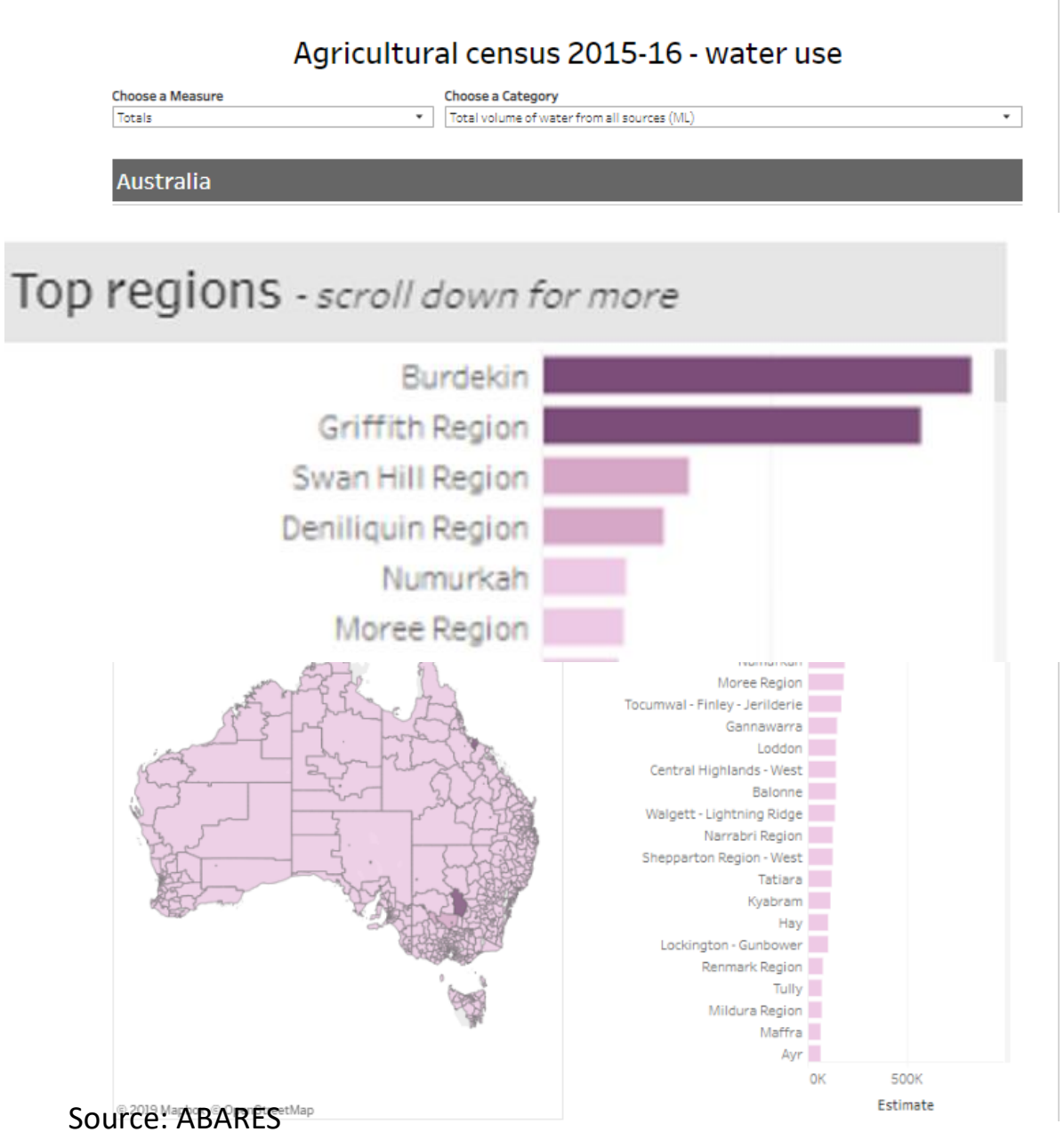
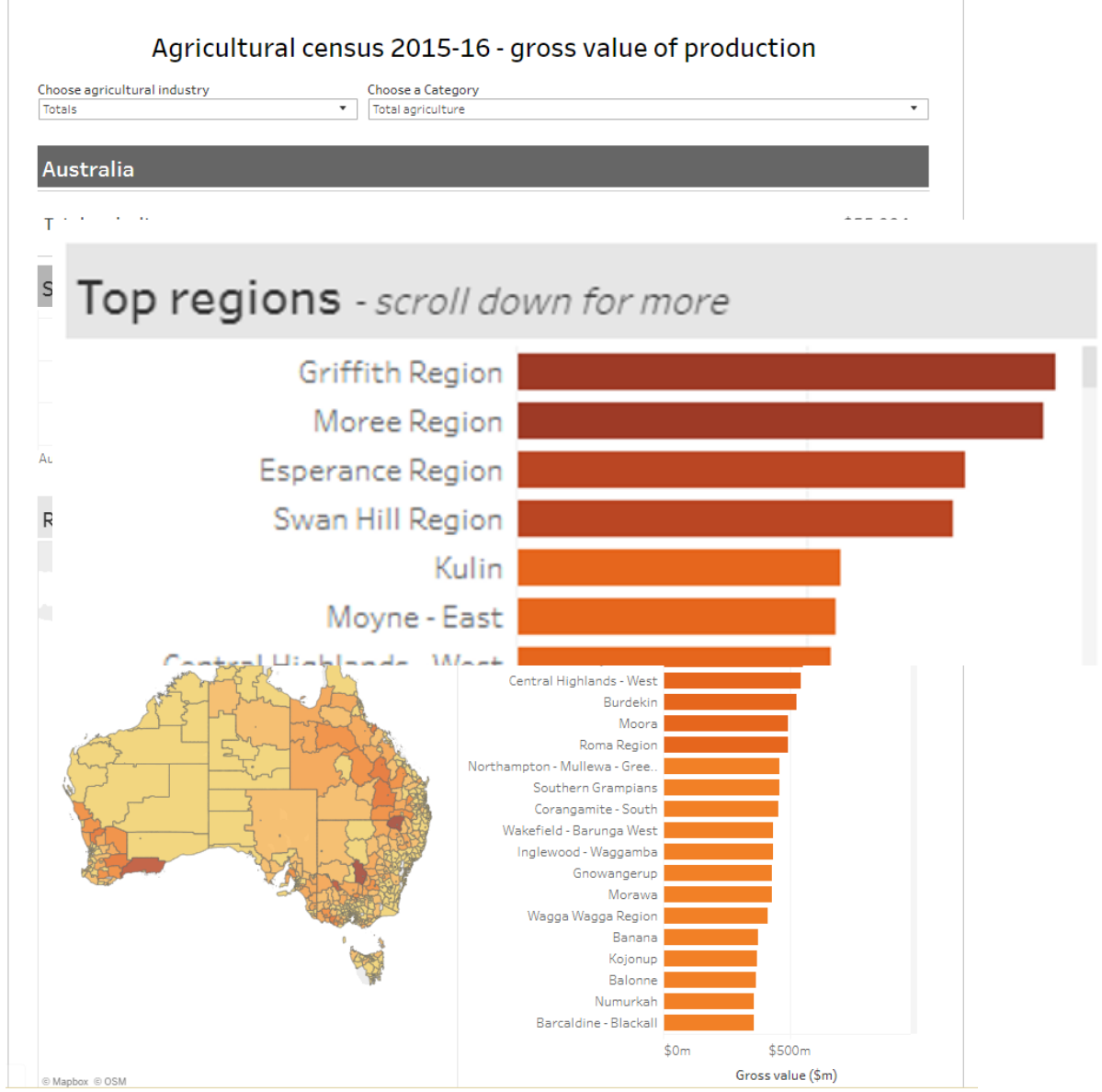
Water Irrigation Efficiency
Dr Rose Brodrick, CSIRO Agriculture and Food, Australia

