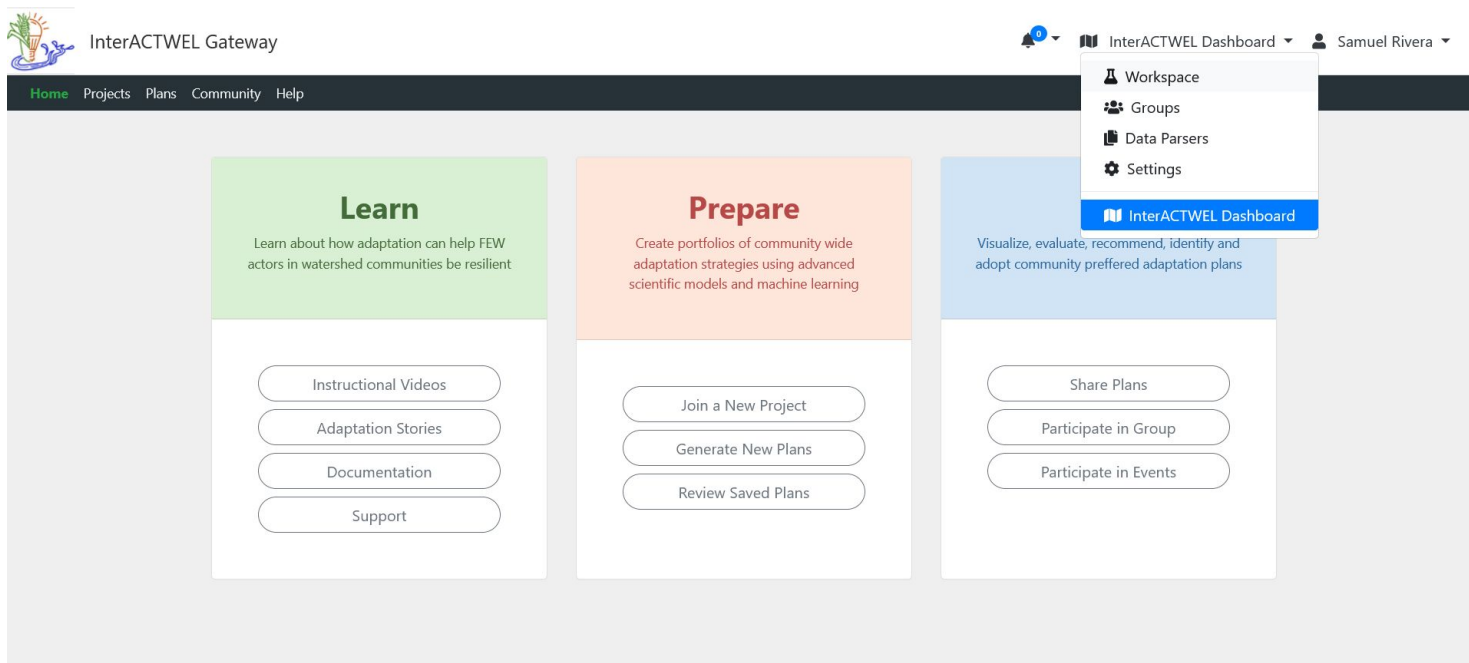
- **Hydrologic Response Units (HRUs)**
  - Unique combination of soil, slope, and land use (i.e. crop)
- **Field level HRUs**
  - Each field may be independently managed
    - Crop choice
    - Irrigation source/application technology
    - Fertilizer type/amount
    - Tilling practices



# InterACTWEL: SWAT Model

- Three watershed with significant economic and environmental impacts to the region
  - Willow
  - Walla Walla
  - Umatilla
- **Three** separate SWAT models

