Continuous innovation: the future of water delivery data science

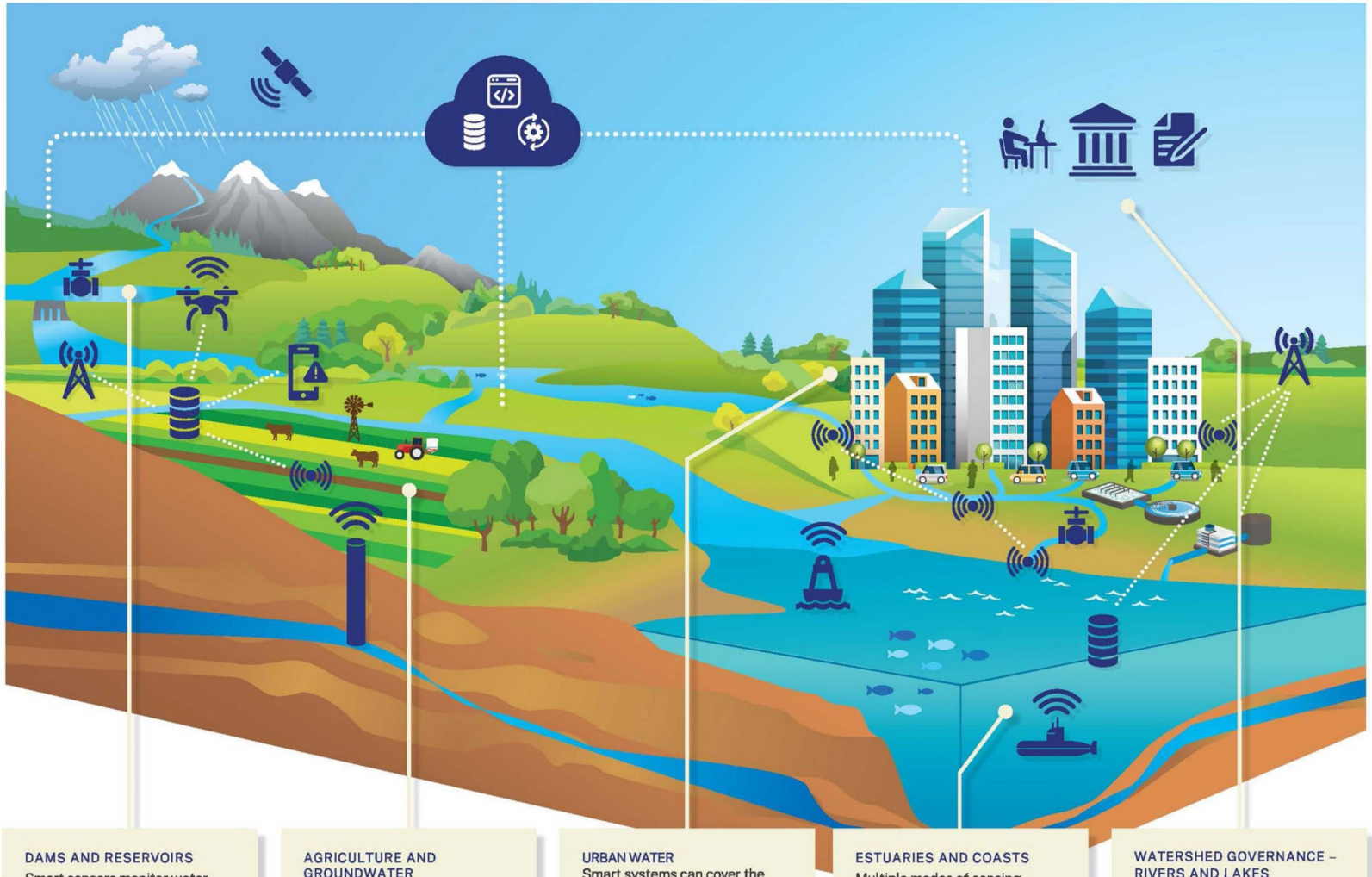
ONE BASIN CRC

A collaboration with:

Water Research AUSTRALIA

aws Australian Water School

Cyber-physical systems across the water cycle



DAMS AND RESERVOIRS
Smart sensors monitor water levels, flow rates and infrastructure safety. Control functions open and close dam gates, whilst sensors provide real-time data for safety warning systems to alert public and authorities about flood and infrastructure failure.

AGRICULTURE AND GROUNDWATER
Smart irrigation systems optimise water delivery to crops based on data from drones, satellites and on-farm sensors. Automatic irrigation systems can be controlled from personal electronic devices. Smart groundwater systems can provide decision support for water extraction.

URBAN WATER
Smart systems can cover the entire urban water cycle, including supply and drainage, or can be highly focused. Smart meters control water systems, whilst cloud computing integrates forecasts for flood response, water quality, and optimisation.

ESTUARIES AND COASTS
Multiple modes of sensing, including mobile sensors attached to buoys, boats, and autonomous underwater vehicles, collect real-time data. Analytics and cloud computing functions integrate data sets and produce actionable information.

WATERSHED GOVERNANCE – RIVERS AND LAKES
Cyber-physical systems are increasingly used to govern river basins, enhancing decision-making through comprehensive, real-time data and analytics. CPS in rivers, lakes and wetlands range from highly specific functions to multifaceted roles.

Current Opinion in Environmental Sustainability

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Water Research AUSTRALIA

aws Australian Water School

Alexandra C, Daniell KA, Guillaume J, Saraswat C, Feldman HR (2023) Cyber-physical systems in water management and governance, Current Opinion in Environmental Sustainability, 62(101290) https://doi.org/10.1016/j.cosust.2023.101290