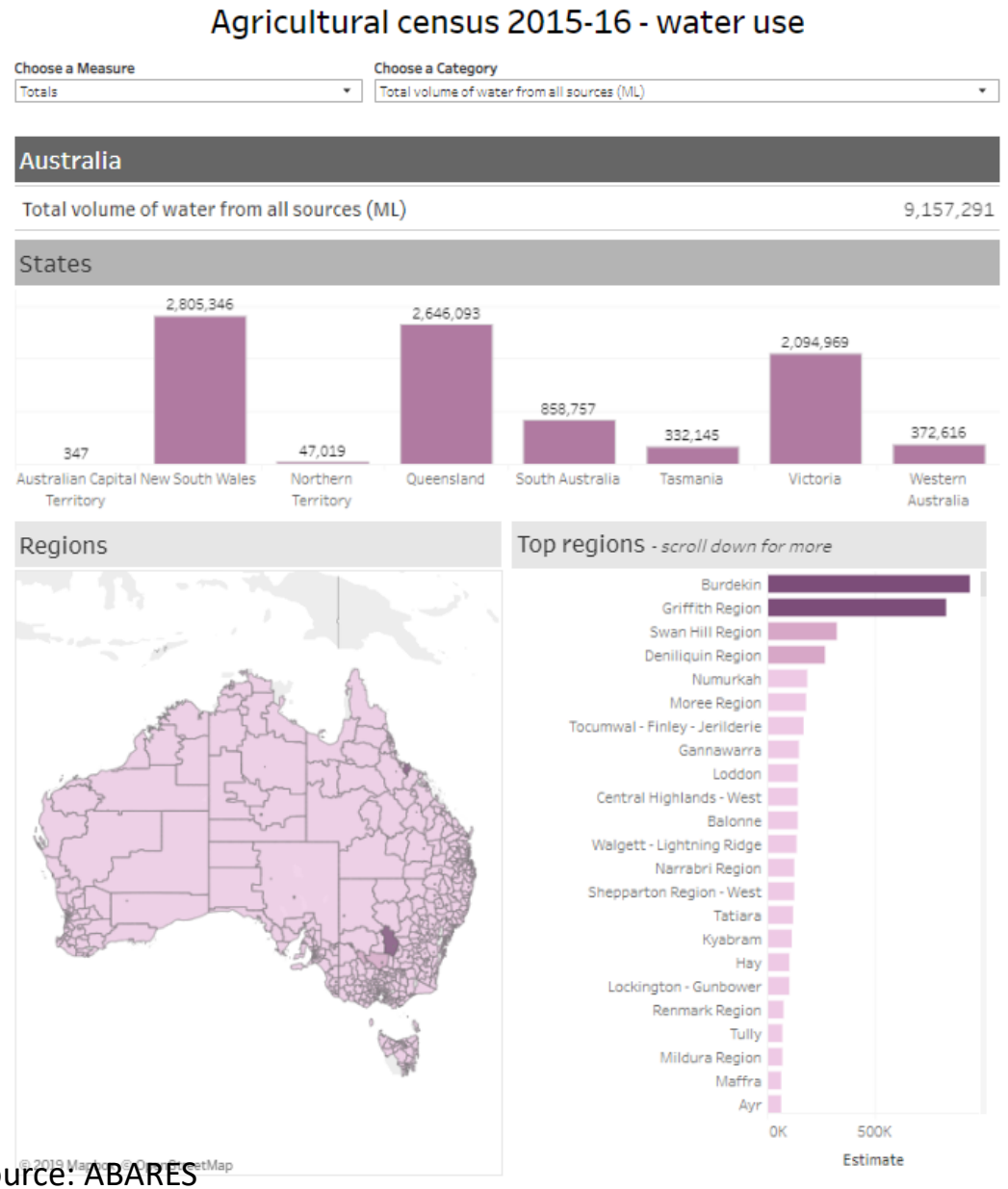
Managing irrigation water is key to future of food and agriculture

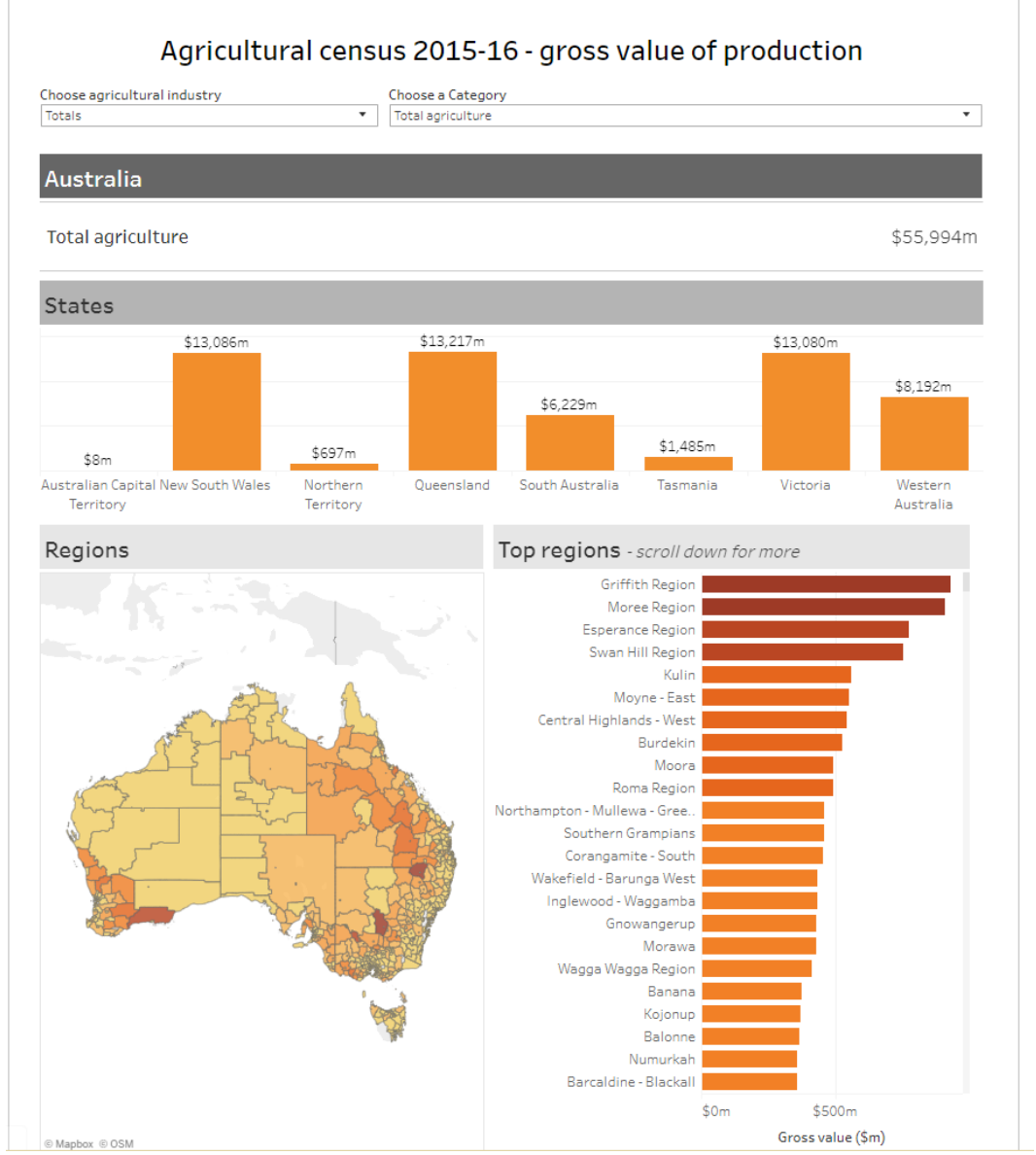
- 70% of water used globally for Agriculture
- 40% of area used for Agricultural production is irrigated
- Average water use efficiency of 38%
- The challenge… improving this!





Source: ABARES





Source: ABARES

Water productivity

- Water productivity has improved 100% in last 60 years!
- Crop water productivity (yield per unit water applied) improvements have been often been driven by yield gains
- Opportunities to improve efficiency through scheduling irrigations to maximise yield – to close the yield gap.
- Lack of confidence in decision making in variable conditions
- Often reliant on experience rather than definitive data to make decisions.

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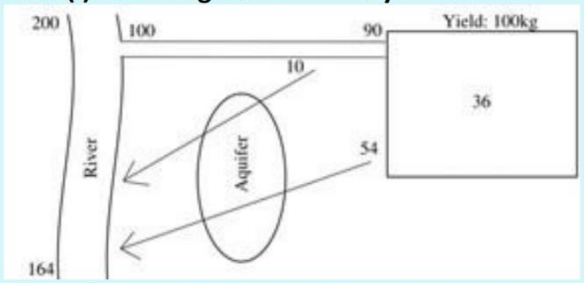
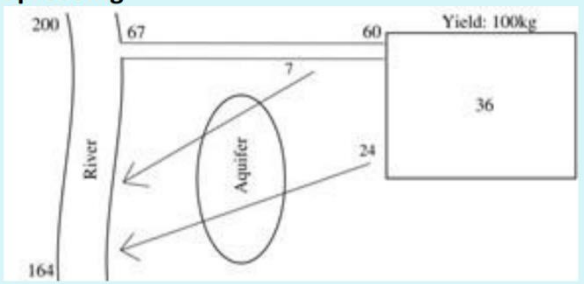
Figure 3: **Effects of Changes in Irrigation Efficiency**