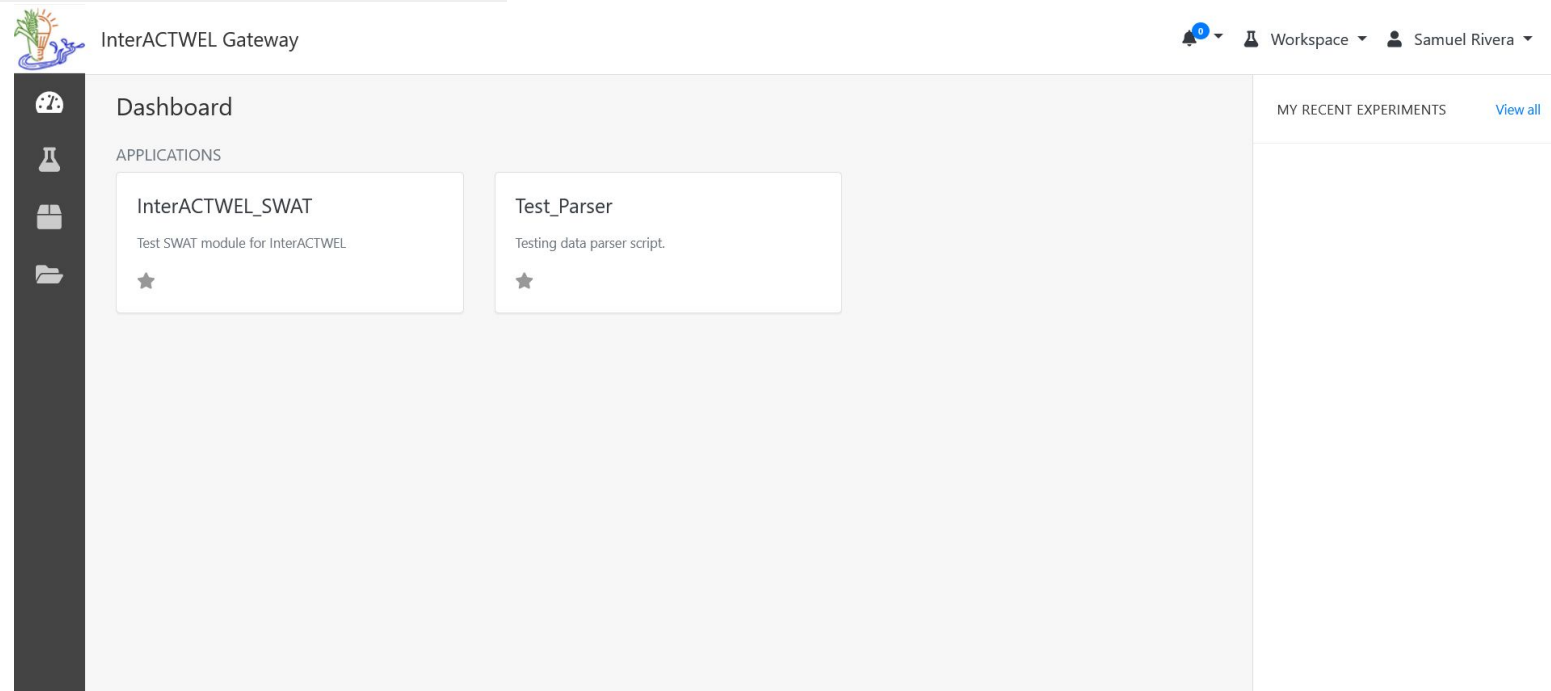




**Global Administrators**

❑ Frameworks & Models are packaged as “Applications” in the ScG.

❑ Global administrators can create or choose an existing “Application” that will be used in their community’s project.



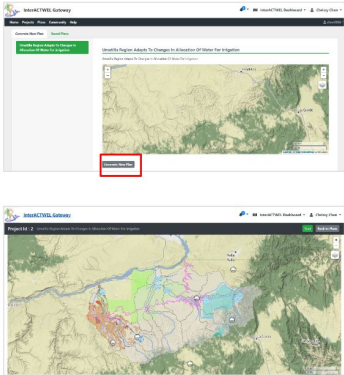
# Dashboard usability testing and redesign

Heuristic Evaluation  
September 2020

Usability Testing  
October 2020

New Mockups  
November 2020

## Plans



Problem	Severity	Heuristic
Low visibility of create button	1	Flexibility and efficiency of use

This is the same problem as the Projects page. Users can't see the create button unless they scroll down. We recommend moving it to the top-right of the page to increase its visibility.

