AgAID: AI Institute for Transforming Workforce and Decision Support

Ananth Kalyanaraman

AgAID Director and Lead PI
Professor and Boeing Centennial Chair
School of Electrical Engineering and Computer Science
Washington State University, Pullman, WA

Presentation at Ag2PI Field Day, August 18, 2021

Supported by:

National Institute of Food and Agriculture
UNITED STATES DEPARTMENT OF AGRICULUTRE

(funded as part of the NSF-USDA National AI Research Institutes program NSF 20-604)

Visit us at
AgAID.wsu.edu

AgAID Institute: Overview and Rationale

How can AI help agriculture secure the future in food production?

Water

- Water scarcity and drought
- Climate change

Status quo: Suboptimal water allocation

Weather

- Weather events can cause severe crop damage and loss (e.g., frost, inversion)

Status quo: Suboptimal management decisions

Labor

- Increasing production costs, and shortage in unskilled and skilled labor

Status quo: Uncertain and variable profitability

Specialty crops: crop diversity (300+), significant fraction (87%) of U.S. Ag workforce, mostly irrigated high value crops, ~40% perennial systems

AgAID Institute: Overview and Rationale

*What should "**Agricultural AI**" look like?*

Complex Systems Modeling

- Nonstationary, multi-scale environments
- Unclear objectives, rewards, and competencies
- Uncertainties due to unknowns

AI ⟺ **Complex System**

Human-AI Partnership

- Roles of humans vs. machines
- Amplification of outcomes

AI ⟺ **Human**

Adoptable AI

"An idle plow tills no earth, no matter how sharp or well-designed"

- Principles of design
- Factors:
  - Usability, Utility
  - Socioeconomic
  - Safety
  - Economics of adoption

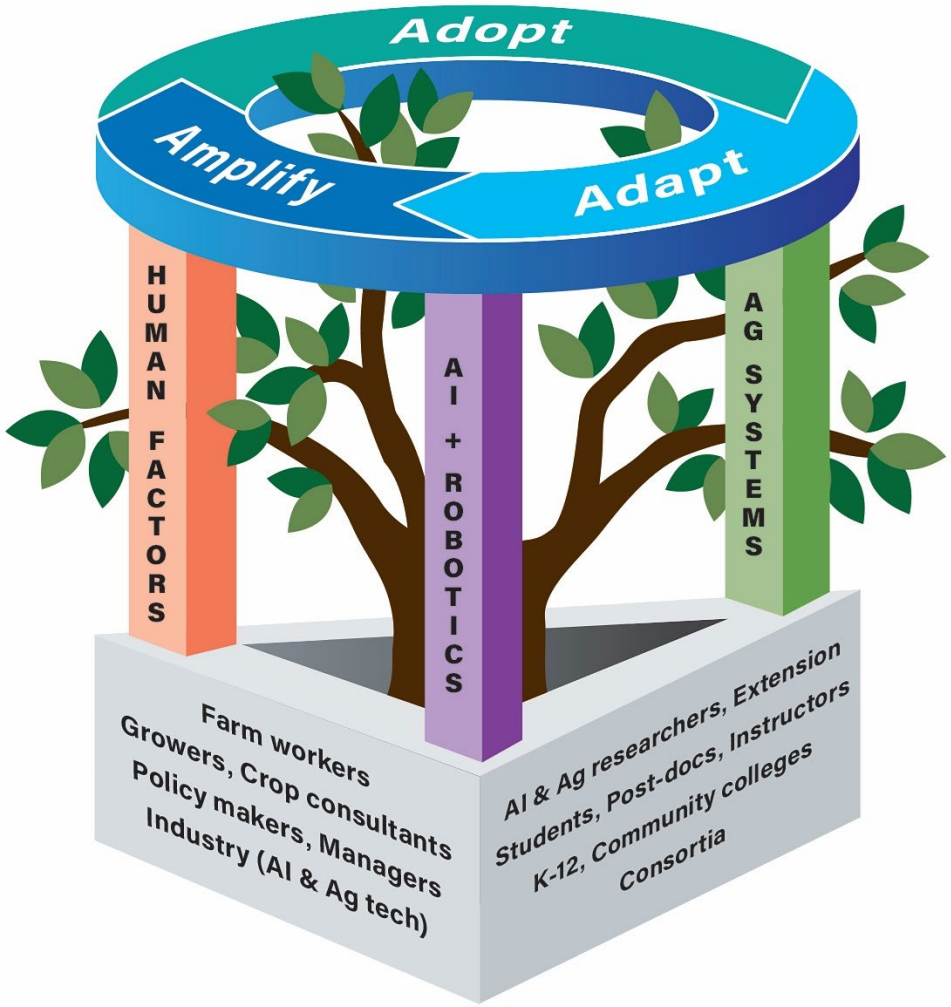
AI ⟺ **Community**

The AgAID Vision and Approach

AgAID vision: We envision a long-term symbiotic partnership between AI, Ag, and human systems that will produce sustained agricultural productivity to meet the future food demands. This partnership will transform the way AI systems are built for complex societal problems in the real world.

AI – Ag – Human Coalition at two different layers:

(system)	*AI technology*	⟺	*Ag human factor design*
(people)	*AI designers*	⟺	*Ag stakeholders*

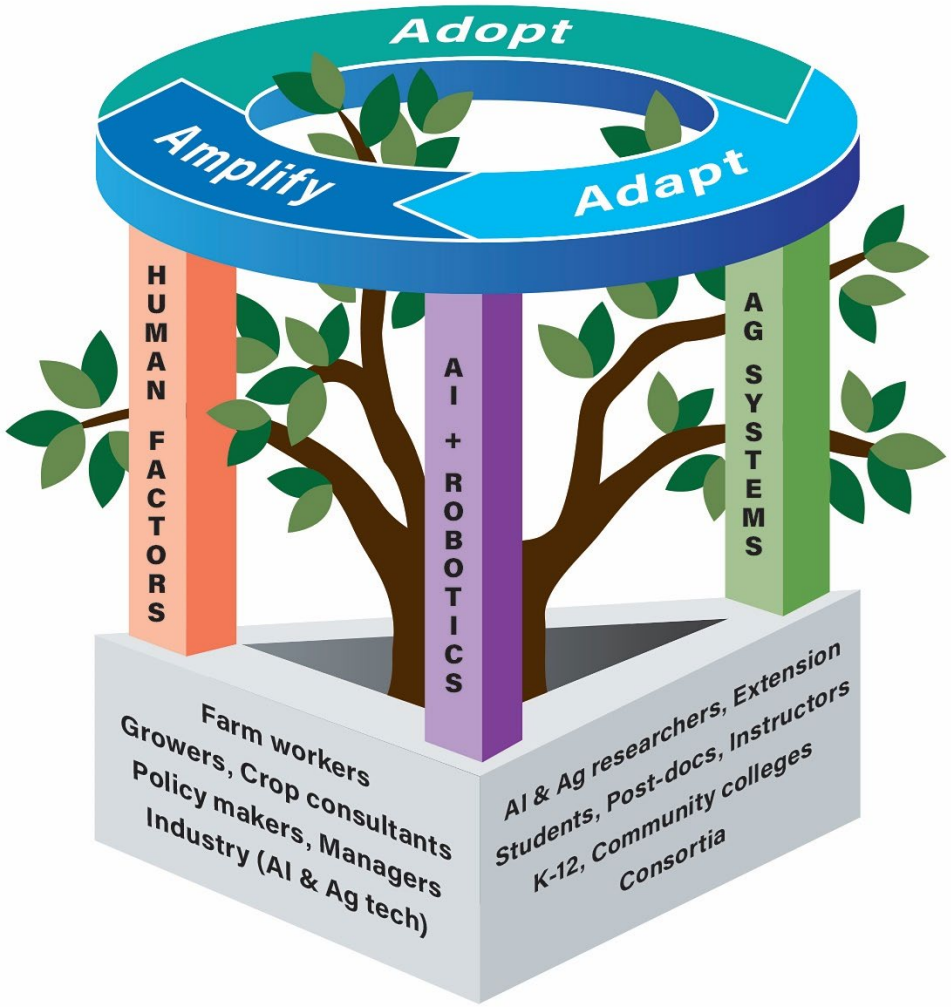


The AgAID Vision and Approach

AgAID Approach: The institute will be guided by three unifying principles: ***Adopt-Adapt-Amplify***:

- **Adopt**ion as a first principle in AI design;
- **Adapt**ability to changing environments and multiple scales;
- **Amplify**ing human skills and machine efficiency through a close human-AI partnership.

Stakeholder engagement: AI designers, Ag researchers, a wide range of stakeholders, and next-generation scientists and workforce.