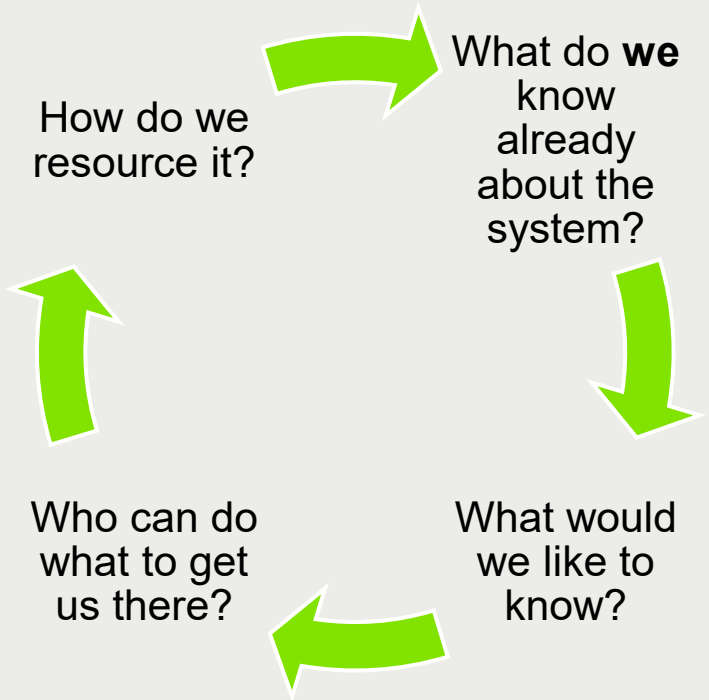
Water delivery data science?

- Spreadsheets
- Buy a new software product
- Software supplier provides update
- Consultant implements bespoke/customised solution
- In-house tool development
- Continuous integration into platform and processes

Continuous innovation

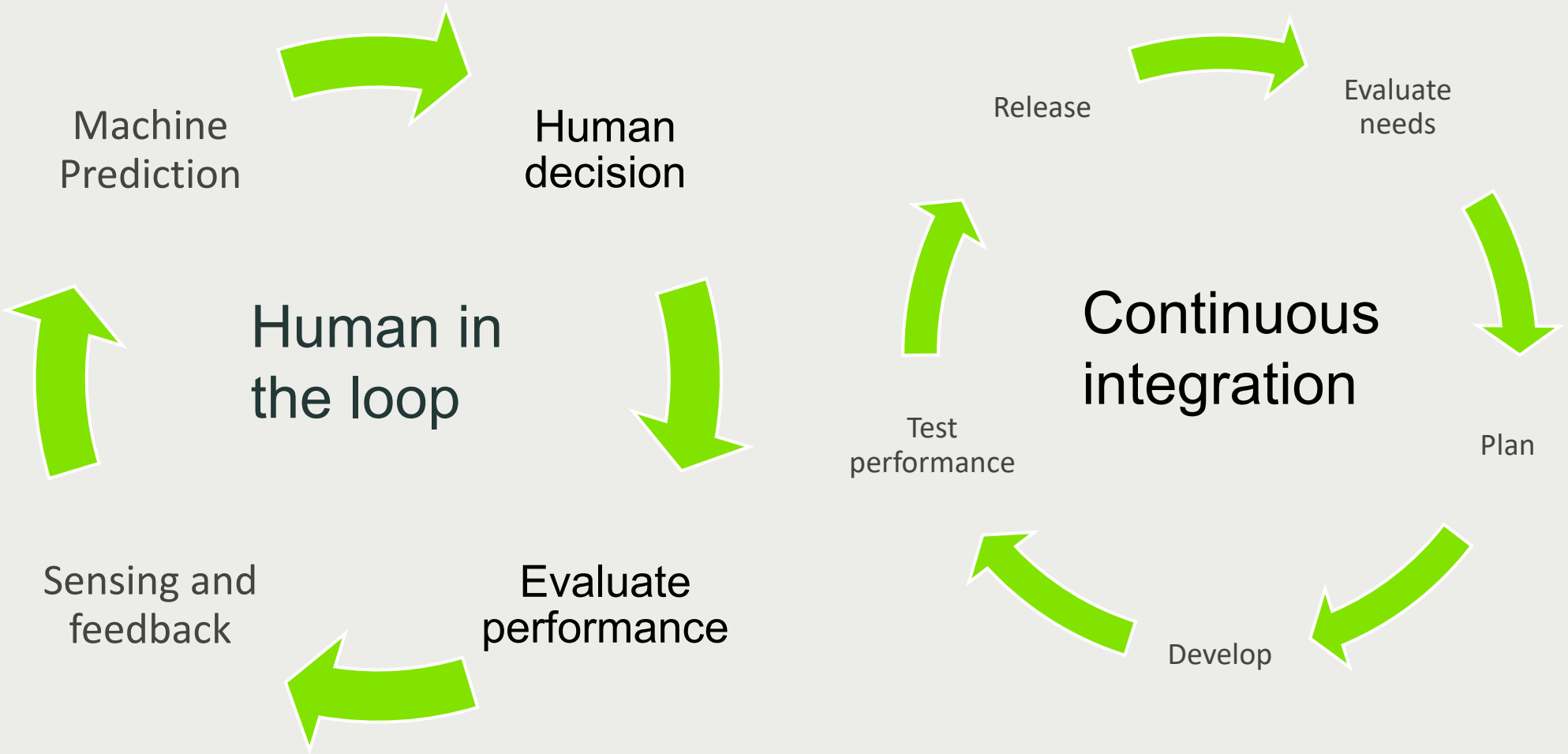
- Capitalising on new data to better track evolution of the system and improve performance
- Building a knowledge system that ensures that knowledge is updated over time and available when a decision needs to be made

- Podcast with Murrumbidgee Irrigation: https://algorithmicfutures.org/episode-7/