Problem	Severity	Heuristic
Extra step	2	Flexibility and efficiency of use

What's the intention of showing the map before creating a plan? This step might cause a little confusion.

## What's with all these tabs?

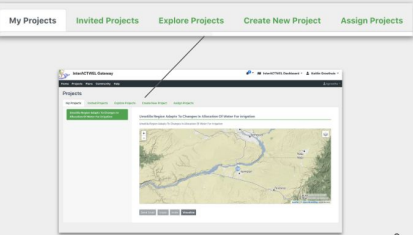
When looking at projects, users got confused about what each category/tab was for. They were confused about the **ownership** and **privacy** of the projects.

One user was also confused about the difference between projects and plans.

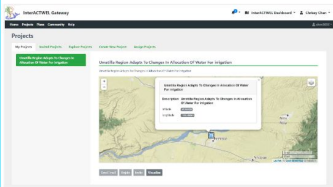
"I assume that these are all my projects and they're private... I'm not sure about projects though because is it just projects I've created?"

[on assigned projects] "I'm not sure how different it is from the other tabs.."

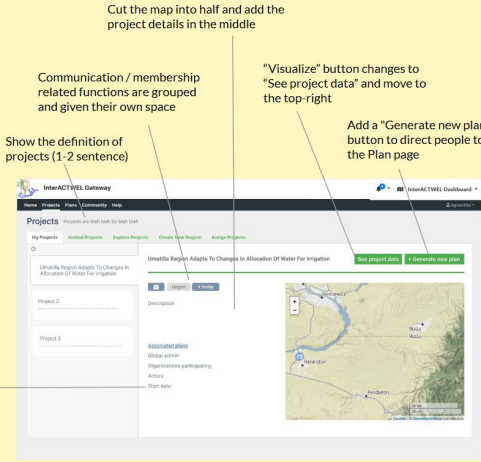
"I don't know what invited projects would be."



## Project Preview



We weren't sure about what to show in the details. Here are just some random thoughts.







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# Gateway development and integration plan

**Eroma Abeysinghe**

# InterACTWEL Infrastructure

ECSS Symposium  
Sept/21/2021

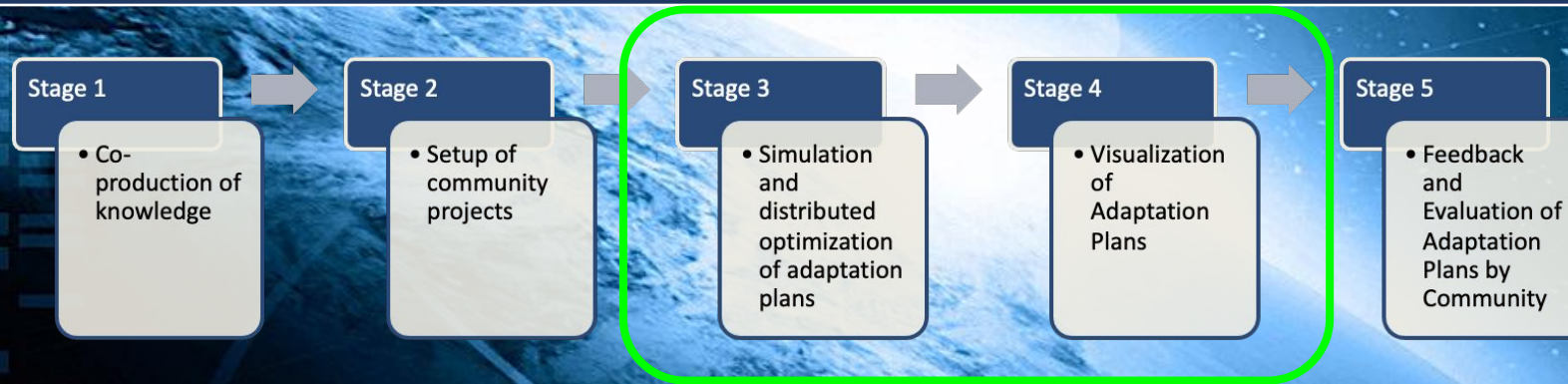
Eroma Abeysinghe and Eric Coulter  
Indiana University, CIRC