AgAID: AI Institute for Transforming Workforce and Decision Support

Organization and Key Personnel (who we are)

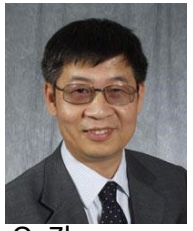
Leadership Team

A. Kalyanaraman
PI and Director

M. Bonnefin
Project Manager

A. Fern
AI Lead

M. Burnett
Human Factors Lead



Q. Zhang
Ag Lead

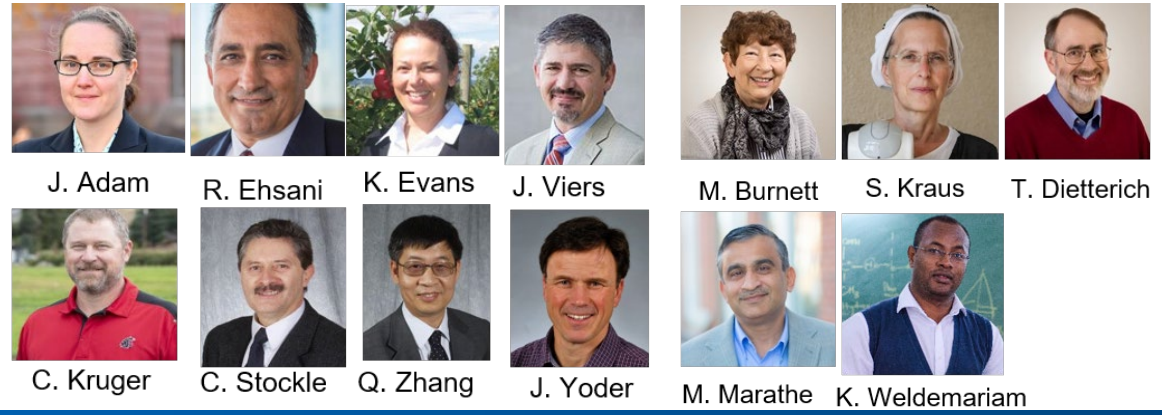
55 team members
from eight academic institutions and two companies

+ 45 collaborators:

7 (academia)
15 (industry, growers, commissions, commodity boards, consultants)
12 (community colleges, K-12 schools, minority alliances)
11 (Government entities, irrigation and conservation districts)

Thrust Leads

Executive Council Members (internal)



AgAID Core Areas of Strengths and Locations

AgAID locations

Ag Hubs
- Washington State University
- University of California Merced

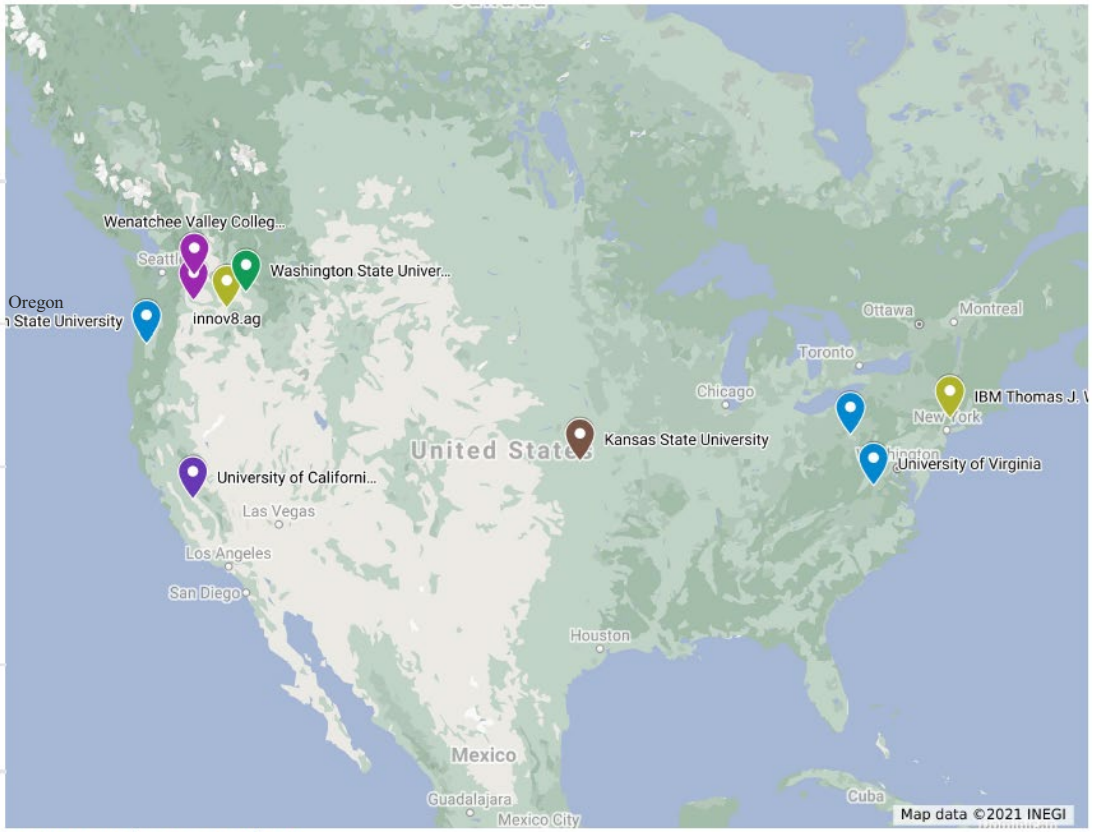
AI Hubs
- Oregon State University
- University of Virginia

Broadening Participation Hubs
- Heritage University
- Wenatchee Valley College

Industry Hubs
- innov8.ag
- IBM Thomas J. Watson Research Center

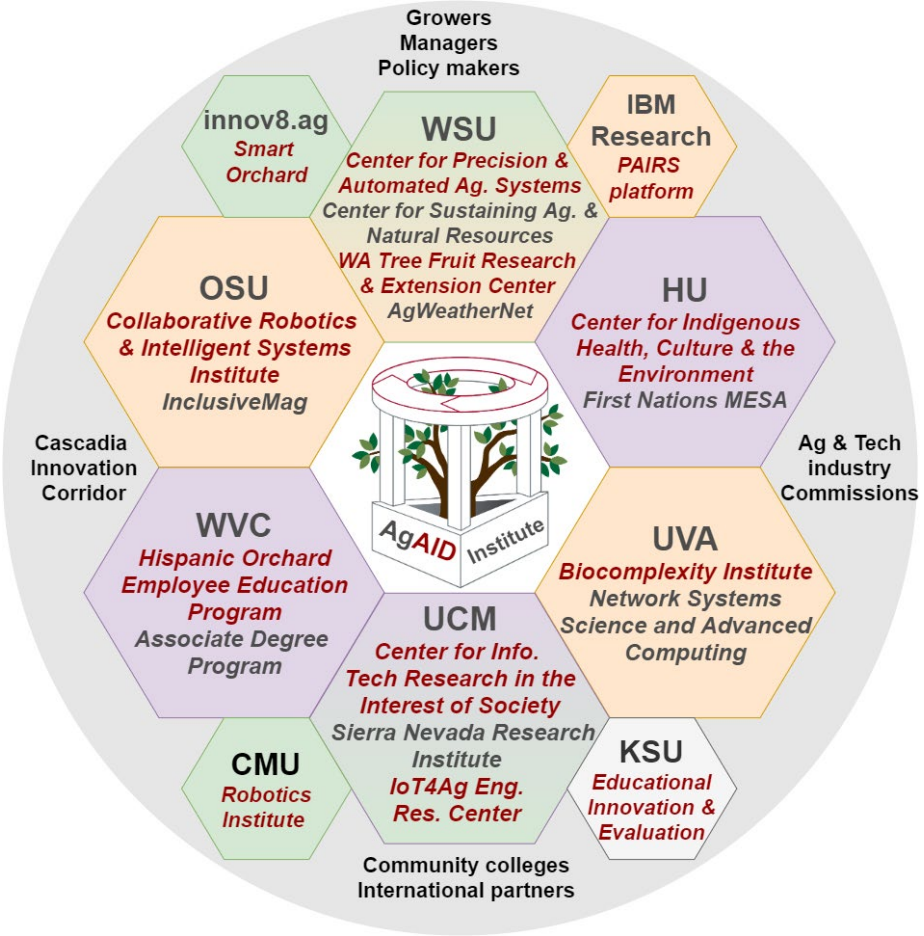
External Evaluation
- Kansas State University