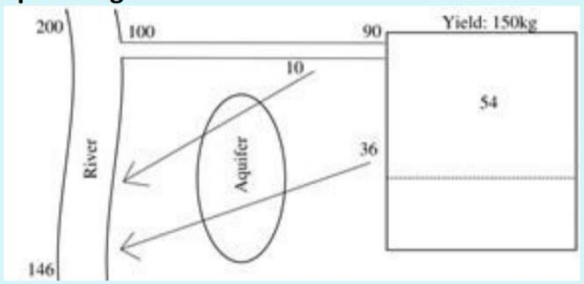
Case (i): 40% Irrigation Efficiency



Case (ii): 60% Irrigation Efficiency, No Water Spreading



Case (iii): 60% Irrigation Efficiency, Water Spreading

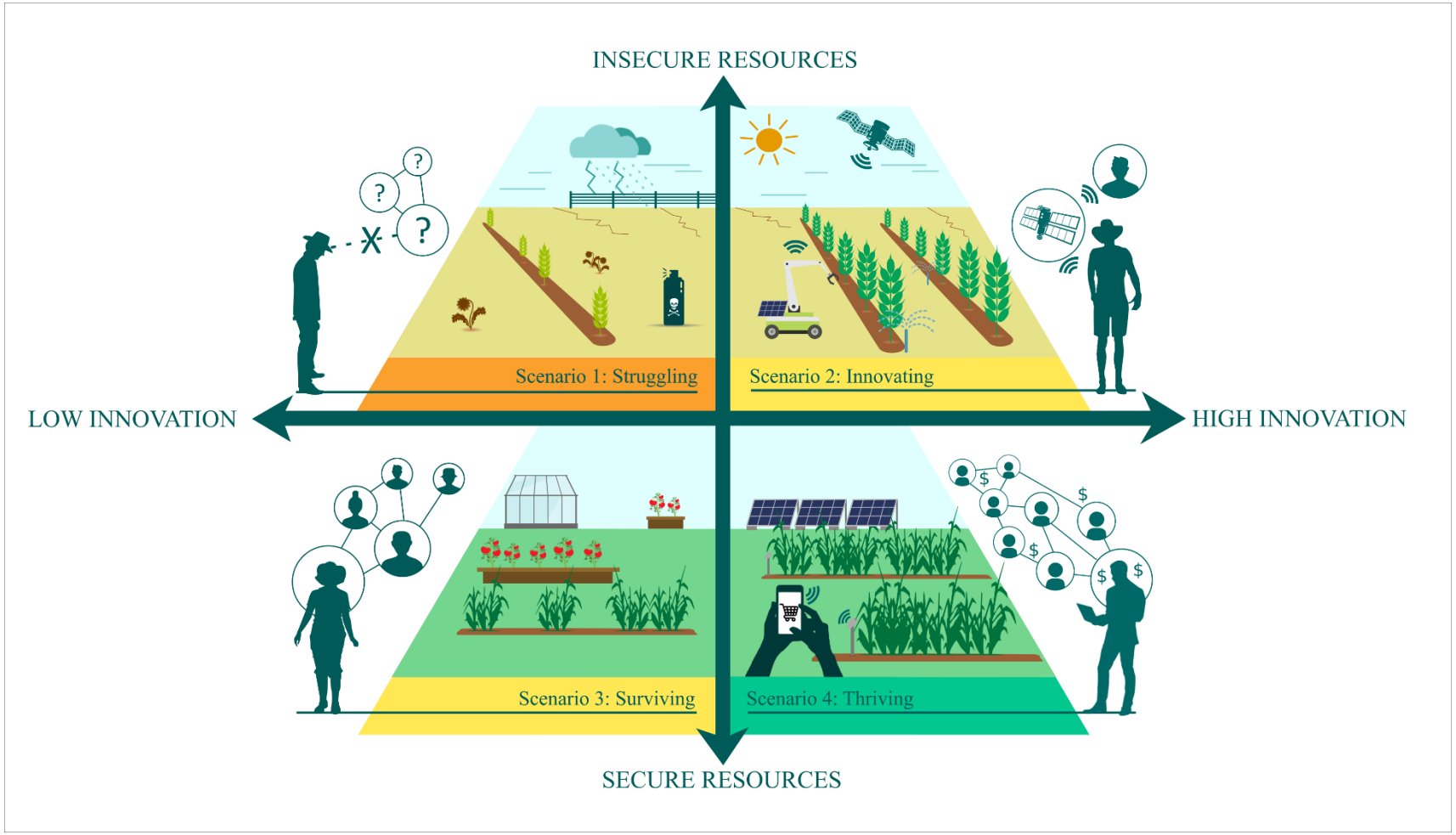


Source: Scheierling et al. 2014.

A ‘climate of change’

- increased variability
- decreased water availability
- rising costs of production
- regulatory constraints
- competing land use
- climate change/carbon markets
- digitally driven agriculture
- Social licence to farm

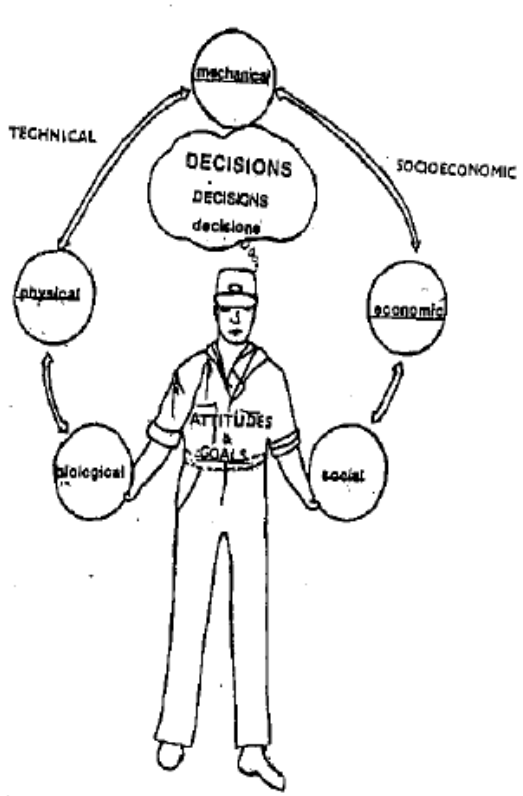
How do we remain productive in the face of changing and uncertain futures

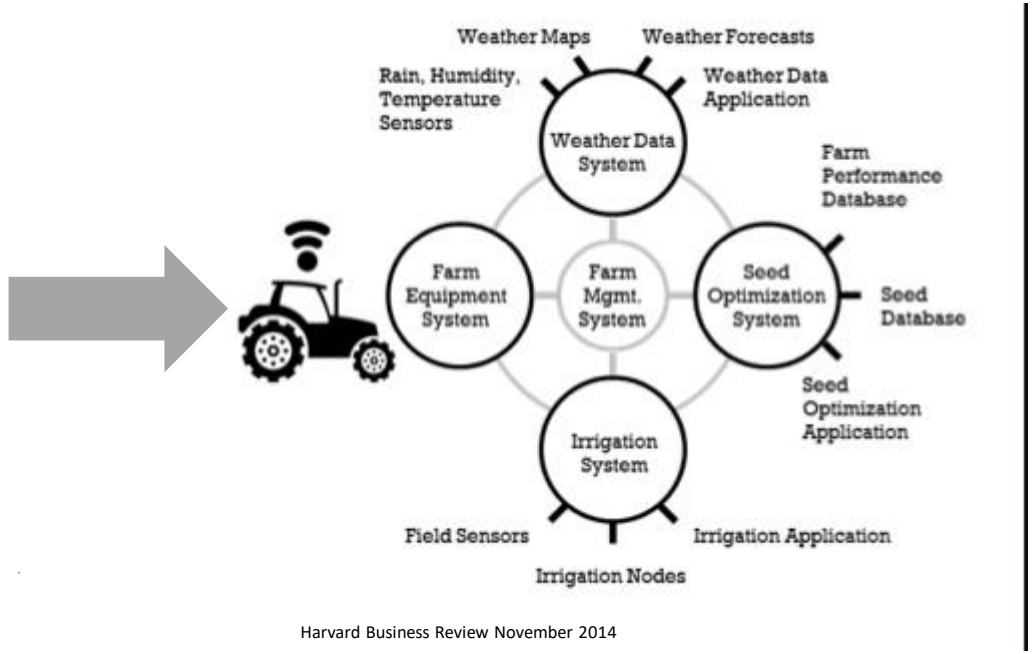


Strategies to adapt to change

- **Increase/maintain yields**
- **Improve production/system efficiencies**
- **Improve the return for Crops/Reduce Costs**
  - **Adaptive Integrated Management**
  - **Harness understanding of existing variability**

Irrigation decision making in a complex and CHANGING system





Harvard Business Review November 2014

- Improvements in water productivity over time have been at the whole-farm level not at the crop level
- Often reliant on experience rather than definitive data to make decisions.
- “Solutions” have often been complex and difficult to implement and situation specific
- Can we develop a simple integrated solution that can be tailored to the system?