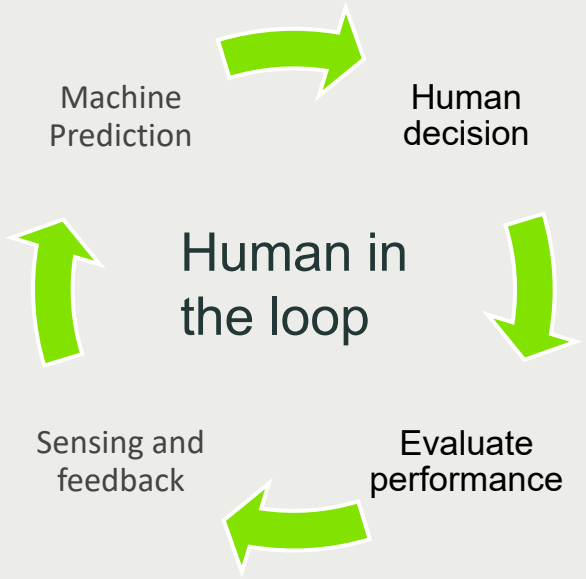


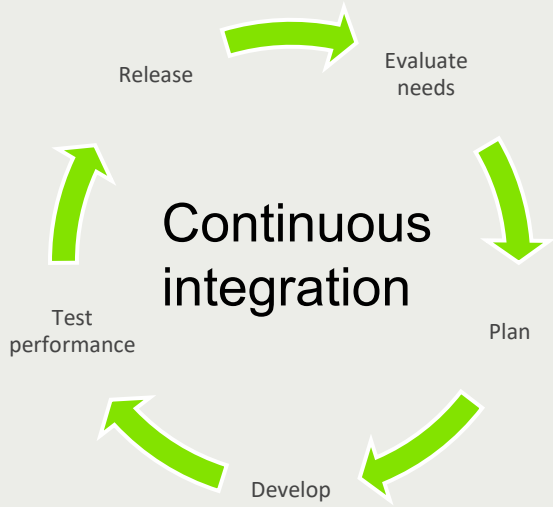
Murrumbidgee Irrigation

Australian National University | INSTITUTE FOR WATER FUTURES


Machine Prediction
Human decision
Evaluate performance
Sensing and feedback
Human in the loop
Release
Evaluate needs
Plan
Develop
Test performance
Continuous integration

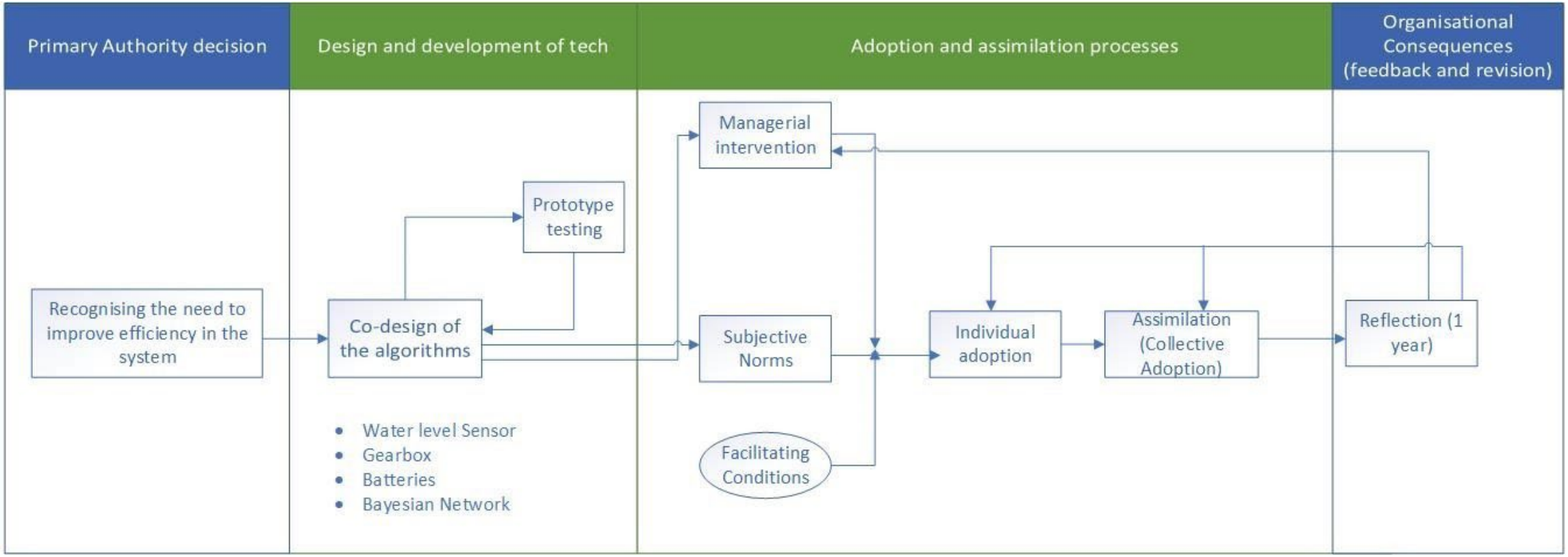
Building a tech accelerator





Clear and agreed procedures, infrastructure, and relationships to help test new ideas quickly

1. Access to real-world data
2. Well defined assessment frameworks
   - shared understanding
   - clear pathways to implementation
3. Efficient onboarding
4. Continuous improvement of assessment frameworks
5. Change management from a systems perspective



adapted from Gallivan (2001)

Organisations

- Agreed clear procedures, infrastructure, and relationships

Tech accelerator

- Licensed data extracts
- Software testing, continuous integration infrastructure
- Training
- Community development
- Continuous improvement processes

Product sales, consultants, research

- Onboarded
- Low barrier to experimentation
- Internships, undergraduate, honours/Masters, PhD projects, competitive grants
- Meet clear assessment requirements

Data science product classes

- Anomaly detection
  - SCADA alarms
  - Complex alarms
  - Fault analysis tools
  - Failure data collection tools
  - ...
- Demand forecasting
  - River ordering demand forecasts
  - …