Ag Robotics Partner
- Carnegie Mellon University



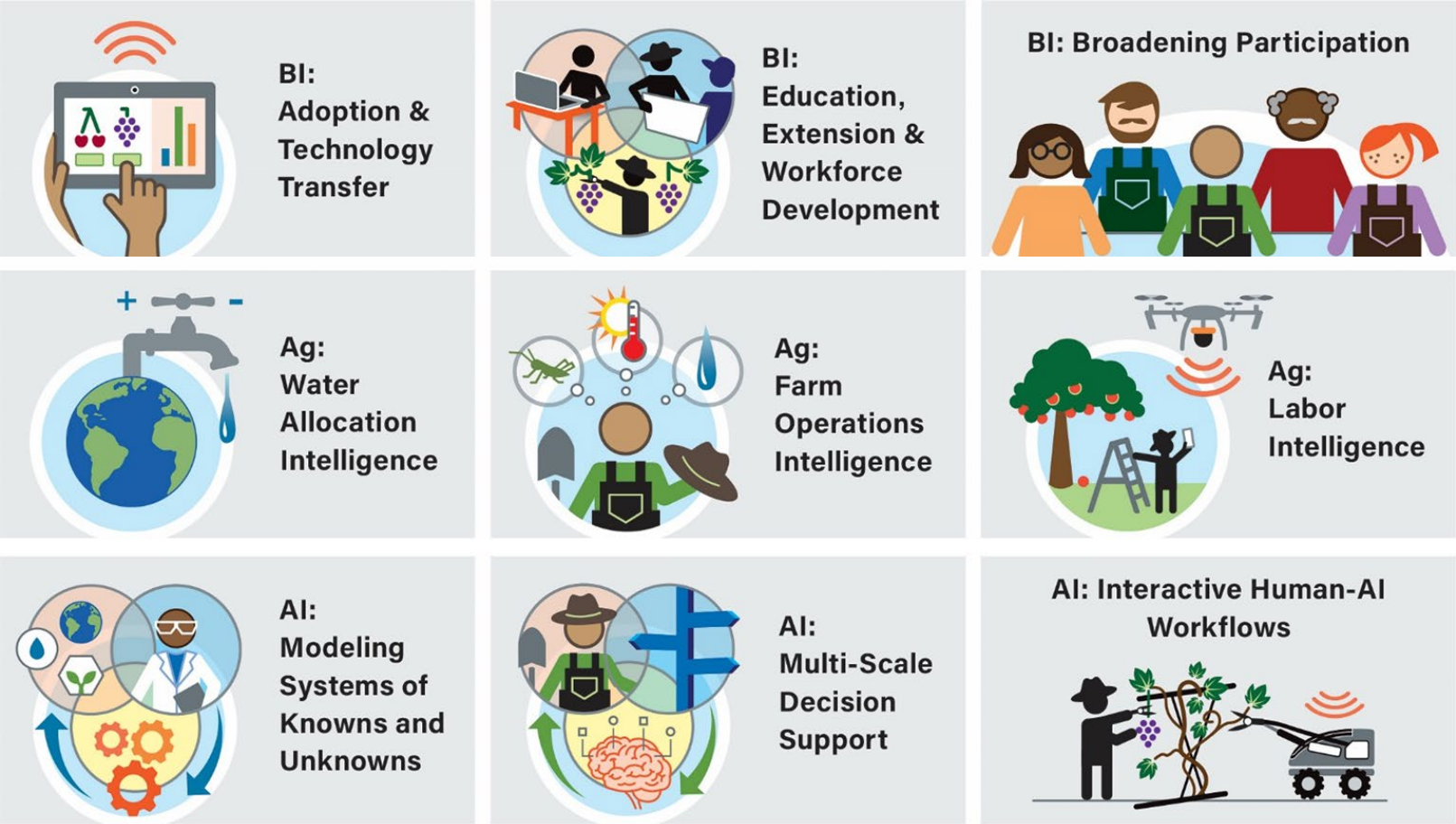
AgAID Institute Locations

AgAID Team and Core Strengths



*Ag Extension will be driven by WSU, UCM, and OSU.
**All institutions will take part in education and broader impact activities.

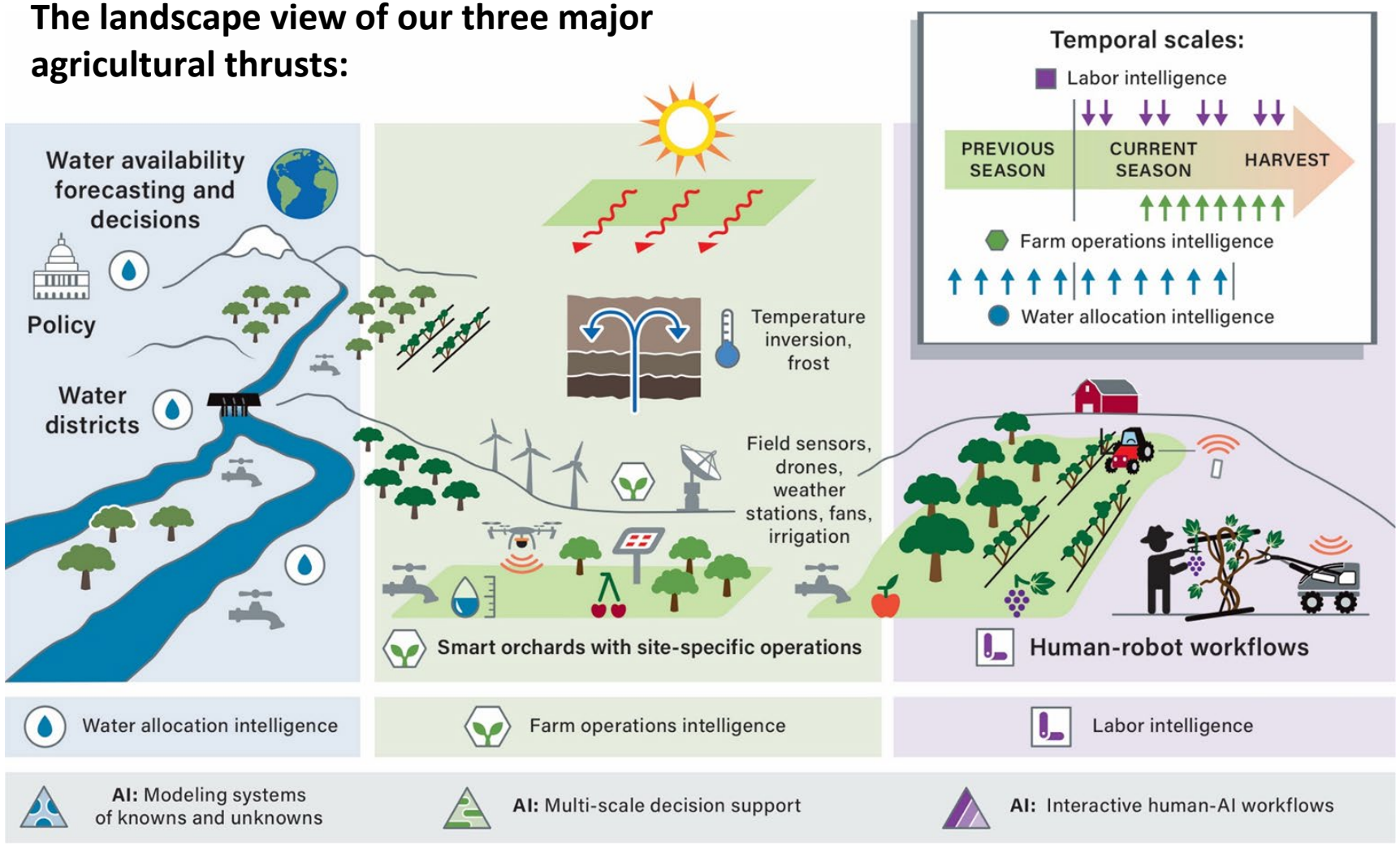
AgAID: Major Thrust Areas



Note the strong ties between research and broader impact activities implied by this overall strategy, as workforce training and stakeholder engagement are embedded within our research activities.