Irrigation decision making

- **Timing is critical to maximise crop yield and quality.**
- **Differences in soil type, regional climate, water availability, system capacity, attitude to risk and the amount of data collected means that any irrigation management tools must be able to be tailored to the system.**
- **Decisions are often difficult when situations are considerably different from normal, such as when extreme weather events occur.**

Irrigation Scheduling

- **Efficient Scheduling – putting the right amount on at the right time**
- **Weather, soil and plant based methods of determining crop water use**

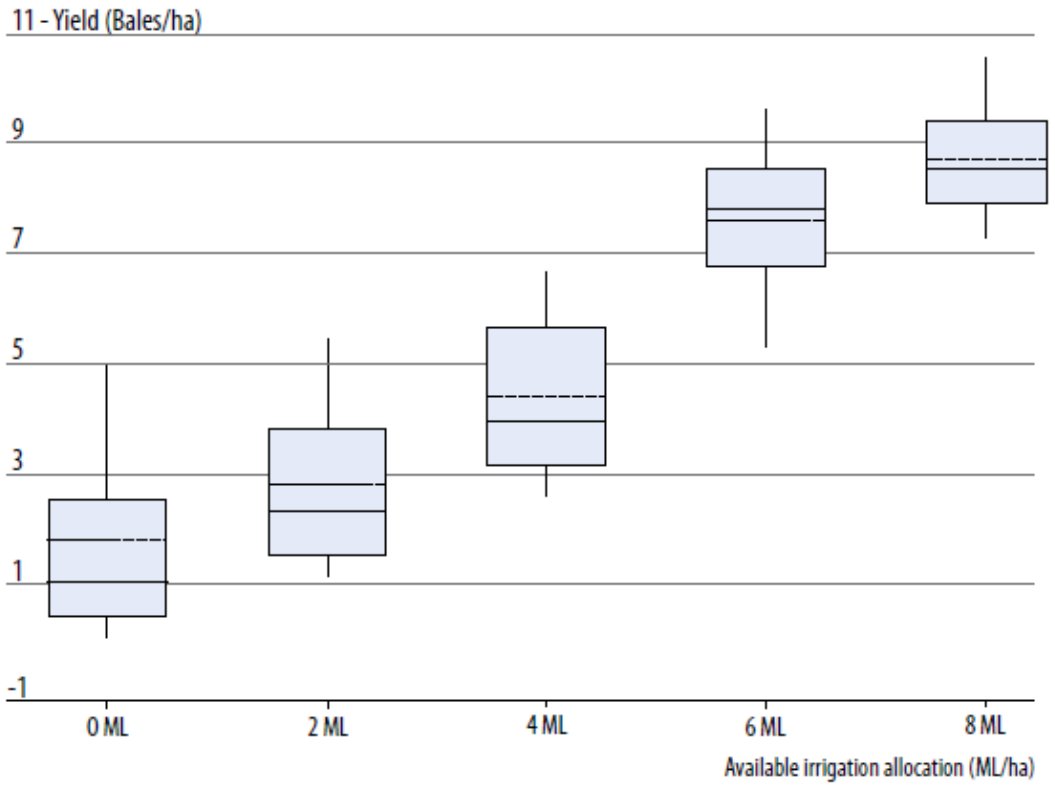
Table 6.2: Optimum deficits for irrigation: vegetative growth, photosynthesis and boll growth.

Age	Deficit for	Irrigation	Minimum Ψ_l uncovered	Relative % reduction		
Days	%	mm	MPa	Vegetative Growth	Photo-synthesis	Boll Growth
61 – 90	50	67 - 77	- 1.8	45	12	Nil
91 - 120	60	93 - 108	- 2.2	82	24	Nil
121 - 160	40	72	- 2.2	82	24	Nil

Source: Hearn & Constable (1984).

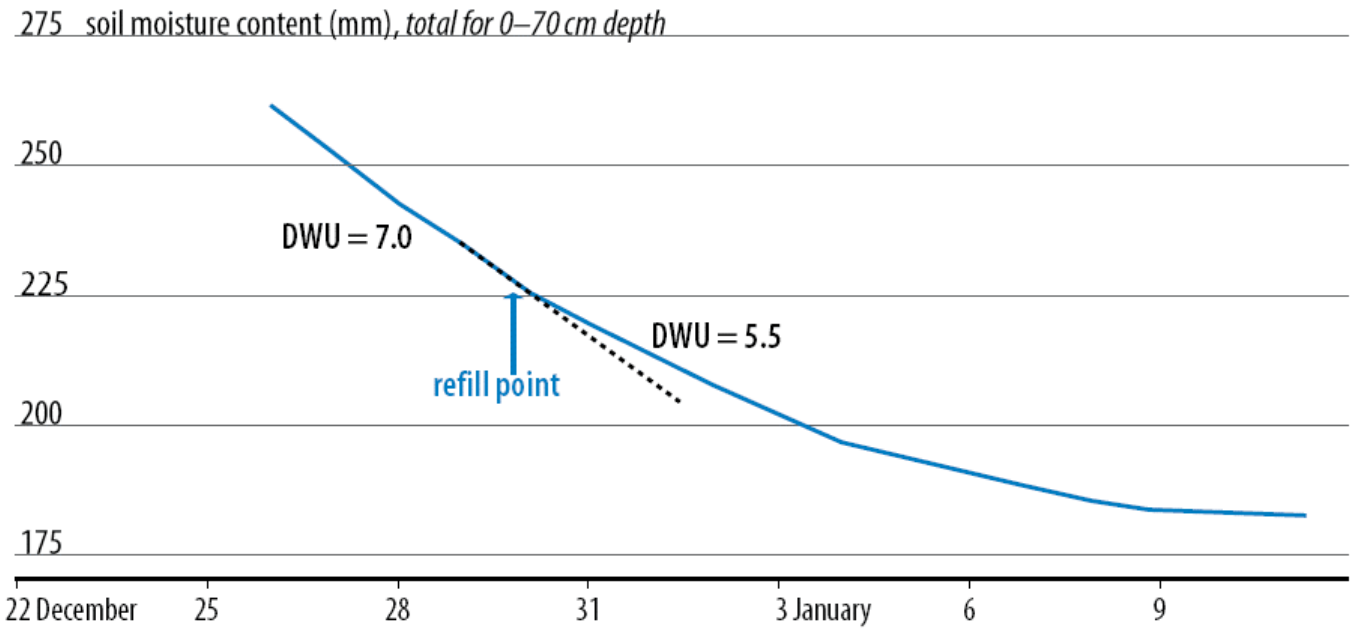
Aim is to reduce variability and optimise yield and water use efficiency

Figure 3.2.3 – CottBASE predicted yield for different irrigation allocations for an example farm at Narrabri .



Irrigation Decision Making Tools and Technologies have often been complex and not integrated

Figure 2.10.3. Setting the refill point by observing the decline in crop daily water use (DWU)