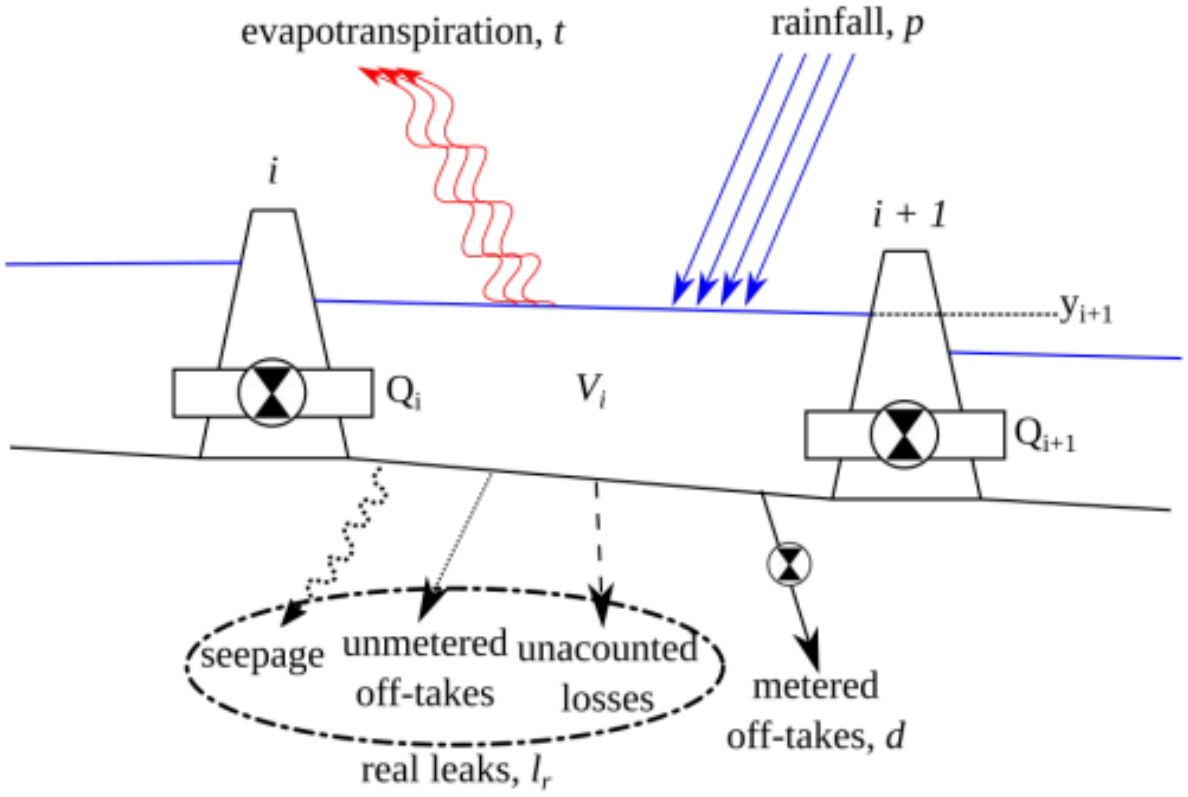


Photo: Sammy Hawker
Diagram: Hutchinson 2021

Anomaly detection for high reliability water delivery

Project: QS5 Water Infrastructure Critical Component Anomaly Detection & Health Prediction Prototype

Trialled processes for co-designing and operationalising new tools to help detect anomalies in water delivery infrastructure

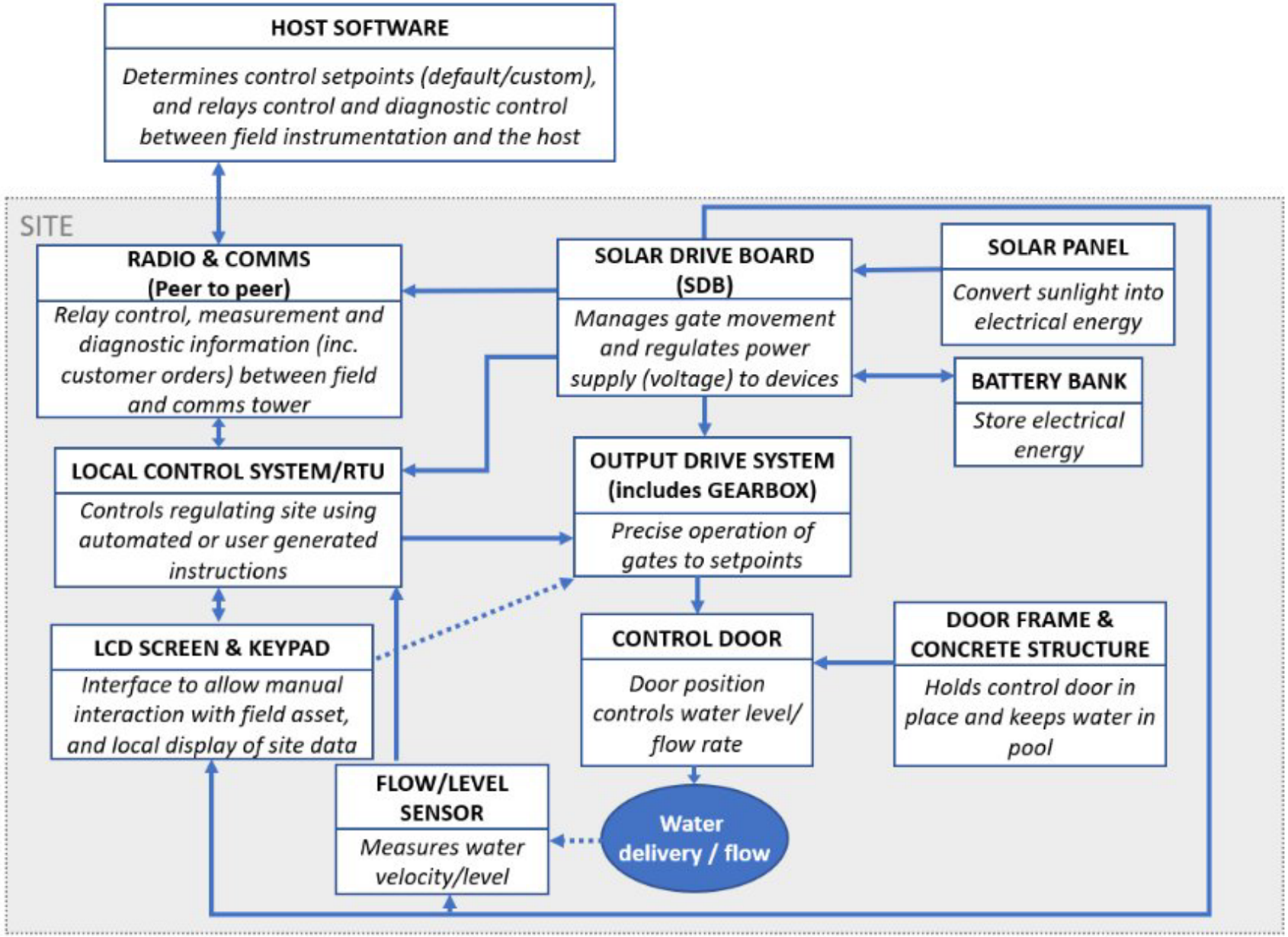
- Improving reliability, reducing maintenance costs and improving data quality.