Supported by OAC 15-48562.

# XSEDE

# InterACTWEL Gateway



- Gateway is hosted with SciGaP (<https://scigap.org/>), with Apache Airavata (<https://airavata.apache.org/>) as the middleware.
- Range of non-traditional users, non traditional gateway.
- Less focus on computations more on visualization and sharing.

# Security and Extendability

- Security is a main focus.
  - Different levels of users, administrators, policy makers, researchers with multiple levels of access.
  - Uses Custos security framework (<https://airavata.apache.org/custos/>) for security features.
- The gateway was developed using Django framework.
  - Easier to modify, extend.
  - InterACTWEL needed visualizing capability for all its different users.
  - PI and the team designs, reviews and develops the user interfaces.

# Data Handling & Sustainability

- Computed output to post process for visualization.
  - Data framework used for data parsing and depositing to database.
  - Parsers are executed in Docker containers.
- Frequent stakeholder feedback sessions.
  - Active development and improvements.
  - Enables seamless development and integration.
  - Continuity beyond ECSS consultation.

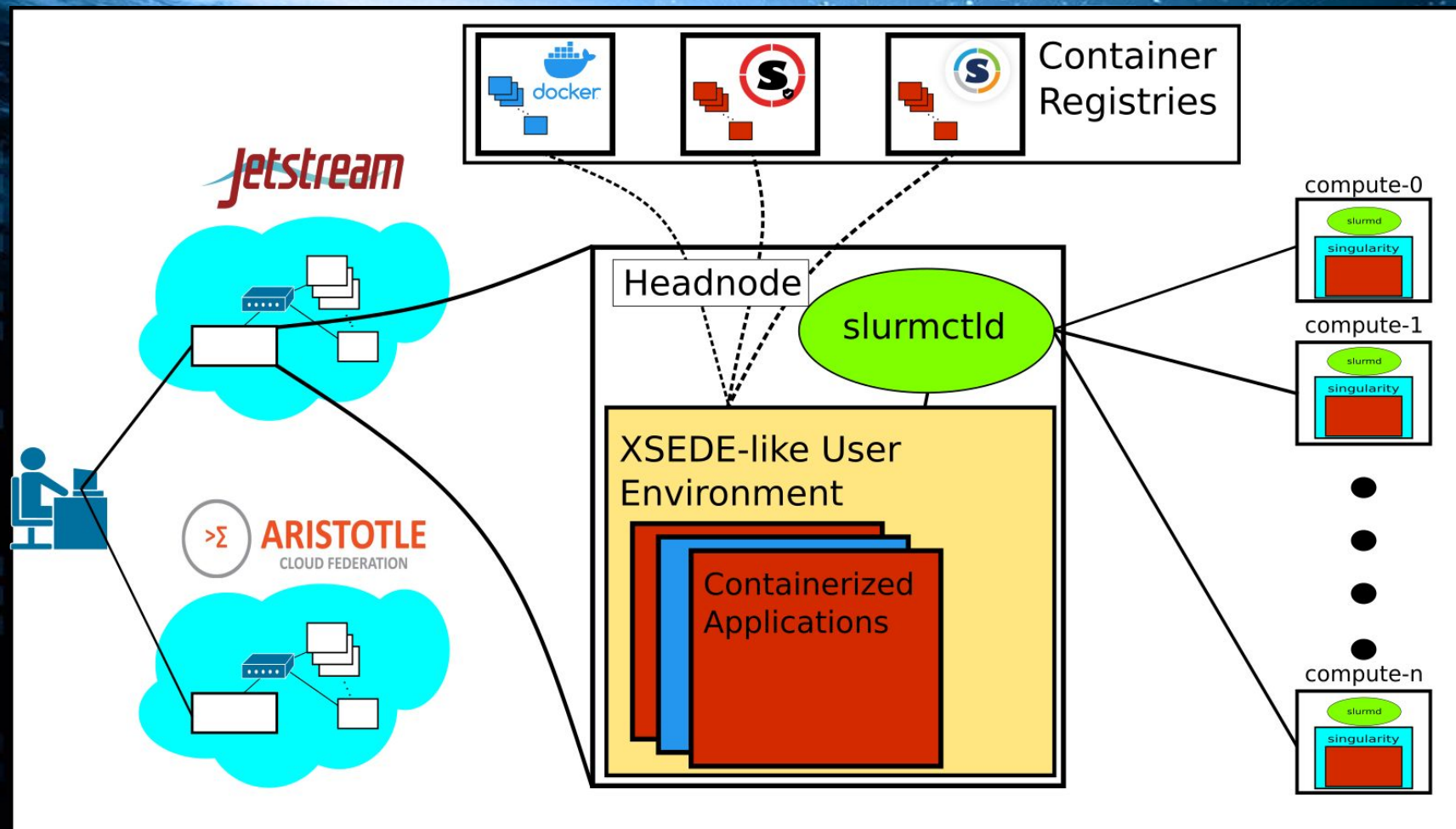
# HPC infrastructure in the Cloud

- Virtual HPC Infrastructure deployable on Openstack clouds
  - Focussed on a handful of open research clouds
- Deployed ~30 production VCs
  - From Quantum Chemistry to Textual analysis
  - Training and education on all sides of the spectrum (Admin -> Users)
- Combine with containers for portability across the resource spectrum



**XSEDE**

# XSEDE CRI Virtual Cluster



# XSEDE

# The building blocks:

- OpenHPC (<https://openhpc.community>)