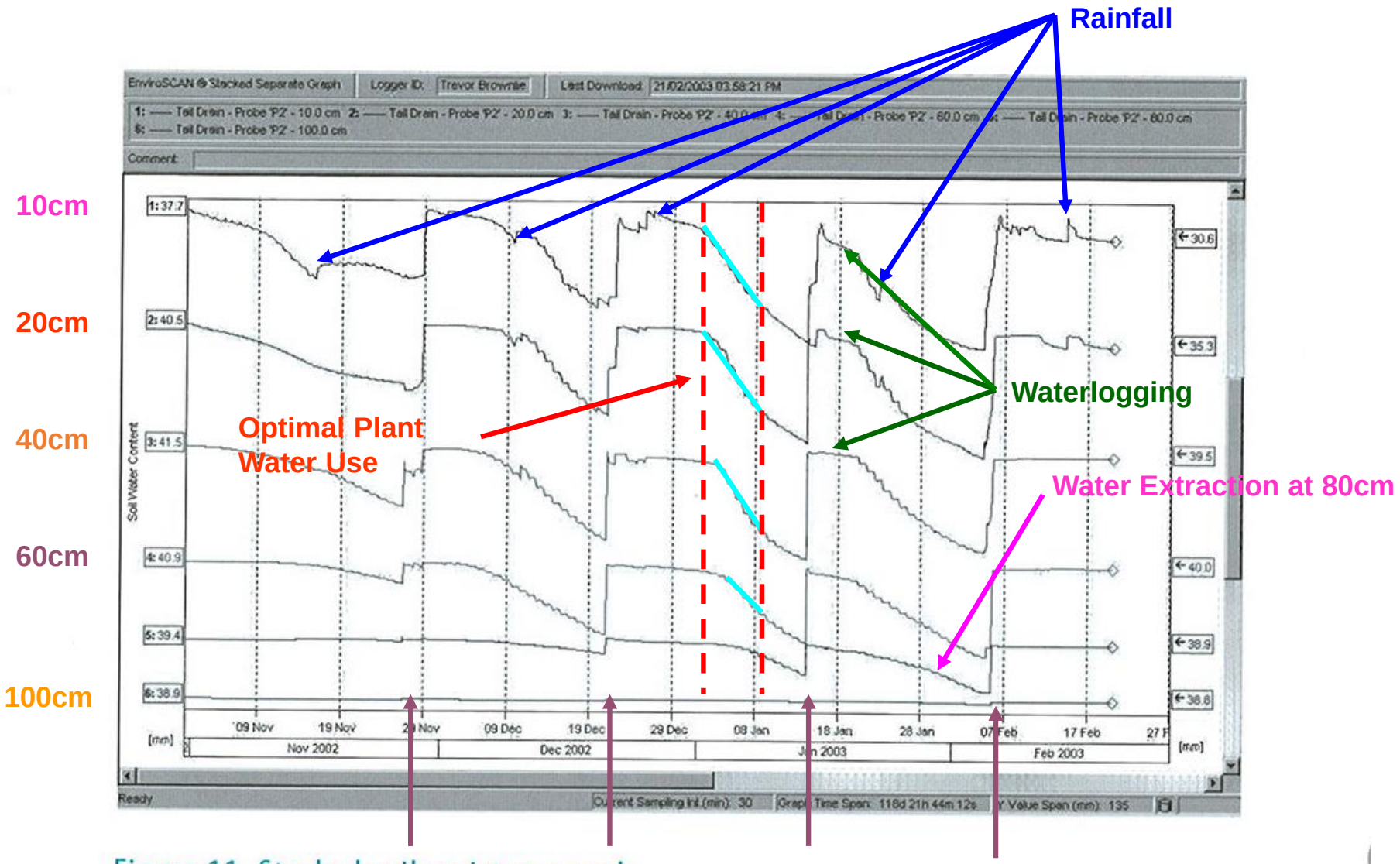


Figure 11. Stacked soil moisture graph

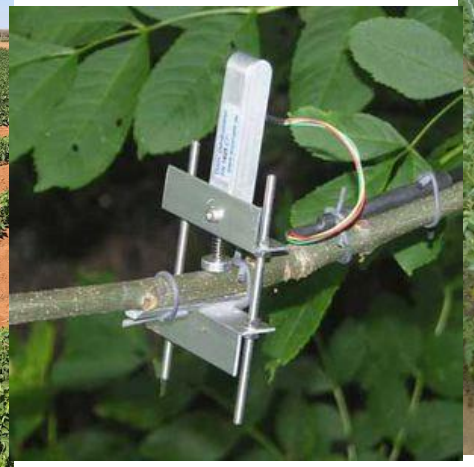
Irrigating to meet plant requirements

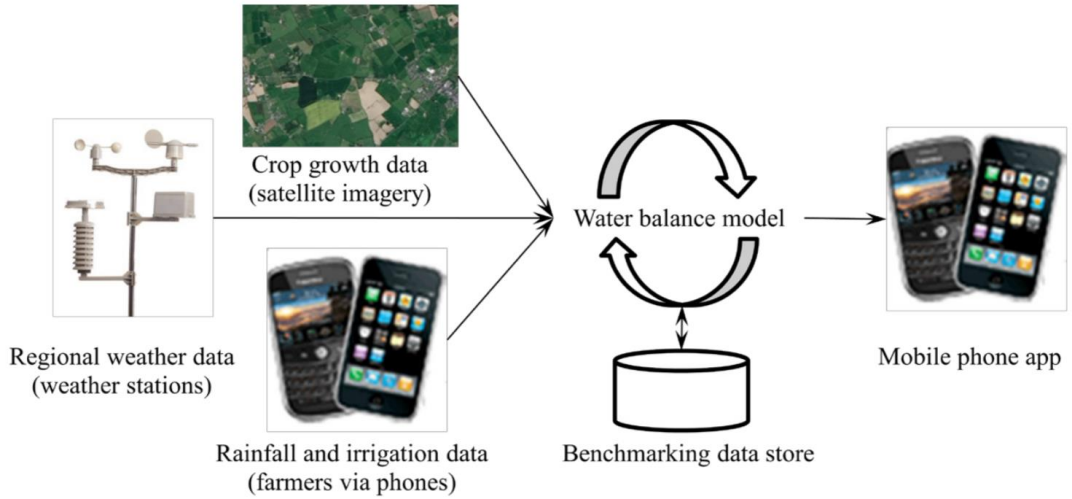
- **More water early can change root development and conditioning of the plant to water stress**
- **Efficient Scheduling – putting the right amount on at the right time**
- **Earlier is not necessarily better – depends on demand from plant and climatic conditions**
- **Aim is to keep the plant functioning at it's biological optimum temperature, balancing vegetative and reproductive growth, keeping in mind soil condition and climatic conditions**

EASY?

A range of options in the ‘Toolkit’

- **Visual Plant Symptoms**
- **Shovel**
- **Weather data (ETc)**
- **Calendar**
- **Crop models**
- **Sensors (Soil and Plant based)**





WaterWise

More efficient irrigation timing through sensing plant water stress

https://research.csiro.au/digiscape/digiscapes-projects/waterwise/

- **addressing the challenges of irrigating high value irrigated crops with limited water**
- **using sensors, models and analytics develop a blueprint to serve an industry quickly**
- **Providing an integrated decision**

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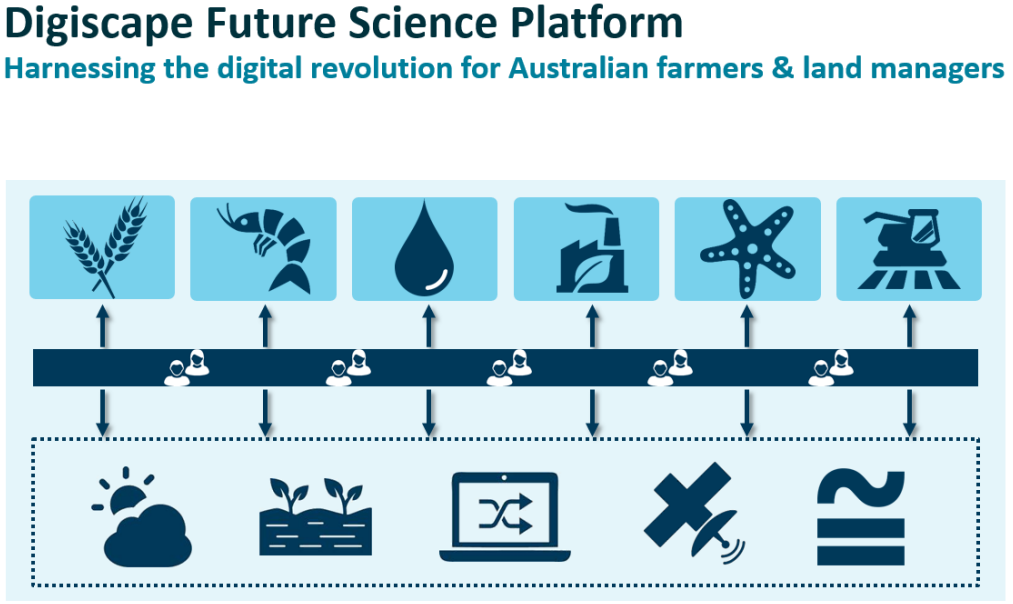
Multidisciplinary Teams

- Systems agronomists
- Data Analysts
- Social Scientists
- Climate Scientists
- Software Engineering
- User Experience testing
- Sensor optimisation
- Uncertainty analytics
- Hardware development
- Technical Support

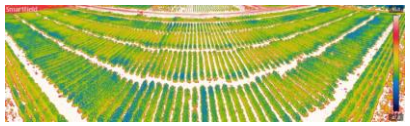


WATERWISE

Quantifying crop stress and the need for Irrigation

Novel Continuous Plant based sensing for stress Quantification

Spatial Measurement of crop stress



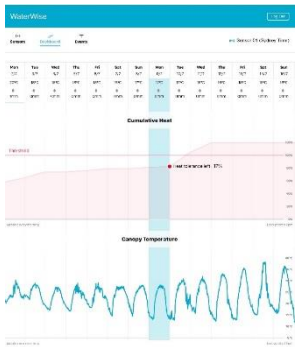
Current and future weather

- Advanced Analytics
- Senaps-LAND
- Image Analysis
- Improved Weather Forecasts
- Underpinning Physiology
- UX expertise

Blueprint for other high value crops

Prototype "APP" for engagement and demonstration

https://waterwise.io



Partner for implementation

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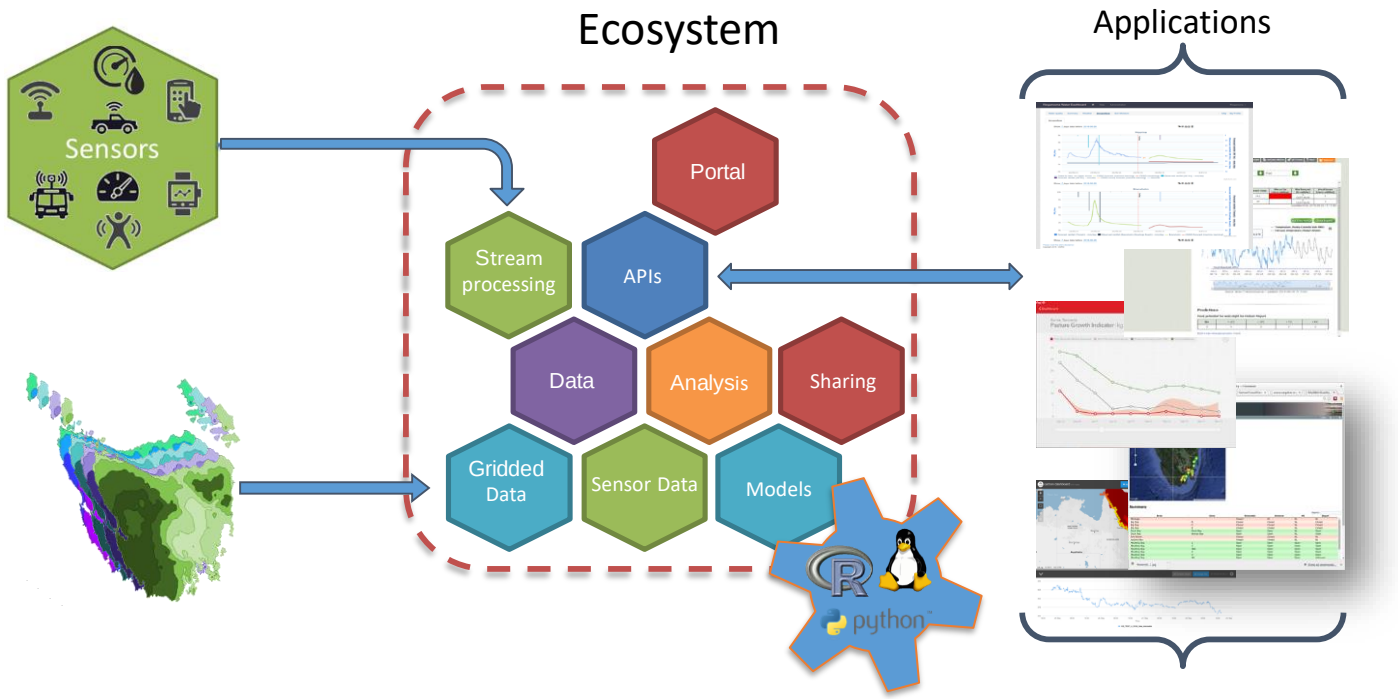
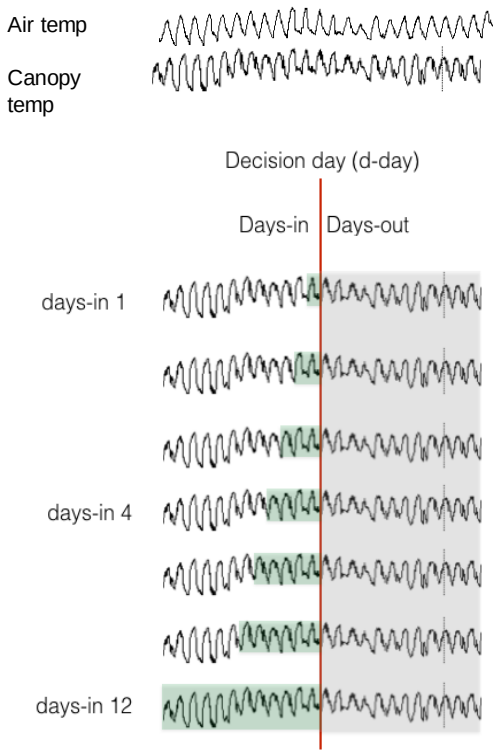
Senaps: sensor data staging system