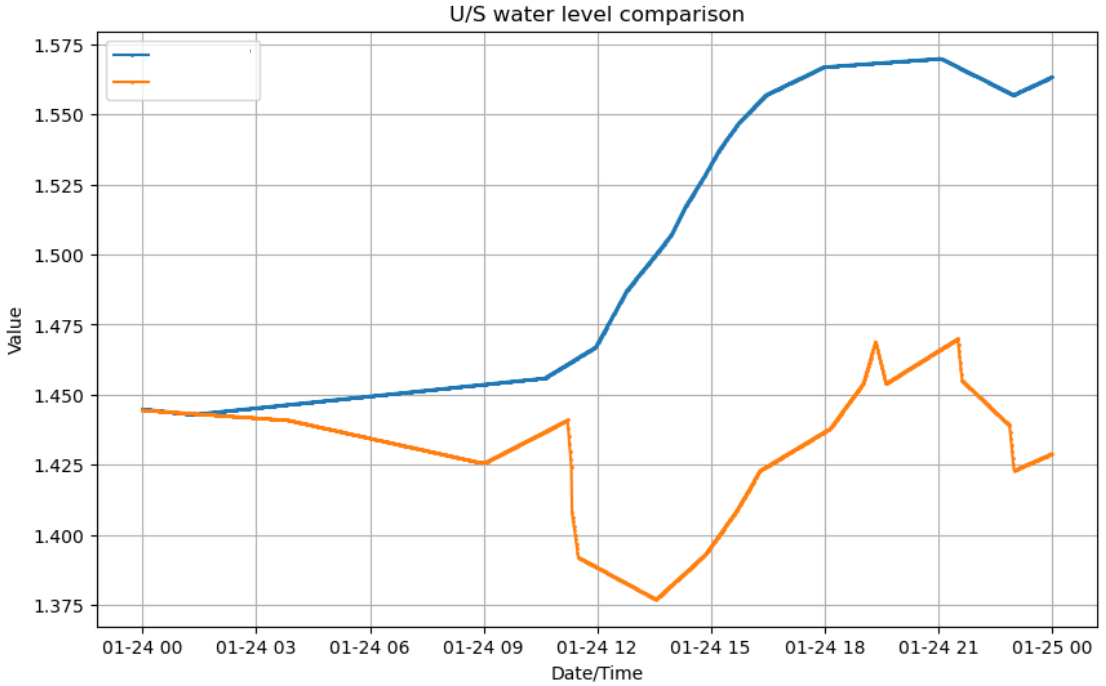
Prototype tools targeted water level sensors and batteries

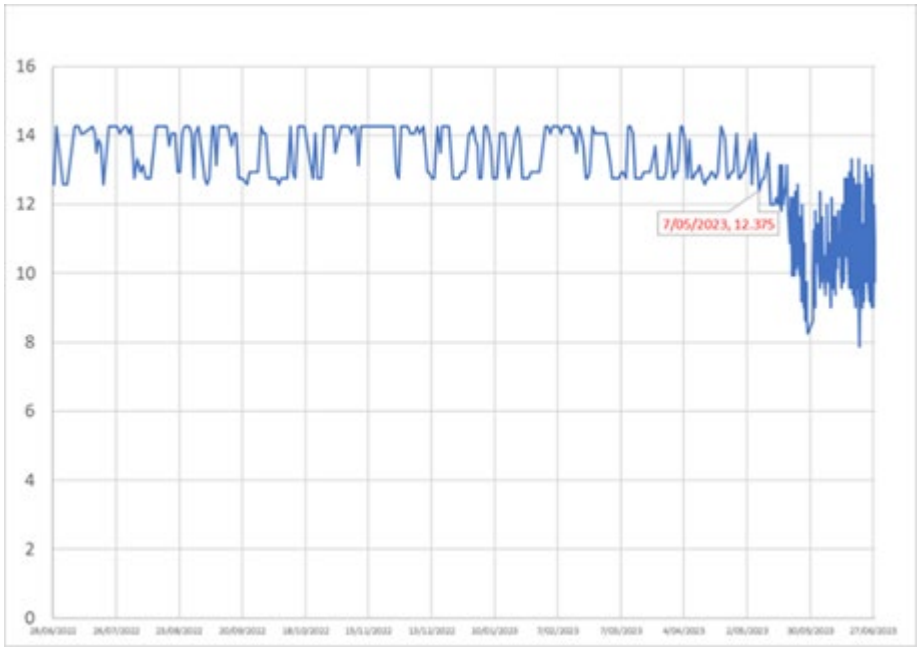
- Building understanding of how these tools fit within a broader failure mode analysis
- What deploying these tools involves in practice.

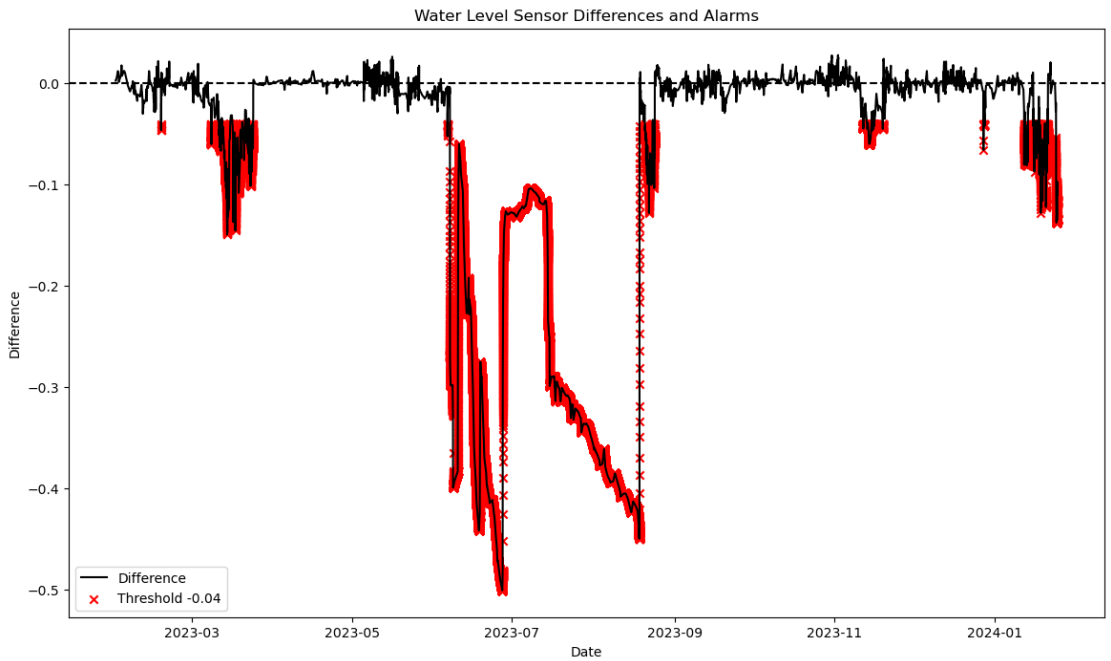
https://rubiconwater.com/wp-content/uploads/2020/03/100216_Rubicon_Shepparton-0377-1.jpg