AgAID: Research Landscape

The landscape view of our three major agricultural thrusts:



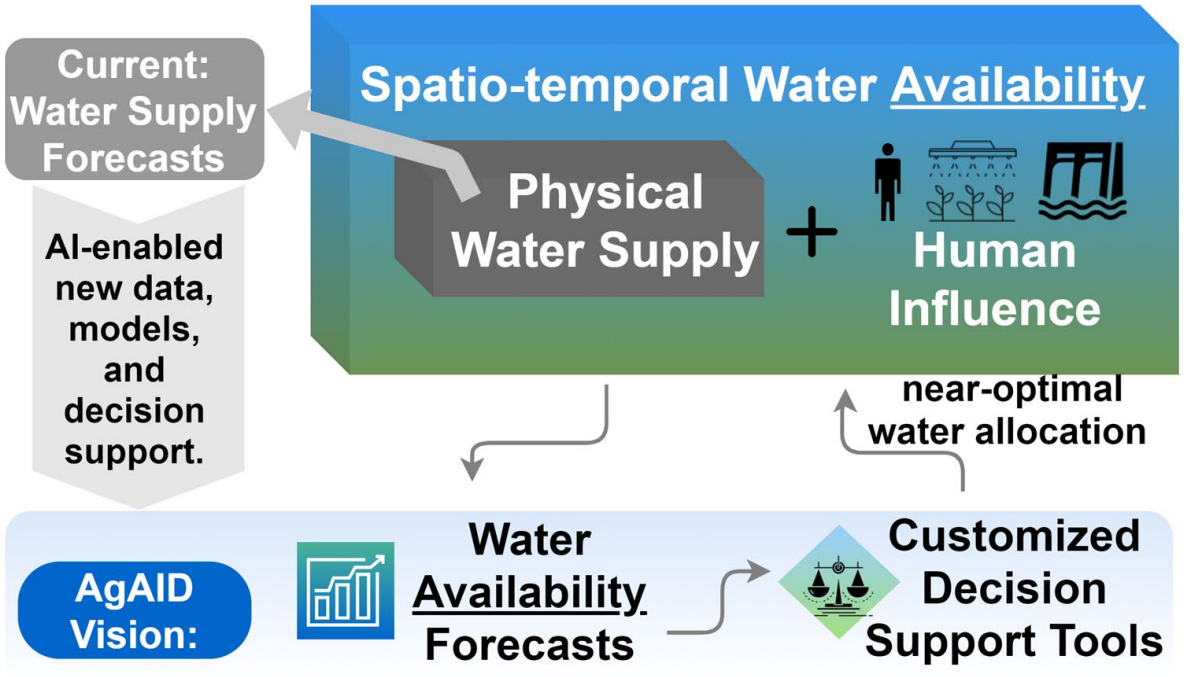
⟸ Ag thrusts

⟸ building on the foundations of AI thrusts

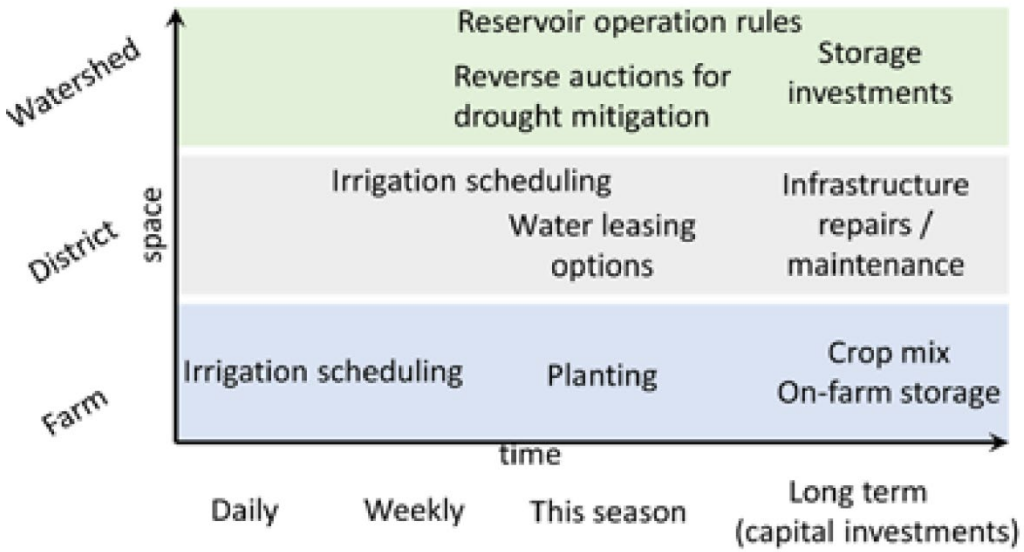
AgAID: Research Landscape

Water allocation intelligence

Ag Thrust: Water Allocation Intelligence



Use-cases:

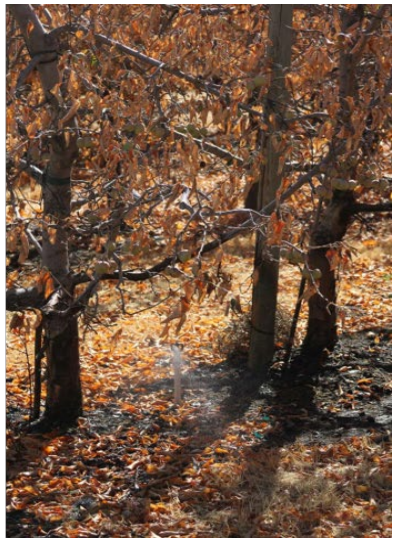


Hypothesis:
Addressing water-scarcity challenges will require new AI-driven models and decision support at the **human-water-climate nexus**.

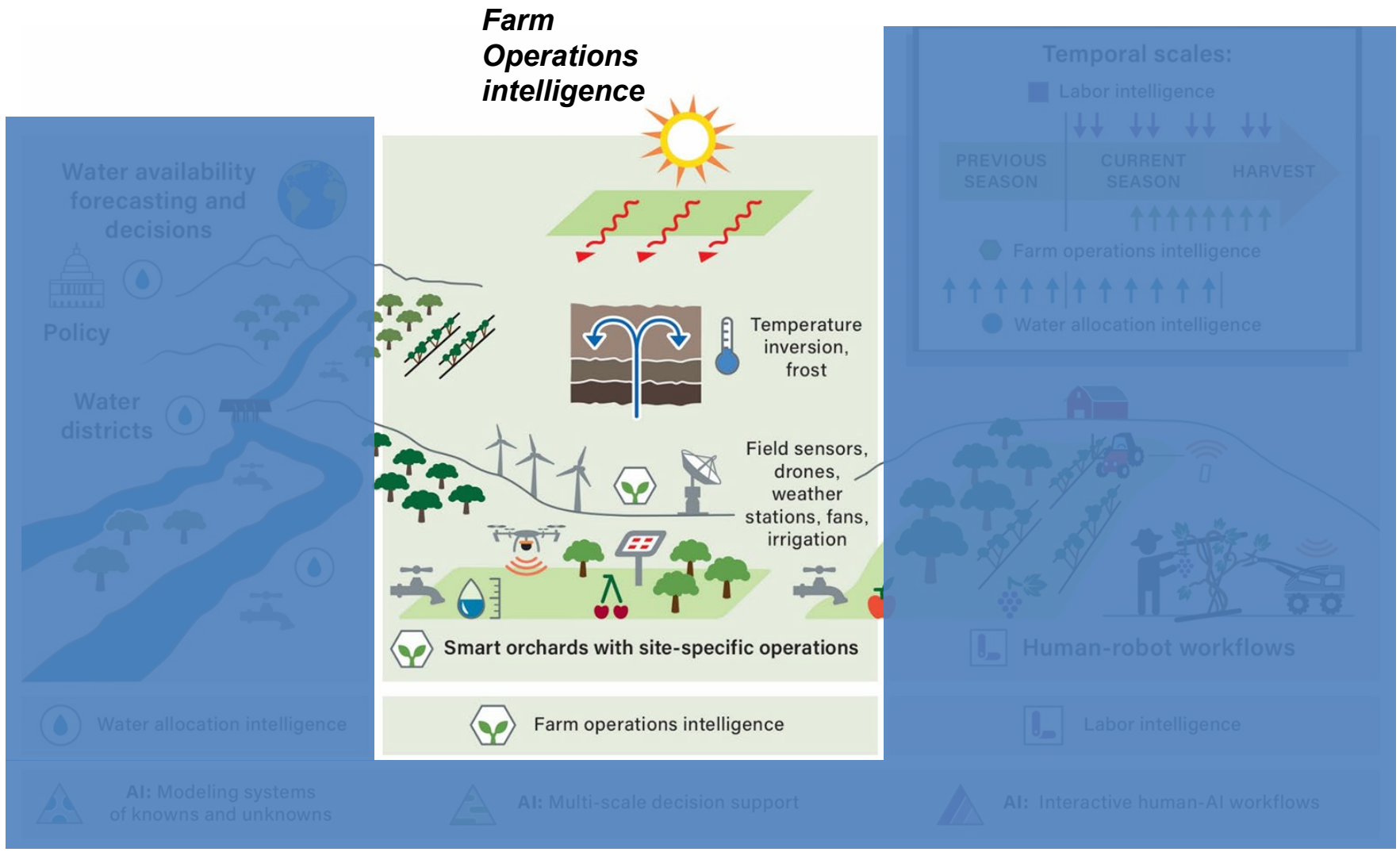
Ag Thrust: Water Allocation Intelligence

Resources to leverage:

- Washington Water Research Center
- Center for Sustaining Agriculture and Natural Resources (CSANR)
- IBM PAIRS database
- Center for Information Technology Research in the Interest of Society (CITRIS)
- UC Water Security and Sustainability Research Initiative



AgAID: Research Landscape



Ag Thrust: Farm Operations Intelligence

Use-cases:

1. Frost mitigation: Reduce crop loss and decrease energy footprint
2. Deficit irrigation: Improve fruit quality with decreased water use
3. Harvest management: Improve fruit quality and optimize labor cost

Frost mitigation

Deficit irrigation

Harvest management

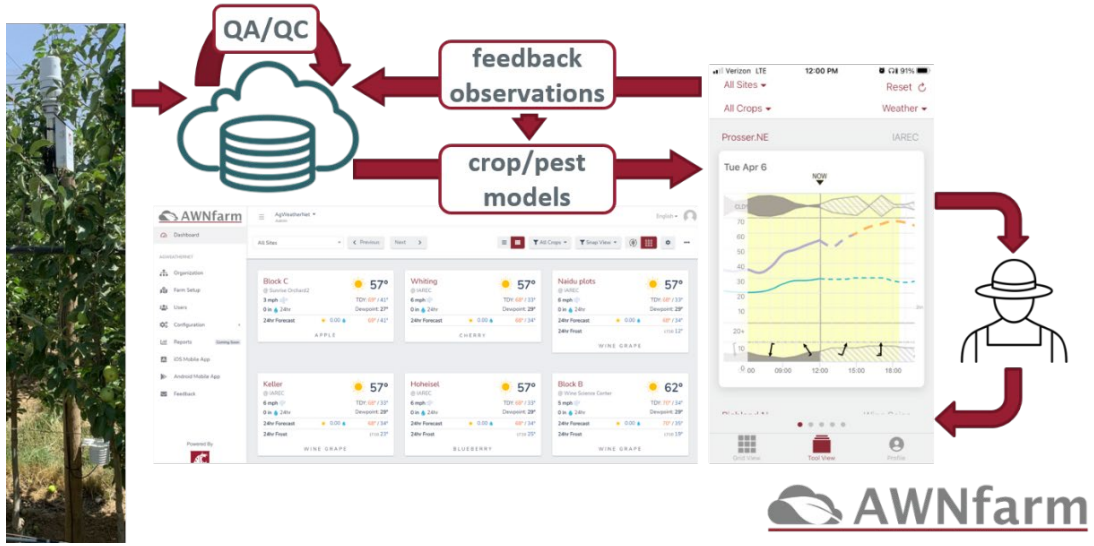
17 billion WA apples per season (10 weeks)

Night shift: Harvesting apples at night. (Good Fruit Grower, 11/26/14)

Ag Thrust: Farm Operations Intelligence

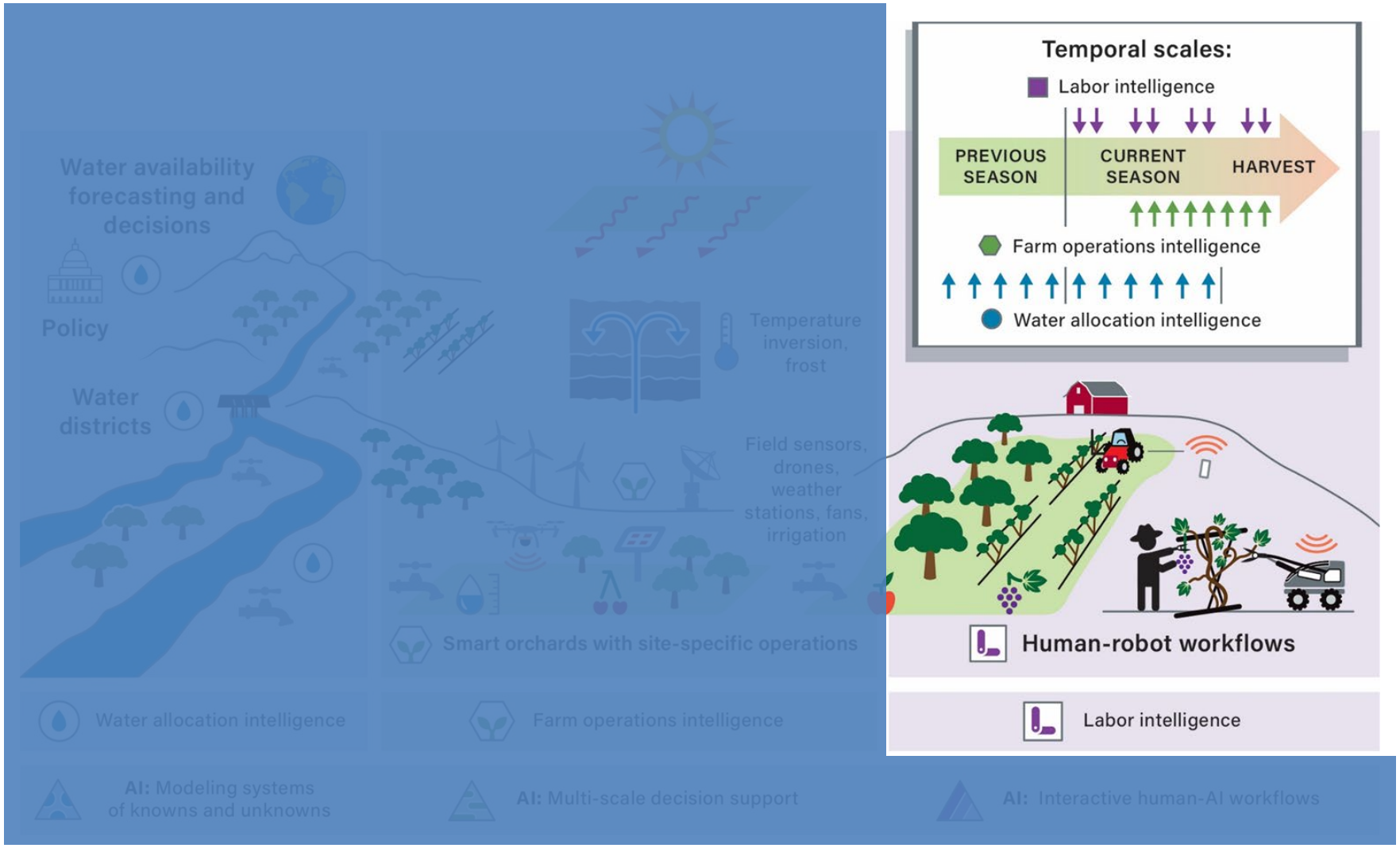
Resources to leverage:

- **AgWeatherNet (AWN):** largest Ag-focused U.S. mesonet, ingesting data from 389 weather stations
- 12,000 subscribers, 25,000 page views per day
- AWNfarm web- & mobile decision-support platform.



- **Industry Collaboration**
- Committed time, expertise, access & data
- Diverse perennial crops, cultivars and locations

AgAID: Research Landscape



Labor intelligence

Ag Thrust: Labor Intelligence

Use-cases:

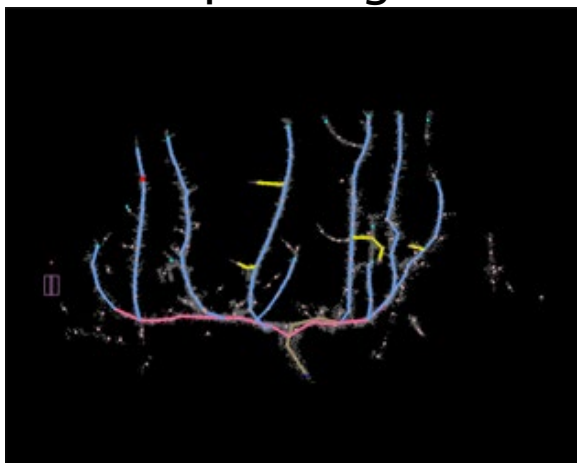
1. Tree shaking: Mechanical harvesting; optimization to increase harvest success (**human-assisted AI**)
2. Blossom thinning: Improve harvest quality and labor productivity with human-AI workflows; needs **AI-in-the-loop** for efficiency and inexperienced worker training
3. Tree pruning: Improve tree health, labor productivity; needs **AI-in-the-loop** for complex decision making

More automation ← → Requires more human skill

Tree shaking

Blossom thinning

Tree pruning



Ag Thrust: Labor Intelligence

Resources to leverage:

- **WSU Center for Precision & Automated Agricultural Systems (CPAAS)** is a world-class facility for specialty crop automation