  - SLURM (<https://slurm.schedmd.org>)
    - with scripts for creation and destruction of worker nodes
  - MPI implementations
  - Singularity
- Jetstream - (<https://jetstream-cloud.org>) and
  - Openstack (<https://openstack.org>)



XSEDE

# Deployment

- Simple scripts for creation/destruction (~10 minutes to running jobs)
  - Headnode instance and Openstack infra is created
  - SLURM+MPI+Singularity are installed & configured
  - Optional shared storage is created
  - A cluster-specific image is created to base compute nodes on (via Ansible)
  - Ready to roll!
  - [https://github.com/XSEDE/CRI\\_Jetstream\\_Cluster/](https://github.com/XSEDE/CRI_Jetstream_Cluster/)



XSEDE

# Supporting SWAT

- Building SWAT on Linux is non-trivial! (in some sense)
  - Took a few days, but we were able to get a workflow established
  - Passed on to Sammy and Meghna, hands-off since
- Next step is to containerize this for greater flexibility
  - This will also create a record of the painful steps involved in getting SWAT working on a Linux environment!



XSEDE

# Questions?

[help@xsede.org](mailto:help@xsede.org) with XCRI in the subject for XSEDE Q's

[circ-group@iu.edu](mailto:circ-group@iu.edu) for Gateways questions

[jecoulte@iu.edu](mailto:jecoulte@iu.edu) - to talk to me

[https://github.com/XSEDE/CRI\\_Jetstream\\_Cluster](https://github.com/XSEDE/CRI_Jetstream_Cluster)

<https://github.com/XSEDE/container-template-lib>

This work funded and supported by Extreme Science and Engineering Discovery Environment (XSEDE), under National Science Foundation grant number ACI-1548562