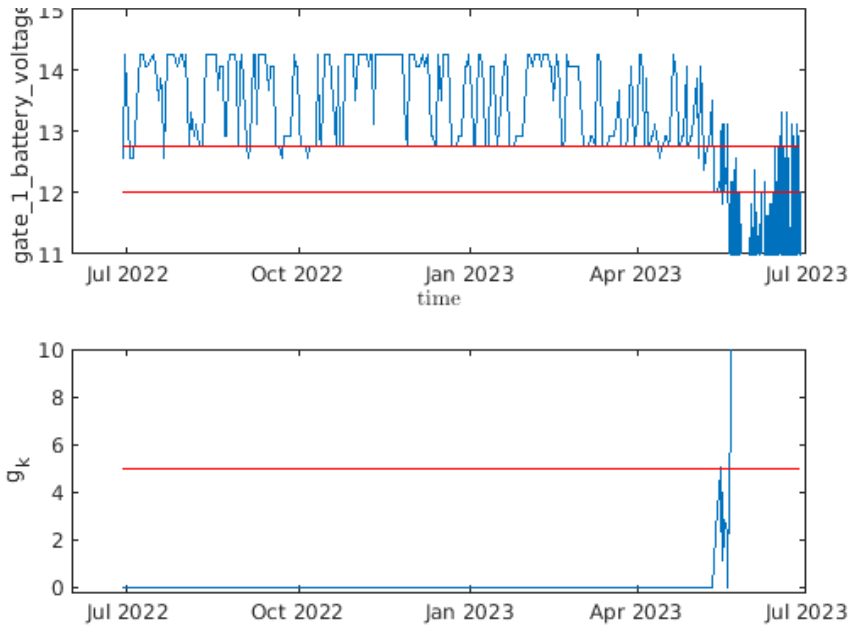
ANU: Joseph Guillaume, Wendy Merritt, Serena Hamilton, Fateme Zare, Su Ki Ooi, Philipp Braun, Tim Molloy, Sam Hutchinson
CICL: Ali Simmons, Steve Oosthuysen
MI: Sam Yenamandra, Aseef Zahir, Waleed Ali
UoM: Sneha Sharma, Erik Weyer, Wenyan Wu
Rubicon: Adair Lang


HOST SOFTWARE
Determines control setpoints (default/custom), and relays control and diagnostic control between field instrumentation and the host
SITE
RADIO & COMMS (Peer to peer)
Relay control, measurement and diagnostic information (inc. customer orders) between field and comms tower
SOLAR DRIVE BOARD (SDB)
Manages gate movement and regulates power supply (voltage) to devices
SOLAR PANEL
Convert sunlight into electrical energy
BATTERY BANK
Store electrical energy
LOCAL CONTROL SYSTEM/RTU
Controls regulating site using automated or user generated instructions
OUTPUT DRIVE SYSTEM (includes GEARBOX)
Precise operation of gates to setpoints
LCD SCREEN & KEYPAD
Interface to allow manual interaction with field asset, and local display of site data
CONTROL DOOR
Door position controls water level/ flow rate
DOOR FRAME & CONCRETE STRUCTURE
Holds control door in place and keeps water in pool
FLOW/LEVEL SENSOR
Measures water velocity/level
Water delivery / flow


U/S water level comparison
Value
Date/Time
1.575
1.550
1.525
1.500
1.475
1.450
1.425
1.400
1.375
01-24 00
01-24 03
01-24 06
01-24 09
01-24 12
01-24 15
01-24 18
01-24 21
01-25 00


16
14
12
10
8
6
4
2
0
7/05/2023, 12.375


Water Level Sensor Differences and Alarms
Difference
Date
0.0
−0.1
−0.2
−0.3
−0.4
−0.5
2023-03
2023-05
2023-07
2023-09
2023-11
2024-01
Difference
Threshold -0.04


gate_1_battery_voltage
time
14
13
12
11
Jul 2022
Oct 2022
Jan 2023
Apr 2023
Jul 2023
g_k
10
8
6
4
2
0
Jul 2022
Oct 2022
Jan 2023
Apr 2023
Jul 2023

Demand forecasting and water delivery operations

Project: QS2 Irrigation demand forecasting for multi-scale multi-objective system storage control optimisation

How new demand forecasting tools can improve water delivery across the landscape

Testing how demand forecasting can support river ordering and the role that demand forecasts play in water operations.