Training and Certifications

AI-Ag Research Testbeds

Extension activities

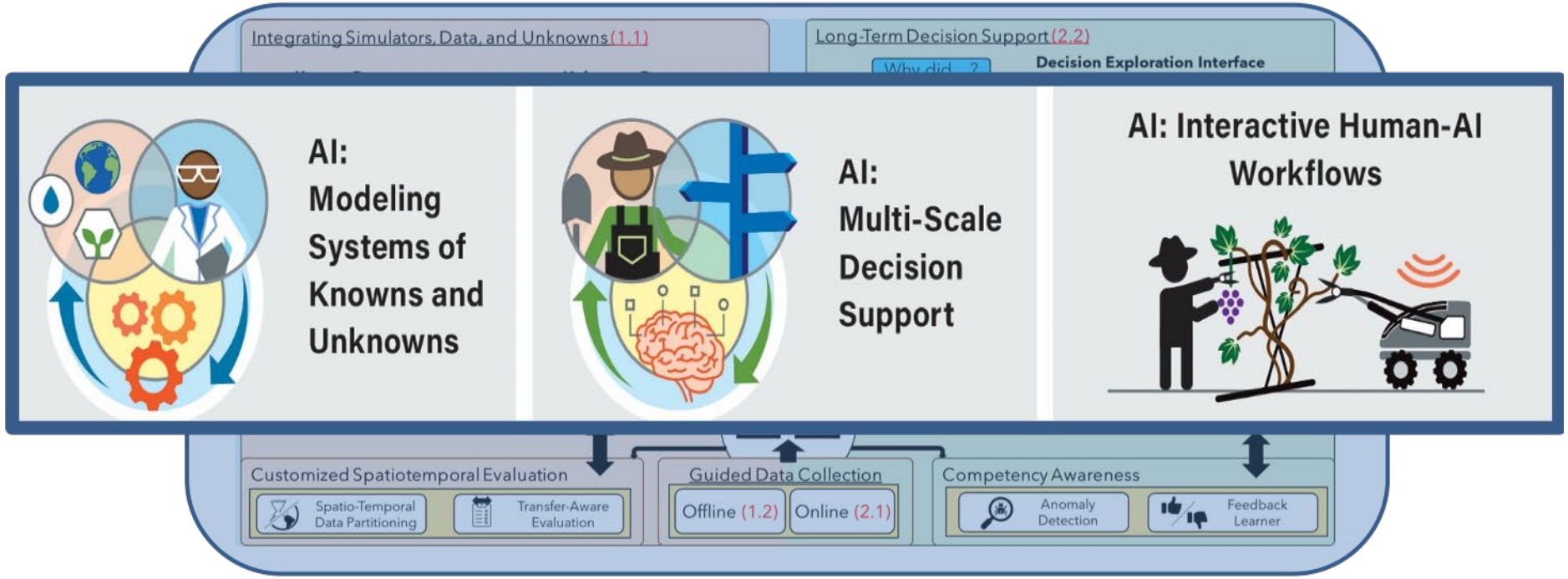
Tech Demos

- **UCM NSF IoT4Ag ERC**
- **UCM Community & Labor Center**
- **UC Labor & Automation in California Agriculture (LACA)**

AI Research Thrusts

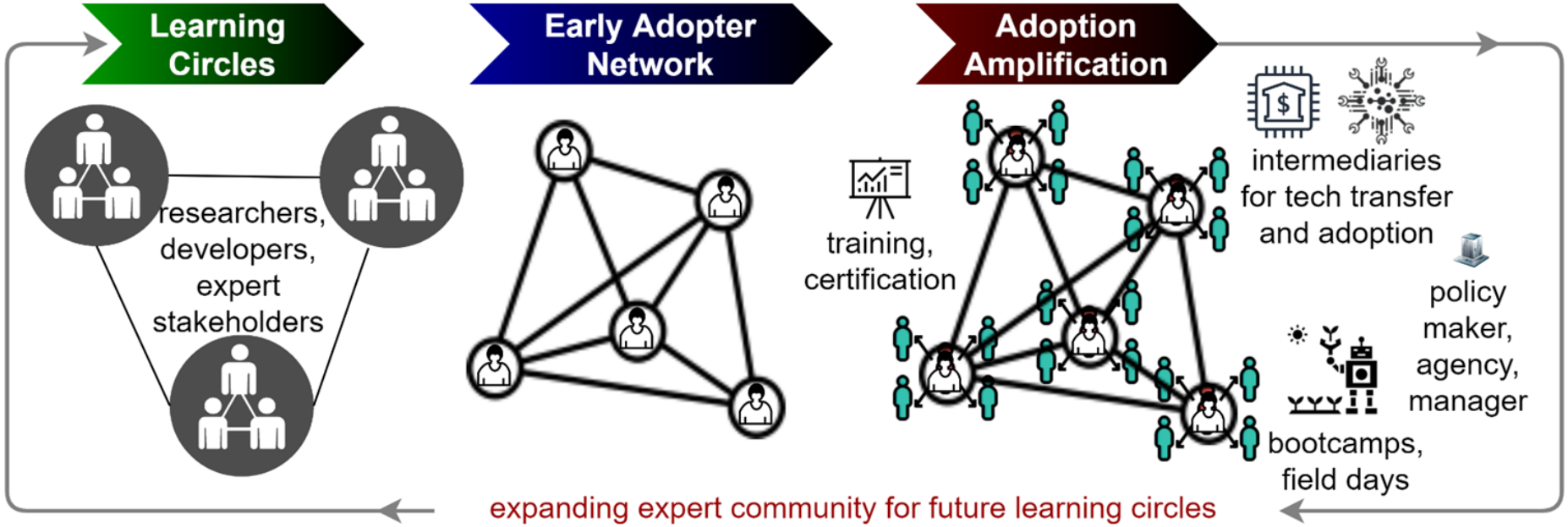
Foundational AI

Use-inspired AI



Engagement via our Adoption Flywheel

The AgAID institute will create a bridge for continuous engagement with stakeholders, researchers, educators, and learners to come together for knowledge co-production and co-dissemination.



Trusted AI tools design by repeated AI-Ag interaction to guide AI design (AAR); Foster trust	**Accelerate development & adoption** by testing early prototypes and identify barriers; multi-lingual education programs	**Sustained path to adoption amplification** by tool training, Digital Ag Certificates, Bootcamps and Field days; TAT team to create pathways to commercialization and tech transfer.

Broadening Participation and Person-Centered Education

K-12	Community Colleges	Undergrad Programs	Graduate & Post-doctoral	Agricultural Workers
Robotics/AI curriculum	Internships		Interdisciplinary PhD/MS (WSU, OSU)	Digital Ag Certificate
Elementary, middle and high school modules for First Nations - MESA (HU)	AI 2-week training curriculum (WVC)			Hispanic Orchard Employee Education Program in Spanish (WVC)
WSU DEMO Farm Tours	Data Analytics: BS curriculum (WSU)		Tutoring Opportunities	
Train the Trainer summer workshops (HU, WSU)	D1G1TAL AgATH0N			WSU DEMO Farm Visits
Cross-age mentoring opportunities				
3500+ K-12 students 350+ from Hispanic and Native American communities	***100 undergraduate internships 500+ AgATH0N participants 25 grad students and 7 postdocs trained***			***500+ workers trained 500+ DEMO farm visits***

Our approach to BP in Education
leverages proven programs that have already built trust
over time.

Engagement via Collaboration and Nexus Activities

AgAID as a global nexus for AI and Ag innovations

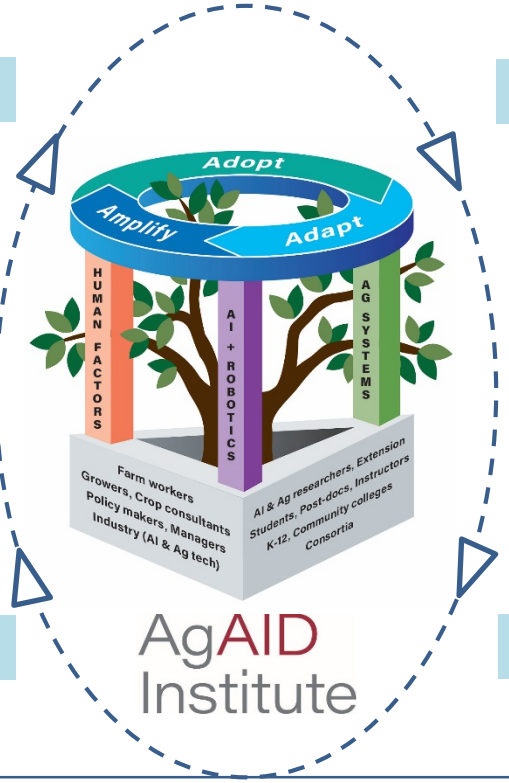
Research nexus

AI researchers
Ag researchers

Summits

Ag/FarmTech
AI industry
Commissions

Industry nexus



Training nexus

Hackathons, TechDay
Certificates, Bootcamps

D1G1TAL AgATH0N 2020

State entities
(Depts. Commerce, Ecology)

Government nexus

AIFARMS*

AIFS*

AIIRA*

IoT4Ag ERC

CASCADIA INNOVATION CORRIDOR
INVENTING TOMORROW TOGETHER

5G OPEN INNOVATION LAB

International partners
(Germany, Spain,
Australia)

NSF Expeditions in
Computing,
Biocomplexity
Institute

For a full list of collaborators, click here.