- **Sensor data management, access control**



Prediction

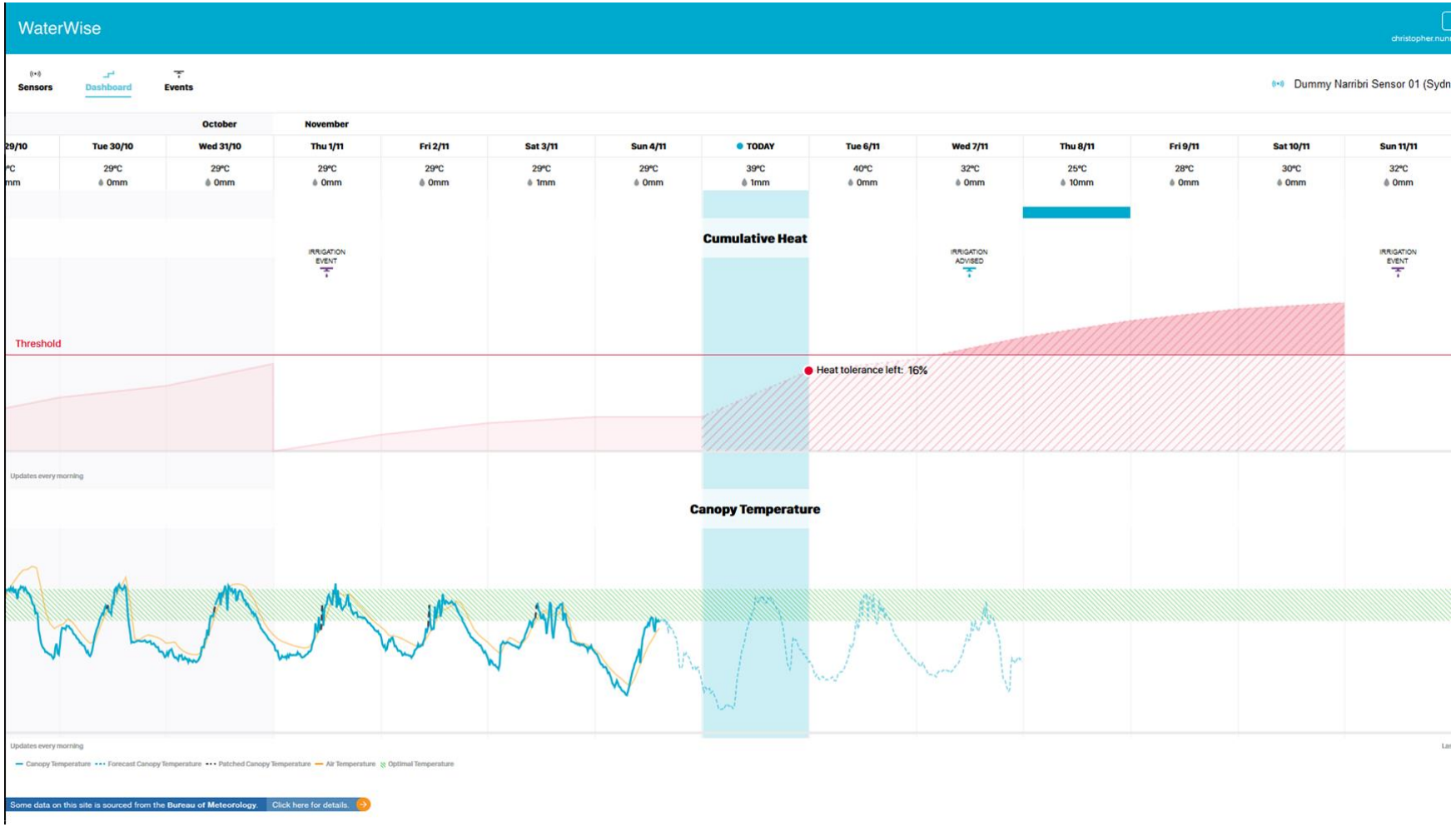


Prediction of Canopy Temperature

- **Predict when to irrigate**
- **End of season water needs**
- **Error checking and patching data**
- **Self calibrating sensors**

Prototype for grower feedback

- **WaterWise V2**
  www.waterwise.io



WaterWise Approach in new crop

- **1st Year:**
  - Asking the farmer who make the decisions in target crops
  - What are the issues
  - What information would be helpful?
  - Sensor deployment for information and learning about how farmers currently irrigate

- **2nd Year:**
  - More intensive sensor deployment, yield and water monitoring
  - Biochemistry for crop
  - Develop irrigation and predictive algorithms

- **3rd Year +**
  - Test the algorithms
  - Get feedback from farmer partners
  - Fine tune and tailor to system

Grower Interviews
(User Experience/Human Centre Design)

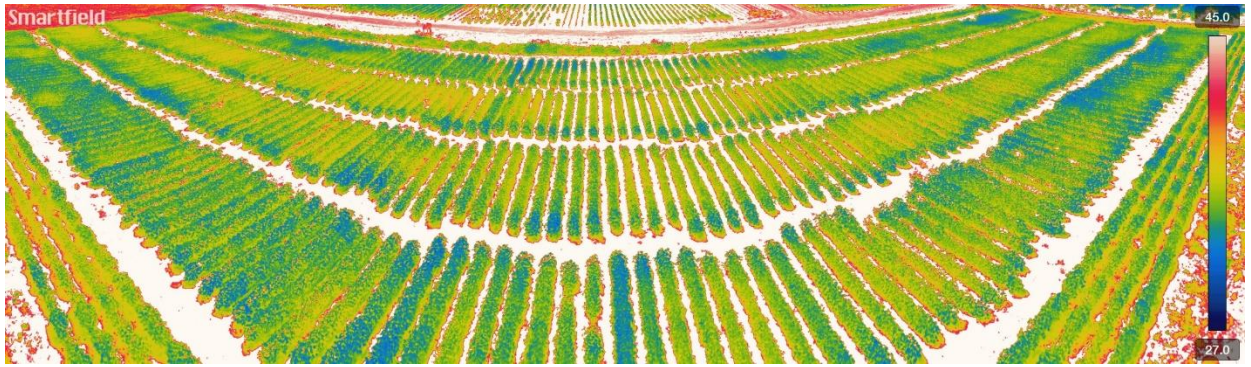
"A lot of farming is about looking back to see whether we made the right decision, and if we didn't, it is about understanding what we should do next time".

"You don't want the crop to be stressed, but it is like your children, you tend to be over protective. So you tend to give them more water than they actually need".