Credit: Murrumbidgee Irrigation

ANU: Joseph Guillaume, Wendy Merritt, Serena Hamilton, Fateme Zare, Caroline Rosello
CICL: Ali Simmons, Steve Oosthuysen
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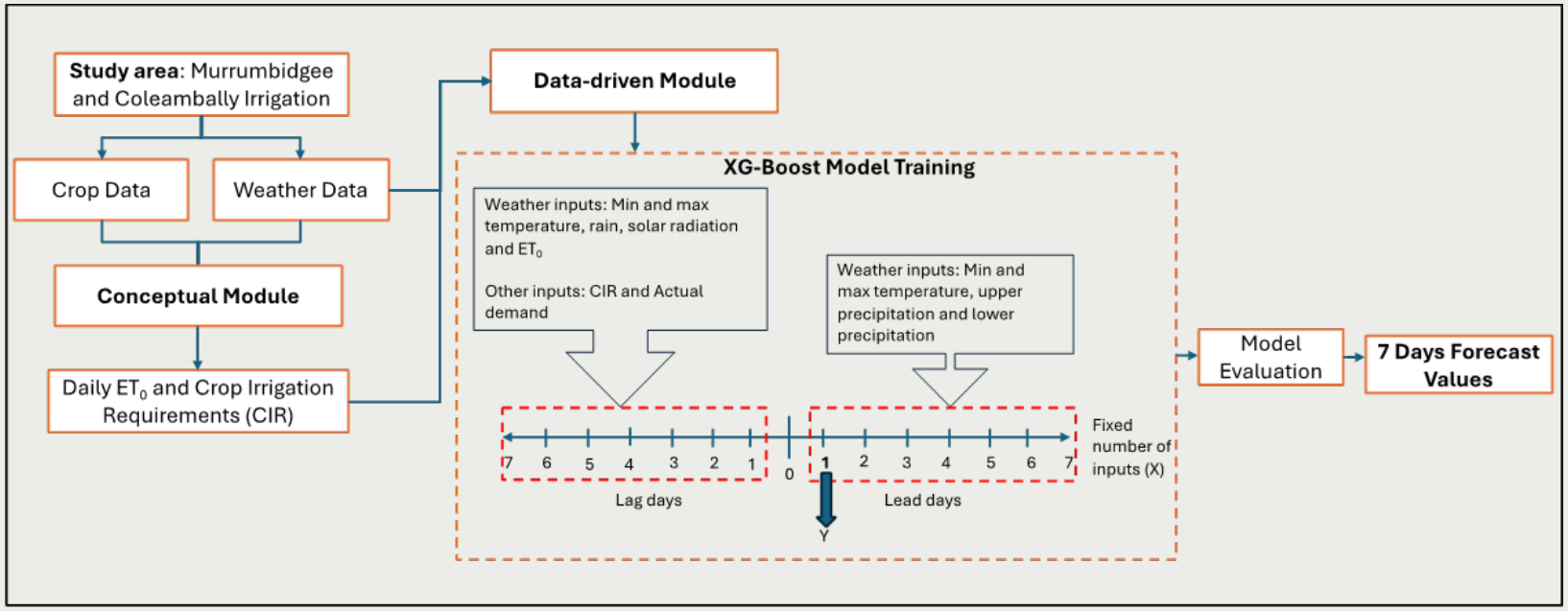
UoM: Sneha Sharma, QJ Wang, Dongyreol Ryu, Andrew Western, Michael Cantoni, Erik Weyer, Wenyan Wu