Engagement via Student-centered Opportunities

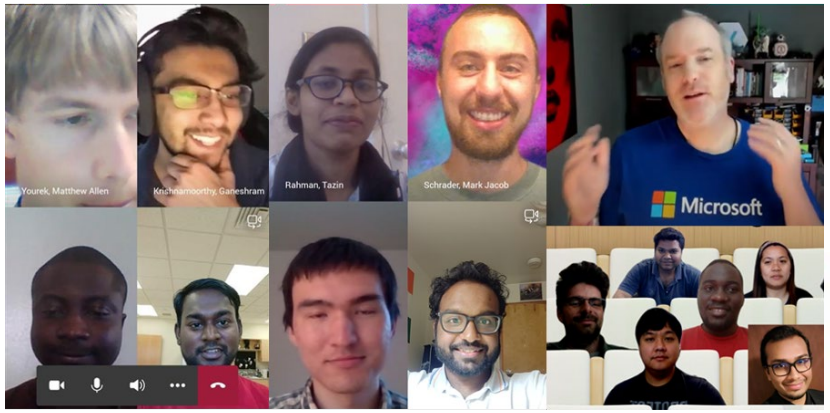
A 2020 D1G1TAL AgATH0N brought together 80 diverse graduate and undergraduate students from 10 different departments, along with industry mentors to work on real-world problems.

AgAID will carry out similar AI hackathons engaging at least 500 students.

01000100 01001001 01000111
D1G1TAL
01001001 01000001 01100111
AgATH0N
00100111 00110010 00110000

2020

Academia – Industry Partnership



https://youtu.be/hEOxXndeOhs

Microsoft

innov8.ag

CASCADIA INNOVATION CORRIDOR
INVENTING TOMORROW TOGETHER

Closing

Visit us* at
AgAID.wsu.edu

Contact us at:

agaid.inquiries@wsu.edu

*
AgAID.org
(after Sep. 1)

Cross-institute Synergy & Potential Venues for Collaboration

AIIRA and AgAID seek to develop and deploy AI technologies across a wide spectrum of the ag ecosystem – with a focus on plant agriculture

We are very interested in identifying opportunities to broaden impact, for instance, to animal agriculture

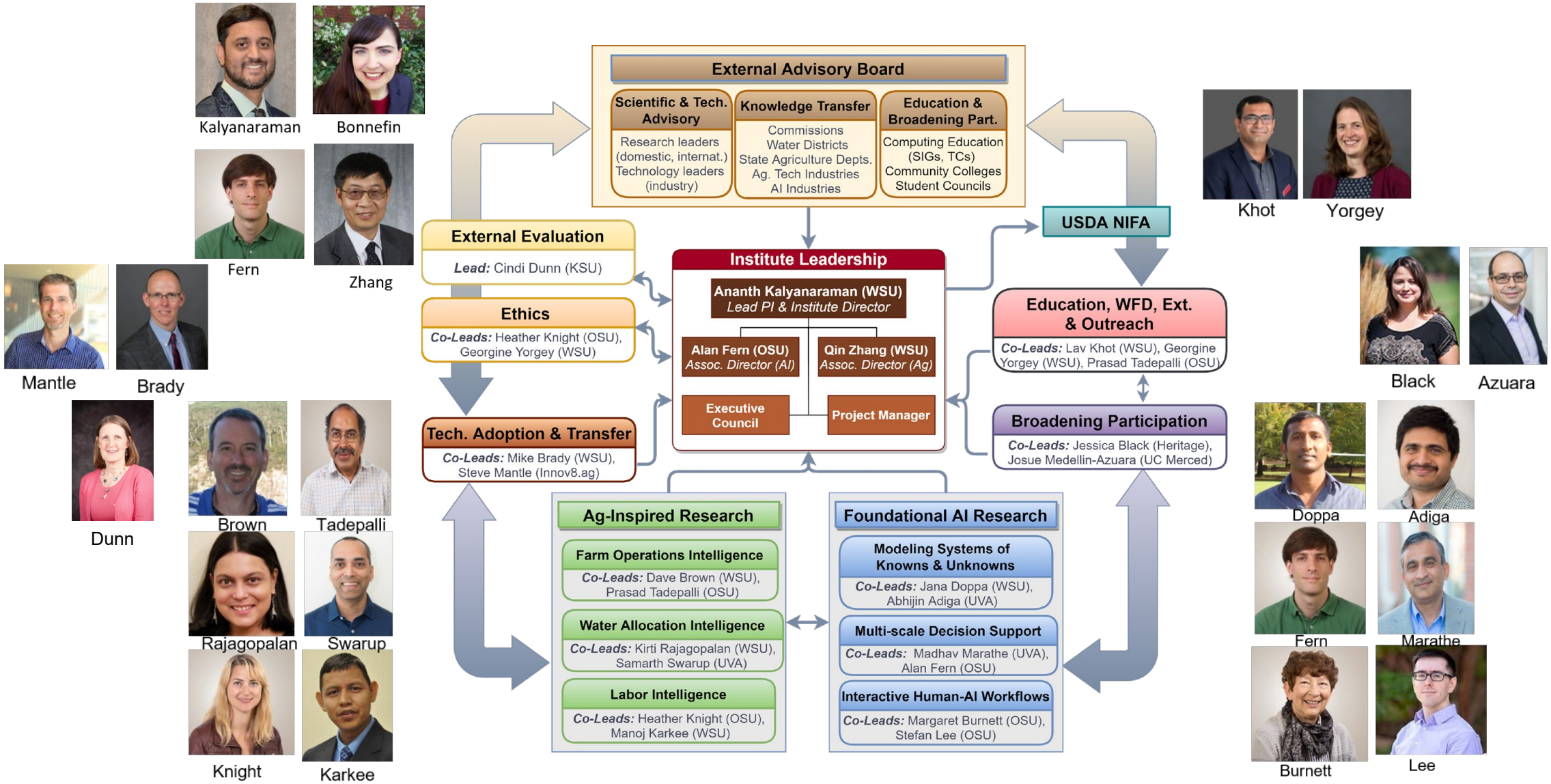
Open discussion on use-inspired challenges:

1) Digital twins [advancing science of crop management]
2) AI-in-the-loop & Human-in-the-loop [advancing AI and application]
3) Climate science [better understanding climate change impact]
4) Workforce development [amplifying training outcomes]
5) Democratizing AI technology [accelerating adoption]
6) Social science [advancing DEI]
7) Resource pooling [sharing infrastructure and data workflows]
8) Stakeholder engagement [building communities]

(ADDITIONAL SLIDES)

APPENDIX

Management and Integration Plan



Click here to go back

AgAID: List of Collaborators

Academic (7)

* WSU Tree Fruit Research & Extension Center
* OSU Institute for Collaborative Robotics and Intelligence Systems
* Universitat Politècnica de València *(Spain)*
* University of Technology Sydney *(Australia)*
* University of British Columbia *(Canada)*
* Leibniz Institute for Agricultural Engineering and Bioeconomy *(Germany)*
* Hebrew University

Industry (15)

* G S Long
* Wilbur-Ellis
* AgTech Insight
* Verdant Robotics
* Almond Board of CA
* Microsoft Tech Spark
* WA Tree Fruit Commission
* WA Wine Grape Commission
* Washington Mint Commission
* IBM Research, Science and Technology

GROWERS
* Mercer Ranches *(wine-grapes)*
* Zirkle Fruit Co *(apples)*
* Wonderful Orchards *(pistachios/ almonds)*
* Allan Bros *(Dave Allan - apples/ cherries)*
* Allan Bros *(Suzanne Bishop - apples/ cherries)*

Education, Broadening Participation (12)

* Merced College
* Columbia Basin College
* Chemeketa Community College
* Yakama Nation Tribal School
* Linn-Benton Community College
* First Nations MESA, Heritage University
* OSU 4-H, DIVE 4 Agriculture
* OSU Center for Diversity and Inclusion
* OSU Extension, Mobile Maker Studio
* OSU Association of Computing Machinery (ACM) - Women's Chapter
* OSU Louis Stokes Alliance for Minority Participation Program
* WSU Louis Stokes Alliance for Minority Participation Program

Government/Non-profit/Ag-allied (11)

* *Grassland Water District*
* *Merced Irrigation District*
* *Turlock Irrigation District*
* *WA Department of Ecology*
* *Okanogan Irrigation District*
* *Environmental Defense Fund*
* *Cascadia Innovation Corridor*
* *CA Department of Water Resources*
* *Central Valley Community Foundation*
* *Walla Walla County Conservation District*
* *WA Department of Ecology, Office of Columbia River*

Click here to go back

AgAID: Curricular initiatives: institute-wide and site-specific

	Introduction to Digital Ag. Course	Digital Ag. Certification	D1G1TAL AgATH0N
Institute-wide curricula	A virtual introductory graduate course surveying introductory topics in AI and applications in Ag.	Professional certification program for farm workers, tree-fruit commission and agency personnel.	Three hackathons ('21,'23,'25) for undergrad and grad students, and postdocs co-organized by WSU, innov8ag, and other AgAID members.
	OSU: MS and PhD in AI from Fall '21	**WSU: PhD in Data Science from Fall '22**	**WSU: BS in Data Analytics (online)**
Site-specific curricula	Special track in the interdisciplinary graduate program. AgAID fellowships for 3-4 PhD students.	Special track in the proposed interdisciplinary PhD program. Data Science certificate from Fall '21.	A Digital Ag. track will be introduced to the existing B.S. in Data Analytics, and made available through WSU Global Campus.