# XSEDE



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# Future Work

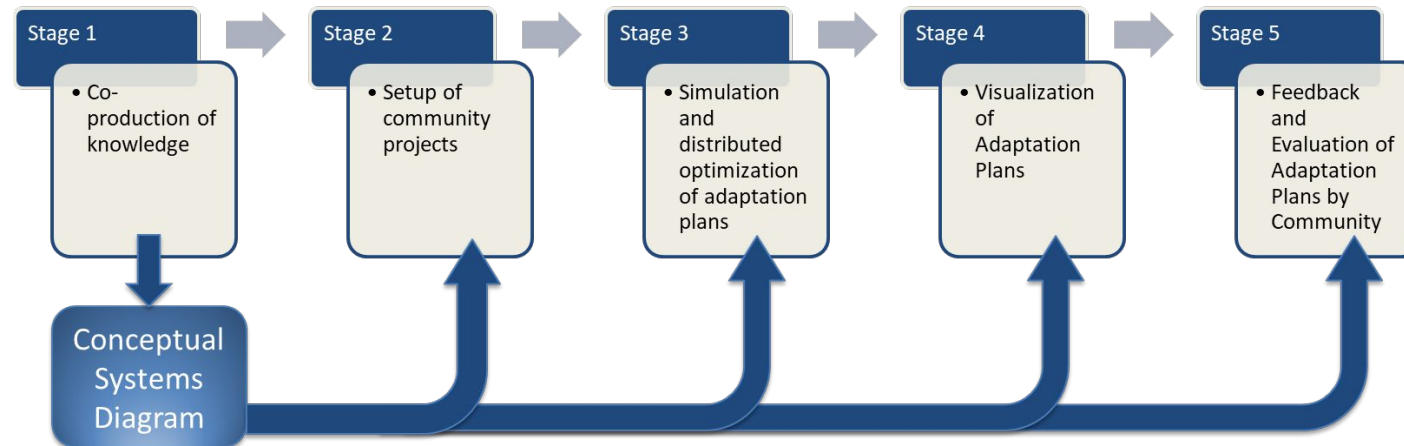
**Dr. Sammy Rivera**

# Lessons Learned and Future Directions



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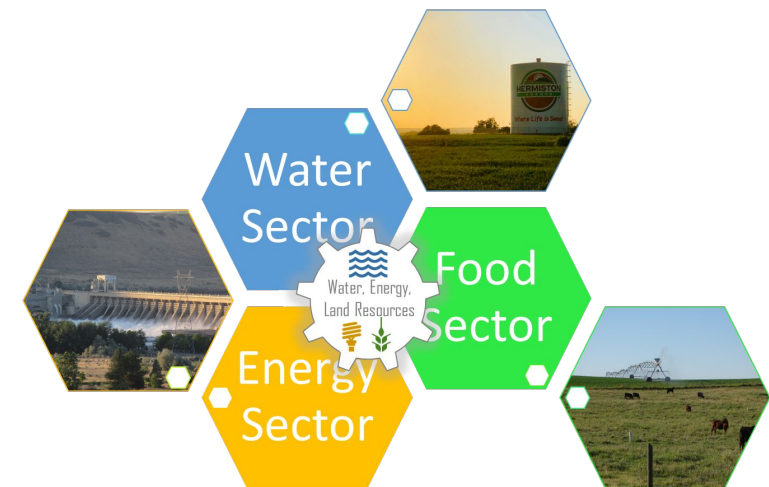
- InterACTWEL as a “safe digital space” for coordinating design of scenarios of community adaptation plans
  - Sustaining long-term stakeholder engagement and community interactions.
  - Maintaining privacy and transparency in decision-making
  - Enabling continual discovery of community insights
  - Sustaining improvements in data analyses and underlying models for scenario development
- Future Directions
  - Build community of practice (researchers and community end-users)
  - Advance Artificial Intelligence capabilities to support InterACTWEL workflows





# Thank you! Questions?

*Project Website:*  
<http://interactwel.org>



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