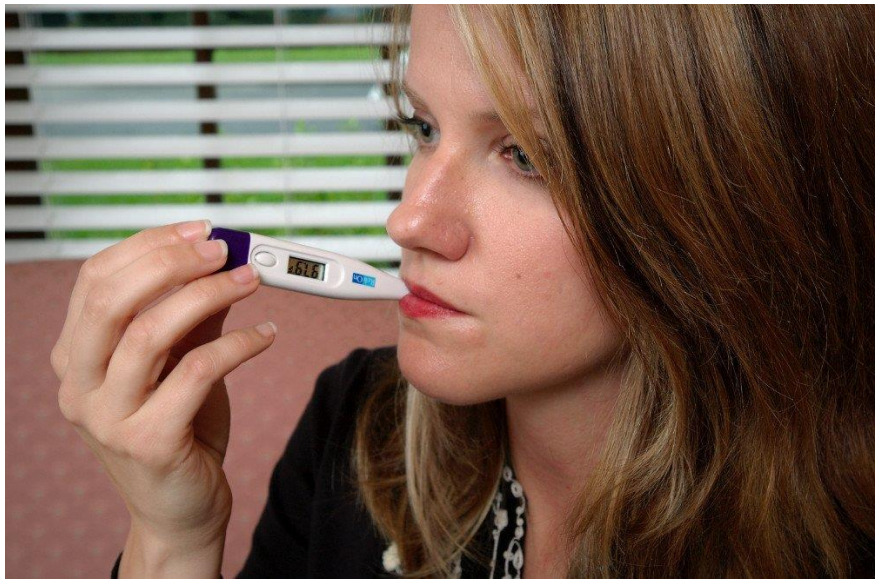
"It (WaterWise) might reduce the number of irrigations. Or on the contrary, people might realise that they should be irrigating more often".

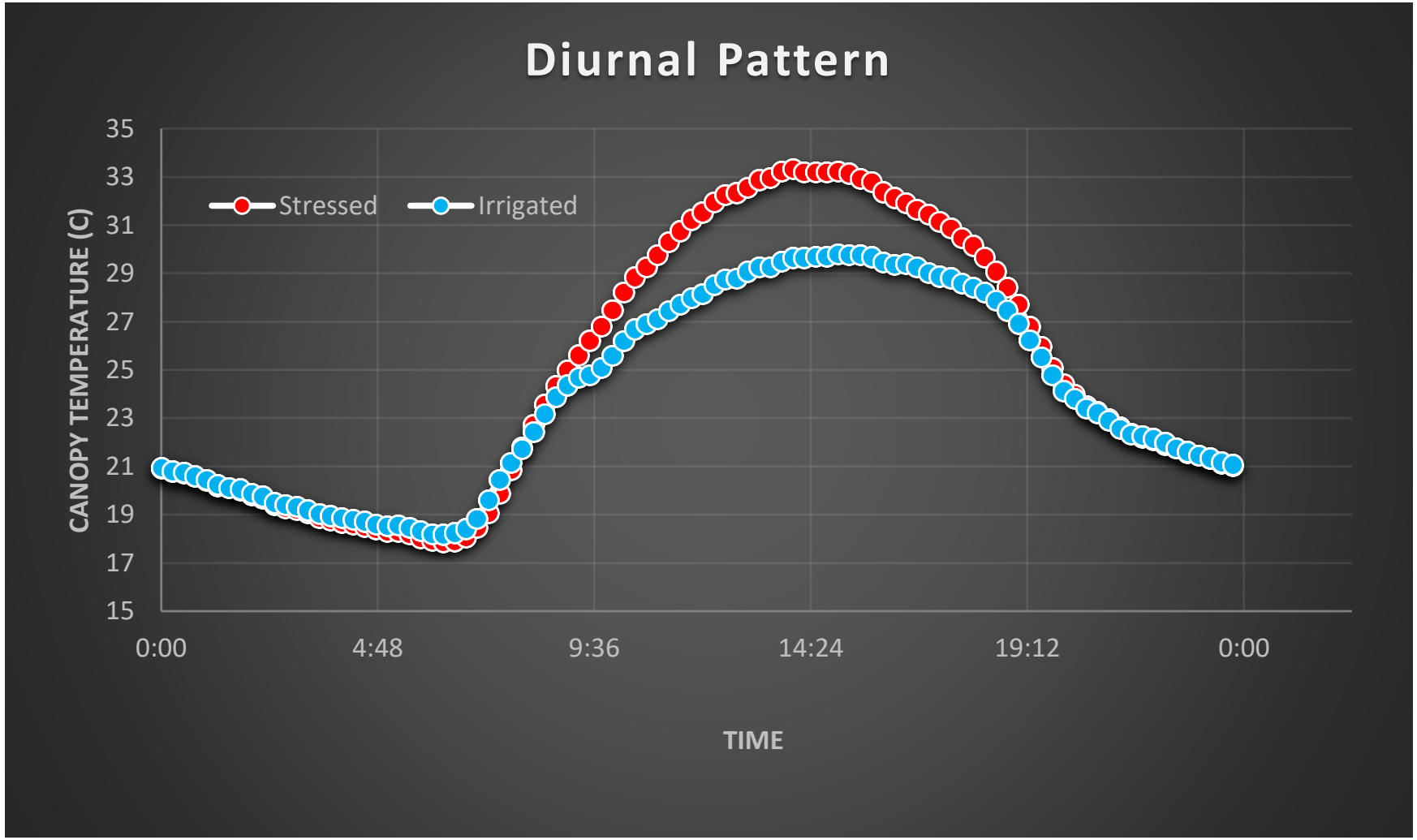
- Perfect tool would be easy to use and integrated.
  - soil moisture,
  - canopy temperature
  - weather forecast
- Scenario Analysis – including the costs/consequence of different decisions
- Record keeping

Proximal and Spatial sensors to deliver measures of crop stress



Physiology – temperature tells us a lot!!

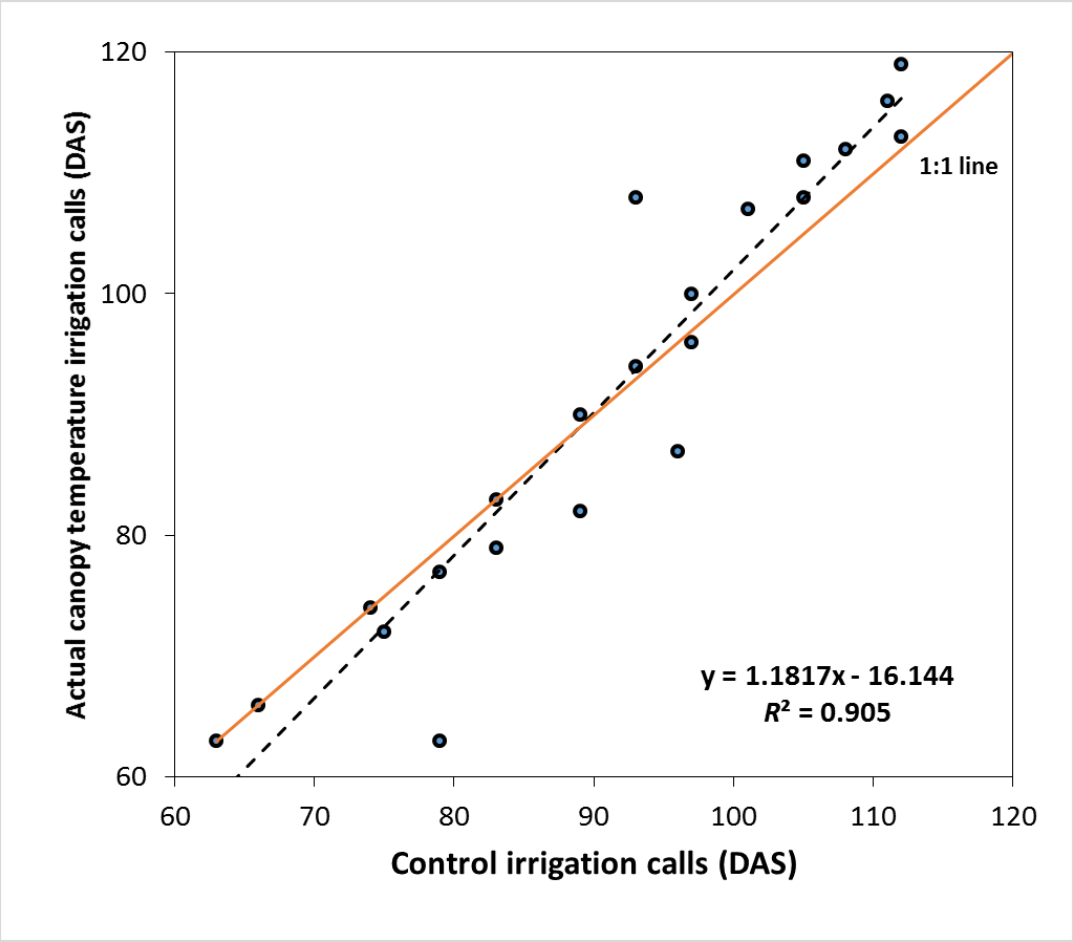



Diurnal Pattern
CANOPY TEMPERATURE (C)
35
33
31
29
27
25
23
21
19
17
15
Stressed
Irrigated
0:00
4:48
9:36
14:24
19:12
0:00
TIME