Key Broadening Participation Activities

Key Broadening Participation activities by Institution, Activity and Outcomes (n: anticipated participation by target population annually)

	Activities	Outcomes
WSU, OSU	Recruit URM UG summer interns	Increase recruitment, retention and advancement of URM UG students in Ag-Tech [20]
WSU, OSU	Implement **4-H robotics, Microsoft TechSpark**, Train the trainer	Increase URM STEM engagement in K-12; influence career paths via teacher training [100]
WSU, OSU	UG mentoring and training via **LSAMP, SACNAS & CAMP**	Increase recruitment and retention of URM UG students [10]
Heritage University	**Teacher training and curriculum development for First Nations MESA**	Increase URM (Native American, Hispanic) STEM engagement in grades 7-12 [350 students annually; curricula to reach 3500+ students annually]
Heritage University	**Intergenerational mentoring** (MESA, YNTS, EM), AgAID interns	Increase retention and STEM skill sets of URM (Hispanic, Native American) students in K-12, CC, and UG [20-30]
Heritage University	Tutoring of HU UGs	Increase STEM performance of URM (Hispanic) [20]

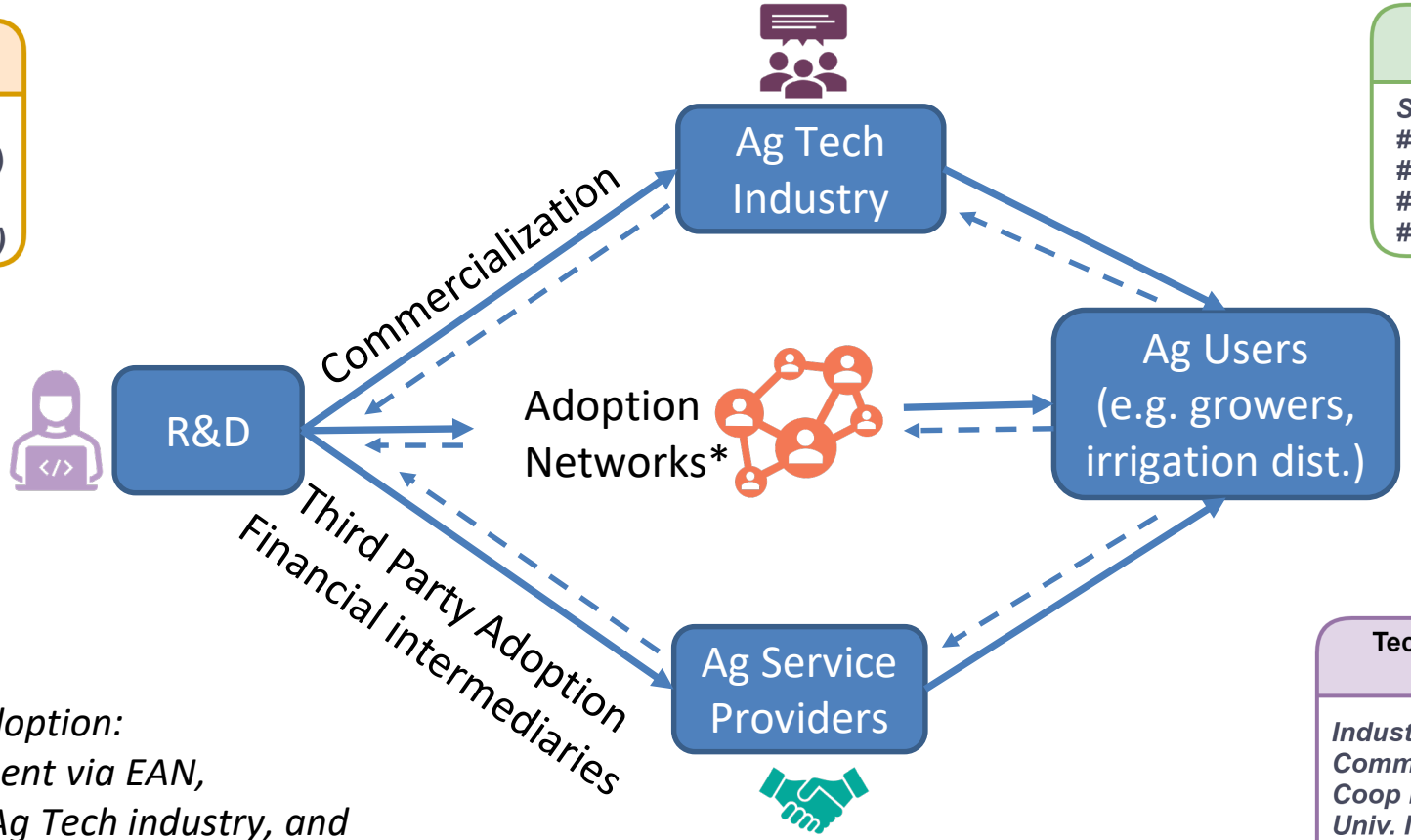
	Activities	Outcomes
UC Merced	Offer multilingual (Spanish, Hmong) **NexTech Robotics**	Increase URM STEM engagement in grades 7-12 [80]
UC Merced	Summer workshops in NSF CS4All and USDA REEU Ag Cyberinformatics	Improve URM STEM education in 9-12 CS teachers and facilitate CC transfers [40]
UC Merced	***¡Valle de Exploración!*** ag-tech career workshops	Improve whole-person skills for URM CC, UG and G students; develop near peers for upscaling [*40*]
UC Merced	Fresno-Merced Future of Food Innovation Corridor Small Farmer Ag-Tech Roundtables	Facilitate URM small farmers in technology ideation, innovation and entrepreneurship; tech demonstration in cooperation with Merced Community College [*30*]
Wenatchee Valley College	Summer internships with AgAID and mentoring of Associate Degree students	Increase URM students with Associate degrees to complete 4-year degrees in **2+2 programs** [20]
Wenatchee Valley College	Bilingual Mobile App Development and Extension	Increase tech adoption in **Spanish-speaking Ag-Tech/farm workforce** [100]

Technological Innovation and Adoption Ecosystem

Objective: To build an *"adoption flywheel"* that will **energize all stakeholders** toward technological innovation and adoption

Adoption Factors

Economic (ROI)
Financial (borrowing limits)
Behavioral (risk aver.)
Social (marketing, learning)



Success Metrics

Size of grower network (EAN, extended)
#Tools piloted or adopted
#Tools integrated into Ag services
#Tools commercialized
#New partnerships created

Tech Adoption and Transfer (TAT) team
Lead: Mantle

Industry partners
Commodity Boards & Growers, Commissions
Coop Extensions (WSU, OSU, UCM)
Univ. I&E IREO (WSU), CITRIS Foundry (UCM)
Univ. IP

Three pathways toward adoption:
(a) direct grower engagement via EAN,
(b) commercialization via Ag Tech industry, and
(c) third party adoption and financial intermediaries.

*Extension as the facilitator.

Extension Spotlight: Demo Farm

AgAID DEMO Farm will provide

- Learning site for AI user studies
- Interactive AI tool development
- Learning site for field research, summer internships
- Digital Ag Certificate Program
- Digital Ag Bootcamps (bilingual)
- Technology specific field days, short workshops

<u>Will be hosted by:</u>

CPAAS AgTech Extension, Prosser, WA: extensive experience training stakeholders in new technologies and data analytics, reaching 3000+ yearly

https://cpaas.wsu.edu/

Education Spotlight: NexTech Robotics

Outreach to San Joaquin Valley schools, where over 90% receive subsidized lunch includes:

- Near-peer education
- Pathways to higher ed & CS
- Computational thinking
- Coding skills (C++, HTML)
- Robotics and UAVs

Evaluations conducted with teachers and students show growth in skills and interest in tech.

AgAID will enable NexTech Robotics to add AI curriculum units and expand to Hmong and Migrant Program students.