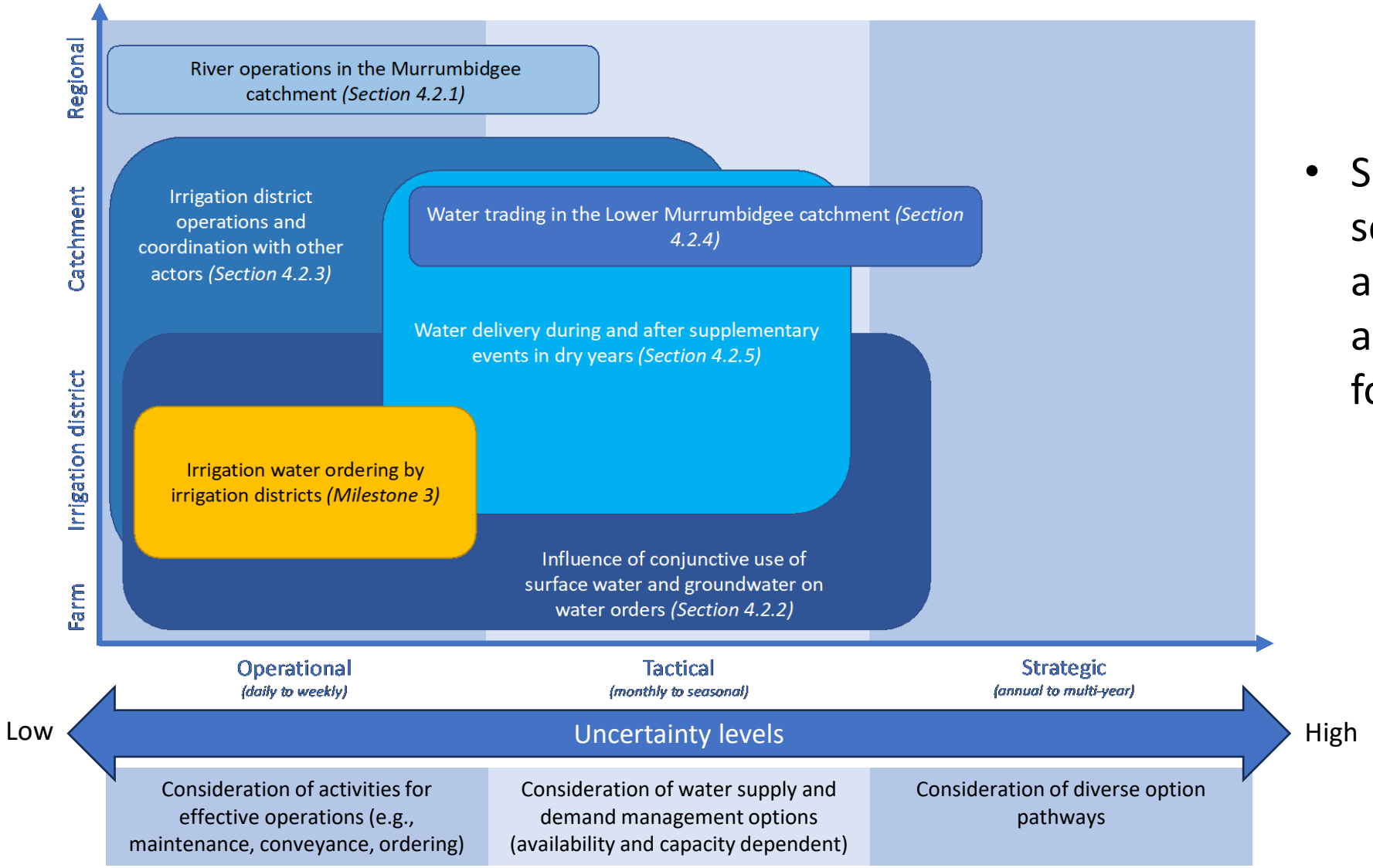
River ordering demand forecasts



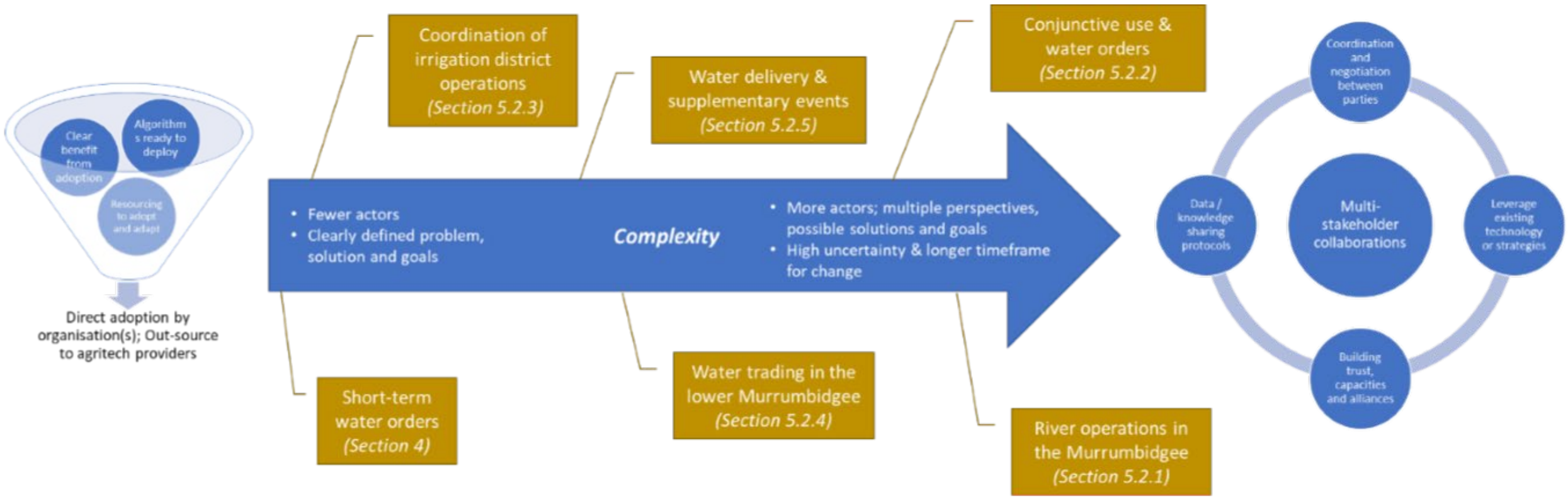
Assessment context: business risks

- Ability to meet demand needs of customers across the short term
  - Errors in 24-hour forecasts to be managed through surge reservoirs etc.
  - Longer forecasts: adjusting orders, river operations anticipating changing conditions
- Ability to adjust to customer ordering preferences due to flexible levels of service, adverse weather conditions etc.
  - Support flexibility; accurate forecasts that become more precise as lead time decreases
- Ability to adjust to supply side factors such as river resource availability, transmission losses and diversions, losses and storage levels in the short term
  - Relative value of demand forecast higher when supply is constrained; potential for loss, storage, asset failure forecasts
- Ability to adjust to organisational interventions to mitigate demand and supply side risks
  - Water storage and water level management across zones with consideration of constraints; Delivery reliability performance

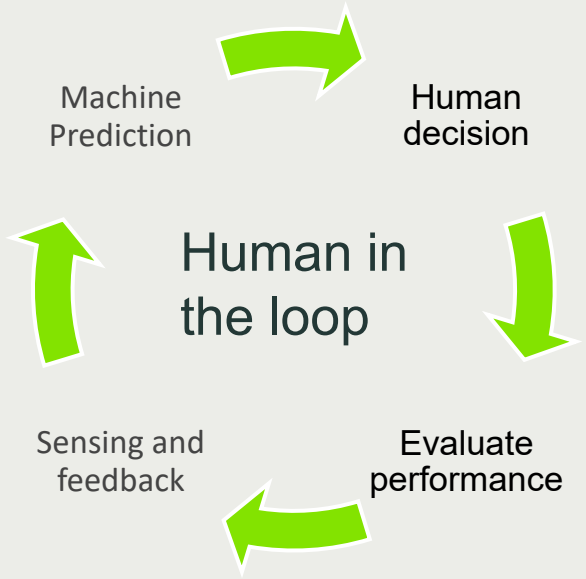
Where could demand forecasting fit across the landscape?

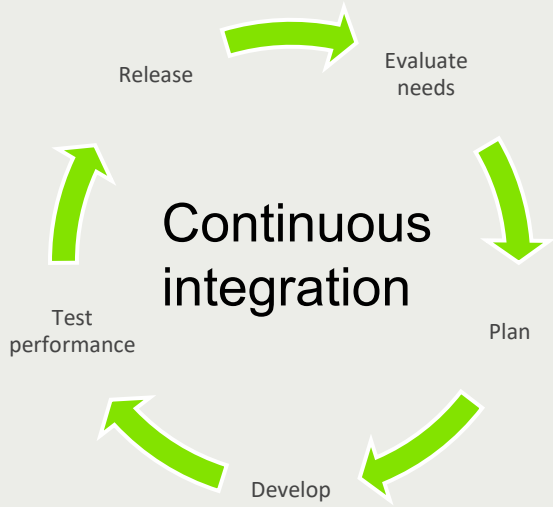


- Spatial and hierarchical scales where decisions and activities of key actors are currently focused


Clear benefit from adoption
Algorithms ready to deploy
Resourcing to adopt and adapt
Direct adoption by organisation(s); Out-source to agritech providers
Coordination of irrigation district operations (Section 5.2.3)
Water delivery & supplementary events (Section 5.2.5)
Conjunctive use & water orders (Section 5.2.2)
Fewer actors
Clearly defined problem, solution and goals
Complexity
More actors; multiple perspectives, possible solutions and goals
High uncertainty & longer timeframe for change
Short-term water orders (Section 4)
Water trading in the lower Murrumbidgee (Section 5.2.4)
River operations in the Murrumbidgee (Section 5.2.1)
Coordination and negotiation between parties
Data / knowledge sharing protocols
Multi-stakeholder collaborations
Leverage existing technology or strategies
Building trust, capacities and alliances

Building a tech accelerator to support continuous innovation





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Questions?

Thank you

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Australian Government
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A short 1-minute survey will pop up at the webinar's conclusion *or complete it on your phone now by scanning the QR code.*

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Thank you

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