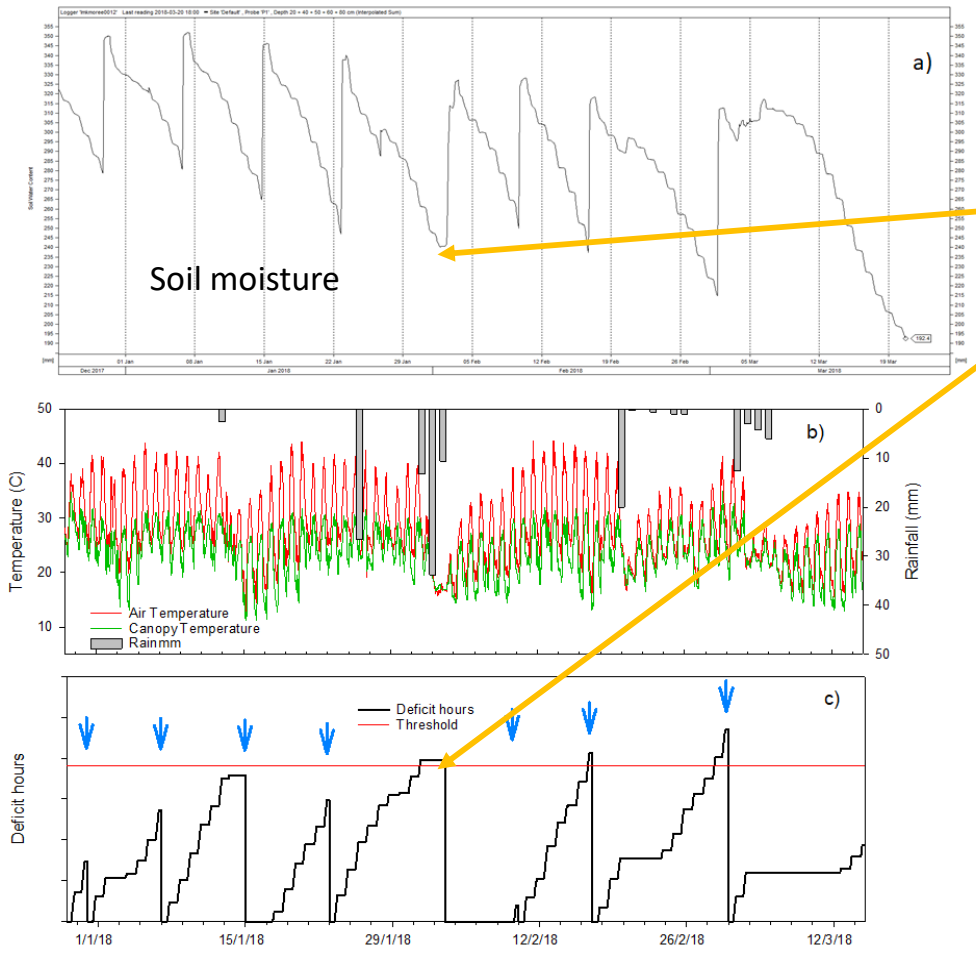
Could we irrigate crops as well as existing best irrigators?

Experiment	Yield	No. of Irrigations
Narrabri 13/14	The Same	The Same
Emerald 13/14	The Same	The Same
Narrabri 14/15	The Same	The Same
Emerald 14/15	The Same	The Same
Moree 14/15	The Same	One Less
Emerald 15/16	The Same	One Less

Comparing the timing of irrigation calls compared to grower practice



DAS – Days after sowing



Grower experience

Grower delayed irrigation using CT and captured rain saving an irrigation

Benefit to cotton producer estimated to be $60 USD/ha.

Based on achieving a 10% water saving 1/3 years with a yield gain of 3% every second year.

Outcomes

- **Quantitatively thus confidently providing irrigators with means to optimise water use, yield, and quality of the target crop.**
- **Water savings**
- **Improving regional economies**
- **Provide stability to industries and regional communities exposed to variable and changing climates.**

No simple answers to complex problems but we can simplify what we deliver to the user

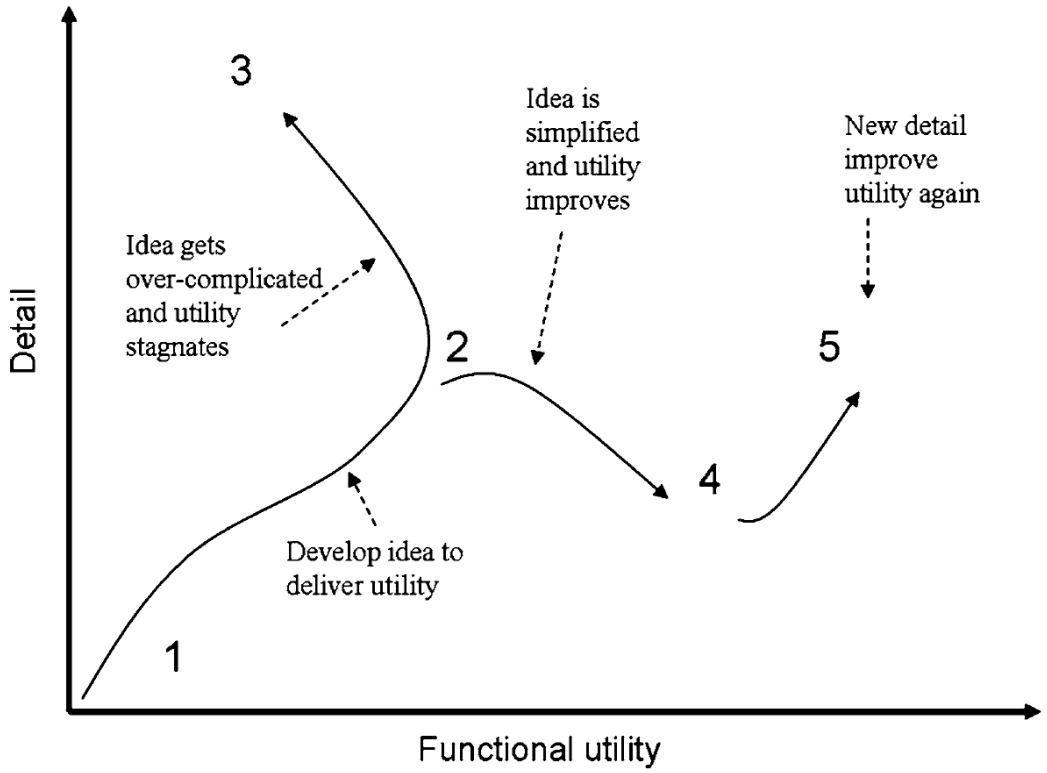
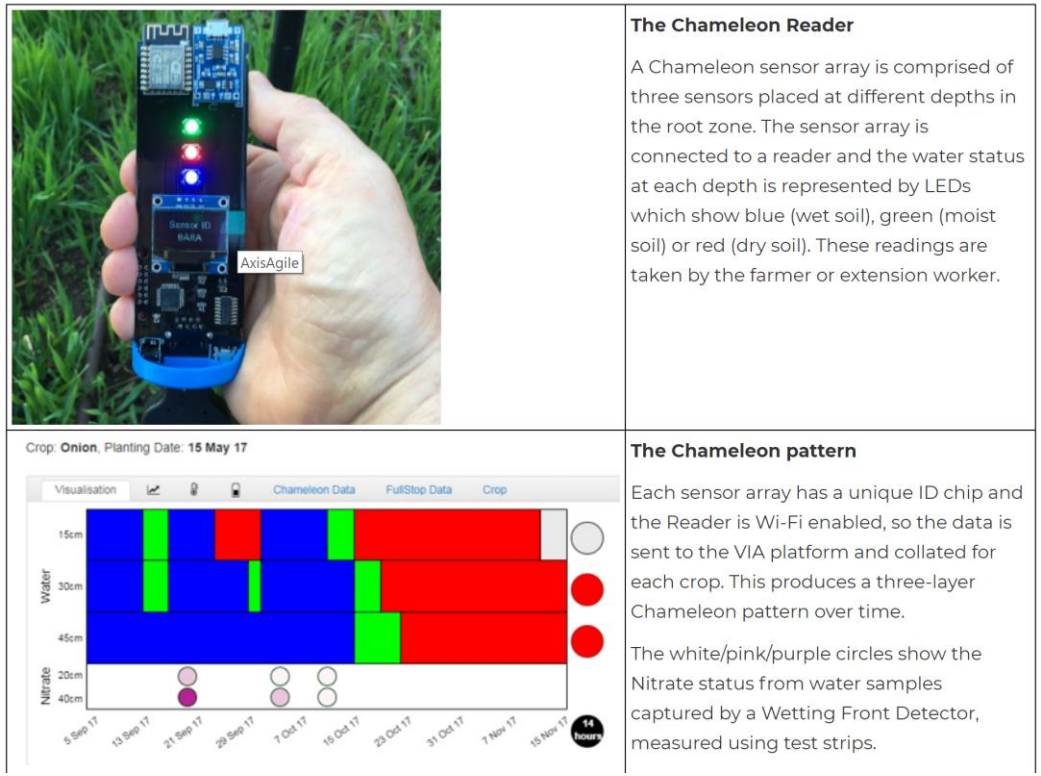


Fig. 2 The simplicity cycle [adapted from Ward (2005]



Learning tools and shared knowledge – not just cool tech

There are many ways to improve crop water productivity

- **Weeds, nutrition and disease**
- **Selection of cultivars or crop type**
- **Cultivation**
- **Bed and field formation and drainage**
- **Use of cover crops or films**
- **Changing planting time**

- **Focus on what are the issues and what tools or knowledge could be applied.**
- **Learning and simplicity – listening and talking to growers can be the fastest way to improvements on farm.**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